Post-Workshop Proceedings for:

crisis management training, design and use of online worlds

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A NordiCHI 2010 Workshop,
Held at the Reykjavik University
Saturday, October the 16th 2010
This volume from Feb2011 contains papers and many of the given presentations

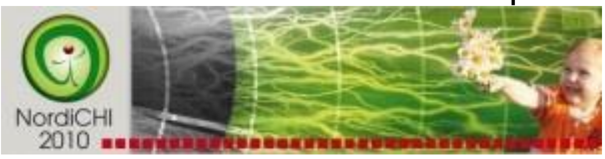
Jointly organised by:
IFIP 13.6 Human Work Interaction Design

and the FP7 CRISIS project.

Organisers:
Rikke Ørngreen (editor in chief / contact person), William Wong, Chris Rooney, Jane Barnett, Ebba Hvannberg and Torkil Clemmensen

Crisis management training: design and use of online worlds

A NordiCHI 2010 Workshop



Held at the Reykjavik University
Saturday, October the 16th 2010

Jointly organised by IFIP 13.6 HWID and the FP7 CRISIS project.

This document contains the original material provided prior to the workshop incl. accepted papers, agenda and practical information as to preparations and place of workshop. It also includes a number of the presentations given at the workshop. The document is edited by the organizers, and authorization to place it in here and online was given, however the copyright of the position papers as well as the presentation material belongs to the authors.

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AGENDA – October 16th, 2010

9.00 - 9.30	Greetings & introduction [Rikke Ørngreen]
9.30-10.30	Panel 1 – [Chair: William Wong] • Adderley & Smith - Assessing Stress in Immersive Training Environments • Clemmensen & Pedersen - HWID perspective on ... ICT systems for climate management • Hansen - Behavior based training improves safety through online simulation environments • Kovordanyi, Rankin, Eriksson - Foresight Training as Part of Virtual-Reality-Based Exercises for the Emergency Services
10.30-11.00	Coffee
11.00-12.00	Panel 2 – [Chair: Torkil Clemmensen] • Barnett, Wong & Coulson - Situation awareness and sensemaking in crisis management • Jenvald, Morin, Eriksson - Challenges for user interfaces in VR-supported command team training • Rudinsky & Hvannberg - Voice Communication in Online Virtual Environments • Ørngreen - Considering the educational and interaction design of mobile equipment for crisis management training
12.00-13.00	Lunch
13.00-14.00	Panel 3 – [Chair: Ebba Hvannberg] • Pinchuk - Semantically Enabled After Action Review • Rankin, Kovordanyi, Eriksson - Episode Analysis for Evaluating Response Operations and Identifying Training Needs • Rooney, Passmore, Wong - CRISIS Research Priorities for a State-of-the-Art Training • Shepherd - Get Real - The Many Faces Of Realism
14.00-14.15	Introduction to group discussions [Jane Barnett / Chris Rooney]
14.15-16.00	Group discussions - Using the CRISIS training scenario as a basis, to which the concepts of the workshop papers can be applied. - Consider what to bring back to the plenary discussion. - Coffee 14.30 – perhaps bring the coffee with you to the group ☺ - [Chaired by: William Wong, Jane Barnett and Chris Rooney]
16.00-17.00	Plenary discussion / reports from the group [Chair: Torkil Clemmensen and Ebba Hvannberg]
17.00-17.30	Closing & future possibilities… [William Wong and Rikke Ørngreen]

All NordiCHI 2010 workshops will take place at the Reykjavik University

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- http://www.ru.is/
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Organisation and Preparations to the workshop

The workshop is divided into a morning session of panels and an afternoon session of small group discussion based on a mutual case, ending with a plenary discussion.

The panel begins with a round of paper introductions and afterwards an open dialog will take place. Only one person from each paper presents and participates in the panel. It is up to you as authors to choose a representative. Each paper presenter has 7 minutes. There will be a projector in the room if you wish to make use of slides or similar – just bear in mind the very short time frame for paper introductions.

The group of papers used in the panels will also be used in the small group discussions in the afternoon. There are a couple of participants that are not authors of papers, you are of course most welcome, and we look forward to your active participation in the dialog as well. Also, there are authors that have co-authored several papers. Consequently, to make sure group sizes are more or less the same in the afternoon session, we have taken the liberty to already assign groups to the participants that we know of. We hope you will all make yourself acquainted with the papers in your group. That is, as a participant in the afternoon group, you have to read the papers of your panel number. If you in the participants list below find that you "participate in the afternoon group with panel 3 papers", you read the papers listed in panel 3 in the agenda, and so forth.

Confirmed Participants – including afternoon discussion groups

- Amy Rankin (participating in the afternoon group with panel 3 papers)
- Chris Rooney (participating in the afternoon group with panel 3 papers - CHAIR)
- Ebba Hvannberg (participating in the afternoon group with panel 2 papers)
- Gyða Halldórsdóttir (participating in the afternoon group with panel 3 papers)
- Henrik Eriksson (participating in the afternoon group with panel 2 papers)
- Hjalti Pálsson (Isavia) (participating in the afternoon group with panel 2 papers)
- Ifan Shepherd (participating in the afternoon group with panel 3 papers)
- Jan Rudinsky (participating in the afternoon group with panel 2 papers)
- Jane Barnett (participating in the afternoon group with panel 2 papers - CHAIR)
- Joris Field (participating in the afternoon group with panel 3 papers)
- Kristian Hansen (participating in the afternoon group with panel 1 papers)
- Michelle Smith (participating in the afternoon group with panel 1 papers)
- Rani Pinchuk (participating in the afternoon group with panel 3 papers)
- Richard Adderley (participating in the afternoon group with panel 1 papers)
- Rikke Ørngreen (participating in the afternoon group with panel 2 papers)
- Rita Kovordányi (participating in the afternoon group with panel 1 papers)
- Torkil Clemmensen (participating in the afternoon group with panel 1 papers)
- William Wong (participating in the afternoon group with panel 1 papers - CHAIR)

Table of Content

Assessing Stress in Immersive Training Environments

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ABSTRACT

This paper represents initial research into ascertaining whether a biometric monitoring device can be used to identify that a trainee, who is undertaking an immersive training session, is being placed under sufficient stress for it to be classified as being realistic. The vehicle used for this initial research was a group of volunteer UK Police Traffic motor cyclists who were monitored during a series of eight hour shifts and their biometric results were analysed against their activities. For the purpose of this research, athletic training zones were used as an indication that an Officer's heart rate had increased to an abnormal level even though they were not undertaking physical activities. The results indicate that, in certain circumstances, Officers' heart rates rise into their training zone indicating that the current activity that is being undertaken may be causing them stress. This indicates that it is feasible to use a biometric monitoring device to measure stress thereby establishing the authenticity of immersive training.

Author Keywords

Stress in training, Training evaluation, Activity analysis, Biometrics.

ACM Classification Keywords

Training, Validation, Verification

INTRODUCTION TO STRESS IN TRAINING

Every profession requires an element of training in order for individuals to perform their daily tasks and routines effectively. However, training is also required to prepare individuals for situations that are likely to happen on an infrequent basis.

In order for a crisis manager to be effective during a crisis, s/he must be able to remain calm, and be able to effectively execute the contingency plan that has been enforced by the organisation. The crisis manager will often adopt a more authoritarian style than normal [33] in order to ensure that the crisis is dealt with efficiently.

Many organisations send their crisis managers on training courses in order for them to learn the skills required to deal with a crisis situation, as crisis management is not as clear-cut as one would imagine. Lockheed Martin UK [24] state:

> Crisis managers need to be able to perform in very stressful situations. They need to be capable of taking responsibility and to exercise leadership in often chaotic and confusing situations [24].

Training courses are run by a number of different companies worldwide, who state that they are able to assess whether those attending the courses have the potential for coping with the crisis manager's role. These courses tend to last several days, incorporating lectures, discussion, practical demonstrations and role play. They often finish with an assessment to confirm competency. Once crisis managers achieve competency, they are then commonly expected to communicate this knowledge to their staff [35].

The UK Police Service uses an immersive learning environment known as HYDRA when it comes to training both senior managers and police personnel, as it is currently the most effective source of training for major critical incidents.

> Immersive learning is learning promoted by the learner experiencing as closely as possible the emotions and the style of thinking of someone in a stressful environment [16].

Immersive learning enables a variety of critical incidents to be simulated in a vivid and realistic manner as the individual is immersed in the given situation and able to experience the difficult decisions that have to be made and any potential repercussions as a consequence. The situation being simulated can vary in complexity, including the challenges faced by individuals and the confusion and disorder often associated with the particular situation.

However, when an individual, whether it be a crisis manager or a member of staff, is placed in a learning environment in order to develop his/her skills when dealing with a specific incident, s/he will experience stress to a degree.

There are many courses run by various companies worldwide demonstrating how stress should be managed in the work place. There are also numerous studies documenting how to measure training stress, but this is related to physical fitness, however the authors could not locate any studies that demonstrate how stress is measured whilst individuals partake in an immersive training exercise.

When individuals are placed in front of a computer in a training environment, the initial thought is that they may not experience any form of stress during the course of the training, as they are merely sat in front of a computer and may treat the training as a game and not take it seriously.

After conducting a literature review, it was found that there was no direct supporting evidence with regards to monitoring the physiological affects that training situations have on the participants. The majority of literature examined related to physical fitness and training zones.

Langan-Fox et al. (1997) [20] looked at stress, coping strategies and power motivation in their study of 34 police trainees during their 19 week initial training, as their aims were to investigate:

> Study 1 (a) the stress and anxiety associated with a training programme; and (b) the relationship between stress, illness and nPower. Study 2 (c) the coping strategies employed in response to the stress of a training programme; (d) whether trainees had a high need for power and whether this need for power was related to coping strategies; and (e) whether trainees appraised the training programme as stressful.

Langan-Fox et al. used the results from the Hassles and Uplifts Scale (HUS) [18] along with the Social Readjustment Rating Scale (SRRS) [14] on all subjects to establish whether external factors were causing the subjects to experience stress outside of the training environment. Their results showed that overall subjects stress levels were elevated prior to the commencement of the training programme compared to two thirds of the way through the course.

> The results of preliminary analyses examining the nature of the environmental conditions appeared to confirm that extraneous stress was not associated with training and was not impacting on trainees [20].

Langan-Fox et al. found that during the training, subjects used problem-focused coping strategies more than emotion-focused strategies. However, they found that whilst there was no direct correlation between coping behaviour and power in the subjects, there was a correlation between problem-focused coping strategies and subjects who were classed as highly power-motivated.

Moran [26] conducted a study to evaluate fire fighter trainee's personal predictions of stress in New South Wales, Australia. Subjects were required to complete a questionnaire during the first and last week of the 20 week training course. Moran found that new recruits did not generally predict very high levels of stress prior to training, however, post training results were marginally higher as recruits were able to interpret their role better. As three quarters of the group had previous emergency experience, it could be believed that their perceptions of stress were a coping mechanism referred to as a "trauma membrane". It was found that individuals, in this instance emergency workers,

> … shield themselves emotionally from unpleasant or threatening scenarios [26].

Moran concluded that recruits may not only be affected by the perceived stress of the job but also the perceptions others have of them in senior roles and the media.

Whilst these studies have been useful, according to the literature review, there are no studies that have been conducted whereby subjects have had their physiological readings recorded and monitored by a body worn sensor, whilst undergoing training and the results subsequently examined afterwards.

It is important when placing individuals in a training environment that it is as realistic as possible, as it must mirror their "normal everyday duties" as closely as possible. One way of achieving this is to place the individual in an immersive environment which reflects normal working conditions/practices/language, thereby exposing individuals to normal daily stressors.

The authors are working together with an EU consortium to develop a **CR**itical **I**ncident management training **S**ystem using an **I**nteractive **S**imulation environment (CRISIS) which will provide a different level of training compared with courses currently provided for emergency service personnel. It will enable the training of crisis managers and their staff in response to a crisis or critical incident at an airport or rail location.

The UK Police Service use an immersive learning environment as previously mentioned, namely HYDRA, to train staff at all levels in crisis management. Within this environment, the Officers also have access to the use of video, audio, photos, operational radio traffic, telephone, maps, intelligence, documentation, background noise, choice of problems and the sequencing and timing of the simulation [17], in order to experience the critical situation in a safe environment.

The objective is to invite a number of trainees whilst undertaking general Police and aviation simulation training to wear a body worn sensor to measure their heart rate, breathing rate and skin temperature. The sensor used by the authors is an Equivital monitoring device. The participants will be invited to wear the sensor throughout the duration of the training exercise in order for full readings to be recorded against each individual training activity.

Even though individuals may not feel as though they are experiencing any stress, their physiological readings may draw different conclusions. The data obtained will be used as the bench mark against which the CRISIS software can be objectively measured.

Once the iterative training and evaluation process begins in Month 16 of the CRISIS project, participants will be invited to wear the Equivital sensor during the training sessions, in order for the heart rate and breathing rate to be captured and subsequently compared against the original data obtained. This will provide an indication as to whether the CRISIS system being developed is as effective as the training systems currently used, and whether it is putting the participants under the same degree of stress.

Whilst participants may not feel as though they are under any undue stress, their bodies may be experiencing a physiological change resulting in an increase in their heart rate, breathing rate and skin temperature. This would indicate that their physiological readings are signifying that the participant is experiencing stress to a degree. Thus, by placing an individual in an immersive environment that is providing real-time training of a major incident, s/he is likely to experience events that s/he would not necessarily experience within his/her daily routine. As a result, stress levels may automatically be increased.

INTRODUCTION TO STRESS AND ITS IMPACT ON HEALTH

Stress is a catch-all term that describes bodily reactions to a range of perceived threats, both physical and psychological. Once essential for survival, the pace of modern life and its myriad demands has turned stress itself into a major threat. Cortisol is secreted into the body by the adrenal glands and is an important hormone involved in a range of functions including being secreted in higher levels during the body's reaction to stress in the "fight or flight" syndrome. Small increases have positive effects such as providing a quick burst of energy, heightened memory functions and lower sensitivity to pain. However, prolonged high levels of cortisol can lead to a range of unhealthy conditions such as heart disease [31].

If chronic, stress can have serious health consequences, and is a leading risk factor for heart diseases, diabetes, asthma and depression. However short term stress, which is the "fight or flight" syndrome, can affect sleep patterns in the form of insomnia and fatigue and also result in physical pain in the back, shoulders and neck [29]. It may also affect a person's speech [36].

It has been shown that psychological stress can suppress an immune system's response to infection [30; 7] and slow the rate of wound healing [19]. Lazarus [22] states;

> …It should come as no surprise that many conditions of work such as time pressure, noise, work overload, lack of decisional control, role ambiguity, conflicts with superiors and subordinates and so on are stressful for large numbers of workers… (page 8).

Despite its impact on health, however, it is not unfeasible for physicians to continuously monitor our stress levels, nor is it practical (or objectively possible) for us to keep logs of our internal states throughout the day. Thus, a device that could monitor stress over extended periods (from weeks or months) would provide individuals and their caretakers with hard data with which to monitor progress and determine the most appropriate interventions. A number of physiological markers of stress have been identified, including electrodermal activity (EDA), heart rate (HR), various indices of heart rate variability (HRV), blood pressure (BP), muscle tension, and respiration. However, in order to gain acceptance as a method of stress management in the workplace, wearable sensors must be minimally obtrusive, so that workers can perform their tasks with complete freedom, and inconspicuous, to avoid anxieties associated with wearing medical devices in public. These usability considerations preclude some of the above measures from being considered as a long-term solution for stress monitoring. As an example, EDA is one of the most robust physiological indices of stress, but electrodes must be placed in the fingers or the palm of the hand, which severely limits dexterity; electrodes can be placed in the feet, but the resulting measurements are then dependent on posture. Another indicator of stress, arterial blood pressure, is equally unsuited for long-term monitoring; accurate measurements are invasive (e.g. a needle must be inserted in an artery), whereas non-invasive methods (e.g. inflatable cuffs) are cumbersome and inaccurate. Fortunately, a wealth of information can be extracted from the heart. Measurements of cardiac activity are robust and, with the advent of consumer-grade heart rate monitors (HRM), are relatively unobtrusive and affordable.

To this end, this research explores the feasibility of detecting short term stress in operational Police Officers by using a biometric monitoring/recording device and concentrating mainly on an individual's heart rate.

MONITORING PHYSICAL CONDITIONS

Early research by Darwin [9] was the first exponent who stated that neural modulation of the heart was a contributor to emotion and stress.

> …when the mind is strongly excited, we might expect that it would instantly affect in a direct manner the heart … when the heart is affected it reacts on the brain; and the state of the brain again reacts through the pneumo-gastric [vagus] nerve on the heart; so that under any excitement there will be much mutual action and reaction between these, the two most important organs of the body. (p69).

The vagus nerve has a number of functions including: helps to regulate the heart beat, controls muscle movement, keeps a person breathing and transmits a variety of chemicals through the body. Recent research relating stress with measures of cardiac vagal tone is focused by the assumed relationship between the central nervous system and the vagal control of the heart [27]. Many researchers have expounded that the neurally mediated oscillations in the heart rate pattern reflect a variety of mental states including stress, emotion, consciousness/alertness and attention [28].

Stress causes sympathetic responses (such as higher cortisol level, smaller HR variability (HRV), and higher blood pressure). Heart rate variability (HRV) is the variation usually measured as the beat-to-beat interval. The accuracy is dependant on precisely detecting the R-wave peak and the precision of the timing between the RR intervals. Porges & Byrne [19] recommend that researchers strive to attain 1 ms accuracy as, in certain areas (high risk populations), +/- 1-2 ms can be significant. Movement can produce spikes in the ECG trace which may be falsely assigned as R-waves. One of the more global and simple measures of HRV is the standard deviation of the mean R–R interval (SD_{RR}) [3]. When healthy subjects are acutely stressed, HR increases and SD_{RR} decreases transiently [4; 10].

The greater the range of the phasic increases and decreases, the "healthier" the individual. In some situations when measuring HRV it is possible to identify task effects when the average heart rate is static [23]. As yet, only a few studies have investigated the impact of acute stressors on various HR complexity measures in healthy individuals. Anishchenko [2] showed in healthy young subjects that short-term psychological stress was associated with both decreases and increases in HR complexity (i.e., normalized entropy) regardless of the type of stressor (i.e., noise exposure, mental arithmetic, arithmetic against noise, and examination stress). Moreover, Hagerman [13] demonstrated in ten healthy individuals (33–51 years of age) that the dominant largest Lyapunov exponent (LLE) of HR significantly decreased during exercise stress.

It has been established that wearing a body sensor to record heart rate (R-R signal) is as accurate as a three lead electro cardiogram (ECG) [6]. These authors also show that by using a classifier, they could determine their human subjects were being subjected to mental stress when taking a word and/or mental arithmetic test, by measuring their heart rate.

For the purpose of this paper the authors propose to use an athletic measurement of heart rate [5] to suggest that a Police Officer may be subjected to stress. This was decided as, during the time each Police Officer was monitored, none of them were involved in any overt physical activity which means that to register a heart rate in the training zone the body must undertake a physiological change if not through activity then possibly through stress. Table 1 illustrates the 5 training bands that are currently used by the Concept2 training guide. In this research the training zone refers to the bands UT2 and UT1, aerobic training.

- MaxHeartRate = (208 – (0.7 * age))
- %MaxHeartRate = 50/60/70/80/90%
- ((MaxHeartRate – RestingHeartRate) * %MaxHeartRate / 100) + RestingHearRate

To test the feasibility of measuring physiology during operational Police duties a group of volunteer UK Police Traffic motor cycle Officers was utilised. Each Officer wore the monitoring device for one or more complete eight hour shift and maintained a timed activity log. It was not possible to ascertain an Officer's resting heart rate as when the device was worn, they were immediately on duty, so the average heart rate was substituted in the above calculation. The average heart rate would be higher than the resting heart rate, which would have the effect of narrowing the training zone. To suggest that an Officer's body has undergone a substantial physiological change which may indicate a stressful activity has occurred, only readings that were in the training zone for more than ten minutes were accepted were accepted by the authors.

Band	Type of Work	% MHR	What it is good for	How you feel
UT2	Utilisation 2. Light aerobic, low intensity work. Sustainable and fat burning.	55-70	General CV fitness.	Relaxed. Able to carry on a conversation.
UT1	Utilisation 1. Heavy aerobic work using more oxygen.	70-80	Higher level of CV fitness.	Working. Feel warmer. Heart rate and respiration up. May sweat.
AT	Anaerobic Threshold. Harder work. On the aerobic limit. Pushing into anaerobic area.	80-85	High level of CV fitness. Building mental and physical tolerance.	Hard work. Heart rate and respiration up. Carbon dioxide build up. Sweating. Breathing hard.
TR	Oxygen Transportation. Working hard. Unsustainable for long periods.	85-90	Developing oxygen transport to the muscles under stress. Increasing cardiac output.	Stressed. Panting. Sweating freely.

AN	Anaerobic (without oxygen). Short bursts of maximum effort. Unsustainable. Burning carbohydrate.	90-100	Anaerobic work. Increasing speed. Accustoming the body to work without oxygen.	Very stressful. Gasping. Sweating heavily.

Table 1. Heart Rate Training Bands.

METHODOLOGY

The group of Police Officer volunteers comprised 2 male Sergeants and 7 male Constables all of whom are experienced motor cycle Traffic Officers.

During their tour of duty, Police Officers undertake self generated work, general patrol and are dispatched to recorded incidents. In general terms, a recorded incident is where a member of the public contacts the Police to report something such as a disturbance or crime. There are 84 incidents categories on the UK Home Office Incident Category List [15] which have been placed into 39 "super categories" for the purpose of identifying activities in this work.

Each Officer was invited to wear a monitoring device. Figure 1 illustrates the Equivital monitor [11] and demonstrates how it is worn. The shoulder strap (Figure 1a) is particularly useful as it assists in retaining the actual monitor (Figure 1b) in the correct position on the chest (Figure 1c). The retaining belts are slim and pliable ensuring that the entire device can be worn comfortably for long periods of time. Each Officer wore the device for a working shift of eight hours and maintained an activity log of their work which enabled the physiological readings to be aligned to actual tasks that were undertaken by the Officers. Whilst the participants are all male, the Equivital monitor is also suitable for female use.

Figure 1. Wearable Body Sensor.

Vocabulary	Meaning
Arrest	Taking a member of the public into custody for an offence and processing that person
Bike Safe	Official motor cycle training for members of the public
Blue Light Run	Responding to an emergency call
General Patrol	On duty patrolling the City streets
Incident Attendance	Being despatched to an incident [15]
Office Duties	General paperwork and office related duties

Table 2. Activity Vocabulary.

Activity	Avg. Heart Rate	StdDev
Arrest	86.44	45.7
Bike Safe	102.2	10.42
Blue Light Run	78.12	15.7
General Patrol	79.66	19.35
Incident Attendance	76.46	14.03
Office Duties	68.58	20.56

Table 3. Heart Rate by Activity.

Two Officers wore the device four times each; one, three times; three, twice each and three each wore the device for a single shift. A specified vocabulary was used to ensure that subsequent analysis could be accurately aligned to the relevant tasks. Table 2 lists the activity vocabulary used during this research

PRELIMINARY RESULTS

Whilst the Equivital sensor provides a multitude of different physiological readings, the authors have chosen to use heart rate for the purpose of this paper.

The average heart rate for the entire group was 79.48 with a standard deviation (StdDev) of 20.72. There were only two Officers with an average heart rate outside of the group average, Officer 6 and Officer 8. Their readings were:

- Officer 6 – Heart Rate 100.92; StdDev 21.45
- Officer 8 – Heart Rate 116.84; StdDev 37.36

Further analysis was undertaken to ascertain the average heart rate and StdDev for each activity which is illustrated in Table 3. All incident attendance was averaged into one figure.

For example; explaining the figures in Table 3 - Office Duties. The average heart rate for that task from all Officers is 68.58 and the StdDev was 20.56 meaning that the average range of all Officers' heart rate was between 48.02 and 89.14 beats per minute.

Table 3 raises some interesting issues:

- Office Duties generally cause the heart to beat less than any other activity.

- Officers undertaking Bike Safe activities, which involve the tutoring of members of the public in riding motor cycles, have a higher average heart rate than being involved in a Blue Light Run. This is due to Officers receiving extensive driver training and are subsequently conditioned to drive at high speed, in heavy traffic when being dispatched to operational incidents. As a result, they are trained to be clam when travelling to and dealing with any incident.

The results in Table 3 were extended to identify individual Officers whose average heart rate was above the activity heart rate when added to the activity StdDev, as illustrated in Table 4, which is an indication that the individual's heart rate is exceeding the normal band for the activity. Neither Officer 9 nor Officer 7 were undertaking any physical activity but both of their average heart rates for their respective activity were above the activity average plus the standard deviation. This is an indication that the Officers were subject to a form of stress.

However the aim of this preliminary research is to ascertain whether an Officer's heart rate may be an indication of undergoing stress by being in the athletic aerobic training zone when not undertaking any physical activity.

Officer No.	Activity	Avg Heart Rate	Activity Avg	Activity StdDev	Activity + StdDev
9	Office Duties	99.71	68.58	20.56	89.14
7	General Patrol	100.2	79.66	19.35	99.01

Table 4. Heart Rate Activity by Officer.

Officer No.	Activity	Mins in Training Zone	Time of Day
5	General Patrol	23	0333 hours to 0356 hours
5	Incident	11	0400 hours to 0411 hours
5	General Patrol	96	0413 hours to 0549 hours
9	Office Duties	30	0719 hours to 0749 hours
1	Office Duties	43	1158 hours to 1241 hours
1	General Patrol	18	1249 hours to 1307 hours

Table 5. Officers Undergoing Possible Stress

Examining the results in Table 5 raises some questions:

1) Officer 5 – All of his entries occur during the early hours of the morning (during a night shift) this could be due to general fatigue.

2) Officers 9 and 1 are both Sergeants who have a range of compulsory office duties. Could this indicate that these duties are causing the body's physiological change (stress)?

3) Officer 1 – on completing his Office Duties he undertakes General Patrol. This indicates that it has taken 18 minutes to relax from the pressures of the office before his physiology returns to within normal boundaries.

4) Generally, Office Duties has the lowest average heart rate but in Table 5, during the hours mentioned, each Officer's heart rate was in their training zone. Was the work that they were undertaking at that time causing them stress?

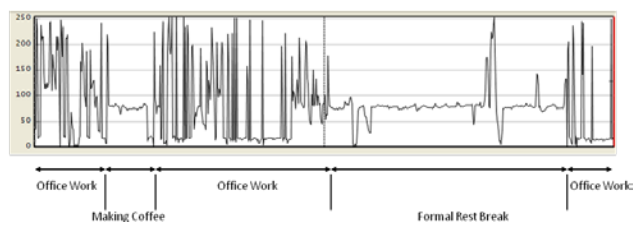

Figure 2. Officer's Heart Rate Trace.

Figure 2 illustrates a heart rate trace for a Sergeant who is mainly involved in Office work. It is clear to see that taking breaks away from his desk has a positive affect on his heart rate and it is possible to suggest that his office duties may be causing him some stress.

CONCLUSION

It is accepted by the authors that the number of participants in this research is insufficient to ensure that the results are statistically significant. However, the results that have been obtained suggest that, under certain circumstances, when not undertaking physical activities, Officer's bodies undergo a physiological change which is an indication that they are experiencing stress at some level. This is an indication that it will be possible to objectively measure crisis managers' physiology when undertaking immersive training to establish the realism of that training.

FURTHER RESEARCH

There is a range of further research that will be undertaken by the authors in relation to the CRISIS project:

1) Establish the stress that current trainees experience whilst undertaking existing crisis management training.

2) Compare and contrast the stress experienced by trainees undertaking CRISIS training to that currently experienced during current training.

3) Linking IPIP personality testing with biometric measurements and stress.

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Situation awareness and sensemaking in crisis management: Similarities between real world and online co-operative environments

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ABSTRACT

How similar and therefore how transferable are team-based skills learned in online co-operative environments to team-based skills used in real world situations such as crisis management? This paper briefly describes some of these similarities, paying particular attention to situation awareness, i.e. how teams acquire an understanding of their surroundings during both game-play and operations. Using two online co-operative games as examples, we show how efficient team-based situation awareness is an important contributor towards successful management of the crisis. The paper concludes by outlining what can be learned from online team-based environments for developing, design and use of training simulations for real-world crisis management. In addition, exploration of these similarities may offer a fruitful basis for theory development and testing.

Author Keywords

Co-operative, online environments, crisis management, situation awareness.

ACM Classification Keywords

K.3 COMPUTERS AND EDUCATION, Computer Uses in Education, *Collaborative Learning*.

INTRODUCTION

Past studies have used online team-based environments as a testbed to explore team-adaptation factors. Although this research area is in its preliminary stages [1], studies have used online environments to further explore situation awareness and sensemaking. For example, "Neverwinter Nights" (developed by BioWare, 2002) [2] was a valuable tool that was used to explore co-ordination, information retrieval, leadership, situation awareness, and team adaptation within groups of infantry soldiers. Additionally, the war game "Full Spectrum Command" (Pandemic Studios, 2004) provided an ideal opportunity to explore decision making processes adopted by military officers [3].

In the real world, a commander and his/her team will manage and respond to a variety of crisis management factors in order to successfully manage a crisis scenario. Similarly, team-based activities in online co-operative environments (e.g. "Left 4 Dead 2": Valve Corporation, 2009; "World of Warcraft": Blizzard Entertainment, 2004) also require a commander and his/her team to manage similar factors in order to defeat a hard-to-overcome threat.

We have organized this paper as follows: First, we briefly describe crisis management factors experienced and implemented in the real world, then explain how these are applicable to online co-operative worlds. Following this, a brief description of online co-operative games is provided, leading into a detailed commentary of typical team-based activities experienced in these environments. Case studies involving lack of, or efficient use of situation awareness are presented which highlight the importance of this crisis management factor and its contribution, or lack thereof, to team success or failure. To conclude, the games described here clarify potential research opportunities to explore and understand leadership and team-based activities within dynamic environments.

CRISIS MANAGEMENT FACTORS

Teams generally need to work quickly and efficiently in order to effectively manage a crisis. Because crisis scenarios are often unpredictable and require spontaneous decision-making, there are a number of factors which impact on the team's attempts to gain control of the crisis scenario. Each factor may not be present throughout all stages of crisis management, and they do not occur in any particular order. Instead they form an action feedback loop where one or more of the factors may influence the progress, success, or failure of the crisis scenario, and the crisis situation evolves in time as the unfolding situation is responded to, and modified by, the actions of the team tasked with its management. These factors are briefly discussed here [for a review see 4].

Crisis management involves the collaboration of *multiple team members*, who are led by a team commander. Most crisis situations are *unpredictable dynamic environments* where failure to respond quickly can lead to rapid deterioration of the situation. This places commanders and their teams under immense *time pressure* to decide and to act. There are however, also real *consequences* to wrong decisions or from failing to correctly *assess* a situation and *anticipate* likely outcomes. Each team member shares an *organisational goal*, that is, to control the crisis scenario. And unlike laboratory situations, decision making is further constrained by, for example, resources once assigned or expended cannot be used in future decisions until they have been replenished or made available.

These crisis management factors characterize the environments in which crisis management personnel have to make decisions, and the decision making strategies invoked by personnel in situations characterized as above, has been described as *naturalistic decision making* [5]. Team members with higher levels of expertise, compared to novices, will be more likely to make quicker decisions by bringing their expertise to bear on the problem as they mentally compare the current situation with those they have previously encountered. They would then apply or modify courses of action that have worked successfully in previous situations. If a similarity or match is found then this course of action will be taken, even if a successful outcome is not guaranteed [5]. In order to make these decisions, the commander and team need to maintain an awareness of other team member activities, and their surroundings i.e. *situation awareness*.

Situation Awareness (SA)

Situation awareness can be described as, "the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future," [6]. He further describes SA in terms of three levels: Level 1 SA **perception**, i.e. where elements of the situation are located within the crisis scenario; Level 2 SA **comprehension**, i.e. understanding what the situation is about; and Level 3 SA **projection,** understanding how the crisis may develop and change in the near future [6]. In addition, team members need to assess the location of the crisis and its surrounding area, and their own location in relation to the threat. With a high level of situation awareness, a commander and their team can make sense of their situation by taking into consideration crucial aspects of the situation and by projecting how these aspects might change as a result of their actions, or inaction. By s*ensemaking*, and implementing Endsley's three levels of SA (1995), the team can anticipate an outcome by monitoring and understanding the crisis, their role in the crisis scenario, and their individual role within the team's activities [4]. In this way, sensemaking can be defined as, "… a continuous cycle of learning and action …," [7], that "… arises when people face new problems or unfamiliar situations, anywhere their current knowledge is insufficient," [8].

We now turn to a consideration of how massively multiplayer online environments offer virtual analogs of real-life crisis scenarios.

What is an Online Co-operative Environment?

Massively multiplayer online games (MMOs) have been set in a variety of worlds such as medieval fantasy, post apocalyptic landscapes, and science fiction universes. In these settings, thousands of players interact and cooperate within these massively multi-player cooperative online games to accomplish in-game goals many of which are impossible to accomplish independently, and as such provide fascinating opportunities to explore human behaviour [9]. For example, researchers have created their own characters to observe and interview other players, thus allowing a unique insight into how a combination of play style, environment, and social interactions affect players [10].

Crisis Management Factors Present in Online Co-operative Environments

The crisis management factors described earlier are experienced and confronted by teams formed in online co-operative environments. Online-based commanders and their teams need to successfully navigate areas containing multiple enemies, or defeat hard-to-kill monsters. For example, team members may need to make several rapid decisions simultaneously – available weapons may only be effective against a particular type of enemy so the team member needs to quickly decide their most effective weapon before engaging the enemy. Team members should also remain aware of their location in relation to other team members, in addition to the location of nearby enemies, and any potential escape routes or areas of cover nearby. In this way, the commander and the team can quickly plan their next course of action.

These types of naturalistic decisions within online co-operative environments have been explored by [11]. They compared levels of motor and perceptual skills between a group of gamers and non-gamers. The results showed that gamers who regularly participated in online co-operative games showed higher levels of visual attention, which is an aspect of situation awareness, and an increase in multi-tasking effectiveness, or naturalistic decision making. They were also more adept than non-gamers at monitoring and making sense of complex environments.

In the online co-operative game "Left 4 Dead 2" (Valve Corporation, 2009), teams of four players need to navigate and fight through complex built-up areas. Team members can defeat enemies by choosing the most effective weapon from a limited arsenal e.g. knives, guns; Often enemies can attack the team in large groups, which forces team members to make decisions under pressure (Figure 1). Each team member is provided with life preserving expertise, which they can use to heal the injured. A health icon displayed on the game screen shows team members who are injured.

However, should all team members die, the team has unlimited opportunities to replay the mission. Hence, following say, informal after-action reviews, mistakes leading to the deaths of the team can be corrected with repeated practice. The environments, or 'maps', within which the action takes place are structured, but the placement and movement of enemies are spontaneously generated by the game engine, with the result that no two scenarios are identical. The team members are therefore presented with a novel experience in what may well be a familiar environment.

Figure 1. Team co-operation in "Left 4 Dead 2" (www.ign.com).

"Left 4 Dead 2" requires four team members to achieve in-game goals. Other online co-operative environments such as the MMO "World of Warcraft" require teams of 10 or 25 members to kill a hard-to-defeat monster. Another common feature of MMO design is the emphasis on *social networking* for coordination and decision making to successfully progress through the game. MMOs vary in terms of content and challenges, and have many similarities with real-world crisis management teams. For example, players organise 'Command and Control' teams to coordinate each team members' particular area of expertise to overcome the toughest challenges.

Team-based Activities

Large teams of players, including a commander who leads the team, will use their specific areas of expertise to fight powerful enemies. Teams must adapt to the threats which correspond with the *crisis situation* in the real world; and the changing environment where they have to develop and maintain their *situation awareness*; and make sense of the situation so that they can predict how their expertise, co-ordination, and communication can be effectively combined to defeat the threat.

These team-based activities are designed to be challenging where each powerful enemy requires specific tactics to be defeated, and can be time consuming where teams can expect to fight a powerful enemy for 10 minutes or more. At the same time, the powerful enemy will attempt to defeat the commander and his/her team using its own areas of expertise. It is vital that the commander and his team pay attention to their surroundings at all times, seeking to understand the nature of the threat. This means assessing the situation moment-by-moment and predicting the outcome, which is dependant on choices they make, remaining aware of the enemy's location, each team member's location, and location of the self in relation to others and the threat during the encounter. At the same time, the commander and his team each have their own area of expertise, i.e. a series of offensive or defensive abilities that aid the progression of the fight. These roles vary according to the role the team member has been assigned before the session begins.

For example, real-world medics use their expertise to treat crisis casualties. In online environments, team members with life-preserving expertise, known as 'healers', keep the team alive, while other team members use their offensive areas of expertise to defeat the threat. In the real-world fire fighters will use their expertise to extinguish a fire. Figure 2 briefly compares the organizational structure in real world situation with an online game.

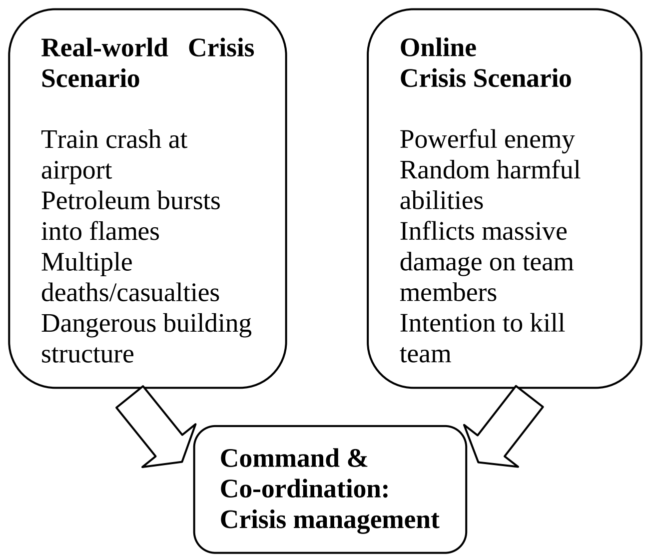

Figure 2. Real-world and online scenarios share the same team member structure, and implement the same crisis management factors.

Situation Awareness in Online Team-Based Activities

As mentioned previously, managing and defeating a powerful enemy in an online cooperative environment means the team must maintain a high level of situation awareness at all times. Team members can control the game's camera and look around the threat's location by using the mouse or keyboard. Situation awareness can also be achieved by providing information via communication. The game's mechanics provide a text-based chat channel that the commander and his team may use to relay vital information about the crisis. The commander also has the ability to add 'urgent' sound effects to their text to ensure the team is listening. Teams may also use voice-activated software, which is often quicker than text-based chat for relaying instructions.

Through understanding situation awareness, "… we may not only be able to strengthen our ability to develop situational awareness in crisis situations, but may also be able to better understand the enemy's situation awareness, which in turn might permit us to get inside his situational awareness loop to degrade his situational awareness, with potentially important benefits to ourselves," [12; p.2].

This paper now turns to an example of low and high situation awareness, and how they may have an effect on the outcome of a team-based goal.

Team Failure: Low Situation Awareness

A lack of situation awareness from the team, even for a second, means that the likelihood of defeating the threat decreases. The crisis scenario will fail when the threat has successfully 'killed' the commander and the team. A recent study found that commanders and team members respond in different ways when their team fails [13]. Whereas a minority may blame team members for the failure, others will provide suggestions for improvement before attempts are made to tackle the encounter again. All suggestions form an *after-action review*, and allow the commander to pinpoint problems that affect team performance.

Team Success: High Situation Awareness

If the commander and team members remain aware of the location of the threat, then the likelihood of successfully managing the crisis, with minimal casualties is high. Each team member has access to a variety of tools, which assist with managing and defeating the crisis, and these can be accessed via the game's User Interface (UI). Figure 3 identifies the four important areas of information gathering. (1) indicates the text-based chat channel mentioned previously. Members can leave instant messages to the team throughout the duration of the crisis encounter. (2) identifies a series of icons, each one representing a specific ability that corresponds to the commander's area of expertise, and can be selected using a mouse or keyboard. (3) points to the moment-by-moment action review. This continuous scrolling text provides the commander with information about the team's activities, in addition to the effectiveness of their expertise. Finally, (4) is the mini map, where the commander and the team are provided with an 'at a glance' location awareness of other team members whose roles are colour-coded for easy identification, e.g. life preservers appear as green dots.

Figure 3. Commander's user interface in "World of Warcraft" (www.tankspot.com).

Successful management of the crisis situation involves team members successfully engaging in all aspects of situation awareness and sensemaking; **perception** of the threat's position and current status, as well as that of other team members; **comprehension** of what is happening and which actions they as an individual need to perform; and

projection in terms of knowing where they need to be, either to engage the crisis, assist those engaging it, or avoid its immediate damaging effects. Therefore, to defeat the threat, high levels of situation awareness and sensemaking must be maintained throughout the encounter.

Figure 3 also illustrates the threat's activities as it tries to 'kill' the commander and team members. The threat itself is indicated by (5) - he will rapidly spin himself to random areas of the room, damaging team members who do not move quickly out of the way. In addition to a spinning attack, the threat will also randomly cover the floor with flames, (6). The randomness of the threat's abilities makes them difficult to avoid.

Online game scenarios are often more complicated than just described. However, if team members listen to their commander, maintain a high level of situation awareness, communication, and co-ordination, then the probability of success is enhanced. Team members therefore must constantly assess their surroundings, avoiding spinning attacks, and flames, but at the same time using their areas of expertise to defeat the threat and overcome the crisis.

CONCLUSION

This paper explored crisis management factors that are experienced by both online and real-world crisis management teams, with a particular emphasis on situation awareness and sensemaking. This work extends previous research using online environments to explore team adaptation and situation awareness [2,3].

While online training environments clearly do not directly replicate real world experiences, they nonetheless provide plausible opportunities for individuals to train their crisis management and team adaptation skills. Death is not permanent in online environments, but instead provides teams with the opportunity to reflect on their mistakes and adapt accordingly with subsequent tries. In addition to managing teams, online environments can provide training for problem representation, achieving goals, following procedures, assessing strategies, and making quick informed decisions [14]. These applications identify a positive element to game play which has been neglected in a gaming literature predominantly focused on the negatives.

A recent review explored the effectiveness of online environments as training tools [1]. Although this field of research is still in its preliminary stages, the authors have stressed the need for the development of measures that will permit an in-depth exploration of problem-solving and decision-making skills in online scenarios. In addition, there is also a need for empirical evidence that explores human behaviour in online games, and whether training learned in these environments can transfer effectively into the real world.

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SOURCES

Figure 1: www.ign.com; Figure 2: Authors; Figure 3: www.tankspot.com

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A Human Work Interaction Design (HWID) perspective on Internet- and sensor based ICT systems for climate management

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ABSTRACT

Internet- and sensor based ICT systems for climate management in greenhouses presents challenges for the understanding of how technology mediates the interaction between humans and specific work contexts, which is the topic of the field of Human Work Interaction Design (HWID). In this paper, we will analyze and discuss how to combine empirical work analysis with interaction design techniques, with a focus on sensor-based prototypes. The proposed method is action research that will use a combination of theory from usability, work analysis, and prototyping techniques. We wish to investigate possibilities for designing, using and evaluating interactive sensor based prototypes for designing systems, learning key skills, and enhancing current training methods, all of this in a work context.

Author Keywords

Human Work Interaction Design, sensor-based prototypes, usability, work analysis.

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

Internet- and sensor based ICT systems for climate management in greenhouses presents challenges for the understanding of how technology mediates the interaction between humans and specific work contexts, which is the topic of the field of Human Work Interaction Design (HWID) (Pejtersen, Orngreen, & Clemmensen, 2008). Currently greenhouse growers spend several hours daily with the computer, working with the greenhouse climate management systems. What are they doing? Is it all functional, rational problem solving? Is it process control? Is it learning? Is it enjoyment, pure fun? What are the social, cultural, organizational and technical contexts of the computerized climate management? Insight into the needs and reasons for spending much time on a certain task using a computer can help in planning future software systems for the needs of the growers and to contribute to reducing unnecessary work time and stress while increasing time for pleasure, eventually increasing work efficiency and reducing labour costs.

Human Work Interaction Design (HWID)

This paper contributes to the field of Human Computer Interaction and in particular to Human Work Interaction Design (HWID) which is the topic of IFIP (international federation for in-formation processing) WG (working group) 13.6 on HWID. HWID is concerned with how technology mediates the interaction between humans and specific work contexts, and touches upon topics such as; e.g. cross-cultural usability testing, user personas, usability evaluation method in medical context, usable techniques for hand-writing recognition, mobile application for construction workers, promoting usability in large enterprises, design conversations, social usability in second life for distance learning students, interactive kiosks for museums and more (Katre, Orngreen, Yammiyavar, & Clemmensen, 2010). The research advances and supports international usability research, including mobile usability, usability in safety critical domains, aesthetic approaches to usability and user experience, user innovation, and empirical studies of usability. These research areas are complemented with the research presented in this paper and its proposed focus on usability in contexts.

Domain knowledge: Climate management

Near stress conditions can be identified and characterized in relation to different plant species in a greenhouse under dynamic climate conditions. This e.g. includes effect of high or low humidity that might often be associated with energy saving conditions and cause disease problems. Combining the different technical possibilities of measuring microclimate, enable the application of crop specific models for a large range of climate management purposes. Plants can be established under standard growth conditions and subjected to a desired degree of dynamic temperature, humidity and light conditions combined with different screen conditions and light use. For example, different greenhouse crops have very different needs for climate control. Among them are year round roses, cucumbers, seasonal poinsettia. However, they have the common denominator of large energy requirement both in terms of temperature and light. The management of a dynamic climate may induce physiological changes, and characterization and quantification of these may have importance for the interaction design of the systems for climate management. In a sense, climate management situations are comparable to well-known types of safety critical, emergency and disaster situations, by the urgency of reactions, the disastrous long term consequences, and the decision making aspects of the situations. In this paper, we will analyse and discuss how to combine empirical work analysis with interaction design techniques, with a focus on sensor-based prototypes. In particular we want to discuss the pedagogical aspects of allowing users to train themselves on key scenarios for climate management. The paper is thus narrowly focused on climate management in greenhouses, but takes up the broad discussion of how people adapt and learn to act in new (often extreme) situations. Online worlds (which include simulations, virtual environments, augmented reality, and massive multiplayer games) have potential to aid in training staff to deal with crisis situations. In our paper we focus on a new type of online world that we call sensor based prototypes. We wish to investigate possibilities for designing, using and evaluating interactive sensor based prototypes for learning key skills and enhancing current training methods.

Sensor-based interaction design prototypes

One of the challenges we are faced with when talking about sensor-based prototypes are how to actually do the *physical* modelling. In example, it is difficult to create and test a real sensor-based prototype. Some of the reasons for this are that it requires a different skill set than other prototyping efforts such as Internet programming or standard GUI design. In terms of creating/visualizing a normal user interface intended for a PC, we can usually resort to a drag and drop editor, which are already part of a programming language integrated development environment (IDE). This holds true for languages found in the Microsoft .NET suite and the Java programming language. In the latter case, the popular Eclipse programming environment provides a visual editor. It forms an easily approachable and inexpensive prototyping platform.

In a sensor-based environment, we are not so fortunate. If the requirement is that the sensor-based prototype is dynamic/responsive in any way, then we are required to connect the sensors to each other and to the intended management console. In order to do so, we would need the skillset of electronic engineers and/or mechanical engineers. The electronics and sensors have to be wired, and prototyping boards will be manufactured. It is possible to do so, but at an additional cost (both in terms of time and money) than purely software based prototyping.

A second option is to settle for a modular prototyping platform such as Lego Mindstorms. It features the Lego construction that many is already familiar with. Moreover, it is a candidate for sensor-based prototyping because the Lego Mindstorms NXT ships with various sensors. There are ongoing efforts to provide this platform as a prototyping platform for languages such as C and Java (see http://nxtgcc.sf.net).

Evaluation of sensor-based prototypes

A key element in evaluation the use of prototypes - also prototypes of online worlds - is usability and user experience measures (Hartmann et al., 2006). International standards define quality in the use of ICT systems in terms of a single concept „usability" with three aspects: effectiveness, efficiency, and satisfaction, achieved in a specified context of use (9241-11, 1998). The idea that usability can be treated as a unified concept „u", analogous to Spearman's „g" for general intelligence, has found support in reviews of usability test practice in major US companies (Sauro & Lewis, 2009). In contrast to this idea, theoretical work has shown that many really different images of usability appear to be relevant (Hertzum, 2010): 1) Universal usability, i.e. the systems can be used by everybody, 2) Situational usability, i.e. quality-in-use of a system in a specified situation with its users, tasks, and wider context of use, 3) Perceived usability, i.e. the user's attitude towards a system based on his or her interaction with it, 4) Hedonic usability i.e. joy of use, 5) Organizational usability, i.e. groups of people collaborating in an organizational setting, 6) Cultural usability, i.e. different meanings depending on the "users' cultural background.

Analyzing usability in context is important for connecting empirical work analysis and interaction design of the ICT system to explain how technology mediates the interaction between humans and specific work contexts. Industrial techniques (Preece, Rogers, & Sharp, 2007) often give - seemingly - similar results when applied in diverse social, cultural, organizational and technical settings, but experience shows that we need a deep understanding of the different contexts to interpret the results, and to transform it into interaction design. Empirical work analysis offers such deep understanding by studying closely the work, how it does (or does nor) follow plans and procedures, what great and small troubles that people run into during their work, what those who really know the work can tell us about it, and where the work actually is done in our mobilized world (Button & Sharrock, 2009). A promising approach in combining empirical work analysis and interaction design is the use of throwaway (rapidly made, easily discarded), sensor-based prototypes. First, prototypes are low-cost and flexible constructions, which allows for evaluating a number of different setups that with the use of sensors can include more contexts. Secondly, there is an advantage about reproducibility; namely that such prototypes can be reconstructed from simple and clear building instructions, making the evaluations of the prototypes more easily verifiable by other researchers (March & Smith, 1995; Storey, 2008). Specifically, the focus will be set on the three questions:

1. Is there a measure „u" of usability, i.e. is there a single, unified concept of usability that can capture the relation between the human and the computer across the different social, cultural, technical and organizational contexts of an ICT system?

2. How do empirical work analysis (studies of work and the workplace) inform and interact with paper design sketches and functional prototypes?

3. What are the benefits of using sensor based prototypes in ICT user interface design?

METHOD

To answer the research questions, we suggest an action research based approach where researchers work closely with greenhouse growers and consultancy houses, and with software developing vendors that are specialized in systems for climate management. These parties will together have to perform a full iteration of user inter-face development activities on the different components (e.g., climate control, decision support, communication platform) of a greenhouse management system. The iteration will 1) be based on an agile interaction design lifecycle model with usability evaluation as the central element (Hartson & Hix, 1989) to ensure useful user interface designs will be a results, and 2) be overlaid with extensive data collection and systematic reflection on findings, including reflective exercises with stakeholders, to ensure answers to the research questions. Existing systems and modules will firstly be evaluated one for one. Based on that, improvement will be worked out and sketches and prototypes created for each part of the system. To ensure a complete working system, where the complimentary sub-systems are embedded, the researchers may take the lead and create a guideline, and, in cooperation with the industry partners, give suggestions for a complete system house style that ensures a high usability, good user experience, and a clear common style, keeping however the separate functions of each sub-system apart.

EXPECTED RESULTS

The researchers will, in collaboration with the industry partners, be responsible for delivering different research products:

1. Usability and user experience specifications for the primary target user groups.

a. diary study with ten greenhouse growers, two weeks, elicitation diary

b. work observation, two greenhouse growers, onsite, six weeks, participating as an apprentice, following the growers around, screen capture of climate management computer use

c. repeated individual interview, primary stakeholders: 4 growers, 4 advisors,

d. online community, e.g. internet based communication and knowledge sharing tool, establishing a user community

2. Analysis of the climate management task, based on:

a. hierarchical task analysis, ten interviews with experts from consultancy houses

b. persona creation, one person per target user group (e.g., small/large, flower/vegetable nurseries), use of existing marketing statistical data, if necessary questionnaires

c. scenario writing, usage scenarios, two focus groups with four-five growers in each

3. Evaluation of effectiveness, efficiency and aesthetics of prototype through:

a. think aloud usability testing, repeated four times, five participants each time

b. heuristic aesthetic evaluation, repeated four times, focus group interviews,

c. task time performance prediction

4. Conceptual design of the interaction between gardener and system by:

a. sketches, post-it note, at least ten different sketches, animated sketches

5. Prototypes that demonstrate key aspects of the interaction between the software users (typically the growers) and system:

a. horizontal, flat, broad functionality, paper, html, java or similar, more than 4 prototypes

b. sensor based vertical throwaway prototypes, a series of at least five experiments with simulated sensor based climate management with useful functions and a basic set of sen-sors, using Lego Mindstorm programmed in Java, with two group of participants (10 expert users (greenhouse growers), 100 novice users (university students))

6. Implementation user evaluation:

a. work observation of the grower"s work with the new climate management system

b. diary study with four growers, two X one week, feedback diary

DISCUSSION

The idea that we can use Lego Mindstorm sensor based vertical throwaway prototypes to do interaction design will hopefully be versatile. Other research in reflective physical prototyping through integrated design, test, and analysis have shown that, after an initial period of learning the prototyping tool's interface, participants will spend the major parts of their time doing design thinking, i.e. thinking and talking about how the interaction design should be from the user's point of view, instead of wondering about how to implement a particular behavior in the user interface (Hartmann, et al., 2006). What is currently less clear is how explorative and sketch-like such sensor-based prototypes will be. Sketches support different kinds of design thinking (Goldschmidt, 2003).

An interactive, sensor-based prototype may be used as a greenhouse environment simulator, e.g., in the form of a scaled down version of greenhouse including real-time monitoring control systems(Cenedese, Schenato, & Vitturi, 2008). Greenhouse environment simulators have been designed to be used as educational tools for e.g. demonstrating the physics and biology of greenhouse systems and environmental control principles (Fitz-Rodríguez et al., 2009; Pearce, Murphy, & Smith, 2008; Pearce, Smith, Nansen, & Murphy, 2009). For example, scenarios can be simulated to show how a specific greenhouse design would respond environmentally for different climate conditions (e.g., four seasons of the year, or four geographical locations), and to evaluate how system designs work for achieving the desired environmental conditions (Fitz-Rodríguez, et al., 2009; Speetjens, Janssen, Van Straten, Gieling, & Stigter, 2008).

The user is one of the key factors in successful climate management, due to the need for leaving part of the decision freedom in the hands of the grower. Current approaches for user accepted climate management rely on a concept of division of responsibilities, where the short-term effects, e.g., photosynthesis and evapo-transpiration, are controlled by automated systems, while the long-term effects are left to the grower working with flexible decision support system based on crop models (Van Straten, Challa, & Buwalda, 2000). The measures of usability will thus have to be able to accommodate these kinds of two-levels supervisory control activity models. As data from the different metrics will provide insights into different aspects (Pyla et al., 2009), this will provide challenges to the idea of integrated usability concept.

While the HWID research is concerned with how technology mediates the interaction between humans and specific work contexts, it is not clear what concept turns out to be central or the cases studied. Recent studies of work psychology and design suggest that socio-cultural concepts such as processes of trust-building, social identification and community-based learning may be highly important(Rohde, 2007).

CONCLUSION

The expected results of HWID research include application of HWID in a new domain, green-house horticulture, and how the combination of empirical work analysis and interaction design theories and techniques function in this domain. This includes the results on the benefit of using sensor based prototypes in interaction design.

The idea of developing a single, unified metric for usability across different software platforms, functionalities and user groups is controversial; some studies show that there is a high correlation between the different measures of usability, e.g. effectiveness, efficiency, satisfaction, while other studies show a low correlation between such measures. Thus the evidence for and against this idea that we will gain from the proposed research will enter a current debate in the international research community.

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Behavior based training improves safety through online simulation environments

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ABSTRACT

What we want to obtain from all our training educational initiatives is to reduce risk, and minimize the consequences if an accident occurs, but why is it that we still see an unchanged number of accidents. Even as the number of safety procedures and regulations increase. In this paper we argue why it's neither lack of knowledge, insufficient procedures, poor equipment, or extraordinary conditions that lead to incidents and near-miss-accidents. The paper suggests areas of improvement.

Author Keywords

Behaviour based training, Co-operative, online environments, crisis management, situation awareness.

ACM Classification Keywords

K.3 - COMPUTERS AND EDUCATION, Topic K.3.1 - Computer Uses in Education

INTRODUCTION

How did we learn to drive a car? Did we read a manual of 100 pages about the mechanics of an automobile, the human psyche, traffic rules, road planning, basic kinetics? Did a supervisor flip 20 power points and explaining how to drive the car and afterwards granted us our driver's license – where after we jumped behind the wheel and control the car just perfect guiding ourselves flawless through traffic in complex interaction with other drivers, bicyclists, and pedestrians? Or, did we take driving lessons, slowly – and safely – learning all of the above in a realistic environment assisted by an instructor? The latter, right?

Now, by drive your car every day are you experience live exercises that are keeping you alert and adding safe routines to your driving habits.

Conclusion; if we want to be excellent in doing something that is risky we have to train it, every day!

THE HUMAN RISK FACTOR

We have to be aware of the fact that the human species have a strong generic component to show our reckless behaviour, this is a way of showing how 'physically fit' we are (Darwin, 1871).

BEHAVIOUR AND TRAINING

The point is that organisations need risk takers in order to develop and survive. We 'just' have to turn the implosive risk taking attitude into risk awareness behaviour.

Most safety experts and companies that operate with high-risk environments tend to focus on business processes, risk management personal safety equipment and communication about risks. This is important issues but far from enough if we what zero fatalities and near-misses incidents.

BEFORE AND AFTER THE HELMET

25 yeas ago, an average rig or platform would have approx. 25 accidents per year. Then Personal Protection Equipment 'PPE' was introduced and the number dropped to 1-3 accidents per year!

Now, how do we reach zero accidents per year? By wearing two helmets, putting up more warning signs, and checking the escape routes an extra time? Not very likely …

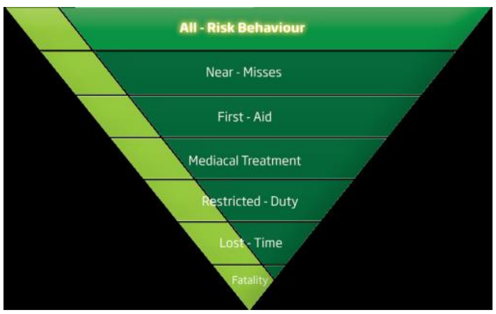
If we want to change something, we have to change the way we do things. The argument is that it's neither lack of knowledge, insufficient procedures, poor equipment, or extraordinary conditions that lead to incidents and near-miss-accidents – it's our perception of risks!

TURN THE PYRAMID UP-SIDE-DOWN

Looking at the old and well-known safety pyramid and the relationship between near-misses and fatality incidents give us a very good idea of where to start.

If we turned that up-side-down we will try to create a new dogma in terms of cause-effect-impact in high-risk industries:

By concentrate our efforts on reducing at-risk behaviour in combination with build-up a much safer environment. We will reduce the overall number of accidents and save lives.

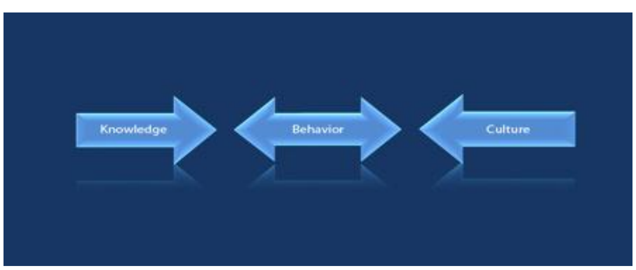


THE OBJECTIVE OF EMERGENCY TRAINING

In short, what we want to obtain from all our training educational initiatives is to reduce risk, and minimize the consequences if an accident occurs. We want certain behaviour – and a certain consistency in the behaviour – from our staff. We want improved risk- and situation awareness!

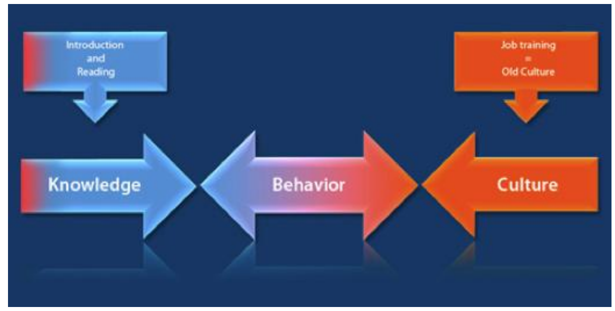
BACKGROUND – TODAY'S WAY OF TRAINING

Two factors influence on our behavior:



Knowledge is related to what we have learned during our life and the educational inputs we have received.

Our idea of behavior is as well infected by our culture which consists of the generic heritage and habits. It's important to remember that knowledge is lost over time:



How can these factors be affected; first by adding new knowledge to the existing and secondly by changing the culture through training?

There are a few psychological aspects that have to taking into account that make it difficult. As to how we explain a risk factor to people:

Aspect #1: Your environment is too safe

As mentioned people are risk takers. It's part of our nature, one important brick in the evolutionary puzzle. But today there are minimal consequences for risk taking due to multiple safety precautionary measures. In our work environment, people cannot learn (evolve).

Aspect #2: Risks are objective

Can we expect people to change the way they do things, if they don't consider what they do to be risky? Risk is a perception and we are very poor at estimating odds vs. risks

It's dangerous to be alive and risks are everywhere. Luckily, not all risks are equally serious. For present purposes I use three dimensions to describe the magnitude of a risk: scope, intensity, and probability. By "scope" I mean the size of the group of people that are at risk. By "intensity" I mean how badly each individual in the group would be affected. And by "probability" I mean the best current subjective estimate of the probability of the adverse outcome (Nick Bostrom, March 2002) – by the way, that's the foundation of the business model for Lotto-games!

People cannot perceive numbers, figures, and statistics; they have to have an image of the situation – for instance the vision of themselves winning 10 million in the National Lottery. Therefore we need to create subjective risk.

Aspect #3: Risks are not visible

People are not afraid of risk in general, just risk that induce fear, thus people need to fear the risk. In order to fear a risk, the risk needs to be visible.

What is the level of realism in the current training methods?

#1: Theory vs. practice

The correlation between theory, practice, and evaluation does neither reflect nor affect the actual objective of the training. The live-test has to get much, much closer to representing real-life situations. Contrary to what you may think, real-life emergency training on off-shore rigs is not particular close to representing a real-life emergency situation! That may be the case for other industries as well?

#2: In the current set-up it's impossible to train staff-cooperation in real-time

Fact: The handling of an emergency situation or a process depends on the cooperation between the staff-members, the equipment, and time. In short: Who does what, when with what!

#3: Your current solution only allows processes to be trained individually

Fact: Most incidences and near-miss-accidents occur because several processes fail simultaneously. (IADC, 2010)

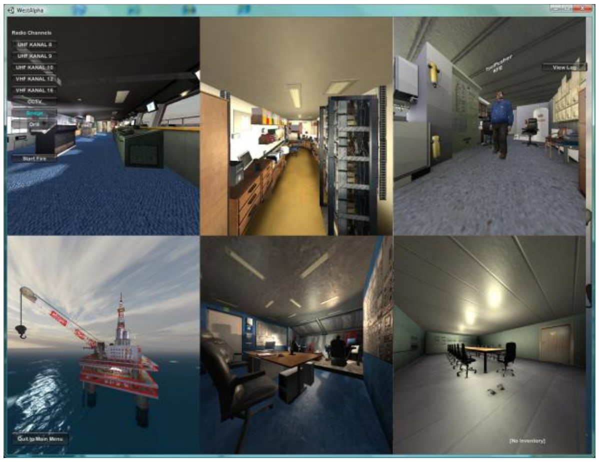
Conclusion: It is inefficient to use yesterday's methods to fight the problems of today!

WHAT CAN BE DONE

Based on the knowledge mentioned above combined with a close dialogue with the offshore industry, we have developed a 3D training simulator that enables real-time behavior training in a realistic environment.

The Training Simulator

It consists of a 3D computer model of your rig or platform in photographic quality and a number of scenarios. The scenarios will reflect real situations – either controlled by the instructors or chosen at random.



Personnel Involvement

Only the relevant people will be involved. The employees will simultaneously log into the training simulator via their computer and do focused training on communication, delegating tasks and discipline.

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Challenges for user interfaces in VR-supported command team training

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ABSTRACT
Virtual Reality (VR) enables new ways of training emergency-response personnel to manage various critical situations. However, the new opportunities also raise questions how trainees interact with the VR-environment. In this paper we explore different interfaces that can be considered in training a joint command team with members from different professions.

Author Keywords
Team training, command-post training, virtual reality.

ACM Classification Keywords
K.6 Management of Computing and Information Systems, K.6.1 Project and People Management, *Training*.

INTRODUCTION
The command and control of the response to critical incidents in high-risk operational environments—such as major airports and harbors—requires that the efforts of resources from different organizations are coordinated in time and space. Establishing and maintaining this coordination is the task of a multidisciplinary command team. There is an increased awareness of the importance of training in order to create and maintain readiness to manage critical incidents and crises. However, traditional exercises can be difficult or even impossible to carry out in some environments due to continuous operations and rigorous safety rules.

Virtual Reality (VR) environments [1, 2] can support emergency management training without interference with the real operations. VR can also add flexibility and controllability by allowing instructors to adapt existing scenarios to create specific training conditions. Military applications indicate that VR training can provide higher flexibility and reduce cost compared to real-world exercises [2]. Unfortunately, introducing VR adds another layer of technology to the training environment that the trainees have to deal with. Careful design and integration of the interfaces to the VR environment are imperative to avoid a negative impact on the training outcome.

In this paper, we investigate the challenges related to the training of multidisciplinary command teams in a virtual environment. Our starting point is the established principles for simulation-based training (SBT) of command teams. We ask how VR can extend the capabilities of SBT and what the trade-offs are. Particularly, we explore the interfaces between the trainees and the VR-environment in the command team training situation.

TEAMS, TEAMWORK, AND TEAM TRAINING
The concept of *team* is central to the dynamic control of complex and dynamic situations, where control demands extend beyond the capabilities of a single commander. A team is a ‘distinguishable set of two or more people who interact dynamically, interdependently, and adaptively toward a common and valued goal/objective/mission, who have each been assigned specific roles or functions to perform, and who have a limited life-span membership’ [3]. The team members bring specialized task-relevant knowledge to the team but also require core teamwork skills to be able to acquire, integrate and share information from multiple sources, to coordinate interdependent tasks, and to communicate effectively within the team as well as with other actors. An expert command team can maintain control in situations where it faces shifting and competing goals high stakes, time constraints, and incomplete, ambiguous or even contradictory information.

Effective team performance requires general teamwork competencies that can be characterized using eight dimensions applicable across teams and tasks in various domains [4].

- *Adaptability*: detecting and adjusting to critical changes in the environment
- *Shared situation awareness*: forming mutual knowledge of the internal and external environment
- *Performance monitoring and feedback*: seeking, giving and receiving feedback that helps keeping tasks on track
- *Team management*: planning work, organizing the team, and assigning, directing and coordinating tasks
- *Interpersonal relationships*: cooperating, resolving conflicts, and building moral
- *Coordination*: managing resources and pacing activities to make sure that tasks get completed in time
- *Communication*: exchanging information efficiently

Figure 1: Picture from a command team exercise with the Swedish International Crisis Support Team. Photo: Johan Jenvald.

- *Decision making*: integrating information, identifying alternatives, selecting courses of action and evaluating the consequences

Research demonstrates that team training promotes teamwork and enhances team performance [5]. It is successful because key teamwork competencies have been identified [4] and addressed in the design of training programs. In particular, SBT is a powerful method for team training where participants engage in role play and where they have to use their teamwork competencies [6] and receive feedback based on team performance.

COMMAND TEAMS

Command teams are composed of leading officials representing multiple organizations supported by staff officers and systems operators. Typically the team members assemble at a designated location, which serves as the command center. Figure 1 shows a command team in its command center. The team members work individually or in groups under the supervision of the team leader, supported by maps, computers and communications equipment. In this example, the team was composed of experts on fire–rescue, medical response, logistics, human resources and military operations. Information is posted on the walls in a structured way to facilitate information sharing among team members. At regular intervals, briefings and situation reports will be conducted to bring everybody up to date and to settle any issues.

A command team operates in a hierarchical structure (see Figure 2). It has to coordinate the activities of subordinate units to achieve valued objectives, while maintaining liaison with collaborating units and organizations and being attentive to the needs of stakeholders and supervisors.

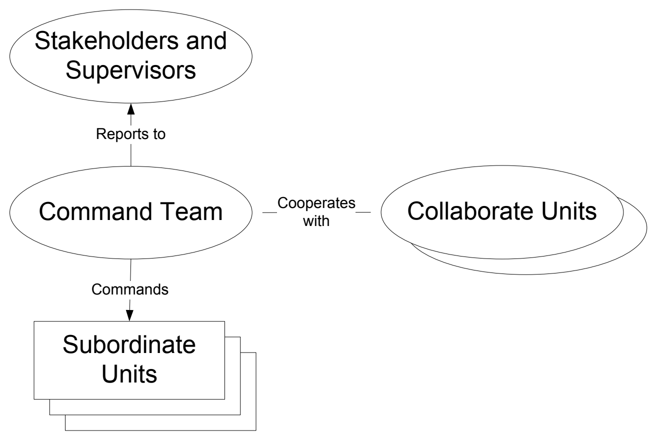

Figure 2. The command team operates in a hierarchical structure.

COMMAND TEAM TRAINING

In our investigation of VR-support for command team training, we shall explore the case of simulation-based command team training using role-playing exercises.

Prerequisites

In a multidisciplinary command team, all members must have basic training in their individual profession and sufficient experience from working in a command team. They must also have theoretical understanding of the different roles and responsibilities in the team together with knowledge of the plans and procedures for alerting and initiating the command team in a critical situation.

Event-based approach to training (EBAT)

EBAT [7] was developed for simulation-based training. EBAT starts with formulating learning objectives based on an inventory of the group of trainees, their professions and previous experience, and their task proficiency and teamwork competencies. The learning objectives serve as the foundation for creating a scenario. An exercise scenario is constructed from a series of events, deliberately selected to create learning opportunities that match the learning objectives. Instrumentation is prepared to support performance measurements and feedback. After the exercise, the training outcome is evaluated and new learning objectives are identified.

Role-playing exercises

Role playing exercises (RPE) are simulation-based exercises where the participants are real decision makers, who act in their professional roles [6]. The settings are strictly steered by realism in order to achieve high validity of the RPE. All activities are continuous and changing as in reality. Time is at the same speed as in reality. Temporal behavior and functionality of resources in the simulation corresponds to reality. Thus RPE strives for realism in that it uses real groups, tasks, ecological settings, and social system in the simulation content.

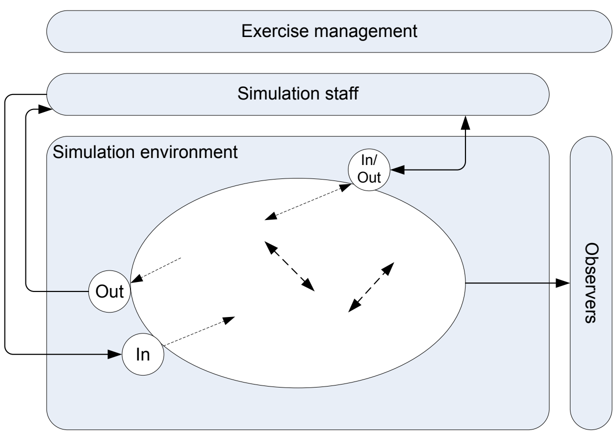

Figure 3. In an RPE, the command team members interact face to face, but all contacts with the (simulated) external world take place through interfaces to the simulated environment. For example: (Out) may be e-mail, (In) may be a fax, (In/Out) may be a telephone. The simulation staff answers on the other end of the line, enacting external parties. Observers monitor performance as a basis for evaluation and feedback. The exercise management controls the pace of the exercise and ensures that events are injected according to the scenario. (Adapted from [8])

The external environment of the command team is controlled by the members of the simulation staff. They represent actors and functions outside the command team that do not participate in the exercise, for example by injecting events according to the scenario script or by playing roles. The simulation staff communicates with the participants using interfaces (see Figure 3).

Observers monitor the activities of the participants and collect data for evaluation of team performance and feedback to the participants. Figure 1 shows an RPE where the command team operates in the front, while the simulation staff is located outside the room and observers work in the rear area cordoned off by the striped tape.

INTERFACES IN COMMAND TEAM TRAINING

In the training situation we want to replace the real environment with a simulated environment in order to simulate havoc without putting anyone at risk. At the same time the trainees must have the opportunity to receive information about the unfolding situation in the simulated environment. They can get this information through a number of interfaces.

In the following we present a number of interfaces and discuss how they are implemented in traditional SBT and how a VR environment can be used.

VR representation

The first level of VR support is to use the VR environment as a common representation of the state of the simulated world (see Figure 4). This level of VR support helps the simulation staff to keep track of the state of the simulated world.

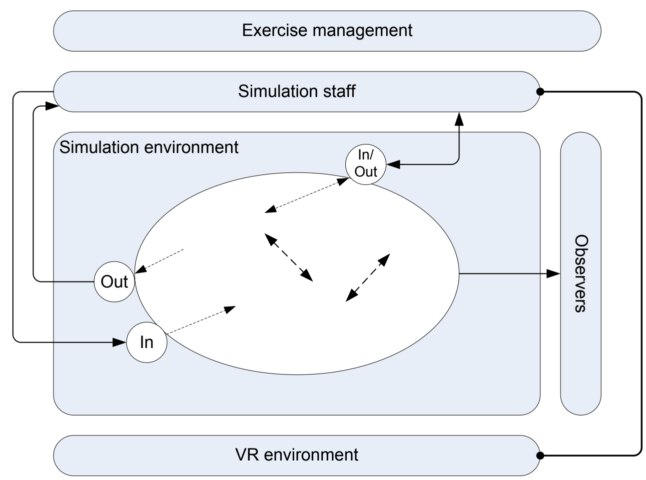

Figure 4. VR representation – The VR environment provides a common world representation used by the simulation staff.

The members of the simulation staff access the VR environment through a first-person perspective interface. In order to answer questions from the trainees, the members of the simulation staff have to move around and explore the virtual environment and report back their findings. Decisions made by the command team are executed by the simulation staff representing subordinate and collaborating units. Thus, the trainees use their ordinary communication equipment, such as radios and cellular phones, to communicate with the team leaders and other external parties played by the simulation staff interacting with the VR representation.

The idea is that the once the VR environment has been set up, it can accommodate for various scenarios customized to match particular learning objectives. Thus the time and cost for preparing a series of exercises can be reduced by reuse of the VR environment. This level of VR support relieves the simulation staff of the task of keeping track of the state of the world, which makes it a less demanding task to be a member of the simulation staff. The trainees do not interact directly with the VR environment, but benefit from this level of VR support by an increased level of realism in communication both in content and in the amount of time required to establish the state of the world.

VR stimulation

The next level of VR support adds the ability for the command team to receive information directly from the VR environment by means of stimulation (see Figure 5). Stimulation means that a subset of the information available in the VR-environment is presented in various displays.

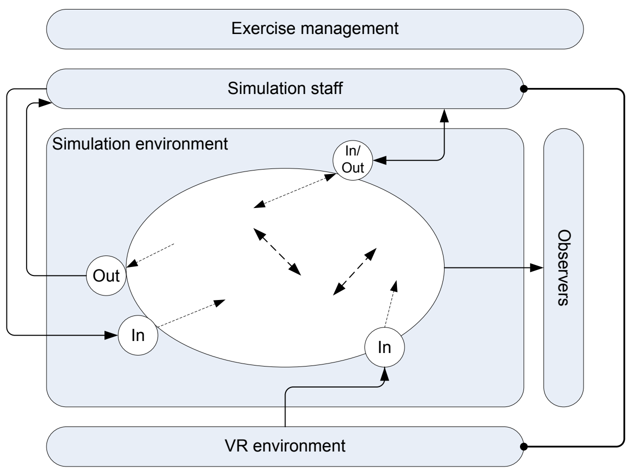

Figure 5. VR stimulation – The VR environment conveys information directly to the trainees through input interfaces, either through virtual displays or instruments or through stimulation of real systems.

One example of such displays is to replace any real windows with virtual windows, realized by a computer screen, which allows the command team to physically view a part of the simulated environment. An alternative is to provide displays showing computer-generated video from virtual surveillance cameras located in the VR environment. Instead of waiting for the simulation staff to report the state of the environment, the command team must monitor and detect significant changes.

Command posts and control rooms often have support systems that convey important information from the facility—for example alarm signals or critical instrument readings. Instead of having the simulation staff reporting these conditions manually, VR stimulation can be used to feed data from the VR environment to the ordinary support systems. This stimulation forces the command team to monitor support systems, but requires that an interface is developed to enable the data transfer.

VR stimulation gives the command team direct access to the simulation environment as represented by the VR environment. This step introduces the need to monitor and detect critical changes in the evolving situation, and thus adds essential tasks to be managed by the command team in the training situation. Virtual displays to mimic real windows or camera monitors are straightforward to realize in a VR environment, but interfaces for stimulating real systems may be significantly more difficult to develop due to system restrictions and proprietary data formats.

VR immersion

An additional level of VR support introduces the ability for command team members to be immersed in the VR environment (see Figure 6). In VR immersion the command post is represented in the VR environment—facilities, communication equipment, support systems. All interaction between command team members and with the simulation staff takes place through virtual interfaces. The nature of the interfaces to the VR environment can range from wearable computers and head-mounted displays to standard desktop computers.

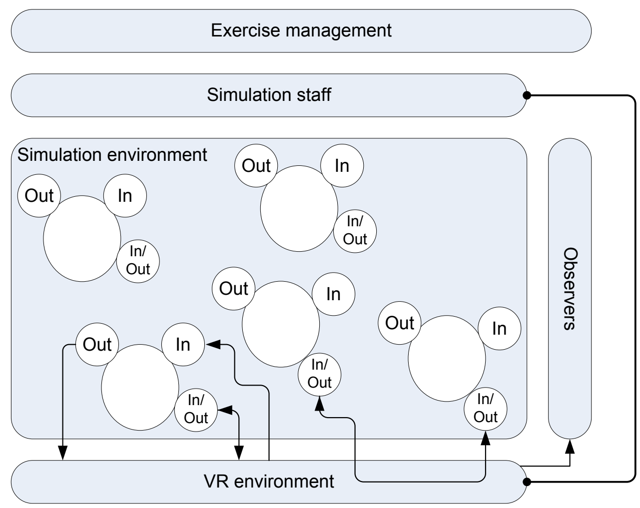

Figure 6. VR immersion – The VR environment is the sole interface between command team members and the simulation staff.

One advantage of this approach is that the trainees do not need to be physically present at the same geographical location to participate in a training session, which would reduce the time and cost for travel. Also, command team members are not confined to the command post. They can move around in the VR environment using a first person-perspective interface to liaison with other actors or to gather information. However, interacting with fellow team members through a VR interface instead of face to face introduces a significant change in the way teamwork is performed. All the eight dimensions used to characterize teamwork competencies are affected by this intervention as the human face to face interaction is left out completely.

VR immersion introduces additional challenges to the way performance monitoring and feedback are conducted. Observers must observe command team activities through an interface in the VR environment. Similarly, feedback to the trainees will have to be mediated by the VR environment.

DISCUSSION

We have used the RPE as a baseline for state-of-the-art command team training. RPE emphasizes realism in participants, tasks, ecological setting, and social system.

The basic way of introducing VR support in RPEs is by means of VR representation, which provides the simulation staff with a means of retrieving the state of the world by inspection rather than having to manually keep track of all changes. This support simplifies the task of the simulation staff, but does not directly affect the way the members of the command team work. Indirectly, however, the command team will benefit from the VR representation in the sense that the simulation staff will use it to find information and answer questions. As a consequence, communication between team members and simulation staff will be more open-ended and realistic.

Adding VR stimulation makes the VR environment accessible to the command team, albeit in a limited way. Virtual windows and camera monitors provide views into the VR world and introduce the need to monitor the progress of events, thus increasing task realism related to shared situation awareness and performance monitoring. Still, the command team in the training situation will operate in a setting which is very ecologically similar to its ordinary command post location.

VR immersion decouples the command team members and introduces an artificial interface between team members. This separation enables distributed training, but changes the way teamwork is carried out. It changes both the ecological setting and the way social interaction takes place in the training situation. As a result, communication and interpersonal relationships will be managed in a different manner, affecting crucial teamwork competencies.

VR representation and VR stimulation have little effect on training design since the members of the command team will operate in a similar way to the RPE case. Conversely, VR immersion presents several challenges to how training sessions are prepared, conducted and evaluated.

CONCLUSION

VR can extend the capabilities of established and time-tested simulation-based methods for command team training. Interfaces based on VR representation and VR stimulation are straightforward to introduce in the training situation, whereas it necessary to proceed with caution when considering solutions based on VR immersion. VR immersion is a technology that affects the fundamental principles of teamwork and team training.

ACKNOWLEDGMENTS

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Foresight Training as Part of Virtual-Reality-Based Exercises for the Emergency Services

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ABSTRACT
Due to the chaotic nature of accidents and crisis, emergency responses tend to unfold in a highly dynamic fashion. It is therefore of key importance that emergency service staff are continually trained on being mindful of risks and to spot early signs of things that could go wrong during an emergency response. This article suggests a way to adapt existing regimes for foresight training to the needs of emergency response organizations. Foresight training is currently being tried out in healthcare, and similar ideas, i.e. to base training on "what-if" discussions of typical high-risk scenarios, have also been implemented in the mining industry, and in the off-shore oil and gas industry. We follow this trend and suggest a way for foresight training to be integrated into virtual-reality-based emergency response exercises as part of the after action review (when the emergency response exercise is debriefed). The material for foresight training could be based on events that were encountered during the preceding exercise, as well as other typical high-risk situations, and subsequent discussions could, for example, be focused on the factors contributing to an elevated risk level and to what extent a negative development of events could be avoided through insightful actions. Hence, focus is on training to recognize typical risk factors and associate these with appropriate defensive steps.

Author Keywords
Foresight training, mindfulness, emergency services, organizational resilience.

ACM Classification Keywords
H.5.3 Group and organization interfaces: Evaluation/ methodology.

INTRODUCTION

Real-life emergency responses to crisis are highly dynamic—sometimes even chaotic, and comprise a large number of factors that could interact in unpredictable ways, giving rise to unforeseeable situations during an emergency response. Rescue actions may not produce the expected outcome and risky situations may arise as the response operation unfolds. To minimize the risk for mishaps during an emergency response operation, it is important that the on-scene personnel can identify significant risk factors and can back off or call in reinforcement when the risk factors start to add up.

Mindfulness is a term commonly used to describe a careful, defensive style. An individual who is mindful recognizes early signs of potential danger so that he/she can back off, or in some other way counteract a dangerous development of events. For example, a nurse assisting with an operation, who realizes that there is a swab (small piece of cotton) missing, would be mindful if he/she asked the surgeon to pause the operation and look for the swab, in spite the fact that this is not mentioned in any safety procedure.

This kind of *individual mindfulness* in the emergency services (ES) seems on the face of it to potentially work against a strict chain of command. However, mindfulness is not so much a matter of disobedience as a question of dynamic, reciprocal communication across organizational levels. An on-scene commander needs feedback from the individual emergency responders in order to assess risk levels and make well-grounded decisions. If something is on the verge of going wrong, the commander needs to know about it.

Through real-time and after-action feedback given by emergency responders, individual mindfulness can in fact strengthen an organization, and make it more resilient, that is, less accident-prone and more efficient at recovery. *Collective mindfulness* refers to mindfulness on an organizational level. Collectively mindful organizations are continually on the lookout for new ways in which something could go wrong, in order to prepare for these [1], [2]. Reason suggests that individual and collective mindfulness lie at the basis of organizational *resilience*, that is, an organization's ability to avoid mishaps and accidents, and a strong ability to recover on those rare occasions when something still goes wrong [3], [4].

At the very core of being mindful lies the ability to foresee bad things coming. This ability to foresee possible future mishaps can be learnt. *Foresight training* refers to a training program mainly targeted at front-line personnel, who is trained to recognize those personal, contextual, and task-related factors that could indicate a dangerous development of events. In addition, the trainees also learn to come up with alternative ways of action, and they learn to imagine how these alternative actions would affect the course of events.

Foresight training has previously been used in healthcare and in various high reliability organizations (HRO), such as nuclear power plants, and in the mining and chemical industries. There are a number of differences between HROs, which are presently offered this sort of training, and ES (the emergency services). HROs are committed to a broad range of activities, from risk management and accident mitigation to recovery after an accident, and HROs do normally not work under time pressure. ES, on the other hand, have to operate in chaotic accident scenes, and work under extreme time pressure, which means that decisions are often made on the basis of analogues and a holistic evaluation of the situation at hand, rather than through a complete analysis and comparison of all available options [5]. In this article we suggest a way for foresight training used elsewhere to be adapted to the needs of ES.

Considering the above, foresight training of some sort could be potentially useful not only in HROs, but also in emergency management. This could, for example, be seen in a recently conducted resilience-workshop with accident investigators. The investigators were asked to come up with ideas on how they would want to work with practical applications of resilience engineering and safety culture. The eleven participants came from varying safety-critical areas, such as patient safety, nuclear safety, maritime safety, occupational safety and road safety. They were asked to “think outside the box” and envision their future work with safety, i.e. not focus on hindrances such as money, resources, politics, but rather try to identify how they would like to work in order to achieve safer systems.

During the workshop the investigators were divided into four different groups and asked to discuss and envision the best options for the future. All groups discussed training as a necessity for increased resilience. This topic included training in simulated environments as well as discussion groups. These were some of the benefits identified:

- Simulating not only complex but also every-day situations will help to create a more secure working environment as personnel become increasingly comfortable talking about minor incidents and failures that occur in their working environment. This is important as most of the incidents and accidents occur here.
- Training will increases awareness of possible risk in the every-day working environment. This may also increase the amount of reported adverse events.
- Identify risks by discussing real or fictive events with persons from different levels of the organization will create a “collective knowledge”. The organization has a lot of experience that is “unused” and should be fed back into the organization.
- Training environments will improve the competence and skills needed when something happens. It is essential to know how to prioritize and how to act in a state of emergency.
- Simulating possible events can help creativity, for instance to improve current procedures or try out new technology.

An illustrative case of lack of foresight

A rescue operation went from bad to worse on 30th of May 2002 when nine climbers fell into a crevasse on Mount Hood, near Oregon, USA. Helicopters were sent to the rescue. Mountains this high are known to be dangerous for aircraft as the air is thin at these altitudes, which entails reduced intake of oxygen to the engines that in turn makes the aircraft slower to maneuver, requiring more planning ahead from the pilot. Also, thin air will reduce the lift under the wings or rotors. Sudden wind surges can aggravate the problem of weak lift and bad maneuverability. This particular day was windy, with suddenly changing wind surges. In the midst of the rescue operation, one of the rescue helicopters “… crashed while attempting to airlift one of the critically injured climbers. The chopper lost lift, dipped to the Southwest, impacted nose first into the mountain and rolled eight times down into the mountain’s crater. The accident injured the five crewmembers on board at the time — one seriously …” (see Figure 1) [6].

The US Air Force Accident Investigation Board (AIB) concluded after its investigation that “… the crew used inaccurate performance planning data, and therefore lacked the [engine and lifting] power required to accomplish the mission. The pilot immediately recognized the slowing of his main rotor RPM [rotation per minute], which was most likely caused by the loss of favorable headwinds. These headwinds had very probably initially compensated for the crew’s inaccurate performance data…” [7] (see also [8] for a live video footage of the rescue operation).

Figure 1. Rescue helicopter crash on Mount Hood (photo from http://www.katu.com/features/seeit/3871892.html).

Although the pilot was aware of the strong winds and of the risks associated with thin air, “rescue fever” might have pressed him to ignore these signs of potential danger. This case demonstrates the importance of acknowledging risk factors, especially when these add up. In other words, it is important to think “what if”, and to always be prepared for the worst, that is, to have foresight.

EXISTING FORESIGHT TRAINING METHODS

According to a systemic view, ES personnel, supported by road infrastructure, vehicles, tools and technical equipment, can be regarded as an aggregate socio-technical system that should be studied as a whole. As this system functions in a holistic way, accidents are caused by the system as a whole. Various parts of the system will perform unevenly, due to weather conditions, stress, fatigue, temperature changes, etc. The performance of system components thus varies incessantly. When the variation of several components converges in a bad way, it can lead to an accident [9]. According to this systemic view, variability (including human variability) is inherently bad.

However, human flexibility can also be an asset. In real-life socio-technical systems, emergency procedures might not cover all situations, technical equipment may not function as intended, and so on, which means that human flexibility, creating workarounds, might be the actual stuff that keeps a system functioning in the first place [1]. According to this view, human flexibility, creativity and foresight should not be restricted, but should instead be capitalized on.

What risk factors to look for

Existing methods for foresight training focus on the recognition of risk factors which can be identified according to the *three bucket model* [10]. The three bucket model is used as a simplified tool for subjective assessment of high-risk situations. When the three buckets are close to being full of “brown stuff”, the situation at hand is highly risky (i.e. the — might hit the fan), and it would be well advised to take a step back from the situation. The three buckets refer to three types of factors that can affect risk level. The first bucket contains factors related to the individual, for example, self-assessed levels of fatigue, recent negative life events (e.g. divorce), whether feeling sick, and how well subjectively perceived competencies meet the requirements of the given task. The second bucket relates to contextual factors, such as availability of necessary equipment, time pressure, imminent or recent shift handover, etc. The third bucket collects factors related to the task at hand, for example, the complexity of the task, and whether one has reached an error-prone portion of the task (where there is a lack of cues as how to proceed), or if one is close to the end of the task (when most errors are made). The combined contents of the three buckets can give a rough indication if one should go ahead, proceed with caution, or back out.

Foresight training in healthcare

Boakes [11] describes an example of foresight training in nursing care using scenario-based discussions. A series of scenarios are verbally described or showed on video to a group of nurses. The scenarios are meant to serve as a starting point for a discussion among the nurses of what contributed to the events and what could have been done differently. The scenarios that were used were developed with the help of active professionals. Four focused group discussions with healthcare professionals (nurses) yielded four types of scenarios:

Reflection on action—The first type of scenarios contains paper-based descriptions of a patient incident. These descriptions are aimed to facilitate discussion of possible contributing factors and how foresight would have made a difference.

Storytelling—The second type of scenarios comprises paper-based stories that are designed to trigger the trainees’ own experiences of how they stepped in to prevent an incident.

Spot the difference—The third group of scenarios include video-sequences showing two versions of an event. In version A the risk-level increases for each action taken. Version B begins in with the same initial situation, but here different actions are made, and the risk for subsequent incident is mitigated for each action.

Garden path—Finally, the fourth category of scenarios are such that they unfold in an unexpected way. The video presentation is stopped at certain key points and a discussion is initiated about what has happened so far, which factors are at play, and what could be done at this stage to prevent bad from going worse.

The scenarios were pilot-tested on ten voluntary teams of professionals. Feedback from these evaluations indicates that foresight training might benefit not only front-line personnel but also team leaders. Making the transition from healthcare to emergency management, these results seem to suggest that foresight training could benefit emergency responders and on-scene commanders working directly on the front line, as well as command post staff.

INTEGRATION OF FORESIGHT TRAINING INTO EMERGENCY RESPONSE EXERCISES

Foresight and preparedness requires constant vigilance, however, the mishaps that could offer a training opportunity and an opportunity to gain experience occur seldom. It is therefore important to offer alternative means for foresight training.

A highly suitable way to train high-risk situations during an emergency response operation is through simulated mishaps and unforeseen complications using a virtual reality (VR) environment, where the trainee can be immersed by being involved in a dynamic interaction with the simulated environment and other real-life actors. One great advantage of simulated training environments is that high-risk events can be practiced without exposing the personnel to real danger. In addition, all details of the training session can be recorded—and analyzed after the exercise. Although simulator-based training normally covers a wide range of situations and learning goals, in this article we place particular emphasis on foresight training, the learning goal being a more mindful personnel and a more resilient organization.

As mentioned previously, there are clear differences between the HROs presently utilizing foresight training and the conditions under which ES have to operate. Among other things, accident scenes are chaotic and there is often no time to evaluate and compare all options. Instead, decision making is forced into a quicker mode, where the present situation is evaluated in a holistic way on the basis of previously encountered similar situations. Actions that worked well in the previous situation are attempted in the present situation, what is called *recognition primed decision* (RPD) [5].

The question is how foresight training can be integrated with this context. The goals of foresight training can be boiled down to 1. Correct risk assessment 2. Creativity when generating alternative actions and 3. To imagine the outcome of these alternative actions. Goal number 3, to imagine the outcome of actions, is already practiced as part of RPD. Goal number 2 is *not* practiced in RPD, as new alternatives for action are normally not generated until the current option has been rejected as being unfeasible. This single-alternative mode works fine as long as risk levels are low to moderate. When risk levels start to soar, the single-option style becomes suboptimal.

To have an added value, foresight training for ES should focus on training goals 1 and 2: Correct risk assessment and to *always* be creative when it comes to preventing a potentially dangerous development of events. One caveat is that correct risk assessment is often neglected during an emergency response, due to time constraints.

If a simplified scheme for risk assessment were learned, and highly practiced, time constraints would seize to be an issue. As correct risk assessment is a prerequisite for the other training goals, goal number 1 should be of primary concern in foresight training for ES. One way to practice risk assessment and the detection of indicative signs of imminent danger is by being subjected to unexpected, but realistic development of events. These should preferably reflect a course of events that have occurred during real-life responses.

To obtain realistic and useful scenarios, these could be based on interviews and/or focus group discussions with emergency service personnel. These scenarios are meant to cover high-risk situations that could emerge in the course of an emergency response. Some of the scenarios should describe situations that actually went from bad to worse.

These scenarios could be included as injects into the VR-training environment, adding an element of surprise to the training exercise. The trainees' actions during the foresight inject could then be discussed during the after-action review (debriefing) that normally follows an emergency response exercise. After the discussions, the foresight injects could be rerun with the same group of trainees in order to allow them to try out alternative actions.

Following the foresight training method used in healthcare, we suggest four phases of foresight training:

The concept of contributing factors—This first phase is meant to introduce the three bucket model. Scenarios describing an incident should inspire a discussion of possible contributing factors. Could the incident have been avoided if these factors would have been recognized in time? The scenarios should contain elements corresponding to bucket 1, 2 and 3 in Reason's three bucket model, in other words personal, contextual and task-related factors that could affect risk levels.

Personal experiences of successful risk mitigation—In the second phase of foresight training, the scenarios could contain unfolding events that have occurred during the emergency response exercise—preferably minor "close calls" that were appropriately handled during the exercise. The point here is to actualize the theoretical concepts introduced during the first phase, by triggering the trainees' personal memories of similar events, where an imminent danger was successfully mitigated. In this phase, trainees will realize that it is often possible to handle a high-risk situation by taking preventive measures.

Spot the difference—In the third phase, scenarios could comprise injects that could have unfolded in one of two ways. In development A, risk-level increases at each step, in development B, risk-levels decrease as a result of preventive measures. In this phase, trainees will hopefully become aware of the potential power that every individual has to affect a course of events through cautious thinking and preventive actions.

How will this end?—This concluding phase of the suggested foresight training for ES could contain scenarios based on especially tricky events that unfold in a way that is difficult to foresee. Content should, if possible, be based on actual events (like the helicopter rescue described earlier). The purpose of this final phase is to exercise what has been learnt. A recording of the trainees' actions during the inject will be replayed during the after-action review. After a discussion of which factors are presently at play, what might happen and what could be done to prevent it, the VR-simulation can be rerun, in order to allow the trainees to try out alternative actions.

CONCLUDING REMARKS

Training, as outlined here, could be offered to all categories of personnel in ES: the emergency responders, the team leaders and the on-scene commander, as well as the command post staff. Details of the training could be adapted to organizational level, but will have the same main goals: to help develop a more risk perceptive and less fatalistic, more flexible way of action during an emergency response.

We would also like to note that foresight training for ES can have a beneficial effect not only at the individual, but also at the organizational level (even if only front-line personnel are trained). The mindset that is practiced through foresight training is associated with an increased feeling of power to change the way things are. Provided that front-line personnel is encouraged by management to be mindful, they will take an increased responsibility for safety work in the organization, creating a more reciprocal information flow across the organizational levels. In this way all personnel will feel responsible and will actively partake in achieving organizational resilience.

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Semantically Enabled After Action Review

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ABSTRACT
This paper describes how Topic Maps technology, natural language question answering and graph visualization can assist in After Action Review of crisis response training simulations. Crisis response training simulations produce large amounts of data. It is shown that it is possible to assign semantics to these data. User interfaces exists to browse semantic data, however it is still difficult to browse very large data sets. A combination of natural language question answering and graph visualization provides a natural and user friendly query mechanism over the data.

Author Keywords
Crisis Management, After Action Review, Semantics, Topic Maps.

ACM Classification Keywords
H.5.2 User Interfaces (D.2.2, H.1.2, I.3.6).

INTRODUCTION

This paper describes how Topic Maps technology, natural language question answering and graph visualization can assist in analyzing large amounts of data created by crisis response training simulator. Topic Maps and the problem context are first explained. Then it is detailed how semantics can be attached to the data available. User Interfaces are discussed next - browsing interface, graphical visualization and natural language question answering. Finally, related work and future plans are presented.

TOPIC MAPS

Topic Maps is an ISO standard (ISO/IEC 13250:2003) for knowledge representation and information integration. In Topic Maps, each subject in the knowledge domain is represented by a topic. In Figure 1, Puccini is a topic representing the composer Giacomo Puccini [5]. Each topic may have a type. Here, the topic *Puccini* is typed by the topic Composer, meaning that Puccini is a composer.

Topics can be associated with other topics. The topic *Puccini* is associated with the topic *La Bohème* and the association type between them is *composed by*. The fact that topics are associated with each other provides a structure that corresponds to the way we conceptually grasp knowledge. It also allows asking questions about the knowledge within the topic map, e.g. *"Who composed La Bohème?"*. Association is built from players, role types and association type – all are topics. For example, *Puccini* plays the role *composer* in the association of type *composed by* and *La Bohème* plays the role *work* in the same association.

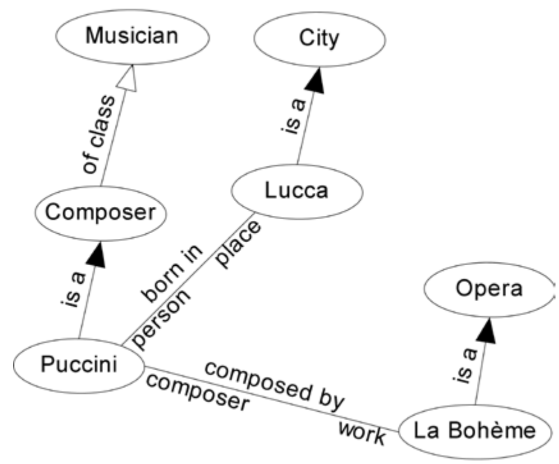

Figure 1 - Excerpt of the Italian Opera topic map

Each topic can hold extra information called occurrences. These are pieces of information about the topic, similar to paragraphs in a book that are referenced by the book index. Occurrences can be simple textual information or references to any other media, such as web pages, audio, video, etc. Like associations, occurrences are also typed. For example, the topic *Puccini* may have occurrences of type *Date of birth* containing *1858-12-22* or of type *Article* containing *http://en.wikipedia.org/wiki/Giacomo_Puccini*.

Topic names, variants, occurrences and associations can all be scoped. The scope can then be used in order to filter those elements in or out when using the topic map.

Scopes can be used to provide different perspectives (e.g. describing crime scene from different points of view) in the same topic map. They can also be used in order to describe dynamic situations. For example, a train can be associated to a certain platform with the association located in. This association can be scoped by a topic that represents the period in which the train is actually in that platform. This way, a topic map can model the dynamics of a train station.

AFTER ACTION REVIEW IN CRISIS RESPONDING TRAINING SIMULATOR

Large crisis situations, such as a terror attack in an airport, are very complex to handle. Such situations involve many responders of different levels, many unforeseen factors, and huge psychological pressure. Because of the facilities (e.g. airport, train stations, etc) and amount of people involved in such scenarios, it is practically impossible to conduct realistic exercises. Therefore, in order to address this issue, a crisis management training simulator will be developed by partners working on the CRISIS project.

This simulator will be built as a multiplayer first-person shooter game, where the crisis responders (police officer, fire brigade personnel, paramedics etc.) play their roles in a dynamic and realistic scene. The simulator will also include computer generated avatars acting as individuals in the crowd.

In order to realize the full potential from an exercise in such simulation, an After Action Review system will be designed. Because the exercise is simulated, a lot of data from the exercise is easily available:

- Location of the different avatars.
- Actions of the different avatars.
- Communication between the avatars.
- Data about other events which happen during the simulation (e.g. data about an explosion).
- Telemetry of the players (e.g. pulse rate of the players).

Some of this data can be used for playbacks of the simulation during the After Action Review sessions.

However, in large simulations involving many participants, finding the interesting moments and understanding the chain of events is very difficult *because* the amount of data available is so large.

ATTACHING SEMANTICS TO THE DATA

In order to be able to browse, query and understand the data available, we suggest to first organize the data.

The data has different semantic levels:

- Background data - these are the things we know about the overall scene: the different locations (halls, corridors, restaurants, gates etc.), the organizational structure (which position is responsible for which domains), the actual people filling in the positions in the organization, procedures to be followed, etc.
- Data streams that can be made easily meaningful by using background data - for example, the location of an avatar is provided by the simulator as (X, Y, Z) coordinates. This has no meaning to the user. However, by using background data, a simple script can be set up to convert such coordinates stream to names of locations.
- Raw data such as audio recordings of communication between the players - it is more difficult to get the meaning of such voice recordings. Even if voice recognition algorithms are successful in processing such recording, the resulting transcripts are still unstructured text, usually lacking the context. Yet, semantics can be attached also to raw data by relating it to other available data - who communicated with whom, when the communication happened, and the location of the parties.

That is, by linking the different data available, we can attach semantics also to the data which is usually meaningless.

The linking or the federation of the various data available can be done by organizing the data in a topic map. This is demonstrated in the simplified topic map excerpt shown in Figure 2.

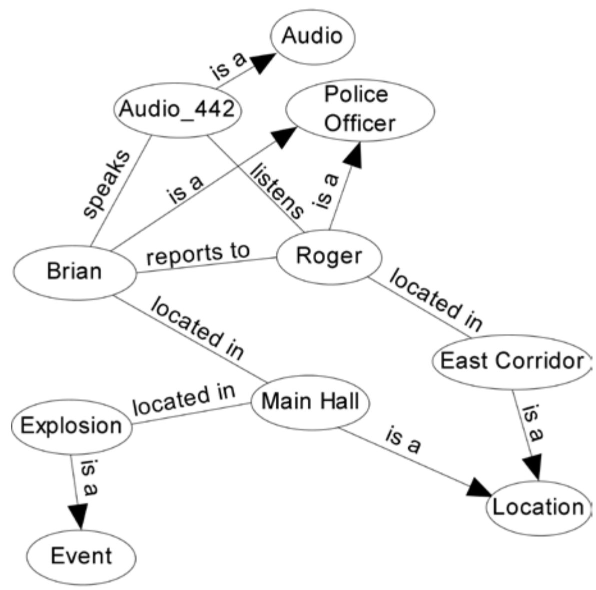

Figure 2 - Excerpt of crisis response training topic map

This topic map excerpt describes one moment during the simulated training. It describes the situation where the police officer Brian who is located in the main hall is speaking to his commander, Roger, who is located in the east corridor. At that time an explosion occurs in the main hall.

However, the above example does not describe the whole training, but only one moment in that training. In order to describe the whole training, scopes must be used.

For each event during the simulation, such as movement of avatars from one location to another, explosions, or communications between avatars, we can assign a start and end time. For example, Roger entered the east corridor at 15:32:11 and left it at 15:32:49. That is, *Roger* is associated to the *East Corridor* with the association *located-in* only during that period. To describe that, we can create a topic that describes this period, and use it as a scoping topic for this association. This is demonstrated in Figure 3.

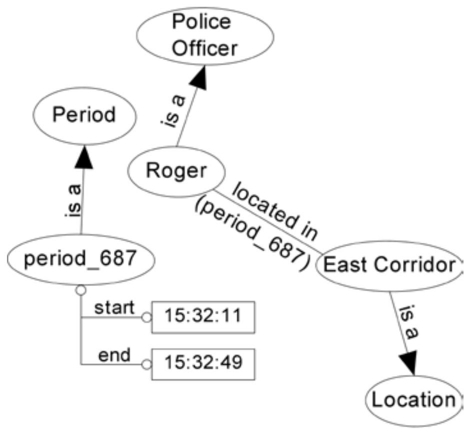

Figure 3 - Dynamic modeling with scoping

By scoping associations, occurrences and names with a topic describing periods, the topic map becomes dynamic. By filtering in only the scoped constructs of a certain moment, the topic map representing that moment becomes available.

THE USER INTERFACE

The created topic map federates all the meaningful data available from the training. This topic map can be accessed in different manners.

One way to access topic maps is by using a browser which allows browsing through the associations. Figure 4 depicts one such browser (which is also an editor) called ScienceCast. In ScienceCast, the user always views one topic at a time. However the context in which this topic is presented is very clear: the two right frames describe the hierarchy of the current topic, and other instances of the topic type (the sister topics of the current topic). All the rest of the frames describe the topic name, occurrences and associations to other topics. All the other topics mentioned in this page (topic types, occurrence types, association and role types and associated topics) are clickable and a click on them will take the user to the page describing the chosen topic.

Yet, two problems arise with regards to browsing the topic map. The first problem is the great size of the topic map as is the case with a topic map that represents a crisis response training of few hours in a large realistic scene. In such a case browsing alone is not sufficient and a query mechanism is necessary. The second problem is that even if the interface of the browser is very well organized, a graphical visualization of relevant excerpts of the topic map provides a much clearer picture to the user.

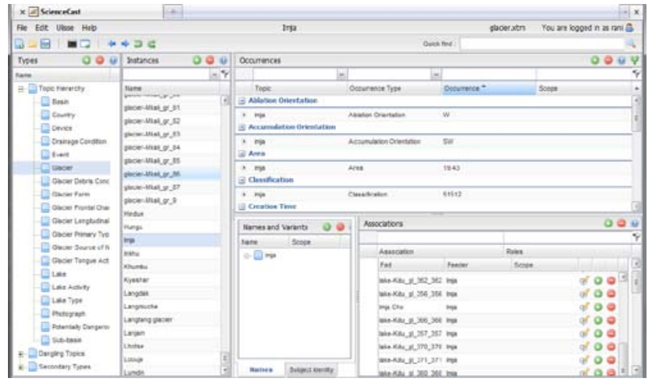

Figure 4 - ScienceCast

These two problems are addressed by a natural language question answering that has been developed over Topic Maps [4]. This question answering system takes advantage of an algorithm which finds a graph connecting all the topics relevant to the question [6].

During the development we realized that visualization of the created graphs is very valuable for the users as a way to communicate how the question is understood and how the answer is achieved. That is, even when the question is not resolved correctly, this visualization usually provides hints to the user with regards to how the question should be reformulated to get better results.

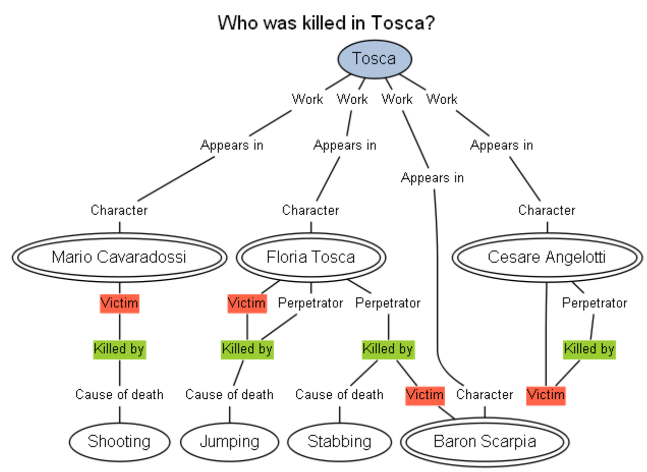

Figure 5 - Example of resulted graph from QA

This is demonstrated in Figure 5. The graph provides the full context of the question and the answer, and from it one could not only learn "Who was killed in Tosca", but also how and by whom.

We conclude that question answering that provides this kind of a visualization of its results can be used as a user friendly query mechanism over complex and large data sets, such as the data from the crisis responding training simulator.

RELATED WORK

ScienceCast - the browser and editor over Topic Maps, and the graph algorithm [6] used in the question answering were developed in the ULISSE project[1]. In this project results from experiments made in space in seven different disciplines are integrated and made understandable and accessible using Topic Maps.

The natural language question answering over Topic Maps is a work in progress done in the LINDO project[2] [4]. One of the use cases in this project is a video surveillance application. In this use case, a similar topic map to the one described in this paper is developed. In that topic map, background data about a train station and the time table of trains is federated with raw video and audio data to be able to find faster the interesting video clips. In this project, initial work is also done with regards to the identification and the resolution of time expressions.

The DIADEM project[3] addresses an ICT system for collaborative decision making that effectively supports the protection of the population and the environment against chemical hazards in industrial areas. In this project it is checked how using Topic Maps for After Action Review can be done over logged data from distributed agents [1].

FUTURE WORK

In the CRISIS project, we plan to implement the above described After Action Review over the developed crisis responders training simulator.

In addition, two related research goals will be sought:

- The user interface provided by ScienceCast will be extended and an advanced time slide will be included. This will allow users to browse the topic map over time, and to visualize specific relationships between topics over time.
- In the LINDO project, we currently only resolved simple time expressions [2,3]. These time expressions always mention an absolute time (e.g. "Thursday afternoon"). In CRISIS we plan to extend the time expressions resolver to cope with queries such as "where was Brian when the explosion occur". That is, identifying an event, finding its time, and relating it to another event.

[1] ULISSE - USOCs KnowLedge Integration and dissemination for Space Science and Exploration, is an FP7 project under the Space Theme (grant agreement n°218815).

[2] LINDO - Large scale distributed INDexation of multimedia Objects, is an ITEA2 project. In its Belgian part, domain portable natural language question answering over Topic Maps is developed. This work is partly funded by the Flemish government (through IWT).

[3] DIADEM - Distributed Information Acquisition and Decision-making for Environmental Management, is an FP7 project under the ICT Theme (grant agreement n°224318).

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Episode Analysis for Evaluating Response Operations and Identifying Training Needs

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ABSTRACT
In Crisis Management (CM) teams are faced with dynamic and complex situations, often involving multiple teams and organizations working together under stressful circumstances. One of the key issues observed in emergency responses is inadequate communication. The communicative difficulties may stem from various areas such as political, personal or jurisdictional. In order to improve communication and coordination, we need to gain a profound understanding of what the communication problems are and, further, we need to provide meaningful inter-organizational training regimes targeting these issues. We suggest *episode analysis*, a qualitative research method, to better understand the communication taking place during an emergency response. Using an example of episode analysis, we show how this method provides a way to code and analyze data involving multiple teams and organizations as well as a way to study more informal communicative functions that would otherwise be difficult to capture. Moreover, we suggest that episode analyses can be used to identify training needs and be helpful in creating meaningful training scenarios.

Author Keywords
Episode Analysis, Crisis Management, Training, Simulations, Qualitative research method

ACM Classification Keywords
H.5.3 Group and Organization Interfaces: Evaluation/methodology.

INTRODUCTION

Coordination and communication between teams and organizations is a key component for successful Crisis Management (CM). The dynamic and unpredictable nature of emergency responses makes successful communication vital and at the same time all the more demanding. The overabundance of information may create misunderstandings as well as problems with determining priorities, utilization of equipment and personnel, sometimes resulting in delays in services or the duplication of efforts [3, 6]. Further, functions and roles may have to be improvised to handle impending tasks, creating ad hoc structures not easily identified [6, 8, 11]. To improve the communication and coordination skills of responding teams it is becoming increasingly evident that we need a wider perspective encompassing what *does happen* during the responses, rather than focusing on what *should happen*.

However, due to the nature of CM, there are some great challenges in studying and evaluating the efficiency of emergency response operations. Difficulties arise from, for instance, wide geographical distribution and a large number of different actors. Often, multiple organizations and teams are communicating at once, several events are taking place simultaneously, and new situations within an existing crisis scenario are constantly being created.

In this paper we suggest *episode analysis* for analyzing coordination and collaboration within and across multiple emergency services involved in an emergency response operation. Episode analysis is a bottom-up, data-driven qualitative research method used to study communication where multiple participants are involved [5]. The method provides the means to handle large amounts of data involving multiple teams and organizations as well as considering more informal issues influencing the task at hand.

This method has previously been applied to studies of joint emergency response operations [1, 8, 12]. These studies have shown that episode analysis has great potential for gaining in-depth insight into processes and functions, formal and informal, which arise during the emergency response operation. We suggest that episode analysis could be used to give scholars and practitioners better insight into what actually goes on and help create ecologically valid and meaningful training scenarios.

Communication is key to coordination of response operations

The definition of *coordination* has significantly varied in studies and literature. From simple interactions between organizations participating in an event to a more involved process of deliberately adjusting to each other and relaying information so that individual efforts can be intermeshed with those of others (for a review see Drabek & McEntire [3]). Due to the loose definition it may be difficult to separate from communication [2]. However, it appears evident that one of the most important elements of coordination is communication.

In his comprehensive review of emergency response literature, Auf der Heide [2] showed that one of the most consistent observations about crises is inadequate communication. Reasons for this may be that boundaries not normally affected in daily emergencies are crossed, for example, taking on unfamiliar tasks, breaking jurisdictional boundaries or rapidly restructuring the responding organizations. A few of the factors identified as promoting trust and therefore fostering good communication were: informal and personal contacts, joint training and organizational planning, preplanned agreements between the various emergency services and adaptation of similar terminology.

Emergent phenomena not captured by traditional methods

When studying a CM organization, documentation of communication during response operations is a key factor for understanding the human experience. However, capturing the processes, adaptations and underlying demands impose a great challenge; unexpected and rapidly unfolding events, geographical distribution, coordination of multiple teams and organizations are just some of the difficulties faced.

One very important issue discussed in coordination research is *emergent phenomena*, which arise when organizational personnel structure themselves to resolve the task demands placed on them. This type of emergent self-organization has been shown to enable a quicker and more effective emergency response [3, 6]. The ability to improvise organizational structures and roles is key to successful response operations [3, 6, 7, 8, 9, 11, 12, 13].

The caveat is that many of these phenomena are not identified or captured by traditional top-down methods using predefined categories formed by the various missions the teams are performing [10]. An improved method of structuring large amounts of complex data is therefore necessary in order to give CM organizations the right training and tools to support their work in real events.

EPISODE ANALYSIS

In episode analysis episodes emerge from the data and not from predetermined missions of the task at hand. This open-ended analysis gives the opportunity to explore not only how the mission tasks are handled, but also issues not directly associated to the task at hand, such as emergent phenomena and improvisation.

In the analysis communication is broken down into subunits, called “episodes” [5]. Each unit contains an unbroken chain of actions internally bound together by a topical trajectory and/or a common activity [4]. An example, taken from a simulated CM response operation, is the episode “air quality” (a more detailed review is given in the next section). Within the episode all information, i.e. recorded interactions, observations and notes, concerning the issue of handling the air quality during the forest fire is bound together in an episode [8].

It is not sufficient to analyze communication without acknowledging surrounding information about the situation and unfolding events. The episode analysis uses a context dependent approach and episodes are created based on factors that initiate the situation. The initiations can be grounded in a *situation, cotext*[1] or *knowledge* [4]. If an episode or subunit is grounded in a situation, this means that an occurrence has triggered an event in real time. This could for example be a new fire, a phone call or something else in the context that triggers the event. A subunit grounded in cotext signifies that a previous event within the interaction has triggered the current event, for example a previous topic is once again brought forward etc. Knowledge based events are triggered by previous knowledge and experiences, for example a request for ambulance assistance as a result of previous experience from similar emergency response operations [12]. Other constraints such as physical, organizational, and cultural aspects influencing the performance of the participants also need to be taken into consideration by the researcher.

An example of using episode analysis

In this section an example of an episode analysis in CM is given [8]. The analysis was performed on data collected from a simulation that was a real-time role-playing exercise for command staff in the Swedish Response Team (SRT)[2]. The scenario was based on a real event; the 2007 California wildfires. The main task for the SRT was to offer support to Swedish citizens in the area and prepare for potential evacuation. The main focus of the analysis was to better understand the participants’ adaptive and improvised behavior. For this an episode was chosen where two commanders had to take on a task they were not trained for - the previously mentioned “air quality” episode. The task involved, for example, increasing awareness about hazardous smoke and providing information on what protective face-masks may be suitable.

A large set of data was collected during the exercise: five observers were present and four video cameras were placed in the room. All phone calls were recorded and e-mail communication was logged, as well as the participants own notes, logs and reports.

To perform the episode analysis all interactions, observations and notes concerning this task were compiled.

[1] *Cotext* is the *textual context* of a text. This means that an initiating trigger comes from something going on in the conversation. This could for example be a previously discussed idea re-surfacing and being applied to the current circumstances.

[2] The SRT is a rapid response taskforce that can be deployed to assist and support the Ministry of Foreign Affairs through the Swedish embassies. Their primary task is to assist Swedish citizens affected during serious emergencies abroad.

The episode was, in this particular example, broken down into smaller units, so called "sub-episodes" (SE) (see figure 1). This main reason for this was to better understand what triggered each event that affected the progress of this specific episode. This was done by using the categories mentioned above; situation, cotext or knowledge. Figure 1 shows the eleven sub-episodes on a spatial-temporal scale. The horizontal line indicates the temporal scale. The simulation continued for approximately four hours. Overlapping sub-episodes show the spatial scale; if they are overlapping this means that the two episodes are present in the same interaction. For instance, sub-episode 2 (SE2) involves two staff members searching through newspaper-articles and reports to gather information about the hazardous smoke. A phone-call about the smoke is made to one of the two staff members; this is the event that triggers SE3, but both SE are present in the same interaction and therefore overlap in the figure. The coloring is of no significance other than making it easier to distinguish one SE from another.

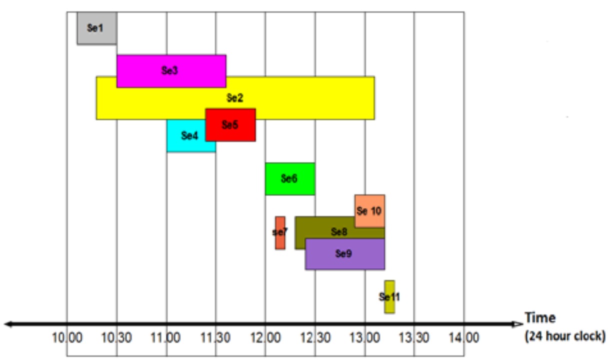

Figure 1. The episode "air quality" broken down into sub-episodes [8].

Three examples of what the episodes contain as well as what triggered them are given below. SE1 is a joint briefing initiated by the staff commander taking over the command post previously established by the assessment team (played by simulation staff). This episode falls under the category *situation* as the initiating factor is something happening in real-time, i.e. the staff members have arrived and are briefed on the current situation. SE6 is initiated by one of the staff members sending an e-mail to the Swedish Civil Contingencies Agency asking for expert advice on face-mask filters. This episode falls under the category of *cotext* as the issue of different filters had been discussed in previous interactions. Contacting the authorities for more information was, however, initiated at this point. SE10 was initiated by two members of the staff introducing a rotating schedule for staff members. The reason for this would be to avoid any one person being exposed to hazardous smoke for a long period of time. The triggering event of the SE was categorized *knowledge* as it was initiated by previous knowledge and experience of the two staff members.

Identifying triggers of events gave the opportunity to map out the teams' reactive and proactive work [8]. This showed a trend of how the response team became more proactive further into the simulation. Initially they acted on reactive bases (*situation*) but then subsequently started to be more proactive; reiterating previous issues (*cotext*) as well as using their expert knowledge (*knowledge*) to manage the task. The analysis also provided a map of how information was mediated throughout the teams and organizations, which helped to pin-point when and why misunderstandings took place. The analysis exposed failures in the teams' ability to improvise roles which were not detected by the participants or the expert observers on site during the simulation. Further, the detailed analysis of communication showed where shortages occurred, uncovering how information got distorted as it travelled through the organization.

Creating scenarios for training environments

We suggest that episode analysis can be used as a tool for identifying the training needs of organizations. Previous studies show that the method can give valuable insight into ongoing processes and identify issues that are perhaps not evident on site. Informal communication and improvised roles are some of these. We do not want to eliminate these aspects of teamwork as they play a critical role for successful response operations. Rather, we want to maintain resilient organizations and make sure that the personnel are trained to be flexible and able to adapt to the prevailing situation.

An analysis to identify training needs can be performed on either real-life events or previous training exercises. Using simulated environments is, of course, of great advantage for the researcher as it makes it easier to document all communication and to control the initial scenario. On the other hand, studying CM in real life settings is necessary for increased validity. An example of how episode analysis can provide support for scenario creation is given below. The example is taken from the episode analysis performed on the Swedish Response Team (SRT) [8].

Several of the team members in the SRT had to take on roles they were not specifically trained for, and as a consequence, had to improvise. The analysis showed that this caused some rather serious problems due to information being misunderstood. The analysis identified three main causes of this [8];

(1) Insufficient domain knowledge

(2) Language/communication difficulties

(3) Poor organizational structure

The first reason, insufficient domain knowledge, is not surprising considering that the staff members were acting outside their own field of competence in their improvised roles. The second reason appears to stem from the constant switch between English and Swedish; within the team the staff members spoke Swedish, but when communicating with outsiders they spoke English. The third reason for the misunderstandings was that responsibilities were unclear and for that reason proper hand-overs were not executed. These main reasons led to information getting lost and/or distorted. Interestingly, it appears as if the combination of all these factors were necessary for the mistakes to take place, several small issues here and there led to a few major misunderstandings. The findings imply that when some parts of the system are weaker - in this case it was the missing expert knowledge - other parts, such as the organizational structure, in terms of proper hand-overs and clear responsibilities need to be stronger[3] [8].

From this analysis it is evident that response teams need more training on how to keep the organizational structures strong *and* flexible. Creating scenarios where certain functions are missing will give participants the opportunity to act in different roles and identify risks that may occur when the team is stressed in various ways. The analysis shows that the persons acting outside their field of competence neither requested nor received increased support from the organization. This led to a weakened team and tasks were subsequently abandoned. Training for these types of situations will provide increased awareness for teams and draw their attention to the pitfalls of improvising.

DISCUSSION

Episode analysis has been found to be a useful method for breaking down large amounts of data where multiple persons and organizations are involved because it provides a natural way of categorizing several events and tasks that occur simultaneously [1, 8, 12]. The bottom-up approach also allows room for informal issues to surface and deepens the understanding of functions and events taking place that may not be possible to identify using a top-down approach. For example, misunderstanding taking place during the SRT training were not detected during the training by on-site observers, but surfaced only in the subsequent episode analysis [8].

The importance of understanding these informal functions was made clear in the study by Trnka & Johansson [12]. In their study of fire fighters they concluded that the response would not have been successful had the commanders stuck strictly to their formal organization and predefined roles. Furthermore, it was made clear that the organization's technological structure did not support the informal structure created during the response.

The method also has the potential of identifying training needs. Having access to a detailed description of mistakes and their true source can be of great assistance when creating new training scenarios that will make response teams aware of the communicative difficulties that so often exist in inter-organizational response operations.

Naturally, there are some drawbacks with this method. One of these is that episode analysis is time consuming. Although this would likely be the case in most studies facing a large amount of data, using a bottom-up approach is generally more time consuming than a top-down approach. Furthermore, to gain the greatest benefit the method requires sufficient amounts of data to be able to recreate and understand the events, contexts and communications that have taken place.

CONCLUSION

We believe that episode analysis can be of great assistance in further understanding coordination and communication in CM. It has so far provided new, in-depth perspectives on, for example, improvised roles. Therefore, episode analysis is an important tool that can help us understand teamwork, for example improvisation, in terms of both organization and technology used. So far, the method has only been applied to data collected in simulated environments. We do suggest, however, that future research should explore the method by applying it to data collected in real events to increase ecological validity. Further, we suggest that this type of analysis can be used to identify weaknesses in teams and organizations, whilst providing a unique insight into their training needs, in addition to the type of scenarios that will support those needs.

ACKNOWLEDGMENTS

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CRISIS: Research Priorities for a State-of-the-Art Training Simulation and Relevance of Game Development Techniques

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ABSTRACT
The main aim of the CRISIS project is to develop a simulation that will train first responders and crisis managers how to respond when a crisis occurs. By building an interactive graphical simulation based on video games technology, the aim is to allow trainees to safely train, on demand, in a virtual environment. This paper summarises how the CRISIS project will attempt to extend the state of the art in crisis training. A broad statement of CRISIS simulation priorities follows and the paper continues with a review of how some aspects and techniques of game development may apply to the development of a training simulator.

Author Keywords
training, simulation, video game, game engine, graphical realism, engagement, behaviour, interaction, serious games

ACM Classification Keywords
H.5.1 Information Interfaces and Presentation: Multimedia Information Systems—*Artificial, augmented, and virtual realities*

INTRODUCTION

CRISIS (CRitical Incident Management training System, using an Interactive Simulation Environment) is a three year, EU FP7 funded project. The main deliverable of the project is an immersive simulation-based training system. The system aims to be on-demand, meaning that a single user could use the system to perform catch-up training between shifts, or allow multiple users to run through large scale, day long scenarios. The multiple users can either be within teams (e.g., a team of on-scene fire fighters) or across teams (e.g., the fire team communicating with the local command post). The key training foci are decision making, problem diagnosis, planning and acting beyond procedural familiarity.

As well as the core simulation, CRISIS will also contain solutions for planning training exercises and executing a comprehensive after action review. The exercises planning system will allow the instructor to select both the main scenario and a set of distractors (small, unexpected events) to complicate the exercise. The after action review will allow for trainees to receive detailed feedback almost instantly after the exercise has finished.

The system will need to be reconfigurable such that different corporations and public services can easily adopt the training system; ranging from airports and train stations to oil rigs and nuclear power plants. Procedures and command structures must also be configurable, providing a test bed to try out new tools and procedures in a safe environment. Any new tools or procedures that perform well in training can then be implemented in the real world.

The remainder of this paper is divided into four sections: (i) the related research in the area of training simulations, (ii) six ways in which the CRISIS project can advance the state-of-the-art in training, (iii) the main priorities of CRISIS in the area of simulation and interaction, and (iv) the research issues that are raised when tackling these priorities. Some of these issues have already been identified in the gaming industry, where appropriate examples will be described. The remaining areas help identify the novel research core of the CRISIS project.

BACKGROUND

Table top training is common in many workplaces and helps decision makers to play out a crisis scenario and see the outcomes of the decisions they make. These exercises tend to use only pen and paper, and sometimes a map. While trainees often immerse themselves in this type of training, it is difficult for them to both visualise the scene and see the consequences of their actions. Another problem with table top exercises is that they usually focus on the high level decision makers, and not those who are first to respond to a scene.

Computer based training simulations have become more popular since their early use in the 1990s, for example, training new road drivers [1]. The improving ability to simulate the human body has increased the demand for medical training simulations. By combining virtual reality and haptics, medics can be trained in fine grain techniques such as suturing [4]. Simulators for more coarse grain medical training such as triage are also available [3]. Other examples of simulated training include military training [5] and launch team training at NASA [6].

Training simulations that place the user in a virtual world share many attributes with video games known as *first person shooters*, where the gamer plays the game from the first person perspective of the main character. The unfortunate truth is that there is lot more financial investment in the gaming industry, leading to more research and development. Larger game companies tend to develop their own game engine, which gives them a base for building new games. A game engine is a piece of software designed for creating and developing video games, and typically includes functionality such as a rendering engine for creating the 3D or 2D graphics, a physics engine for movement and collision detection, and other functionalities such as sound, animation, artificial intelligence, networking, and memory management; and may also provide an integrated development environment for rapid game development.

Game companies will offer the use of their engines, either under licence or for free, to smaller game companies and simulation developers, which helps to reduce costs and development time. One example of a simulation that uses a third party game engine is America's Army, which uses the Unreal Engine [8]. America's Army is a primarily used as a recruitment tool for the U.S. Army. It is free to download and allows teenagers to interact with realistic weapons and environments, and work together to overcome a common goal. It has a community of over 10,000 members at the time of writing, and is now in its third generation. The Source engine has been used to develop a training system for laboratory accidents [2], and a more recent version of the same engine was used to simulate fire drill training [7]. In both cases, the game engine made it much easier for the researchers to develop their own virtual world, and create visual effects such as smoke and fire.

HOW CRISIS ADVANCES STATE-OF-THE-ART IN SIMULATION TRAINING

From a research perspective, it is important that CRISIS advances the state of the art in simulation training. There are six broad area in which CRISIS can specialise:

(1) Generating an understanding of how crisis management is currently coordinated in large scale, multi-agency scenarios. This includes identifying the team coordination, the hierarchical command structure and human interoperability.

(2) Complementing current expensive, live training exercises with a cost effective simulation, including techniques to reduce the effort for after action review data analysis and incorporate training on-demand.

(3) Developing an immersive simulation environment that is based on cutting edge game technology and integrates both the first response and command levels involved in managing a crisis incident.

(4) Developing real-time decision support and knowledge management tools to access procedures and security policies mid-training, including solutions for querying events and actions that occur within a training exercise using natural language.

(5) Developing user interfaces that are natural and compatible for use in emergency management training.

(6) Developing a theoretical framework for identification, abstraction, and representation of relationships that are crucial for sense-making in critical incidents.

The above list is broad and covers many research areas. For this reason, the remainder of this paper will focus on simulation (3) and interaction (5).

CRISIS SIMULATION PRIORITIES

For the main training simulation, which will be the core of the CRISIS system, a set of six priorities have been identified, they are as follows:

Training

The training priorities for CRISIS are in situation assessment and decision making. The aim is that a realistic immersive world will provide trainees with enough detail to assess the situation as they would do in real life. This assessment would then be passed on to the command team, who again can make realistic decisions based on this information.

In addition to the types of training, it is also important to understand the transfer of learning. Rather than just *playing* through the scenario, trainees need to learn the procedures to follow, and correct decisions to make. How can the transfer of knowledge be maximised so that trainees learn everything they need to from the simulation? If this cannot be maximised, how does one measure the amount of knowledge that has been transferred?

Realism

Realism is a difficult term to define, and can cover a broad range of topic areas, ranging from graphical realism to procedural realism. It is much more than just high fidelity graphics and accurate physics. Realism can also refer to the way in which characters in the simulations behave; rigid movements or poor voice acting are not realistic and can break the immersion. Another example of realism involves the training scenarios themselves; if events occur that would not happen in real life, then trainees will find it difficult to immerse themselves in the simulations. The question is what aspects of realism are important in training?

Engagement

Engagement follows on from realism; having a realistic simulation will help to engage trainees. There are, however, other methods to further the engagement. One method is to tailor the simulation to suit an individual, which can make the training feel more personal. An example of this is psychologically profiling trainees before the simulation. Their current attitudes and stress levels can be captured, altering either the pace of the scenario or interactions with non-human characters. Another possible method of engagement is to make trainees work along side their real team-mates. We need to establish whether engagement matters in training, in addition to how it can be produced.

System Performance

High fidelity graphics, artificially intelligent characters and multi-player capability all require a large amount of processing power. To keep the simulation running smooth and in real time, optimization and performance are important factors in the design of the simulation. The use of a game engine can help since they often come with plug-ins and algorithms to improve performance (e.g., occlusion culling). Rendering a large geographical area is often done by segmenting it and loading the segments when required, producing loading screens. Breaking up the interaction in this fashion may be detrimental to keeping trainees immersed, and is unacceptable for the CRISIS project. How can system performance be managed to produce an acceptable experience?

Situation Assessment and Decision Making (No-Prompts)

Computer-based training systems often omit the situation assessment stage of the decision making process and instead present trainees with a set of multiple choice options from which they choose one. In such computer-based training simulations, wrong or poor assessments of the situation can be compensated by selecting a recognisable action that is likely to be correct. This is limiting in two ways: (i) trainees are not practised in assessing a situation and understanding the nature of the problems that the situation presents, and (ii) trainees are not practised in developing courses of action as they would have to in a real-world situation. CRISIS aims to address this by designing the simulation such that trainees will be required to assess a situation and to know when a decision is required and what makes it appropriate, without being prompted by the system. This is a much more difficult approach since the simulation needs to offer these affordances without relying on recognition of artificial prompts. For example, when performing triage, trainees should spontaneously know (and be able) to check the pulse, rather than prompted to choose the action from a set of options.

Variable Uncertainty

The problem with repeated, on-demand training is that trainees start to complete the scenario from memory rather than by following real world procedures. As mentioned earlier, CRISIS scenarios will offer variable uncertainty by injecting distractors (a set of events) into the system. Variable uncertainty is the functionality in CRISIS to control the number of events that occur in the simulation per period of time, the randomness of event presentation during the simulation, and situational complexity of the event. By randomly varying the uncertainty with which events are generated along these three dimensions, it is possible to have a different training exercise each time the simulation is run. In addition, by being able to control the variation along the three dimensions, it is possible to create classes of events that are focused on training different levels of skills (Figure 1).

For example, we can create exercises for drill-type training by minimising the number of events, tightly controlling when an event occurs, and minimising situational complexity. This makes such drill repeatable. We can create exercises for intermediate levels of expertise by keeping the number of events low while increasing the situational complexity and the randomness of the event occurrence. In the final class of training exercises, we can create exercises for advanced levels of expertise by maximising the number of events, their situational complexity, and their randomness of occurrence

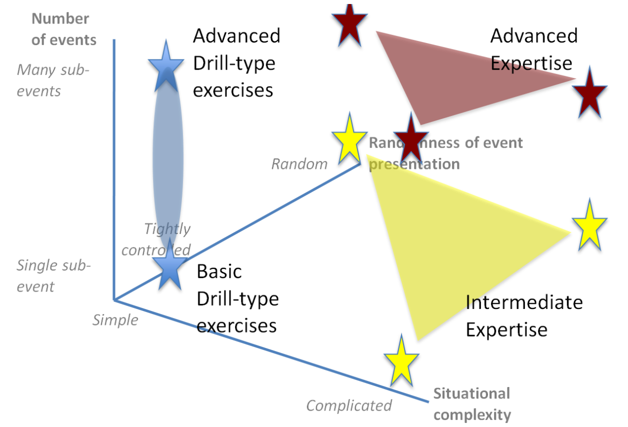

Figure 1. The three degrees of variability; number of events, randomness of events and situational complexity.

Another interest for CRISIS is the use of uncertainty in the decision making process. Normally the correct decision will provoke a correct response, however, varying the response would allow for multiple outcomes. The difficulty here is the variability; how to introduce a variable set of outcomes and avoid a rigid scenario structure. How can variable uncertainty be systematically managed?

VIDEO GAME DEVELOPMENT TECHNIQUES AND THEIR APPLICATION TO TRAINING

This section reviews video game development techniques that are relevant to the design and implementation of the CRISIS project as a new form of training capability. These techniques would differentiate on issues that matter in a training as opposed to computer games. A computer game's success is determined by the degree of emotional engagement of gamers with the game, if gamers do not enjoy the game the game fails. This may be contrasted with a training simulation in which success may be determined by whether the learning outcomes have been achieved. Given these different evaluation criteria there are a range of open questions as to how techniques used in games may be applicable in training. Another difference between video games and simulations is the development cost. Modern video games have enormous development budgets, allowing them to invest heavily in the creation of highly detailed and realistic environments. Infinity Ward's Call of Duty: Modern Warfare 2 had a budget in the region of $45 million for development alone. Simulations systems must be developed for a fraction of this cost.

Based on the above priorities, a set of research areas have been identified. System performance has already been addressed in the CRISIS project by the decision to use an existing game engine (Unity 3D), which is pre-packaged with optimisation tools (e.g., occlusion culling). Two areas that are implicit to the priorities are interaction and the simulation of people, which will also be discussed. For each of the research areas, there are examples of game development techniques. Although we are able to learn from all of these examples, some highlight how simulation training requires a much different approach than those found in video games.

Realism

One aspect of realism is high fidelity graphics. Large development teams and budgets enable video game companies to show detailed examples of how the real world (with buildings, vehicles, people, etc) can be simulated to produce engaging experiences. The issue here is whether a 3D training simulation can achieve a level of realism comparable to modern video games using only a fraction of the cost. The use of game engines, as described above, is one method. The problem is that game companies tend to make their engine available only after they have started work on a new engine for their next generation of games. This always leaves those who do use third party games engines a generation behind. It is most likely the case that the same level of fidelity cannot be reached without matching video game development budgets. If this is so, then it may be more beneficial to put more effort into other areas such as believability.

Believability is a loosely defined term since it has many attributes; from the way in which non-human characters move and respond, to the events that occur within a training scenario. Video games tend not to have an issue with scenario based believability since they are mostly works of fiction, and as such the gamer accepts the fantasy world they are in. This is much different than in training simulations, where a trainee is proceeding through a scenario based on real life events.

What we can learn from the gaming industry is how to animate characters in the simulation; how they walk, run and talk has a big impact on believability. Games such as Rocksteady Studio's Batman: Arkham Asylum contain sophisticated fight scenes, and so it important to make the villains punch and kick in a believable manner. For the development of Mass Effect 2, Bioware employed professional film actors (rather than just voice actors), and used motion capture and artificial intelligence to generate realistic human behaviour. Again these techniques have a large financial demand and so it is important to establish if they can imported into the simulation world at a fraction of the cost.

Engagement

Games are very good at engaging the user by playing on their psychology (e.g., in liking challenges, in being pleased in solving puzzles, in getting pleasure in virtual rewards, or being flattered or praised). Keeping the user engaged and happy in a game is foremost. The question is which games techniques are appropriate in training? Some probably are (e.g., giving the gamer/trainee graded challenges and feedback on their performance) while others are not (e.g., allowing the gamer/trainee to earn virtual money to upgrade their weapons).

Personalised engagement can help to further draw trainees into a simulation environment. For example, Climax Group's Silent Hill: Shattered Memories is one of only a few examples where this occurs in the game industry. In Silent Hill, the gamer is psychologically profiled at the start of the game (using multiple choice questions). The results of these profiles are then incorporated into the main game play. Examples include the appearance of the main non-playable character (whether she is reserved or sultry), or your character being either weak, angry, sleazy or loving.

Tailoring simulations allows the training outcomes to be based on the trainee's strengths or weaknesses. Rather than just asking a set of multiple choice questions, trainees could have their biometrics read. If they are found to be particularly stressed then more random distractors could occur to really test their ability in the training simulation.

Providing Affordances and Avoiding Prompts

Perceived affordances are what the trainee or gamer can perceive to be able to do in their 3D world. For example, in Valve's Half Life 2, gamers discover they can pick up objects such as palette crates, and they also discover that stepping into dark green water kills them. At one point in the game there is a large stretch of toxic water and a lot of crates scattered about. The affordances offered let the gamers pick up the crates and make a walk way through the toxic water. At no point are they directly told by the system that they can do this.

Alternately, games often borrow from the WIMPS metaphor and use menus and icons to assist in the mechanics of the game. The use of these supports the old interface adage that recognition is better than recall, you can offload gamers having to remember information by showing them representations that they can recognise as showing the options that are available. Telltale Games' CSI: Deadly Intent is a good example of a menu based driven game. When gamers investigate a piece of evidence, they then have a choice of four methods of forensic analysis. Recognition allows the gamers to select the correct method.

In real life situations, however, we have to rely on our knowledge and skills in reading and dealing with situations, this leads us to the challenge of the *no prompts* requirement. How can we design affordances in the simulated world such that gamers can interact in a natural manner without resorting to unnatural prompts?

Variability

Video games often praise themselves on having multiple endings. A recent example is Quantic Dream's Heavy Rain. The ability to choose who you kill as the game progresses allows for 22 different endings. The development problem here is that each of the endings needs to be written, designed and implemented. This becomes a long and costly process, and is always restricted by the structured way in which the storyline may flow. This design of scripted variability will not map well to training simulations that require high variability.

An alternative answer to such an issue is to use simulation as in real time strategy games such as E.A. Games' Command and Conquer: Generals. Here the gamer is given the ability to build an army with the object of defeating the opponents army. It is up to the gamer to decide how to do this. The ability to build different types of units and attack from multiple directions at any given time gives the gamer a lot of freedom in how to proceed through the level and allows it to be different every time. Basic artificial intelligence defines how the enemy attacks back, and again this can be varied in the same way, each time making the user plan a different defence system.

Although there are only two outcomes from this type of the game (win or lose), this can map well to a training simulations where trainees either performed well or performed poorly. The path that they freely chose to get to the end of the scenario can be assessed in the after action review.

Interaction

In driving and flying simulations the trainee tends to be seated in a real car or cockpit and look out onto a projected virtual world. In these situations trainees interact with real devices, so the interaction techniques they learn apply to the real world. In simulations such as CRISIS, trainees may need to walk around a virtual world. This requires them to learn how to interact with that virtual world, which would be much different than if they actually walked around the real equivalent. While how they interact is an important implementation question, it is something that occurs in almost all computer games. In most *first person shooters*, gamers navigate through large 3D worlds using either a mouse and keyboard or a game controller. These gaming interactions can be quickly and easily applied to training simulations.

The question is how will non-gaming, variable age-range trainees cope with this? How can we accommodate them, and design for them? We can also ask what differences are there between expert gamers of 3D games and non gamers. It is likely that there are at least two key differences, (i) in physical skill and hand eye coordination in manipulating input devices and (ii) in game literacy, in understanding the constructs of and flows in gaming, in questions around views and cameras, in recognising affordances and presumably many other issues we have yet to identify.

Simulation of People

Infinity Ward's Call of Duty: Modern Warfare 2 and Naughty Dog's Uncharted 2: Among Thieves both have example of simulated colleagues. These colleagues talk to the gamer and help them feel immersed in the game. There is almost no interaction with the colleague, however, since they follow a strict script of dialogue and actions as they accompany the gamer through the level.

As discussed, the CRISIS simulation is for both individuals and teams. When trainees are training individually, their colleagues need to be simulated. The issue here is that there needs to be heavy interaction with the colleague, such as communication, following orders and receiving feedback. If only a small number of interactions are required then they can be scripted into the system, but for a more free flowing set of interactions, and complex artificial intelligence system is required. The games industry experience shows us that simulation of people is hard, and interacting with these people is even harder. Consequently the question is how can we tailor training so that simulation of people or interaction with them is at an acceptable level?

Transfer of learning

The training and learning that happens in *first person shooter* video games is different to that in crisis training. Gamers do learn new skills and improve over time, but they are learning how to better their interactions with the system. Killing opponents by aiming the cross-hair requires high precision and speed, and is a skill that gamers learn over time. The more skilled the gamers are, the easier the game becomes and the higher the score they can achieve.

In CRISIS, we do not want performance to be based on how well trainees can interact. We want their procedural knowledge and decision making skills to improve. A more appropriate video game for this type of learning is Blizzard's World of Warcraft, where a less precise point and click style interface is used to cast spells and flight monsters. The skills that gamers learn instead include knowing the procedure of which spells to cast, and when, assessing when your teammates need help, and working together to defeat the enemy. The question is how can these measures be adapted to assessment of training?

CONCLUSION

This paper has discussed in some detail the EU FP7 funded CRISIS project, which aims to train crisis staff in emergency situations using an immersive simulation. A broad scope of how CRISIS will advance the state-of-the-art in training has been documented and, focusing specifically on the core simulation, a set of priorities have been identified. These priorities lead to a set of research and implementation issues, for which some solutions can already be found in the gaming industry.

At the time of writing, the end user requirements are still being gathered, so it is hard to prioritise the research issues. This will hopefully be identified in the near future; establishing those that can borrow from modern gaming technology, and those that have to be innovative and new. The latter are what will become the research core of CRISIS; advancing the state-of-the-art and improving training simulations for both crisis management and many other domains.

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Voice Communication in Online Virtual Environments for Crisis Management Training

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ABSTRACT
Critical incident management represents a complex process that requires skilled professionals to provide rapid, well organized and effective response. With regard to demands of real-life training methods, an online virtual environment can provide easy to configure, on demand and cost effective alternative. This article reviews voice communication means of virtual environments based on online-games and identifies benefits and constraints for crisis management training. The results indicate that online games including highly coordinated activity such as First Person Shooters or Massive Multiplayer Online Role Playing Games represent relevant candidates for efficient emergency response training using the voice interface. Future work will include an analysis of the transferability these findings to crisis management training.

Author Keywords
Critical incident management, crisis, training, online games, virtual environment, voice communication.

INTRODUCTION

Critical Incident is a traumatic event, or the threat of such which has the potential to harm life or well-being and causes extreme stress, fear or injury to the person experiencing or witnessing the event [27].

A plane crash, an explosion or a fire at the airport could be examples of events considered as the critical incident in the aviation sector. Any such emergency situation or crisis should activate a critical incident management response that must be rapid and well organized in order to protect human lives, minimize personal injury and limit damage to physical assets or environment.

The management of a multi-casualty situation in scale and complexity far exceeds the cognitive and communicative resources of an individual. Therefore the activity must be managed by individuals organized in teams. Each team that may be distant or collocated with others then follows distinct procedures and works with varied information. Information relevant to the actual situation is collected from multiple sources, verified for accuracy and shared with appropriate teams.

The success of crisis management in a multi-agency response is highly dependent on the ability of teams to coordinate their actions effectively. Communication plays therefore a crucial role in the critical incident management throughout all levels of coordination. A coordination structure, based on effective communication, must be put in place to resolve dependencies of team activities and to drive the operation into successful recovery of a normal situation.

It has been observed that lack of information sharing among autonomous response agencies can cause major problems in crisis management such as negative influence on collective decision-making and action coordination [1]. To avoid possible failures in crisis management, the coordination is divided among a multi-level coordination structure. Bots and Sol [2] identify three levels of coordination: among individual responders within a team, at the high-level inter-team coordination within an organization and at the inter-organizational level. Even though it may seem that the higher the level of coordination, the more complex the communication and coordination becomes, obstacles are found at all levels [1].

Crisis management coordination highly depends on responders' training and practical experience. Teams deployed at the incident's site have different professional background and have skills acquired in individual and team training. Therefore an inter-team training must be performed to ensure an effective coordination. Training for crisis management is expensive since it optimally includes a lot of people and a real-life scenario. Hence, simulators have been built to decrease these costs.

With the importance of information sharing during crisis management and its training, the objective of future research is to analyse how already gained experience with voice in online games and virtual worlds can be transferred to crisis management training. With this in mind, the paper reviews individually each of the adjacent topics of voice communication for crisis management training simulation. After reviewing coordination and information sharing, critical incident management training, online game based training, the paper reviews voice communication opportunities and experiences of online games.

COORDINATION AND INFORMATION SHARING

Theory of coordination models [3] seeks to develop flexible coordination mechanisms that can be easily customized for the specific situation and be adapted to crisis management environment. The models' goal is to enable participants' awareness of a common situation, challenges and opinions.

A military theory, the network centric operation (NCO) [4], aims to enhance the communication through robust use of information technology, organization and procedures to achieve the following hypotheses:

- A robustly networked force improves information sharing.
- Information sharing and collaboration enhance the quality of information and shared situational awareness.
- Shared situational awareness enables self-synchronization and enhances sustainability and speed of command.
- These in turn dramatically increase mission effectiveness.

These propositions provide high-level strategies for improving information sharing and coordination. However, there is little understanding of how to design disaster management systems and how they can be well attuned to the information needs of first responders, citizens, and victims. Especially, more research into human-centric approaches is necessary [5].

CRITICAL INCIDENT MANAGEMENT TRAINING

Knowledge and skills of emergency response have to be gained by initial training activity and then regularly refreshed. Humans who experience complex situations during the training exercise and learn how to manage them, show improved ability of decision making under stressful conditions in a similar real situation [6]. Contrarily, when the persons have not been exposed to such a situation before there will not be enough time to evaluate the options during real operation and a chance of effective situation handling will decrease.

The training should be used to expose responders to a range of situations based on potential scenarios that may occur in their jurisdiction as discussed in a study of emergency response [7]. It will prepare them to select the right responses when faced with a real emergency. In multi-level multi-agency training the responder teams should go through similar scenarios to develop similar mental models. It will allow the managers to establish similar approaches and the emergency responders to fully support them.

Real-life Training

An important training method for emergency preparedness in the aviation sector is a full-scale exercise. The large-scale, multi-agency, real-life exercise improves crisis coordination and communication in a close-to-real environment training conditions and results in a thorough preparation across professional domain. However the exercise brings a considerable amount of personnel and organizational complexity that implies significant financial and time demands. Such an exercise is typically trained every two years in the aviation sector, but due to the lack of resources the interval can almost double.

While the large-scale exercise can yield arguable results a subset of these skills can be obtained performing a simpler tabletop exercise. It requires only team commanders' participation, less preparation time and resources and it provides advantage of testing hypothetical situations without causing disruption in a community. The exercise is trained by airport crisis management typically every year.

Apprenticeship is another form of training involving the acquisition of theoretical knowledge and the practice of skills under a guidance of an expert. The drawback however would be the high cost of apprenticeship programs, where a mentor can usually supervise few trainees and trainees may need long apprenticeship periods [8].

The most frequent real-life training method is an individual exercise, where a task is split into sections that do not require coordination with others and it can be repeatedly practiced by an individual to solidify the emergency response skills.

Training in a Virtual Environment

Training in a virtual environment can be a favorable option compared to the demands of real-life training methods. Training using virtual environment can reduce the costs to one-tenth compared to live-exercises [7]. A trainee is allowed to train more frequently throughout a time suitable to the work conditions and also trainees distributed among distant geographical locations can still cooperate in a collaborative training environment. Most importantly the use of virtual environments will allow responders to gain experiences of many different scenarios. The scenarios can be easily prepared based on a template and later reused. It will in turn significantly shorten the preparation time and enlarge the emergency preparedness. In addition the virtual environment has a possibility of real-time observation or recording of multiple trainees and their actions, which makes the after-action review and debriefing easier.

ONLINE GAMES TRAINING

The virtual environment training has been greatly influenced by video game technology during the past few years. The research in the games area affects not only the entertainment industry but also the government and corporate organizations. They can benefit from the training, simulation, and education opportunities and therefore a concept of serious games has been developed.

The definition of serious game can be the following: "A mental contest, played with a computer in accordance with specific rules that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives." [9]

Because of the richness of the area and its potential impacts, serious game divides a broad area of research in three domains: infrastructure, game cognition and immersion [9].

Role of Entertainment

A role of entertainment in learning process has been a perspective of a study, which analysed video game potential to facilitate developmental processes [10]. Three factors of intrinsic motivation have been identified: challenge, fantasy and curiosity. The challenge is imposed through time constraints or a competition with human or computer players resulting in either a positive motivation (to win or accomplish the task in time) or a negative motivation (to lose). The fantasy described as a cognitive and emotional involvement with the video game facilitating the game play skills allows the virtual character to overcome the boundaries a real life would impose. The curiosity is based on sensory perception of the game environment and a cognitive exploration of the game play narrative.

From a pedagogical perspective the games can enhance individual cognitive skills such as spatial abilities, knowledge acquisition, decision making or problem solving, but they can have a negative impact on sensomotor control as well (e.g. usage of firearms, driving habits) or form a negative attitude through the use of violence.

Entertainment-Education Relation

Entertainment can be used as a motivational facilitator to process educational information where the content is not a strong attractor. Alternatively entertainment can be used as reinforcement for educational purposes in a form of scores, virtual money or other reward during the game play. Reinforcement has been found suitable for repetitive tasks. However it can cause the decrease of motivation for already intrinsically motivated individual. But the most pleasure in educational settings is obtained from achieving a goal. Overall, data reveal that a combination of intense practice highly developed interest and intrinsic motivation provides above average performance.

Shared Situation Awareness

Serious game training may help to create shared situation awareness [11] that has considerable importance for crisis management decision making. A number of persons from first responders to commanders involved in crisis management create their own situation awareness models. They perceive available facts, create an understanding of the situation and envision how the situation is likely to develop in near future. In order to create shared situation awareness persons share their individual situation models, while being "aware" of relevant actions and functions of other team members. Voice communication is the primary channel to share the individual models and it can be augmented with facial expression, gestures, and body language and other clues that regularly supplement conversation. Training for effective communication among individuals and team leaders is the most critical issue not only in creating shared situation awareness but for overall coordinated response and decision making.

Adaptive thinking

Another set of skills trained by use of serious games and closely related to shared situation awareness is the adaptive thinking. It is defined [12] as consisting of competencies such as negotiation and consensus building skills, the ability to communicate effectively, analyze ambiguous situations, be self-aware, think innovatively and critically, and exercise creative problem solving skills.

The adaptive thinking concept evolved into Simulation Experience Design Method [13] which makes use of adaptive training systems to produce the communication opportunities. Thus the players learn about their strengths and weaknesses through real-time in-game performance feedback and they can share solutions and strategies during/between/after the game play in order to adapt their skills and understanding.

TYPES OF VOICE COMMUNICATION IN ONLINE GAMES

Relevance of Voice to Online Games

Players of online games need to exchange the information to enhance the possibility to achieve their goals.

In many games typed text has been the traditional medium of online communication. However, implementation of voice in online games is on the rise as speaking is a more natural form of communication; it is faster than typing and it allows use of other game interfaces (mouse, keyboard) at the same time.

Addition of voice communication to online games may enhance the social experience of game play [14], while others argue that it may detract from immersion, insisting that text remains the preferred communication medium [15]. Immersion as stated previously is an important factor in knowledge transfer of online training environments and therefore this deserves further attention.

More positive from the training perspective is research that has shown that voice use can improve the communication and team coordination in a fast-paced action game [16]. However not all users readily adopt voice communication in online games [17]. Research suggests that it may be due to suboptimal configuration of the voice channel in some games [18] which brings further attention to carefully configuring voice channels in order to enhance competitive game performance and social experience. Problems identified by the players themselves include a misuse of the communication channel, difficulty of identifying who was speaking or of choosing whom to speak to.

Online Game Voice Channels

Before voice communication was introduced in online games players used proprietary VoIP applications to talk to one another. In recent years many online multiplayer games have integrated the voice communications. Following are some examples of the use of voice in the online training environments.

Private and public channel

Adaptive Thinking & Leadership (ATL) Training Simulation Game was developed [12] to train adaptive thinking using a single-player tutorial and multiplayer computer simulation. The multiplayer environment enables players to practice their skills and receive a feedback by means of voice communication. Two voice interfaces have been defined; an instructor and a student (may also be used by an observer). The instructor interface enables to communicate privately with each team or to broadcast on a public channel. The students can communicate with others on their team on a private Voice over IP (VoIP) channel or make announcements to all on the public channel.

ATL simulation was deployed in a training program for Special Forces Officers with focus on team communication, cultural expectations, negotiating from different perspectives and how to be more self-aware. It has been found that due to the highly interactive nature of the communication training, it is best to design experiences for small groups and let the individuals switch roles at least three times to play different roles of different teams.

The realism of voice channels

How best to design voice communication for use in online multiplayer games? A study of voice communication design has suggested four modes of player-to-player voice interaction [19].

Broadcast mode or “two-way radio” is the communication channel equivalent to the public channel and describes voice communication that is equally available to all players at all times and all utterances are received by all players. It is suitable to training activity that makes often use of radio communication in real situation (such as crisis management) for example to negotiate location, movement or report findings. Broadcast mode is an efficient way to coordinate a small but geographically-dispersed group in real time. Disadvantage of the channel is that it is prone to channel congestion.

Mobile telephone mode represents transmission and reception available anywhere in the virtual world, but conversations must be deliberately initiated with knowledge of target identity and utterances are transmitted only between two players.

Land-line telephone mode is communication available only at particular places in the virtual world that players must be near to. Telephones normally transmit between pairs of players, but could work in a restricted broadcast or conference-call mode.

Both mobile and land-line telephone are restriction to the broadcast channel and players may only accept them if the overall benefit outweighs losing the ease and freedom of radio of if their use adds to reality of game scenario.

Physical transmission mode simulates a real life communication. Only those players, whose avatars stand close to one another, can hear the conversation. Loudness and clarity of the utterances attenuate with the distance between speaker and listener. This mode not only resembles a natural environment communication the most, but it can prevent the congestion problem of broadcast voice channel. In online games the physical transmission mode may be preferable where team members are normally close to each other and the benefit of cues as to which direction a sound is traveling from outweighs the inability to speak with distant team members.

Proximity voice communication

In the Massive Multiplayer Online Role Playing Games (MMORPG) each player is represented by an avatar in a virtual world and the role players’ characters often stay close together. Thus a simulation of real life communication by the physical transmission mode would be the most suitable communication channel.

A physical transmission mode Dense Immersive Communication environment (DICE) has been proposed as communication medium for crowded virtual places [20]. From the technical perspective DICE represents a compromise between the high Internet bandwidth intensive system and the brute force server model that delivers realistic voice communication service. Compared to the more traditional VoIP communication that works independently, systems as DICE must be aware of the virtual world map and therefore must be integrated to the environment.

EXAMPLES OF VOICE COMMUNICATION

Proximity Voice Chat in FPS games

DICE has been examined in First Person Shooter (FPS) game trial [21] for players’ experience of and their response to it. The results indicated that compared to text communication voice has improved both game-play and the social experience of online gaming. In the trial, players compared the proximity-based communication favorably to the two-way radio. However it took players some time to get accustomed to DICE and technical problems needed to be solved.

Voice Communication in MMORPG

Voice seems to be valuable for online multi-player games that are based on team cooperation. After integration with FPS games voice has moved into MMORPGs. Study of voice use in MMORPG compared three groups of players in Dungeons and Dragons Online and World of Warcraft over a period of three months [22]. The results showed that participants found speaking easier, more natural and more relaxing than text chat. Voice enhanced the gaming experience and freed player’s hands from typing so participants could communicate while carrying out game actions. And new users appreciated the possibility to ask for a help. All participants agreed that voice is better than typing during team raids, the part of MMORPG that most resembles FPS. Here the voice was superior for raid leaders to issue directions to others or it was useful for wounded players to call for help. On the other hand the ease of voice communication made it possible to broadcast too much, where a chatty player could easily dominate the channel and annoy team-mates. Some may also find the voice interface intimidating. From the social perspective knowing other players influenced the perceived voice quality, where voice was better for permanent rather than pick up groups. The use of voice in MMORPG confirmed dependency on number of players, as voice became less useful in large groups, where players start speaking over each other.

Voice in Virtual Worlds

Voice has recently been introduced into Virtual Worlds (VW) such as Second Life. Data gathered by a user study [23] shows some benefits of voice use in VW, but the conclusion is rather controversial. According to the study half of the users had not adopted the voice communication mainly because of following reasons. VW is perceived as a recreational virtual environment, where players create idealized representation of themselves. They rarely want to project maximum amount of real information presence (including voice) because of eavesdropping or unintended transmission fear. Then most players learn to understand which parts of their bodily and situational reality are on display and which are not to construct a performance to achieve social goals. They exploit it to multi-task and 'multi-context' as they engage in multiple conversations with collaborators both mediated and physically co-located. Also the players need to multi-task as they cannot afford to be so immersed in the online world that they ignore offline events. As VW are used by wide range of players with variety of purposes, the voice communication remains to become adaptable to the user needs.

Real-time Voice Communication for Emergency Response

A simulation of a real life emergency response in the virtual environment requires real-time voice communication. Research results indicate the necessity of mixing situated face-to-face and remote shared audio channel communication modalities in training [24]. The voice transmission in a virtual world is highly dependent on network latency and a variance of the propagation time. A technical solution can be a compromise between server vs. client processing of voice as suggested by [20].

TRAINING ASSESSMENT WITH VOICE

Voice communication represents an indicator of team coordination in online games. Voice has an important role in a training assessment, either as real-time feedback provided by instructors during the game or in the form of After-Action Review (AAR). The real-time assessment and feedback builds meta-cognitive skills such as analyzing and assessing decision making processes [25]. AAR provides mechanisms by which instructors and trainees discuss the outcomes of each simulation experience using synchronized recorded sequences, analyses of actions taken and evaluations of observers. Reviewing the recorded game play performs important cognitive and meta-cognitive functions that are imperative to solidifying the learning experience, incorporating feedback, and updating understanding that is demonstrated in later game play [13].

But the role of voice in training assessment of team coordination must be accompanied by application specific data. Maintaining a mental model of the game state while listening to the audio is cumbersome and distracting [26]. Therefore the games used for training should include an interface to evaluate trainees’ performance, where observers search for voice communication between players in synchronization with their game actions. Synchronization is essential to observe both communication and actions in context. Using the interface enabling simultaneous observation from each player’s viewpoint, synchronized with voice communication using log files and time-stamped audio helps perform the AAR effectively.

CONCLUSION

Communication plays a crucial role in critical incident management and voice interfaces have recently been integrated in a range of online games. The use of voice has evolved from game-independent voice clients through private and broadcast voice channels to proximity-based voice chat that simulates real-life environment communication. Studies of voice deployment in online games indicate users’ adoption dependency on the game genre. Results of voice use in FPS games indicate improved game-play and social experience as compared to text communication. Similar advances have been observed in MMORPG during team raids.

As crisis management represents a highly coordinated activity, that resembles FPS and MMORPG raids, the results support an idea of voice interface use for efficient emergency response training. However the voice interface should be designed with an anti-abuse policy and players’ privacy in mind. These were the factors that caused concern in voice adoption of players MMORPGs and in Virtual Worlds. Finally, voice plays an important role in virtual training assessment either in providing real-time feedback or in after-action analysis.

To further research if the experiences of using voice communication in online games transfers to crisis management training, an analysis of scenarios has to be made. As future work, we plan to analyse table top exercises and real-life exercises in crisis management with the aim of refuting or supporting the findings of voice communication in online games and virtual worlds.

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Get Real! -- The many faces of realism in virtual training environments

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ABSTRACT
Realism or fidelity is a fundamental issue for all training simulations, whether computer-based or not. This paper reviews existing research to elicit principles and guidelines for the development of effective interactive simulations designed to train crisis and emergency managers. These simulations are being developed with EU FP7 funding on a project which is using videogame technology to create state-of-the-art 3D virtual training environments. From a HCI perspective, the current paper aims to explore the extent to which realism affects system usability and the nature of the user experience.

Author Keywords
Realism, fidelity, 3D simulations, virtual environments, crisis and emergency training, human interaction.

ACM Classification Keywords
H.5.2. Information Interfaces and Presentation: User Interfaces.

INTRODUCTION
This discussion paper addresses a fundamental issue underlying all training simulations, whether they are computer-based or not. This issue is variously referred to as realism or fidelity. The word 'realism' (and the related words 'real' and 'realistic') is a legacy from the early years of CGI and VR, and features most prominently in the quest for photorealism in cinema and videogames. In this paper, however, much of the discussion is based on the research literature produced by the simulation and modeling communities, which almost universally use the term fidelity.

This paper considers realism in relation to training systems that attempt to represent real-world environments. A different set of principles and guidelines would be required for the design of synthetic or artificial environments. For example, various studies of realism in videogames suggest that believability and storytelling are enhanced by adopting non-mimetic approaches, including exaggeration, simplification and non-photorealistic rendering (Masuch & Röber, 2005). In one study, the authors argue that videogame "production can and should be freed from the 'corset of realism'" (Wages et al., 2004, p.224). Similar arguments are made in the design of virtual reality simulations intended to convey fictional characters. In such contexts, Hoom et al. (2003) advocate the use of increased relevance rather than greater realism. In a similar vein, Nunez (2004) suggests that presence is not unique to VR systems that model the real world; it can also be experienced in non-realistic virtual environments (VEs).

The paper begins with a discussion of the benefits and costs associated with providing high levels of realism in interactive 3D simulations. Next, it unpacks the notion of realism into several dimensions, and considers the interrelationships between these dimensions. Finally, it extracts principles and guidelines for embedding realism in the 3D simulations being created by a major EU-funded project (CRISIS) to provide interactive training for crisis and emergency managers.

COSTS AND BENEFITS OF REALISM IN INTERACTIVE SIMULATIONS
There are several significant benefits claimed for including high levels of realism in interactive training simulations.

User Acceptance
In simulation circles, this is referred to as face validity, and indicates the degree to which a model appears reasonable to users and others who are knowledgeable about the real system being simulated (Banks et al., 2004). Face value judgments , are usually made before a model has been tested, though in some cases an initial level of evaluation may be undertaken in determining the face validity of a model. Thus, for example, "sensitivity analysis can … be used to check a model's face validity. The model user is asked whether the model behaves in the expected way when one or more inputs are changed" (Banks et al., 2004, p.396). Face validity can be an important acceptability test, especially where novice model users are involved.

Immersion and Presence
Realism has been identified in a number of studies as one of a number of contributory variables of immersion and presence in virtual environments (Hendrix & Barfield, 1995; Khanna et al., 1996; Witmer & Singer, 1998). Slater (2003) suggests that immersion is the bedrock on which presence is founded. However, he also suggests that

emotional responses to simulation, such as involvement or engagement, are not the same as presence, and may therefore not be directly linked to it, and nor therefore to realism. Even if one accepts that these constructs – of immersion and presence -- depend in part on realism (in whatever form), then the question remains as to whether immersion or presence bring any identifiable benefits to the simulation. If not, then the contributory role of realism may safely be ignored.

A further cautionary line of evidence about this linkage is provided by Chen and Cairns (2005) who suggest that user immersion in videogames is not entirely dependent on levels of realism, and that high levels of user immersion, which may be contributed by other factors, may compensate for inconsistencies in the realism present. In a similar vein, Bouvier (2008, p.247) argues that "the key point of immersion is not its realism but its credibility". However, great care needs to be exercised in translating such findings into the design of the CRISIS project simulation. Although realism may not play a fundamental role in immersion and presence, it is dangerous to ignore the fidelity imperative for the potentially 'life and death' training of the kind involved in emergency and crisis management contexts.

Realistic Responses

One of the more significant expectations when deciding to use a virtual learning environment is that trainees will behave in a similar way as they would in the real world, or at least in a conventional (non-virtual) training exercise. For example, it is possible to use simulated graphical representations to study people's perception of the beauty of forests and other rural environments (Appleton & Lovett, 2003; Daniel & Meitner, 2001). There is also emerging evidence from research in immersive VR which suggests that not only is this the case, but that higher degrees of realism can induce more realistic behavioural and other responses by trainees. In various experiments, Slater (2009a) has shown that in effectively designed virtual environments (VEs), with a level of realism conducive to immersion and presence, people respond realistically to what they experience. However, while individuals exhibit genuine responses (e.g. physiological responses, feelings, emotions, automatic thoughts), they may also use their awareness of the ultimate artificiality of the situation to control their overt behaviour. Slater (2009b) argues that these findings indicate that it is possible to use virtual environments to study how people are likely to respond in extreme situations.

Performance Improvement

Some evidence is available to suggest that increased levels of realism in 3D virtual environments can lead to enhanced performance when compared with less realistic environments. In one study, for example, Slater et al. (1996) designed an experiment around a 3-dimensional game involving two levels of immersion (exocentric using screens, and egocentric using head-mounted displays), and two kinds of environment (plain and realistic). It was found that subjects in the more realistic environment performed better than those in the less realistic environment, and egocentric subjects performed better than exocentric subjects.

Transfer of Training

Transfer refers to the ability of a trainee to exhibit improved performance in real world operations as a result of a training intervention in a training environment. Singley and Anderson (1989, p.1) go so far as to suggest that "the problem of transfer [of training and learning] is perhaps the fundamental educational question". Especially in mission critical applications such as emergency response training, it is essential to be able to calibrate the likely transfer of training between the training simulation and the real world. Unfortunately, there is ample evidence to suggest that there are significant problems in ensuring that learning transfers from the training context to the operational context. In their review of transfer in training environments, for example, Baldwin and Ford (1988) concluded that "much of the training conducted in organisations fails to transfer to the work environment". Indeed, there is anecdotal evidence that as little as 10% of workforce training may transfer to the job (Georgenson, 1982; Marx, 1986), while more generous survey estimates suggest that the figure may only be between 35% and 50% (Foxon, 1993; Fitzpatrick, 2001; Saks, 2002).

One of the reasons for the failure to transfer training, though it is by no means the only one, is the issue of the fidelity of the training environment. There is a long-held assumption that where the training and operating environments are similar, then this is likely to improve the transfer of training from one to the other. Indeed, this has been a bedrock principle in the transfer of training literature for over a century, since its first enunciation over a century ago as the *theory of identical elements* by Thorndyke and Woodworth (1901). Clearly, the degree of correspondence between the VEs created within CRISIS and the real-world systems they represent will, other things being equal, contribute to predictable levels of training transfer. In some training evaluation studies, departures from identical elements are conceptualized in terms of the *transfer distance* that occurs between the training and application contexts (Baldwin & Ford, 1988). However, this multidimensional construct is also used to capture differences in the task as well as the environment.

There are a number of different views on the relationship between levels of fidelity and levels of transfer. The first is that there is a straight-line relationship: the more fidelity is added to a system (or to its constituent parts), the greater the amount of transfer will occur. A second view, sometimes referred to as the Alessi hypothesis, is that beyond a certain threshold, the addition of further fidelity does not lead to a commensurate increase in transfer (Alessi, 1995). (Alessi also suggested that a high level of fidelity could inhibit initial learning for novices by overwhelming them with details they are unable to assimilate.) A third view is that in some circumstances (e.g. with novice users), lower fidelity simulations can be more effective than higher fidelity simulations (e.g. Havighurst et al., 2003). Finally, a fourth view is that optimum transfer occurs when trainees are exposed to simulations of increasing fidelity. This is variously known as dynamic fidelity (Alessi, 1995) or progressive fidelity (Brydges, 2009; Brydges et al., 2010). In a medical training context, Brydges (2009, pp.ii-iii) found that "when students are directed to practice on simulators that increase progressively in fidelity (i.e., realism) they self-guide their advancement between those simulators effectively and display successful skill transfer." This concept has considerable potential relevance for training using CRISIS project simulations, because it suggests the benefit of grading and sequencing scenarios in terms of the fidelity of various component elements. (Such elements might include the complexity of the scenario and/or the inclusion of randomly injected events.)

One of the key research-related implications of evaluating CRISIS project outcomes for transfer of training effects is the necessity of undertaking longitudinal studies (Cheng & Ho, 1998). These should arguably begin with an understanding of the transfer outcomes of current conventional training methods, so that CRISIS project outcomes can be benchmarked against them.

Against these benefits of high realism must be weighed several disadvantages:

Costs

In general, high fidelity simulations are more costly to produce than low fidelity, whether measured purely in financial terms, in terms of the time and effort taken to produce them, and/or the availability of data required to build high fidelity digital models. There is therefore an onus on developers to demonstrate the cost-effectiveness of higher levels of fidelity. (In this context, note the previously quoted view of Alessi (1998) on a possible law of diminishing returns operating when adding increasing fidelity to simulations.)

Real-time Performance

It has been argued that 3D VEs (including those based on videogame technology) need to compromise on realism in order to achieve real-time responses (Slater et al., 2001). However, in recent years, improvements in graphics cards (and especially graphics processing units or GPUs), processor speeds, multi-core processors, and rendering algorithms have made it possible for VGs to exhibit levels of real-time realism that approach those created for cinema by non-real-time CGI. In addition, it might be argued that the more sedate pace of action, interaction and decision making in VEs designed for training (as in CRISIS project simulations) enables frame rates and response times to be sustained even with relatively high levels of realism.

In concluding this section, it should be noted that that relevant empirical evidence is not always readily available to quantify the costs and benefits of high fidelity simulations. Consequently, there is ample scope for additional research to be undertaken on this issue by members of the CRISIS team.

DECONSTRUCTING REALISM

The proposition that "what is perceived is real" is open to serious contestation. For the purposes of this paper, however, it is more important to recognize that realism, and being realistic, is not a single or simple dimension of virtual environments. For the purposes of effective modeling, it is essential to disaggregate realism into several relevant dimensions, to consider each one when building an interactive digital model for training purposes, and to consider possible interactions between them. As will be suggested in the next section, each realism dimension also needs to be considered in relation to training needs, training components and end users. In the current section, nine significant dimensions are identified, and these are discussed with reference to relevant recent literature. No attempt is made here to rank or prioritise these dimensions, as this is an exercise that is best undertaken by CRISIS partners working on the design of specific simulations.

Perceptual Realism

Since the early years of computer graphics, realism has largely come to mean visual realism, and this in turn has become equated largely with photorealism; it is commonly taken to be a visual property of virtual environments. Considerable research effort and financial resources have been invested in improving digital photorealism. Film CGI has pursued this objective through advanced modelling and rendering, while videogame developers and graphics card manufacturers have pursued the goal of increasing real-time photorealism for interactive games. In VR systems, a great deal is known about the impact of various parameters on visual fidelity in immersive environments (Rinalducci, 1996). Visual realism may thus be considered the default or minimum form of realism to be expected in CRISIS project simulations, especially when they involve the construction of real environments, such as airports or rail hubs.

Human perception, however, concerns more than just the visual channel. Consequently, it is argued here that 3D training simulations need to utilise other sensory modalities, and especially the aural and the haptic, if they are to provide realistic learning environments. Our discussion of perceptual realism therefore is divided into the three most significant modalities.

Visual realism

The various visual parameters of digital images that contribute to visual realism (e.g. viewpoint, illumination, field of view, resolution) are now well understood, and most of the objects that need to be modelled well in order to achieve a high degree of visual realism (e.g. terrain, buildings, street furniture, architectural features) are routinely captured for incorporation in realistic VEs.

Specific components of visual realism that need further attention in relation to the objectives of the CRISIS project are briefly discussed below. (This discussion is meant to be indicative rather than exhaustive.) As with the other main dimensions of realism, decisions on their inclusion need to be based on the cost-benefit ratio attending each one in a training environment.

- *Shadows and lighting*
  Early 3D videogames, and many current virtual reality (VR) environments, look oddly 'flat'. Much of this is down to the absence of shadows. Shadows not only add to visual realism, but also provide additional benefits for interactive users -- e.g. helping users to make better judgements of distances, the locations of objects (e.g. avatars) in 3D space, and the heights of objects above the ground. Shadows are particularly useful where the viewer is stationary, and cannot make use of parallax to determine depth relationships between objects in the VE. Recent research (Slater et al., 2009) has shown that the addition of realistic shadows and reflections in a 3D virtual environment significantly increased subjects' ratings of subjective presence and affected their behavioural responses. Specifically, they increased arousal and anxiety among the participants. (This particular virtual environment was specially designed to generate anxiety. This is therefore of particular interest to the CRISIS project, though it raises several validity and ethical issues.)

  Consideration also needs to be given to whether shadows, and lighting effects in general, should be modelled through circadian and seasonal cycles. If CRISIS emergency response scenarios are to include night-time as well as daytime training, and if they are to involve training locations at various latitudes and at different seasons of the year, including relevant weather effects, such as heavy rain, intense heat or snow (Barton, 2008), then the simulation must be both temporally and locationally aware, and modify its representations according to the time and place within which particular training is meant to occur. (This implies that scenario builders must specify the time, place and duration of each scenario in suitable universal time/date units.)

- *High dynamic range rendering*
  The human eye has a far greater contrast range than most cameras (10,000:1 for static images, and 1,000,000:1 for dynamic images). Wherever there is very high contrast in a scene, it is likely that the imaged representation will be low fidelity in relation to the image perceived by the human eye. High dynamic range rendering (HDRR) mimics the operation of the eye by stretching an image so that the brightest and darkest elements share some of the contrast space occupied by the remainder of the image (Petit & Bremond, 2010). This improves the visibility of most objects in the image, and thereby increases the visual realism of the representation. As Ward (2003) argues: HDRR "...faithfully reproduces the visual field of a natural or simulated scene, resulting in a heightened sense of realism and presence". (See also Ledda et al., 2004.) For CRISIS project simulations, lighting schemes should be designed to utilise HDRR wherever appropriate, in order to achieve appropriate levels of perceptual realism in the visual domain. Apart from providing a solution to the indoors-outdoors situation, it is also able to resolve a problem likely to occur in many CRISIS project training scenarios in which simulated fire suffers from over-brightness in darker conditions and under-brightness in well-lit conditions (Hoang et al., 2008).

- *Mess and dirt*
  The real world rarely consists of pristine-looking buildings and perfectly scrubbed sidewalks. It is frequently untidy, messy and/or dirty. A model that presents too perfect an appearance of the real world will tend to lack visual fidelity. Videogame designers have learnt this lesson well in recent years, so that their environments are now as imperfect as the real world. This is most commonly achieved using complex polygon modelling, non-stock textures, and decals (temporary dirt or litter layers). A further approach, deformation modelling, is considered in more detail below under environmental responsiveness.

- *Stereo 3D*
  Stereo 3D may be a common viewing mode when CRISIS project simulations are delivered to end users, some time during 2013, not only in cinemas, but also on PCs, games consoles and domestic TV monitors. However, stereoscopic vision needs to be considered on its merits, in terms of its potential for delivering greater visual realism. Recent studies indicate that stereoscopic vision offers additional benefits beyond enhanced realism. It is, for example, one of the ways in which visitors to virtual environments are assisted in appreciating the 3-dimensional structure of those environments. As with shadows, stereoscopic vision is particularly useful where the VE visitor is stationary, and/or where objects are not moving relative to the camera position. A significant additional factor in deciding whether to adopt stereo is the incidence of binocular vision impairment, which affects some 12% of the adult population. (This is in addition to those who are monocular.)

- *User viewpoint*
  One of the most important aspects affecting how a player perceives the virtual world presented by a videogame is its viewpoint -- i.e. the location of the player (or the virtual camera) in relation to the virtual environment. Three viewpoints are commonly available: the *first-person viewpoint*, in which the player looks directly into the virtual environment as though looking through a

window; the *third-person viewpoint*, in which the player stands back from their persona in the game which is represented by an avatar which they control; and the *god viewpoint*, in which the player looks down on, or obliquely across, the field of play, directing events from a location that provides high situational awareness. There are variations on these main viewpoints, such as the 'over-the-shoulder' approach of some third-person shooters, in which the player is partly immersed in the scene by following closely behind the seen protagonist, and the 'through-the-rear-window' viewpoint in some car racing games.

From a realism perspective, these viewpoints provide contrasting advantages. While immersion and emotional engagement is more likely with the first-person viewpoint, situational awareness is higher with the other two viewpoints. This provides the CRISIS project with something of a dilemma in terms of its management training objectives: does it opt for a highly immersive first-person viewpoint to enhance the perceived realism of the crisis situation for the operatives at the scene, or does it opt for a more synoptic third-person or god viewpoint to enhance the situational awareness potential for higher-level managers? The answer probably lies in adopting both, and permitting trainees to switch between them as required. Although most videogames have tended in the past to adopt a single viewpoint, in recent years it has become increasingly possible to switch between viewpoints during gameplay. Such viewpoint switching behaviour is particularly important for CRISIS project simulations, because they are likely to be used for training a range of personnel in a variety of operational contexts.

Multi-sensory realism

Although visual realism is usually taken for granted in most 3D videogames and training simulations based on them, the demands of realistic training and the multi-sensory nature of emergencies requires that other human senses apart from the visual should be engaged in CRISIS project simulations (Shepherd & Bleasdale-Shepherd, 2009). Multi-sensory realism refers to the degree to which a simulation provides sensory cues of various kinds to the simulation user. There is another reason, in addition to enhanced realism, for ensuring that multiple sensory cues are included in CRISIS project environments. For trainees who are in some ways visually impaired, the non-visual senses may need to play a more important role in their interaction with the training environment. Again, there are lessons to be learnt here from videogames which are designed specifically to address the needs of disabled players. Indeed, some forms of sensory impairment are considered at a fundamental design level in games designed or adapted for certain groups of impaired player (e.g. Spoonbill, 2007). The games company Deaf Gamers (www.deafgamers.com) reviews games software from a deaf person's perspective, indicating the importance of visual and textual feedback to substitute for lack of hearing, Audyssey (Audyssey, 2010) provides a discussion list for blind gamers, and AudioGames.net maintains an extensive database of games based on sound, and blind-accessible games. Taste and smell cues are also likely to be important in emergency scenes, but limitations in current technology make it unlikely that these can be included in CRISIS simulations within its 36-month development period. The following discussion therefore focuses on sound and touch.

- *Audio realism*
  Videogames frequently use sound to elicit emotional responses in players. Although this role for aural output may not be appropriate for serious training simulations, sound nevertheless has a number of other more practical roles which serve to enhance realism. For example, ambient sounds reflect events and activities in the environment (e.g. vehicle and/or crowd noise), and response sounds (e.g. footstep sounds on varied ground or floor surfaces) provide important feedback to players as they move around the environment. Individual training installations also have their own specific indoor soundscapes (Blesser & Salter, 2007) which may also need to be replicated in a fully realistic simulation. In this context, it should be noted that sound is intimately linked to vision, because of auditory-visual integration in the human sensory system (Larsson et al., 2007).

  A further role for sound in Interactive simulations is in providing locational information. Variously named spatial audio, localised sound, spatialised sound, positional audio or 3D sound, the ability to alert players aurally to the location of characters and events in 3D space is an important element of the soundscape of most modern VGs. The 3D spatialisation of audio implicitly provides scalar feedback by changing audio volume on the basis of a sound source's distance from the player or viewpoint. Most game designers have extensive soundscape-building tools, which means they are able to add sound to a virtual environment by identifying the location of sound emitters interactively and drawing boxes around spaces affected by individual sounds. These can be harnessed for CRISIS project simulations to provide the kind of audio cues that are essential, for example, in undertaking situational assessments.

- *Haptic realism*
  For the purposes of this discussion, the haptic senses are taken to include the vibrotactile (which is mainly located in the skin), and the kinaesthetic (which is mainly located in the joints). The kinaesthetic sense has the unique property of both receiving and issuing force or stress, and is thus uniquely able to engage in active exploration of environments. With the haptic senses, relevant cues include rumble (e.g. when driving a vehicle or walking over uneven ground) and force feedback (e.g. when attempting to push a solid or fixed object). Scalar feedback can also be provided by the

rumble or force-feedback generated by the handheld controller, for example when the amplitude of a sound or the frequency of an aural pulse is used to convey proximity to some object.

It should be noted that in some videogames, haptic feedback is also represented visually (e.g. the ground tremor or blast force resulting from an explosion causes camera shake). In commercial aircraft simulators, attention is also given to the feel of controls and switches in addition to vibration and ambient temperature (Gross, 1999).

Interactional Realism

This refers to the inputs that users provide to an interactive system and the feedback they receive from the system, and the degree to which these match the nature of the interactional inputs and outputs they typically use in the real world. As has been mentioned in the previous section, there is a strong argument to be made for providing multi-sensory feedback. There is also a case to be made for adopting some form of multimodal interaction in CRISIS simulations (e.g. involving text, speech, touch, gestures, etc.). Naturalistic interaction occurs when there is a high degree of relationship between the interactional devices and mechanisms used in the VEs and in the real world. Slater (2009a) argues that this correspondence can lead to the perception of immersion and presence in VEs.

Multimodal and/or naturalistic inputs can provide equally significant benefits to multi-sensory feedback, especially for non-expert users. Recent developments in harnessing touch and gesture (e.g. the Wii, Microsoft's Kinect -- previously Project Natal -- interface, and Sony's Move device) offer considerable promise in terms of naturalistic interaction. However, as was seen with the first generation Wii device, there may be problems in terms of positional accuracy for actions that require precision positioning. In terms of CRISIS training exercises, the evaluation of naturalistic interfaces also needs to consider whether whole-body gestures are a necessary part of crisis management decision making. (This contrasts with the monitoring of partial body gestures, such as head and eye movement, which can be used to foster realistic communication, as discussed later in section 3.8.) The multi-user touch surface has at least two advantages over gestural input. First, it is a less intrusive input approach than body gestures. Secondly, it is similar to the kind of tabletop tactical displays used in some emergency planning exercises.

There is, of course, a significant dilemma here in terms of potential CRISIS simulation users. On the one hand, there are the benefits to be achieved through a greater degree of interactional realism. On the other hand, however, it is likely that most users will be unfamiliar with more 'exotic' forms of computer interaction, and they will only be able to use systems that are equipped with standard input-output devices (i.e. keyboard, mouse and TV monitor). As is well known from studies of videogame interfaces (Shepherd & Bleasdale-Shepherd, 2010), mapping between restricted functionality devices such as these and complex actions within the VE requires complex learning which further serves to reduce interactional realism. One possible solution is to imitate those racing games (e.g. *Forza Motorsport* 2) which provide both a highly realistic simulation mode and a more forgiving driving mode, with the latter requiring far less detail or precision in the user's operational commands.

Content Realism

This refers to what is included in the VE. The selection and spatial assembly of objects in a representational VE is just as important as how each object looks, sounds or feels in relation to the real thing. If a building is omitted, or is not where it is supposed to be, or additional large trees are included in a well-known public space, then however well the individual building and trees are modelled and rendered, the VE will not appear as realistic to the observer acquainted with the real location. Similarly, if an ambient sound differs from that known to occur in a given environment (e.g. traffic noise, emergency claxon), or a control lever presents force feedback that is not commensurate with that provided by the lever in an operational environment, then a realism deficit will be perceived by the VE user. However, it may be hypothesised that high content realism may permit lower sensory realism to be more tolerable.

Relational or Topological Realism

Even when the simulated world contains all of the entities or events found in the real world, there is still scope for a shortfall in mimesis. Relational or topological realism refers to the relationship of elements in a simulated world in relation to those in the real world being represented. Thus, although it is possible to position an erupting mini-volcano in a street block of a busy urban downtown (as may occur in *Sim City*), this adjacency is unlikely to occur in the real world. (Perhaps our Icelandic colleagues have had different experiences.) The level of relational realism is important to those who work in environments modelled as VEs. They expect to find that objects and activities are located in the VE in exactly the place they are located in the real world, and that they exist in proper relationship to neighbouring objects or activities.

Behavioural Realism

This refers to how moving objects (e.g. people, vehicles) in a virtual environment behave (e.g. walking, colliding), and how well these replicate the behaviours of real people and vehicles. (The phrase is also sometimes used to refer to weather effects, and other naturally dynamic features in a model.) In some studies (e.g. Vinayagamoorthy et al., 2004), it has been found that the perceived realism of character behaviour is at least as important as visual realism in inducing higher levels of presence.

A great deal can be learnt about the importance of behavioural realism by examining the design of 3D sports games. Although the visual realism of sports stadiums and team players has been at a considerably high level for several years (in the case of stadiums, this involves licensing the rights to use detailed architectural and engineering plans), many games still do not fully replicate the moves of players as they occur on the field of play. In the build up to the release of the American football game, *Madden 10*, a series of postings was made on the game website by leading members of the design team to indicate the techniques and approaches they were using to increase the behavioural realism of various plays and players (EA, 2009). Some of these involved improvements to the modelling of individual player behaviour, some of which were achieved by introducing procedural awareness (e.g. automatically moving the eyes, heads and shoulders of players in the direction of the ball during a particular play). Other techniques were developed to improve the modelling of coordinated behaviours among several players (e.g. quarterback sackings and blitz defences). Through these innovations, the design team aimed to live up to the vision behind this particular game franchise: “authenticity, realism and simulation” (EA Sports, 2009). Much can be learnt from multi-character videogames to improve the modelling of people interaction in CRISIS simulations.

Functional Realism

This refers to the way in which a modelled system behaves in relation to the laws governing the real world. Functional realism thus includes: the operation of the laws of gravity such that an object will fall off a support if the latter is removed; the operation of the principles of mechanics so that people will (usually) bounce off one another when they collide; and the operation of the principles of friction such that a vehicle will skid if it is driven too quickly around a sharp bend. It also refers more broadly to cause and effect relationships, such that if A leads to B in the real world, then A should also lead to B in the simulated world. Thus, for example, a door will (normally) open when its handle is turned. In short, functional realism refers to the degree to which the simulated world behaves as it is expected to behave in relation to the real world it is attempting to simulate.

Environmental Responsiveness Realism

This refers to the ability of elements of the modelled environment to respond to dynamic events, whether these are generated automatically by the software or as a result of user decisions. Thus, it should be possible for various VE elements to be movable during the playing of a scenario. For example, a CRISIS simulation trainee should be able to: move an item of debris outside a building entrance in order to undertake part of a situation awareness exercise inside the building; open a door in order to move into another room; or clear a crowd of onlookers from a street in order to facilitate the movement of emergency service vehicles. In line with the emergency management theme of the CRISIS project, various forms of abnormal environmental responsiveness also need to be modelled. It is realistic, for example, for a lamppost to buckle or fall over if it is impacted by a car (as it does in the videogame *Grand Theft Auto*), and it is realistic for a building to be partially destroyed in the event of an earthquake or terrorist bomb attack (as it is in *Crysis* and *Mercenaries 2: World in Flames*). There is a great deal more that can be learnt about environmental responsiveness from 3D videogames, some of which (e.g. *Fracture*) use deformation modelling engines.

Communicational Realism

Communication of various kinds will be of central importance in most CRISIS simulations. There are at least two situations in which realistic communication is likely to be significant in various CRISIS scenarios. The first is the degree of fidelity of radio communication among emergency teams and controllers. In a study of air traffic controllers, for example, Lee (2003) found that lack of realistic communications fidelity in air training simulators affected crew performance and the instructors’ ability to evaluate their performance. However, it must be noted that communications in the real world -- and especially during major emergencies -- are far from perfect. (Note, for example, the overloading of cellphone networks during major urban incidents.) Just as photorealism can be too perfect, so too can the modelling of communication networks be too efficient. Lacetera et al. (1997) suggest that radio communications should be degraded in various ways in VEs in order to provide higher fidelity with respect to the real world.

A second application of communicational realism in VEs involves the face-to-face interchanges between individuals rendered as avatars. Gillies and Slater (2005) introduce the concept of correlational non-verbal communication, which they apply to interacting avatars. They demonstrate how various elements of interacting avatars can be coordinated in several ways (e.g. by adjusting avatar proximity, modifying eye gaze, synchronising postural and gestural behaviour, and linking speech responses) to make them more like interactions between real humans than between automated avatars.

Cultural Realism

Some VEs are likely to be highly specific (e.g. a particular airport, shopping centre or rail hub), while others may only need to be modeled more generically. In the latter case, cultural realism refers to adherence to local elements and styles, where ‘local’ may be regional, national or cross-national. For example: building types (and thus building front textures) should reflect those found particular in the specific country and/or region for which the generic VE is meant to be representative; street signs (language and design issues would be nationally specific); vehicle types (some makes of vehicles are more frequently found in some countries than others – especially bicycles). Considerable care should therefore be taken in reusing stock models for buildings, road signs, vehicles, etc. Ideally, several examples of the desired infrastructure (e.g. a small-town high street, rail hub, airport) should be visited within the relevant country or region to obtain suitable reference material.

In conclusion to this section, it should be noted that some dimensions might be more important than others in relation to the type of learning that is involved. For example, Allen et al. (1986, quoted in Thomas & Milligan, 2004) have suggested that *physical fidelity* (look and feel) is more important in cases of the development of skills involving little or no cognitive effort, while *functional fidelity* (realistic cause-effect relationships) is more important in tasks that depend on deeper cognitive processing of task information. It should also be borne in mind that there may be a limit to the benefits brought by increasing the realism dimensions identified above. Because the human perceptual system works in a top-down manner, and is adept at 'filling in the gaps' in the perceptual clues it acquires from the environment, there are thresholds above which realistic representations may not need to be developed (Slater et al., 2009). Determining these thresholds is the subject of further research by the CRISIS team. The important issue of designing realistic training scenarios (Elliott et al., 2001) is also left for future treatment.

INTERACTIONS BETWEEN REALISM DIMENSIONS

The high level of realism achieved by model builders in any one of the dimensions described above may be undermined if there are dissonances between them. Research, especially in VR, indicates that even a low level of dissonance can be perceived, and may be disconcerting and/or unpleasant to system users. For example, a disconnect between high visual realism and latency in head motion response has been the subject of considerable research in VR, in part because of the motion sickness that can result, in particular from mismatches between vestibular sensations and visual perceptions. (Much of this research dates back to the development of Sensory Conflict Theory by Reason and Brand in 1975.) Similarly, the conflict between visual and behavioural realism in videogames is a frequent source of discussion by players. In *Unreal 2*, for example, fighters disappear momentarily into a pillar when punching an opponent, and assailants who fall onto a stone staircase risk having their head disappear into the balustrade geometry. An even more common example can arise when player avatars walk across debris-strewn floors. In *Modern Warfare 2*, for example, soldiers' feet tend to intersect with dead bodies lying on the floor. Another kind of example results from poor collision detection, which can lead to two vehicles appearing to bounce off one another when they do not visibly touch.

REALISM IN SPECIFIC AND GENERIC MODELS

Thus far, the discussion has assumed that the CRISIS VE will be modeled on a specific place or infrastructure -- e.g. a specific airport or rail hub. However, in drawing up realism guidelines, it is also necessary to consider the creation of generic representations of typical or canonical places in addition to the mimetic representations of actual places. For CRISIS, the choice is likely to be a practical rather than a philosophical issue. This is because while the managers of some infrastructures (e.g. an airport authority responsible for a particular airport) may require a highly specific local model, other emergency organisations with a more general remit (e.g. police forces, firefighting services, or A&E services) may only require indicative training environments (e.g. a 'typical' airport, railway hub or high street). For CRISIS, therefore, this issue is perhaps a 'both and' rather than an 'either or' choice.

There is a third approach which may be applied to both specific and generic models. This takes as its starting point the idea that the modeled environment -- the 'given' -- may be usefully varied for the purposes of various training scenarios. We have already considered the ability of environments to be modifiable during the course of a simulation exercise (see 3.7 above). Here, we refer to the modification of the VE for the purposes of introducing What If? training scenarios. These might involve, for example, variations to elements of the VE (e.g. adding, removing, moving, modifying them in some way), to enable the trainees not only to consider unusual and unexpected, but also to analyse the potential benefits of changing the real world referent to improve emergency responsiveness. Examples of such changes might include: changing the locations or performance parameters of particular infrastructure facilities; removing a key facility; modifying the number and/or roles of operational and management personnel; damaging or destroying infrastructure as a result of a major incident. Some of these variations can be injected into a training session as 'random events'; others may require more fundamental design approaches at the models-building stage (e.g. the creation of destructible infrastructural models).

The realism dimensions described above should continue to be used in building generic models, but perhaps interpreted slightly differently. For example, some degree of content realism might be traded off against elements of perceptual realism. However, topological realism remains highly important. In the UK, for example, because of the historical evolution of smaller towns, it is likely that: the main church will have pubs and/or a market square nearby; a railway station will have a large hotel nearby; and large supermarkets and/or department stores will act as 'magnet stores', attracting a selection of higher-end retailers to similar locations. In modeling generic shopping centres, it is essential to include the selection of multiples (supermarkets, drugstores, comparison goods stores, etc.) relevant to the position of the centre in the national urban and retailing hierarchy. Thus, for example, it is highly unlikely that a large department store will be found in a sleepy market town in the UK, and it is equally unlikely that a small family-run grocery store or newsagents will be able to afford the high property rents of the central retail cluster. These considerations reinforce the need for an understanding of cultural realism, as outlined earlier, in the design of generic models.

OBJECTIVE AND PERCEIVED REALISM

It is well known that perceived realism can be as effective as representational (i.e. mimetic) realism. Early CGI experts (e.g. Jim Blinn in the 1980s) soon learnt the art of ‘faking it’ when producing non-realtime animations. Similar approaches and techniques have also been used in cartoons (the majority of all human and humanised animal cartoon characters have a finger missing, a fiction that few cinema goers or TV viewers of the past 70 or 80 years have ever noticed). In the fields of remote sensing and image analysis, it has also been a long-established principle that false colour is often more effective for analytical purposes than true (i.e. realistic) colour. Similar principles are applied in modern videogames.

A user-centred approach to realism may therefore be as important as an objective definition. We have already mentioned the study by Chen and Cairns (2005) which reveals that inconsistencies between visual and behavioural realism in videogames might be compensated for by moderate to high levels of user immersion. A further study by Herrington et al. (2007) suggests that “physical verisimilitude to real situations is of less importance in learning than ‘cognitive realism’, provided by immersing students in engaging and complex tasks”.

Various adjectives have been used to describe user responses to fidelity or realism, including: ‘naturalness’ (Freeman et al., 2005), ‘believability’ (Pegden et al., 1995) and ‘plausibility’ (Boocock, 1972) ‘verisimilitude’ (Kibbee, 1961; Couture, 2004), and ‘credibility’ (Couture, 2004). In one study (O’Sullivan et al, 2003), it is suggested that “for many systems that produce physically based animations, plausibility rather than accuracy is acceptable”. In a study of presence in VR, Freeman et al. (2005) identify ecological validity as a key dimension (one of three), defining it as “a participant’s sense of the believability and realism of the content” of the VE. However, Slater (2009a) reminds us of the dangers in adopting the everyday meanings of words (in his case, plausibility), as an alternative to providing specific meanings to well-defined concepts. (He also indicates that the plausibility illusion which occurs in certain virtual environments – i.e. the user’s perception that what is happening is really happening – does not require physical realism.)

This brings into the equation the issue of individual user variability as well as broader cultural variations in user responses to realism. (This cultural issue might be of particular interest to members of the pan-European CRISIS project.) End users are key to determining what types and levels of realism are necessary in a given simulation. As was suggested earlier, any exercise aimed at defining the level at which individual realism dimensions are modelled should take a user-centred approach, and even adopt user-relative measures. Indeed, certain trade-offs between realism dimensions might be possible, depending on individual user’s physical, physiological and perceptual characteristics. In addition, an intimate understanding is required of the needs of specific training scenarios and the perceptions and prior experiences of trainees who will use the system. Without these, it will only be possible to judge the realism of our models in terms of whether they look and behave roughly the same as the installation they are intended to model.

One design conclusion to be drawn from this discussion is that it may be appropriate to extend the CGI concept of level of detail (LOD) to embrace all forms of realism. One way of doing this might be to construct a level of realism (LOR) scale, which could be defined for each of the realism dimensions discussed earlier. In some circumstances, it might be appropriate for the LOR scale to consist of only three discrete settings: high, medium and low, as is the case with LOD implementations in most videogames. In other cases, it may be more useful to transition gradually between realism levels on a continuous scale, as in the facial morphing system used by Seyama and Nagayama (2007) to test the ‘uncanny valley’ effect. It should also be possible for the user and/or the software to dynamically adjust the level of the LOR scale during a particular scenario, exercise or procedure, as currently happens with LOD. There is considerable scope for research into such functionality during the CRISIS project.

CONCLUSIONS

Realism, or fidelity, is a fundamental element of simulations and models. As Roza et al. (2001) put it: “fidelity is an absolute property of a model or simulation”. However, realism is not an undifferentiated or homogeneous construct. Rather, it may be broken down into clearly identifiable dimensions, each of which may be subjected to separate measurement and evaluation, and the level required of each may be specified separately when designing a particular simulation model. The benefits delivered by CRISIS project simulations will depend to some significant degree on the fidelity of its component elements. However, an appropriate level of fidelity needs to be defined, not assumed, and system modelling activities should be based on carefully recorded characteristics of relevant referents.

The characteristics of the referent systems (including the environments within which the training exercises are to be held, and the training scenarios that will be used), together with suitably detailed knowledge of the learning outcomes of existing training interventions, are essential prerequisites for determining the benefits of the proposed CRISIS project system, and for confirming the general approach to training it espouses. Detailed knowledge of end-user requirements and learning characteristics is also paramount in determining the levels of realism required by CRISIS simulations in relation to specific learning outcomes.

In conclusion, a number of principles and guidelines for the use of realism in interactive training simulations is provided below which emerge from the literature review.

- Visual realism has been over-emphasised. A new approach to realism requires the recognition of a full range of human perceptual abilities, and multiple dimensions of realism.
- Realism dimensions are not independent; inter-relationships and trade-offs need careful consideration when designing interactive 3D simulations.
- Realism can contribute directly to the achievement of simulation objectives, and also indirectly through the enhancement of immersion, presence and engagement.
- Objective and subjective measures of realism and its benefits are equally significant.
- There is no 'one-size-fits-all' level of realism appropriate to all training needs; optimal levels are related to training goals, user differences and other contextual factors.
- High levels of realism can be counterproductive in some contexts, and low levels of realism can be beneficial in other contexts.
- The selection of appropriate realism levels requires an iterative design approach in which end-user research is used to determine the most effective levels.
- From a HCI perspective, realism dimensions and levels need to be mapped onto user interactions to determine the most effective forms of user engagement.

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Interaction and educational design of mobile equipment for crisis management training

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ABSTRACT
As researchers and designers of crisis management training in mobile learning settings, we need to consider ways in which principles of educational design and interaction design can co-exist, in order to reach a higher quality of the analysis and design process. The paper is an input to this discussion, where the empirical data have to do with first aid in general and training cardiocerebral resuscitation in office settings specifically. Consequently, the paper contains design ideas, analysis and evaluation of current work with mobile equipment and augmented reality features, utilizing experiences from Human Work Interaction Design.

Author Keywords
Human Work Interaction Design, crisis management training, educational design, interaction design, work analysis

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Crisis management training often focus on online worlds and social communication patterns using PC like interfaces, and use of simulations and serious games have been addressed within research and development for quite some time (See for example the review in [2])

Many evaluations in serious games literature speak highly of game-based learning, and focus on the learners' motivation as the key catalyst. However, the domain is criticized for having too much attention on the ´fun´ dimension and action-packed games [12]. In other situations, immersion into 3D-worlds is perceived as a vital ingredient that support the learner's to acquire and train behaviors and communicative skills, giving insight into space and time relations of that which is being trained.

In this paper, I investigate another approach to spatial and temporal dimensions, namely digital training systems applied in the physical-world as opposed to online world settings. I explore mobile equipment in first aid training, and discuss design possibilities that are rooted in an analysis of users and their needs. An analysis, that stem from Human Work Interaction Design (HWID) perspectives. The purpose is to investigate relations between educational design and interaction design in mobile crisis management training. The methods include Interaction Design life cycles and techniques, Future Workshops, mobile learning frameworks, embodied learning theories, and possibly use of augmented reality features.

I draw on two case studies, which were developed as students projects. In the two case studies the learning process involved is repetition of first aid techniques. The first study concerned the already existing Danish Red Cross mobile application: Mobile First Aid and the second concerned a concept for training cardiocerebral resuscitation. In the two cases, the concept of management in the term ´crisis management training´ is seen as giving citizens a support tool that will enable them to better manage and act in emergency situations. Specifically, I focus on users in work-situations, e.g. large office surroundings (as opposed to domestic situations or healthcare professionals).

RESEARCH METHODOLOGY AND QUESTION
As my analysis serves as a discussion paper to a workshop, where descriptions are of potential research areas and designs yet to be explored, a narrative and informal style of writing in first person has been adapted.

The methodology is founded on the Norwegian Olga Dysthe's dialogical perspective and on her notion of writing to initiate an inner dialog (this concept is coined as a direct translation: thinking writing [9]). The need to do this analysis transpired as my research and teaching intersected in the domain of crisis management training. The analyses thus rely on my previous research and literature studies as well as from my teachings, supervision, and master students' empirical work, essays and project reports.

In particular, I base the analysis on two case studies, from (as yet) unpublished work of some of my students, who kindly allowed the use of their work for this paper. The students are adults with many years of experience from their practice. Of course, the way we teach and supervise in these programs provide them with insight to new methodological and theoretical ways to work and reflect. However, it is important to note that they bring a pool of knowledge and experiences that is equally important to put into play. We may not analyze and interpret all the empirical data in the same way and we see different ways forward. In this paper, I have tried to report on their work as sample cases as well as to highlight other perspectives I found interesting and ask new questions. It is a dialectical approach.

As such, my work did not begin with an priori defined research question. Rather, the analysis took its starting point from "there is something worth dwelling on here". Therefore, the identification of empirical data and literature followed an explorative approach to educational research [6] that draws on my experiences from HCI and HWID.

HWID AND TRAINING AT THE WORKPLACE

Human Work Interaction Design is a working group (Wg 13.6) within the international federation for information processing under the technical committee of HCI (TC 13). It was established in 2005, where we as founders agreed that though the working group do not have pre-defined domain as such, our target is the analysis of and the design for the variety of complex work and life contexts. The aims of the HWID working group include to: "*…procure a better apprehension of the complex interplay between individual, social and organisational contexts and thereby a better understanding of how and why people work in the ways they do.*" and to "*Promote a better understanding of the relationship between work-domain based empirical studies and iterative design of prototypes and new technologies*." (from http://hwid.cbs.dk/).

I investigate crisis management training within the HWID framework. The body of literature and practical experiences from the general domain of learning at the workplace is far too vast to be included in this paper. Though a lot is relevant, the basis of this paper is different, as this paper do not situate itself as a "learn to manage you work better" or "to network and share knowledge about your work tasks". Rather, the competences that have to be trained in first aid for citizens are different from these citizens everyday work tasks.

The working group is about understanding human work in relation to interaction designs. We have in our workshops and working conferences among others focused on using sketching to not only design solutions, but to understand users and their work process, interrelations etc. [5]. The social, organizational and cultural aspects of HWID have had much attention, and in relation to mobile crisis management training, usability compatibility issues are relevant when we consider localized solutions for organizations that work in many settings [19]. Even when it comes to evaluation of early prototypes, a broad understanding of cultural and intercultural dimensions is required [14] (as observed in the second case study).

MOBILE FIRST AID AT DANISH RED CROSS

In the first student project, Anne-Gitte Mathiasen, postgraduate student in IT didactical design, the Danish School of Education, Aarhus University, investigated an existing mobile learning platform from the Danish Red Cross website during spring and summer 2010. The platform is a repetition tool for people who have attended Red Cross first aid courses (see figure 1). Danish Red Cross released Mobile First Aid in the spring of 2009 and it can be downloaded for free. Mobile First Aid was developed in collaboration with the Danish Red Cross and Infooverflow Aps (a software development company).

Figure 1: Mobile First Aid's content menu. The three headings reads: Cardiac arrest, Bleeding and Suffocation [10]

I would define the work as being within the process of early re-design and pre-phases. Anne-Gitte Mathiasen reflected on the question "How can Mobile First Aid be redesigned, to reach a wider user group?" She investigated: What are the users' requirements to and expectations to the application? What characterizes a broader user group? Which didactic potentials can strengthen Mobile First?

First aid is defined by the Danish Red Cross Textbook on First Aid as: "*First aid is the help given to an injured by the people who are present at the moment the accident happens*" translated quote from [15, p. 5]. A survey compiled in 2009 by Capacent Research for Red Cross has shown that only every fourth Dane has an up-to-date First Aid Course [1].

The project relies methodologically and empirically on:

- Contact to Jutta Helles, who are responsible for First Aid in the Danish Red Cross.
- Analysis of Mobile First Aid and of current first aid teaching procedures. Participants at the First Aid course receive a textbook [15], which is supplemented with an interactive CD-ROM.
- A Future Workshop, based on the principles of Robert Jungk [13], with 6 participants from a potential user group segment (see table 1).
- An interview with manager Jakob Antonsen from the software development company Infooverflow.
- An analysis based on the above empirical data supported by various theoretical approaches: the mobile learning FRAME model [16], concepts of visual cognition and affordance by James Gibson and Don Norman (as visual cognition and learning was seen as very important by the Future Workshop participants) [e.g. 11 & 18], as well as the design complex by Victor Papanek [20].

In her Future Workshop, Anne-Gitte Mathiasen draws on the original method (which has been applied in many versions in HCI). The method originated in 1960 in Vienna, where Robert Jungk, arranged Future Workshops which through active participation wanted to get people to prepare proposals on how they envision the future. Though not explicated by Anne-Gitte Mathiasen, I find Jungk and Müllert's work in finding ways in which groups and communities can organize themselves [13] interesting when considering crisis management training for a broader group. This corresponds well with the resilient communities' perspective.

age	gender	profession	First aid course
36	male	Kindergarden teacher	Yes
34	male	Ambulance driver	Yes
35	female	Producer	No
31	female	School teacher	Yes
34	female	HR-manager	Yes
34	female	Marketing	Yes

Table 1: Characteristics of the 6 participants in the workshop.

In a typical Future Workshop there will be a preparatory phase and three workshop phases: Criticism, Fantasy and the Realization phase. Everything that is said by participants may be visualized, maintained metaphorically and in keyword form (see figure 2). The visualization technique provides an overview of the developed material and the use of keywords enables the participants to remember and leads to new associations.

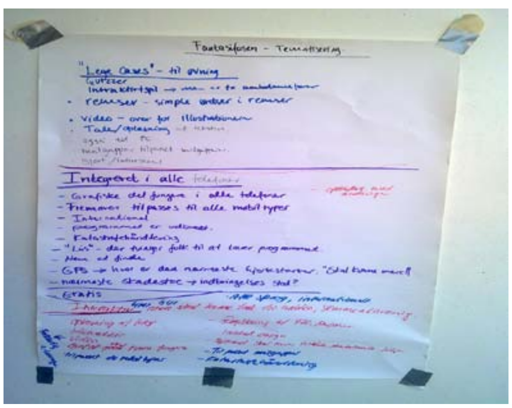

Figure 2: Themes from the Fantasy phase in the Future workshop (that took place 8th April, 2010)

The findings from the Future Workshop, interview and analysis of the existing applications were analyzed through the FRAME model, "A model for Framing Mobile Learning" (figure 3). The model depicts the social construction of mobile learning as an interplay between: the learner, the social and the device. The mobile phone is the device, and is seen as a medium, where the mobile by conveying information supports the facilitation of knowledge in both learning processes and social processes [16].

The FRAME model draws on activity theory, with the phone as the mediating artefact, and on the (Vygotskian) actual and approximate zone of development. It argues that, through mobile learning and social processes between learners and teachers/trainers, the learner can further the approximate zone of development [16]. In well designed crisis management training processes using mobile phones, the learner can be supported in balancing physical and online localization, and supported in interaction with information, time, context and people.

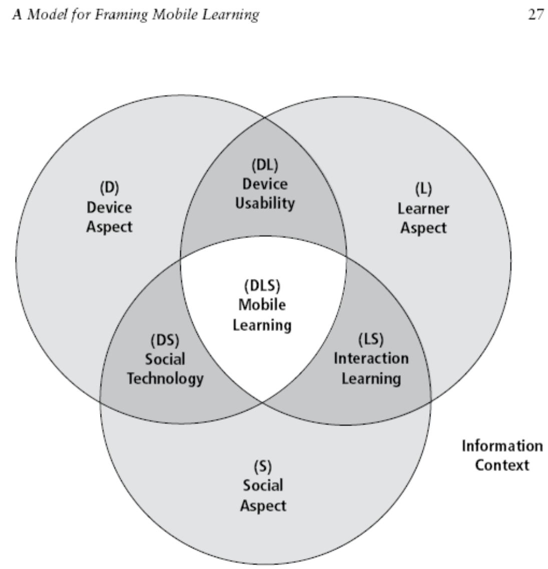

Figure 3: The FRAME Model [16, p..27]

However, the analysis of the learner, the social and the device and the visual learning perspectives, showed that the Mobile First Aid falls short in some of these aspects. In general the Future Workshop participants were positive towards the quality of the content, but found that Mobile First Aid could be better directed to the current user group. They also found the application could be re-designed to support users already in an acute emergency situation – assisting when the accident has happened. Two new user groups were suggested: healthcare professionals and children.

Specifically, the participants found the aesthetic expression in the application and the interaction form uninspiring. The content of the Mobile First Aid is primarily learnt by reading text and illustrations. The "repetition by reading" does not utilise the mobile phone as an active device and mediator in a learning process. The participants found they needed some kind of evaluation process to ensure and show the learner: "what has been learned". The potentials of using the social aspect of mobiles was presented by the Future Workshop participants as a future design potential. The envisioned how professionals could disseminate basic knowledge of first aid to a community relatively rapidly and according to the specific context and situation. Only one of the six participants was able to download the application to their private phone, and the analyses discuss the technical barriers in getting such applications to work on a multitude of mobile phone platforms.

In conclusion, I find that this case illustrates how we need to understand the relations between mobile learning and interaction design in crisis management training. When we consider the interaction design analysis in itself, it reveals that the application seems visually uninteresting, but that the navigation and user interface on its own has an adequate usability. It is easy to use and even contextually understandable (disregarding technical download difficulties). However, when the mobile learning analysis is brought into play, we also see shortcomings according to the learning perspective. These are primarily related to difficulties to train "repetition by reading" and lack of evaluation processes.

TRAINING CARDIOCEREBRAL RESUSCITATION WITH SOUND AND BALL

As part of their Master studies, four students at the part-time program "Master in ICT and Learning" did a project in 2010 on "*Design of user interfaces using an embodied learning perspective*" in the domain of training CPR (cardiopulmonary resuscitation) and in particular compression-only resuscitation or CCR (cardiocerebral resuscitation). The motivation for the project was the growing need for office staff to learn the use of AED (Automated External Defibrillators) and thus basic resuscitation, in addition acquired competencies of the users should be maintained and thus repetition possibilities seem vital.

The four students, Jørn Fryd, Lars Bo Hansen, Vibeke Flytkjær, and Ann Louise Vestergaard, designed a user interface for repetition of previously acquired knowledge and practical skills from a basic course in resuscitation of cardiac arrest. Thus, in this context the user is a male or female office worker, not a healthcare worker.

The project relies methodologically and empirically on the application of the simple interaction design lifecycle model by Sharp, Rogers and Preece [22, p.448], in which theories of learning and repetition are considered in the lifecycle phases. This was established iteratively through:

- Establishment of a need (see above) and analysis of current user interfaces.
- Applying concepts of tacit knowledge and bodily cognition for training CCR.
- Discussion of various possible conceptual models, drawing on theories of learning.
- Sketching of possible ways to design the chosen model.
- Development of a Low-Fi prototype based on audio and bodily movements.
- Video recorded evaluation and test of the prototype with 3 potential users, incl. group discussion about experiences.
- Analysis of the prototype and the empirical data from the evaluations based on theories of learning.

I view the project as an early pre-phase, where the interaction design lifecycle phases are all applied in order to gain insight into the users' needs and requirements. I.e. a full circle of considering: needs, various possible conceptual models, the development of an inexpensive low-fi prototype, and test of this prototype. As such the project was exploratory in nature and did not have pre-defined choice of design and theory.

The group conducted a small search to gain an overview of current user-interfaces. They found that the predominantly used feature was user interfaces designed as algorithms, showing resuscitation procedure using text and images, similar to the previous case from Red Cross.

In their work with the conceptual model, the group discussed which theoretical learning approach was appropriate when the purpose of the user interface was to revise previously acquired practical skills. Tacit knowledge is recognized as being acquired through sensor motor and emotive cognition, as found when learning through use of pictures, sounds and bodily learning. Jørn Fryd, Lars Bo Hansen, Vibeke Flytkjær and Ann Louise Vestergaard argues that this approach is suitable when the domain to be learned is previously acquired practical competencies.

Their theoretical argument is that by resituate to tacit knowledge, knowledge can be acquired that is otherwise difficult to acquire via a logical and rational manner [17, p.43], and the group sees this field as difficult to learn through theoretical approaches (similar to the more abstract theoretical approach that was found in the Mobile First Aid that I presented above). The project participants identify how use of an artefact that stimulates bodily awareness, may lead to that the experience learnt in practice is easily recognizable and therefore repeated in a correct way. In an interaction design perspective, this design stimulates what Sharp, Rogers and Preece in an interpretation of Landsdale and Edmond, describe as recognition-based scanning [22, p.101].

When performing CCR, you must perform the compression with a frequency of 100 beats per minute. This rhythm is very fast and difficult to perform and recall in practice. Since rhythms can be recognized by using music and music and rhythms is acknowledged and remembered tacitly, the project group found this was an appropriate choice to try out. They group found a tune, which had a basic rhythm of 100 beats per minute and searched for artefacts that could be used for repetition of the physical learning. They needed an artefact, where the CCR experience could be recognized and repeated and which was sufficiently mobile that it could be used in an office, during working hours. The group furthermore found that a lightly pumped handball could be used to practice frequency and correct pressure.

The group prioritised to test the idea of learning rhythm through music and bodily learning through the ball. The remaining of the interface was merely illustrated to the user using a storyboard-like sketch. There was in other words no programming done at this early stage.

The test and evaluation method was a combination of video observation of the prototype in use in an office, and a group interview with the participants immediately afterwards (see figure 4). A test plan and interview guide was followed closely.

Figure 4 – The low-fi prototype in use and group interview.

In their analysis of the empirical data, the group identified certain problematic issues related to the test setup and the design. For example the users were uncertain about how long they had to press the ball, and found it incorrect to be sitting down. However, they all believed that learning through music and practicing on the ball was useful. The users provided interesting ideas to the future design, such as having indicators that respond and give feedback to whether or not the rhythm and pressure where carried out in a correct way. In the group interview, the evaluator asked them to beat the rhythm on the table, and all did so. Further, when asked if the song "was in their head", two said yes and one said she "heard" the sound of the AED.

The video recordings, however, shows that only one of the three persons found the correct frequency, the others were far too slow. Jørn Fryd, Lars Bo Hansen, Vibeke Flytkjær and Ann Louise Vestergaard concludes that even though not everyone will find it easy to find a specific rhythm using a song, the concept of pressing an object guided by an interface, met the purpose of repeating bodily learning. The group agrees with the users that the design would improve if a feedback mechanism of correct procedure is given.

In conclusion, and as an additional reflection, I notice that the test and evaluation did indeed work well to test both the project group's prototype design and their conceptual model. When I watched the recordings, I found that the potential users may indeed beat a slow frequency according to correct CCR, as stated in the group's analysis. However, they are *not* beating a slow rhythm. They are just doing what most typical Danes, and probably many westerners, will do when clapping to music, namely clapping to every second stroke (on 1 and 3, or 2 and 4). It is a cultural "bias". That two of the users did not beat the intended pattern is a design problem; and the fact that they almost instantly get "into the rhythm" shows that the conceptual model may in fact be strong and powerful. This case illustrates how we need not only interaction design and analysis, but also theories of learning and models of social, organizational, and cultural understandings (as mentioned in the HWID section).

CONCLUSIONS

This work may serve as a basis for a discussion about the need for interaction design and educational design to co-exist in the analysis, design and evaluation of crisis management training applications and for planning training processes that includes such applications.

It seems that interesting learning models can be developed within the application of mobile equipment to crisis management training of first aid, with office workers as a user group. The designs thus represent some of the perspectives that we are beginning to work with. But more importantly the designs represent work on how to analyze and investigate the users' needs and possible IT designs by integrating models of learning with models of interaction design. Social constructivist approaches and learn-by-doing crisis management training is much advocated for in literature [e.g. 8 & 2], much of which I adhere to. However, a repetitive learning model with positive and negative reinforcement may in this case save lives. As such, there are sub-areas where an instructual design approach is suitable and not only a learning model that is "old school", which is shun upon. Those sub-areas can exist within a larger social constructivist strategy,

I do not see the repetitive learning models as stand-alone systems, and I do not see the mobile phone as replacing human contact, neither in the actual emergency situation nor in crisis management training. But I do see the advantages of mobile equipment - to give a basis from which people can learn to act and create self-help.

The HCI domain does encompass the cognitive and psychological theories of how people perceive the world and of being in the world. Nevertheless, the centre of attention is on user(s) interactions and user interfaces, rather than learning about and learning to act in a certain domain.

My argument is that methods which correlate HCI thinking and learning are necessary to understand and design for users. The cases demonstrate that there are potential for more in-situ sequences, and that the body's presence can be a vital "ingredient" for learning. The paper also shows that the users tend to act differently than what the designers anticipated, and we must know more about how people in general and office workers specifically deal with the new technologies in crisis situations and when training to become better at managing crisis situations.

FUTURE PERSPECTIVES: AUGMENTED REALITY IN MOBILE CRISIS MANAGEMENT TRAINING

In closing, I will set the stage for where our work is taking us now. The two cases suggest a potential for mobile crisis management training and for small portable equipment. We envision organizations to implement the equipment in their training programs and safety representatives at the various departments could have the equipment ready-at-hand in their desk-drawers. We have found that the current designs (the existing Mobile First Aid and the prototype of ball&sound CCR) needs to be redesigned, in particular situational awareness and getting better evaluation of the learning process should be re-considered.

Chen et al provides a good review of current practices in the use of simulations and online worlds for crisis training. They also point to how training small-scaled individual tasks do not provide insight into the many and unpredictable facets of emergency situations [2]. Though it is important to practice repetition of CCR - it is an isolated training task. Similarly, reading by repetition is also an isolated task.

Schöns relates his theories of reflection-in-action and reflection-over-action to Dreyfus and Dreyfus progressive learning model (from novices to experts) and tacit knowledge as original discussed by Polanyi [21 & 7]. Schön finds that people who are already knowledgeable and experienced in a domain (experts), are often able to promptly transfer appropriate behaviour from one situation to a similar, but for them new situation within that same domain. This behaviour is not equal to copying actions, but rather represents reflection-in-action. When on a novice or advanced beginners level, one rely more on the rules of the domain, copying actions and use reflection-over-action. The learner needs experience if he/she should be able to act rapidly and appropriate in new situations. As much crisis management and simulation based literature shows, it is not possible to reach this level of experience in practice as crisis situations do not occur every day. A close-to-reality experience is suitable for reaching a knowledgeable level (as opposed to experts in Dreyfus & Dreyfus taxonomy). For office workers to build a minimum experience base in First Aid and CCR, in as close to reality would mean training in a variety of simulated situations.

Augmented reality can take many forms. There seem to be two streams: The use of real and even live (real time) visual representations imposed into the digital training systems user interface or a combination where live movements in the real world interacts with the interface in the training system [8]. At the world computer congress in Milano 2008, Luca Chittaro gave a talk on Interacting with Visual Interfaces on Mobile Devices, where he presented a mobile evacuation application, that was based on RFID technology and location-aware 3D maps on a PDA (see [3] for an introduction to the presentation). The idea is that the PDA interface shows exactly where the user is situated in the building, and it shows the exit-route as the user moves in the building (figure 5). In 2009 Chittaro and Ranon wrote a paper on the project "Serious games for training occupants of a building in personal fire safety skills" [4]. However, in this 2009 project, they work with a single player 3D game in first person perspectives, not an augmented reality mobile application [4].

Figure 5. The evacuation application. Source: http://hcilab.uniud.it/demos-videos/item14.html

As a training tool, a mobile device together with the hands-on mobile equipment could allow workers to train emergencies individually and in teams, without the effort of having to setup large scale training scenarios, clearing buildings, stage actors or co-workers to act as injured people etc.

Simulations in an online world may provide some of these features, but lack the movements of the body of the rescuer, when handling the situation. The user interface of a mobile device / smart phone can add a simulated procedure in a narrative. The organization can choose to induce stress conditions (limited timeframe, darkness, and noises), communicative features as calling emergency hotlines, and in team exercises, get co-workers assistance and use co-reviews, to evaluate and improve the process. Also, such an evaluation could assist the organization in updating their emergency procedures. Though all this is currently on a sketch level, which we are currently drawing the framework for.

ACKNOWLEDGEMENT:
This paper draws heavily on work performed by 5 of my postgraduate master students, who have all agreed to have their work used here. Many thanks to Anne-Gitte Mathiasen who worked on the Red Cross project, to the people from Danish Red Cross and Infoowerflow for interviews, and participants in her Future Workshop. Many thanks also to Jørn Fryd, Lars Bo Hansen, Vibeke Flytkjær and Ann Louise Vestergaard, who worked with the CCR training of office workers, and to the three colleagues who participated in the test and evaluation of the prototype.

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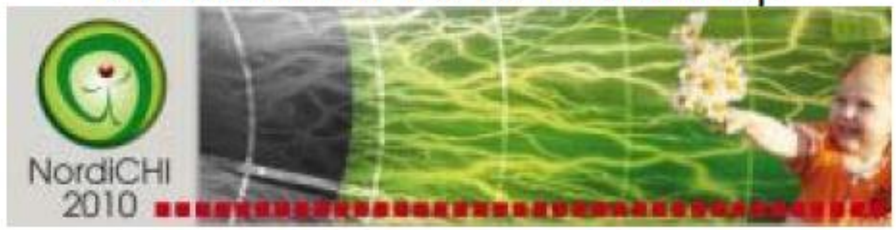
Crisis management training: design and use of online worlds

A NordiCHI 2010 Workshop



To be held at the Reykjavik University
Saturday, October the 16th 2010

Jointly organised by IFIP 13.6 HWID and the FP7 CRISIS project.

The workshop is organised and these workshop proceedings is edited by:

Prof. William Wong Professor of Human-Computer Interaction and Head of Centre **Mr. Chris Rooney** Post Doctoral Researcher **Dr. Jane Barnett** Post Doctoral Researcher Interaction Design Centre, Middlesex University, England	**Dr. Rikke Ørngreen** Assoc. Prof at the research program: Media and ICT in a Learning Perspective, Danish School of Education, Aarhus University, Denmark	**Dr. Torkil Clemmensen** Assoc. Prof., Department of Informatics, Copenhagen Business School, Denmark	**Prof. Ebba Þóra Hvannberg** Professor of Computer Science, University of Iceland, Iceland

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WG 13.6 Human Work Interaction Design (HWID)

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Events

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Contributions

IFIP TC 13

WELCOME to the homepage of
The IFIP working group 13.6 on
HUMAN WORK INTERACTION DESIGN

AIMS

The HWID working group aims at establishing relationships between extensive empirical work-domain studies and HCI design.

To encourage empirical studies and conceptualisations of the interaction among humans, their variegated social contexts and the technology they use both within and across these contexts.

Promote the use of knowledge, concepts, methods and techniques that enables user studies to procure a better apprehension of the complex interplay between individual, social and organisational contexts and thereby a better understanding of how and why people work in the ways they do.

Promote a better understanding of the relationship between work-domain based empirical studies and iterative design of prototypes and new technologies.

Establish a network of researchers, practitioners and domain/subject matter experts working within this field.

CRISIS

Posts Comments

HOME | PROJECT NEWS | PEOPLE | INTERNAL | NORDICHI WORKSHOP

October 2010

M	T	W	T	F	S	S
				1	2	3
4	5	6	7	8	9	10
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« Sep

Home

CRISIS stands for CRitical Incident management training System using an Interactive Simulation environment. The **Goal** of the CRISIS Collaborative Project is to research and develop in Europe:

1. A training and simulation environment that will focus on real-time decision making and response to simulated but realistic crises or critical incidents, focusing primarily on problem diagnosis, planning, re-planning, and acting, rather than just procedural training or familiarity with policies;

2. A distributed, secure, scalable, collaborative and interactive simulation and on-demand-training environment for crisis management training in airports, of individuals, teams, and teams of teams, working across multiple levels of an organisation, between organisations, and across different nations at a command post levels; and

3. A software architecture that will be capable of being readily re-configured and used for different scenarios at other airports, transport hubs, and other critical sites like power plants or factories;

4. A flexible platform that can also function as a test-bed and evaluation tool for new and current operational procedures, information sharing and planning tools.

Recent Posts

- Online Games as Teambuilding Tools
- Natal Renamed Kinect
- Survey points to low Natal/Move interest
- [SPAM: 13.000] Stereoscopic 3D games arrive on PlayStation 3
- Project Kick-Off Meeting Photos
- Consortium Group Photo
- New site up and running

Meta

- Register
- Log in
- WordPress

9.00 - 9.30	Greetings & introduction [Rikke Ørngreen]
9.30-10.30	Panel 1 – [Chair: William Wong] • Adderley & Smith - Assessing Stress in Immersive Training Environments • Clemmensen & Pedersen - HWID perspective on ... ICT systems for climate management • Hansen - Behavior based training improves safety through online simulation environments • Kovordanyi, Rankin, Eriksson - Foresight Training as Part of Virtual-Reality-Based Exercises for the Emergency Services
10.30-11.00	Coffee
11.00-12.00	Panel 2 – [Chair: Torkil Clemmensen] • Barnett, Wong & Coulson - Situation awareness and sensemaking in crisis management • Jenvald, Morin, Eriksson - Challenges for user interfaces in VR-supported command team training • Rudinsky & Hvannberg - Voice Communication in Online Virtual Environments • Ørngreen - Considering the educational and interaction design of mobile equipment for crisis management training
12.00-13.00	Lunch

13.00-14.00	Panel 3 – [Chair: Ebba Hvannberg] • Pinchuk - Semantically Enabled After Action Review • Rankin, Kovordanyi, Eriksson - Episode Analysis for Evaluating Response Operations and Identifying Training Needs • Rooney, Passmore, Wong - CRISIS Research Priorities for a State-of-the-Art Training • Shepherd - Get Real - The Many Faces Of Realism
14.00-14.15	Introduction to group discussions [Jane Barnett / Chris Rooney]
14.15-16.00	Group discussions - Using the CRISIS training scenario as a basis, to which the concepts of the workshop papers can be applied. - Consider what to bring back to the plenary discussion. - Coffee 14.30 – perhaps bring the coffee with you to the group ☺ - [Chaired by: William Wong, Jane Barnett and Chris Rooney]
16.00-17.00	Plenary discussion / reports from the group [Chair: Torkil Clemmensen and Ebba Hvannberg]
17.00-17.30	Closing & future possibilities… [William Wong and Rikke Ørngreen]

Assessing Stress in Immersive Training Environments

Dr. Rick Adderley
Michelle Smith

A E Solutions (BI) Ltd

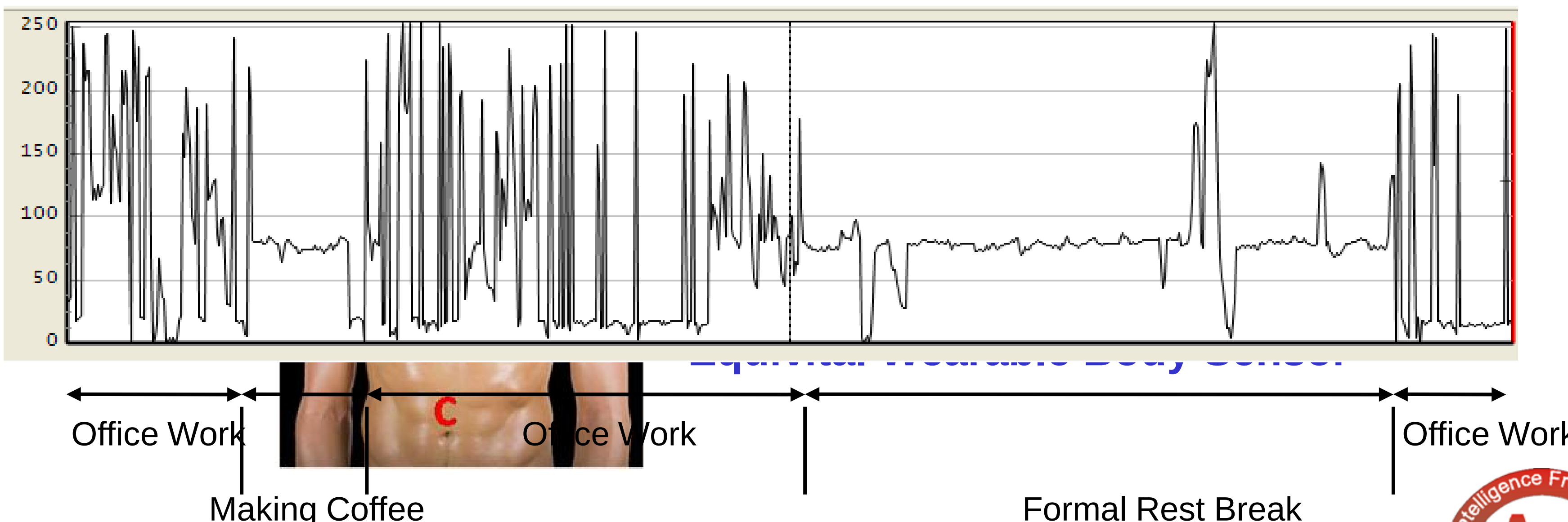
$\sqrt{\frac{a + e}{solutions}} = (BI)$

Crisis Managers

- Crisis incidents do not occur very often
  - Airplane crash
  - Train Trash
  - Natural disaster
- Crisis managers change roles
  - Promotion
  - Resignation
  - Retiring
- Crisis managers lack of experience
- Importance of training

Crisis Management, Stress & Training

- Stress during the actual event
  - Reproduce within a training environment
- Physiological Monitoring
  - Monitor during current training
  - Monitor during the CRISIS training
    - Ensure CRISIS system is sufficiently realistic



Physiological Monitoring

- Demonstration

Questions

Assessing Stress in Immersive Training Environments

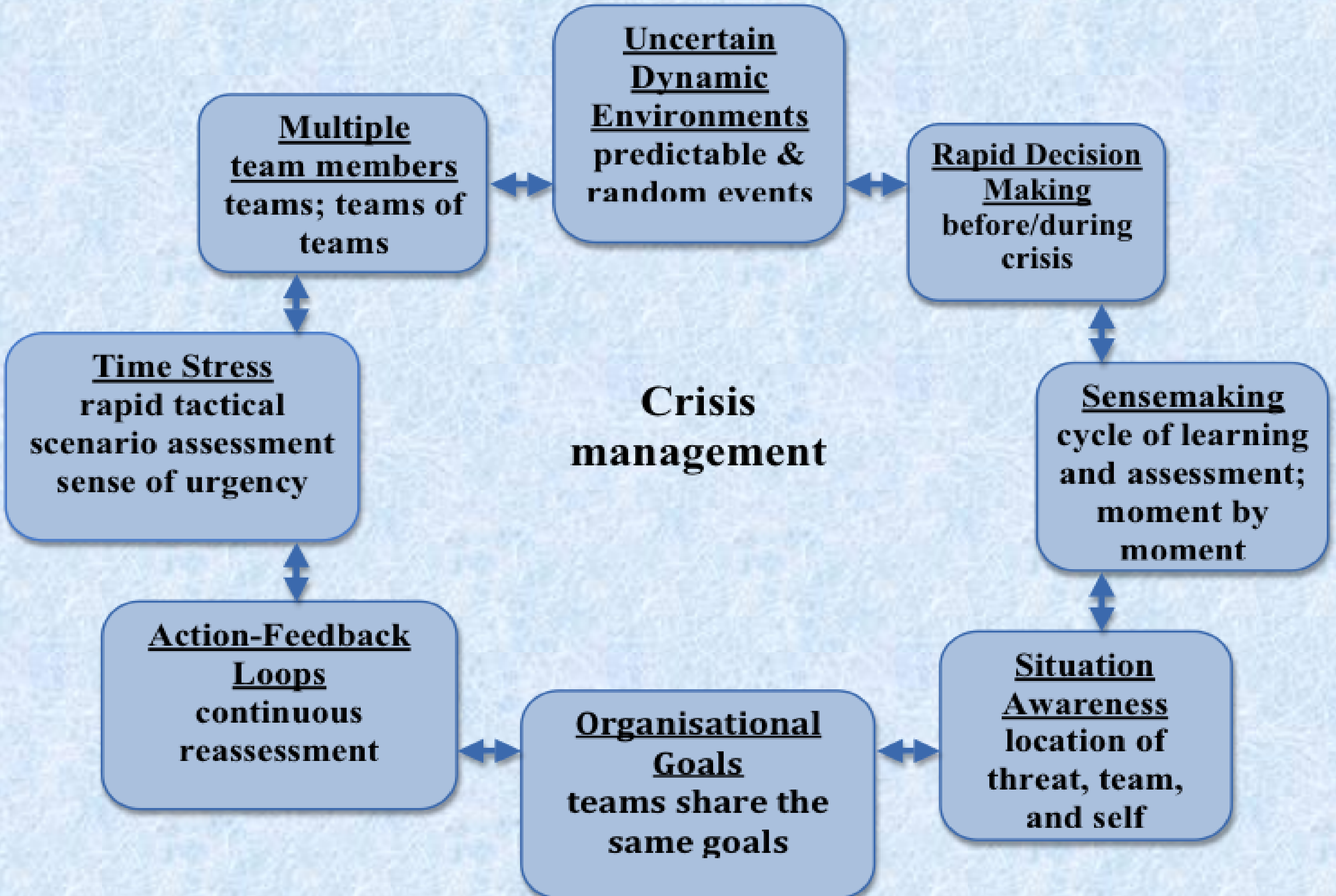
Dr. Rick Adderley
Michelle Smith

A E Solutions (BI) Ltd

$\sqrt{\frac{a+e}{\text{solutions}}} = (\text{BI})$

Jane Barnett, William Wong, Mark Coulson
Middlesex University, London

Situation awareness and sensemaking in crisis management: Similarities between real world and online co-operative environments


Uncertain Dynamic Environments
predictable & random events
Multiple team members
teams; teams of teams
Rapid Decision Making
before/during crisis
Time Stress
rapid tactical scenario assessment
sense of urgency
Crisis management
Sensemaking
cycle of learning and assessment; moment by moment
Action-Feedback Loops
continuous reassessment
Organisational Goals
teams share the same goals
Situation Awareness
location of threat, team, and self

Team Member Expertise

Real-world

- Commander
- Medical – life preservers
- Firefighters extinguish fire

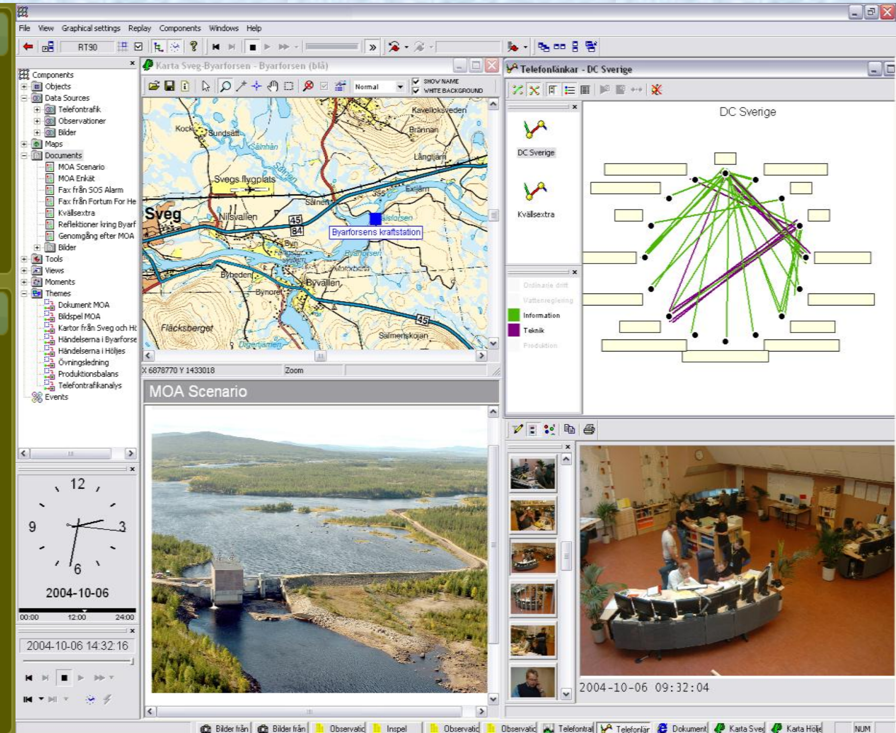
Online

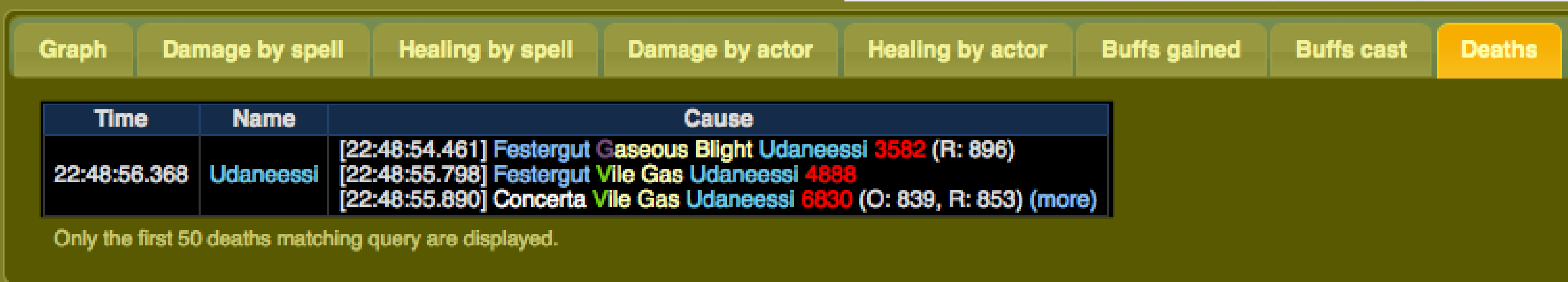
- Commander
- Medical – life preservers
- Damage dealers extinguish threat

Some members have more than one role

Expertise – graded learning

After Action Review/ CITE Explorer





Customisable User Interface

Online worlds as training tools

- Mimic crisis management factors
- Adaptable UI
  - Personalised
  - Learning curve
- Naturalistic environment
  - Safely make mistakes
  - Death is not permanent!
- Learning/Training Expertise
  - Graded exposure
- Allow for
  - Frequent learning

Crisis management and human work interaction design

- Crisis management
  - Time scale of the event that should be managed (seconds, minutes, hours, days, weeks, years, decades)
  - The definition of management (team coordination, team awareness, or leadership?)
  - The definition of crisis/disaster/emergency (safety critical, health critical, quality of human life, important to ecology)
- Greenhouse climate management as an example of crisismanagement:
  - Daily/weekly management, leadership (only a few key persons manage), important to ecology

Greenhouse climate management

- Currently greenhouse growers spend several hours daily with the computer, working with the greenhouse climate management systems.
  - What are the social, cultural, organizational and technical contexts of the computerized climate management?
- Insight into the needs and reasons for spending much time on a certain task using a computer can help in planning future software systems for the needs of the growers and to contribute to reducing unnecessary work time and stress while increasing time for pleasure, eventually increasing work efficiency and reducing labour costs

HWID

- ITGrows case

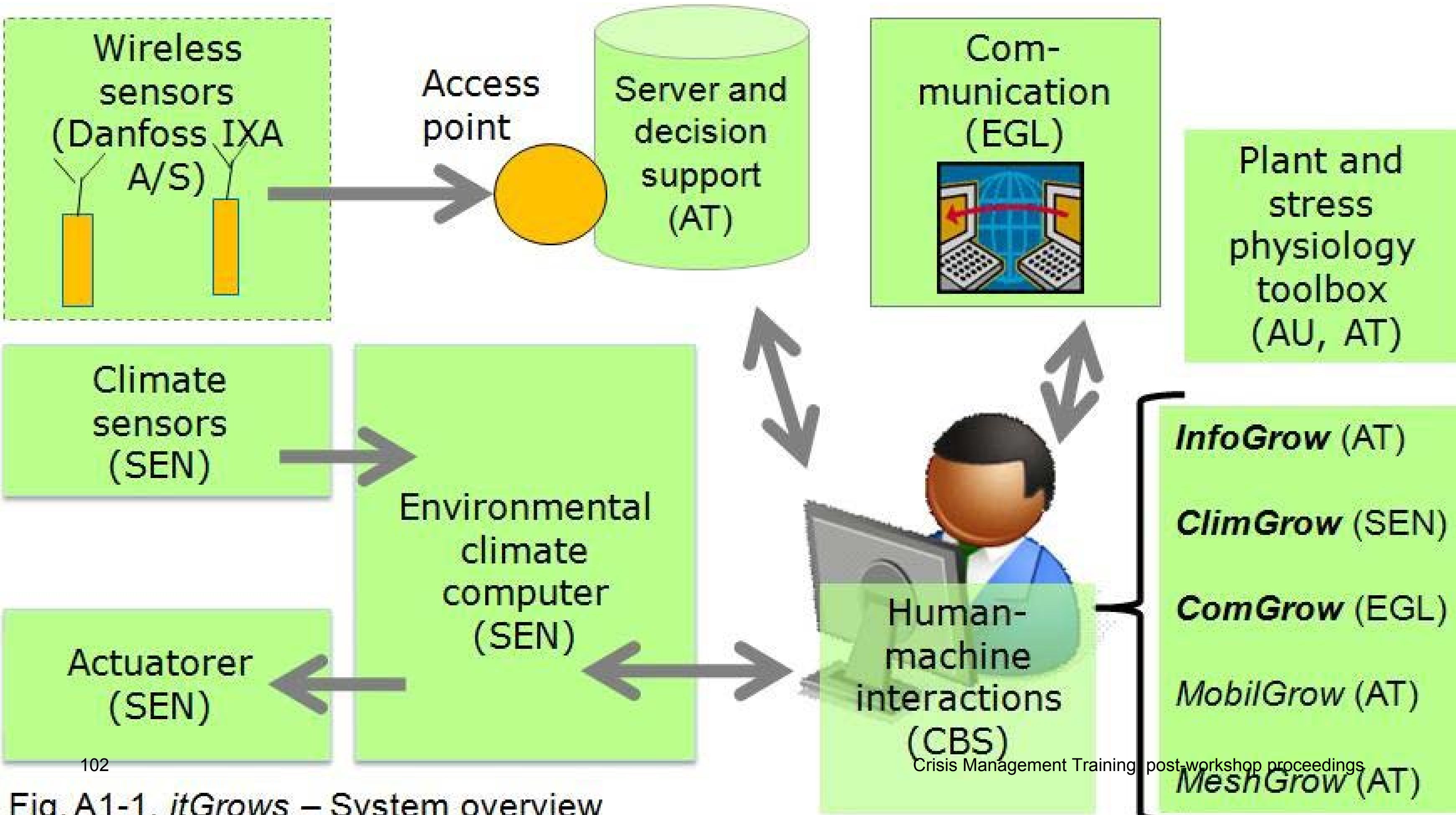
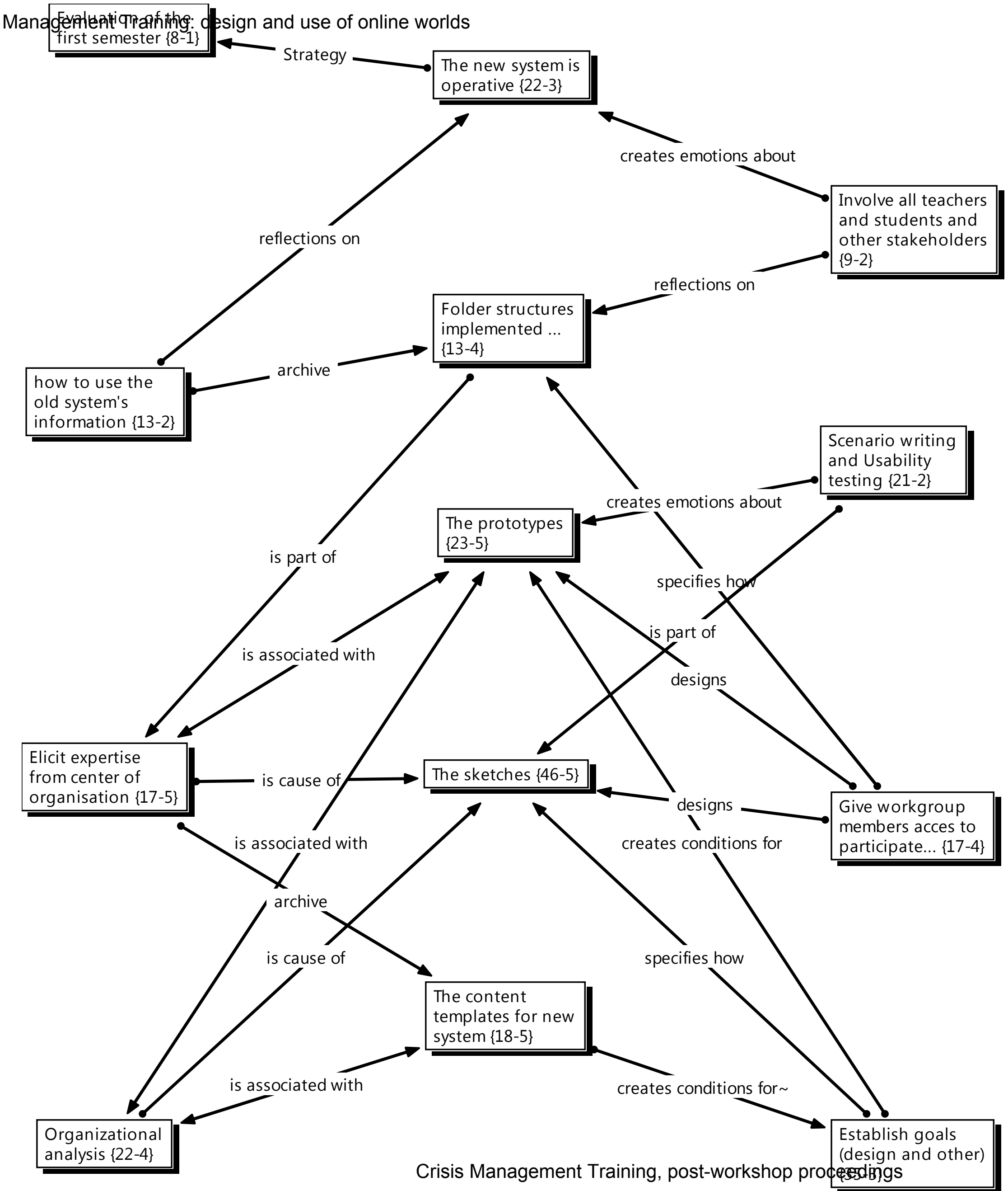


Fig. A1-1. *itGrows* – System overview

Greenhouse climate management

- Currently greenhouse growers spend several hours daily with the computer, working with the greenhouse climate management systems. What are they doing?
  - Is it all functional, rational problem solving?
  - Is it management? (what kind of management?)
  - Is it process control?
  - Is it learning?
  - Is it enjoyment, pure fun?
- What theory? Theory that can explain the climate management in a sensorbased prototyping environment?

A generic example of Human work interaction design



Foresight Training as Part of Virtual-Reality-Based Exercises for the Emergency Services

Rita Kovordányi, Amy Rankin, Henrik Eriksson
Linköping University

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° FP7-242474.

Risky behavior: Why?

- Need a way to assess the effect of alternative actions
  - Continuous learning and adjustment
- Need to test the "boundary conditions"
  - Can then interpolate from these experiences
- In this sense, risk taking is inherent in humans

Risk compensation

- Humans are driven to explore the boundaries
- If safety systems increase the safety margins, users will explore further out…

Remove risky behavior from live operation

1. Train high-risk situations using virtual reality
   - Possible to safely explore the effect of dangerous actions
   - Boundaries are moved, so users will explore further then they would normally do
   - No harm in a protected VR-environment

Remove risky behavior from live operation

2. Change user's mind set
   - Train to be more aware of risks
   - Works well in healthcare, transportation, etc.
   - Effective component in a risky-behavior mitigation package offered in a VR system

Simplified instrument for in-the-field use

Self

- Feeling sick
- Fatigued
- Inexperienced

Context

- Inadequate equipment
- Adverse weather

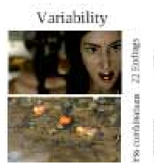
Task

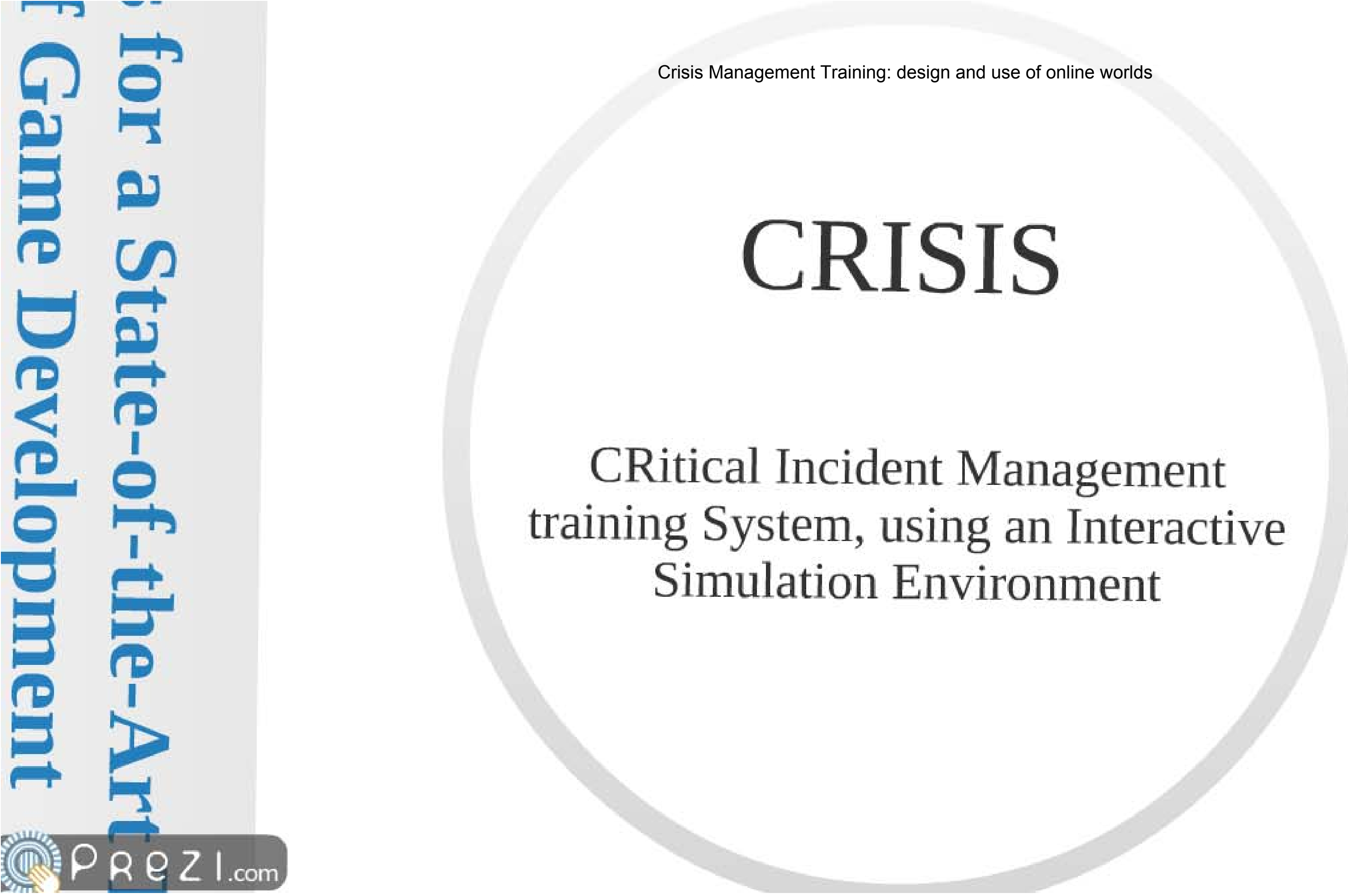
- Towards the end of task
- Complex task

CRISIS: Research Priorities for a State-of-the-Art Training Simulation and Relevance of Game Development Techniques

Chris Rooney
Peter Passmore
William Wong

Middlesex University



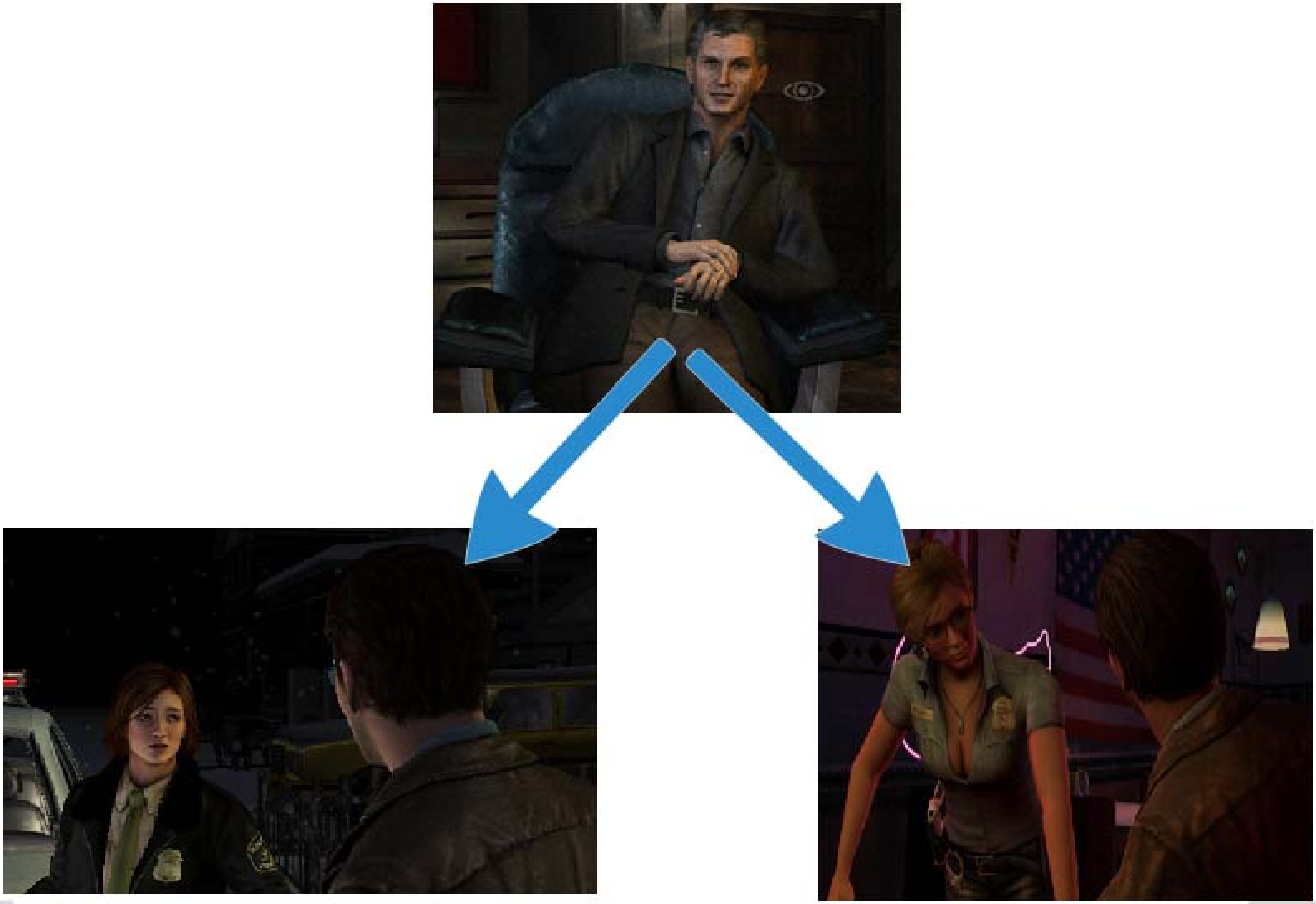

CRISIS
CRitical Incident Management training System, using an Interactive Simulation Environment
for a State-of-the-Art
Game Development
Prezi.com

The application of video game technology

Realism
Engagement
Affordances
Variability
Interaction
Simulation

Realism

Engagement



Affordances

com

Variability

22 Endings

Linear Path

Endless combinations

Only 2 outcomes - win or lose

22 Endings

Linear Path

Endless combinations

Only 2 outcomes - win or lose

Interaction


Microsoft


Microsoft

Simulation

The End!

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Voice Communication in Online Virtual Environments for Crisis Management Training

Jan Rudinsky, Ebba Thora Hvannberg

University of Iceland

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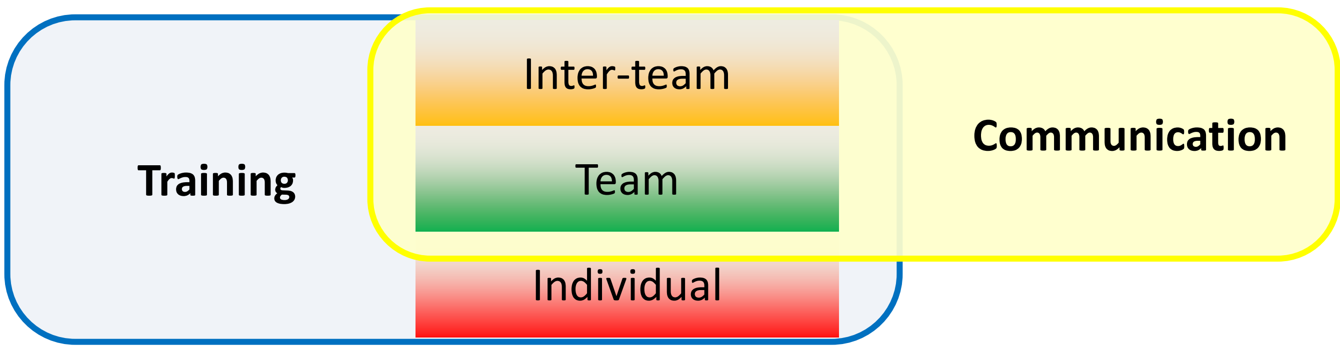
The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° FP7-242474.

Communication in Crisis Mmt. Training

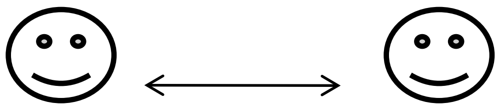
- **Crucial role of communication in crisis management**
  - Activity coordination
  - Shared situation awareness
  - Decision making

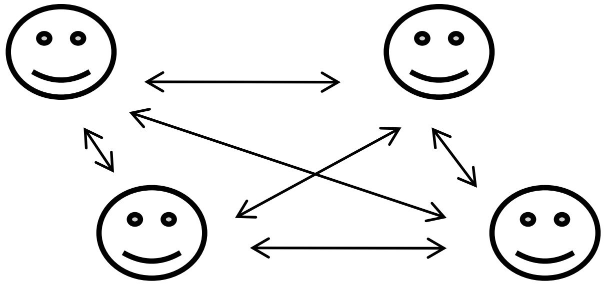
- **Training**
  - Large-scale exercise
  - Table-top
  - Apprenticeship or individual



Online Game Training

- **CRitical Incident management training System using an Interactive Simulation environment**
  - Cost effective, frequent training, adaptation…
  - Serious game concept
- **Information sharing**
  - Text-based chat
  - Voice communication
- **Voice communication**
  - Broadcast
  - One-on-one (mobile, fixed)
  - Proximity (real-life)





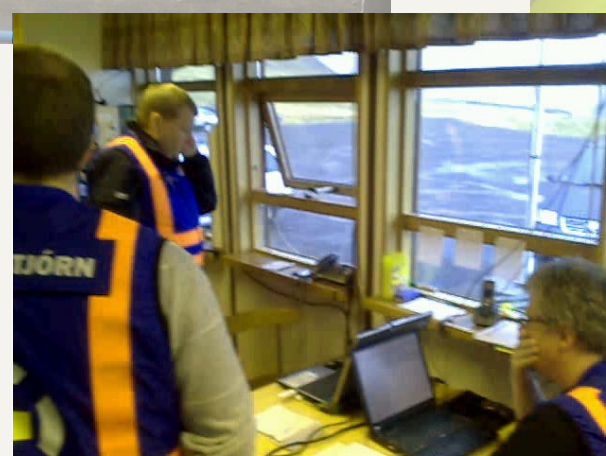
Conducted Research

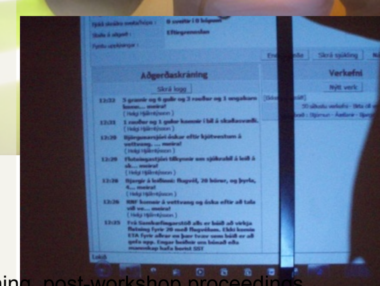
- **Analysis of table-top**
  - Single-team, multi-agency
  - Low requirements on time & res.
  - Hypothetical situation test
    - No community disruption
  - Simulation of real comm.
    - Help of situation overview
    - No technology or env. constraints

- **Examples of communication**
  - Rescue Coordinator to all: *“Scene secured”*
  - Rescue Coordinator - Transport Coordinator:
    - *“Need transport from scene, send ambulance”*
  - Medical Coordinator - Transport Coordinator:
    - *“Can you move green (casualties to hospital)?”*
    - *“How many?”*<decision making>

Conducted Research contd.

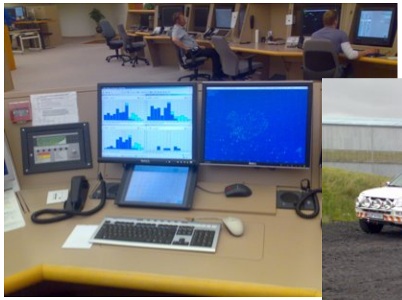
- Live Action Role Play (Large-scale ex.)
  - Multi-team, multi-agency
  - Communication
    - Alert, Coordination, Command
      F2F, radio, logs





Conducted Research contd.

- **Interviews and Workshops**
  - Interviews of crisis managers, coordinators and first responders
  - Communication & technology use
    - Participants, physical environment
    - Channels, hierarchy, equipment
    - Problems of voice communication
    - Role in after-action review
    - Alternative forms of communication



- **Lessons learned**
  - “CT could give more information to 112 from beginning “
  - “Telecommunication needs more discipline” (without long talk an
  - “Inappropriate communication made needless irritation”
  - “Lack of communication between NEC and EOC”
  - “Misunderstanding in FEC caused confusion in EOC's work process”…

Panel 2

Interaction and educational design of mobile equipment for crisis management training

Please note that these slides are not designed for a paper or pdf format, as they contain layered information, which makes a lot of information invisible.

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Design of crisis management training in mobile learning settings

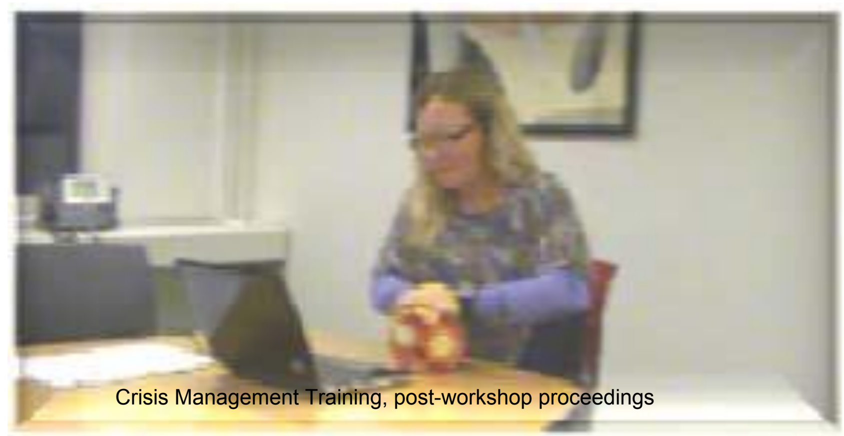
- Consider ways in
  design and interac
- Human Work Inter
  perspectives.

2 case studies

- By postgraduate s
- Repetition of first a

1. Danish Red Cross: Mobile First Aid

2. Concept for training cardiocerebral resuscitation.



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The methods applied included

- Interaction Design life cycles and techniques (sketching, storyboards...), Future Workshops

- Mobile learning frameworks, embodied learning theories, learning and recognition processes

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Motivation and argum conceptual mo

- need for office staff to learn the use of AED resuscitation,... competencies should be ma re
- Ta m pi
- Th st in wa

An artefact, where the CCR exp recognized and repeated and wh mobile that it could be used in working hours

Experiments with soun

VIDEO EXAMP

Only 1 found “the correct rhythm”

- Group concludes though not everyone will find it easy to find a specific rhythm using a song, the concept of pressing an object guided by an interface, met the purpose of repeating bodily learning. The group agrees with the users that the design would improve if a feedback mechanism of correct procedure is given.

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Too slow??

- Users may indeed beat a slow frequency according to

This case illu

how interacti

Could be cor
models of so
understandin

A repetitive learning model with positive and negative reinforcement may in this case save lives. Can exist within a larger social constructivist strategy

The body's presence as a vital “ingredient” for learning… potential for more in-situ sequences

the conceptual model may in fact be strong and powerful