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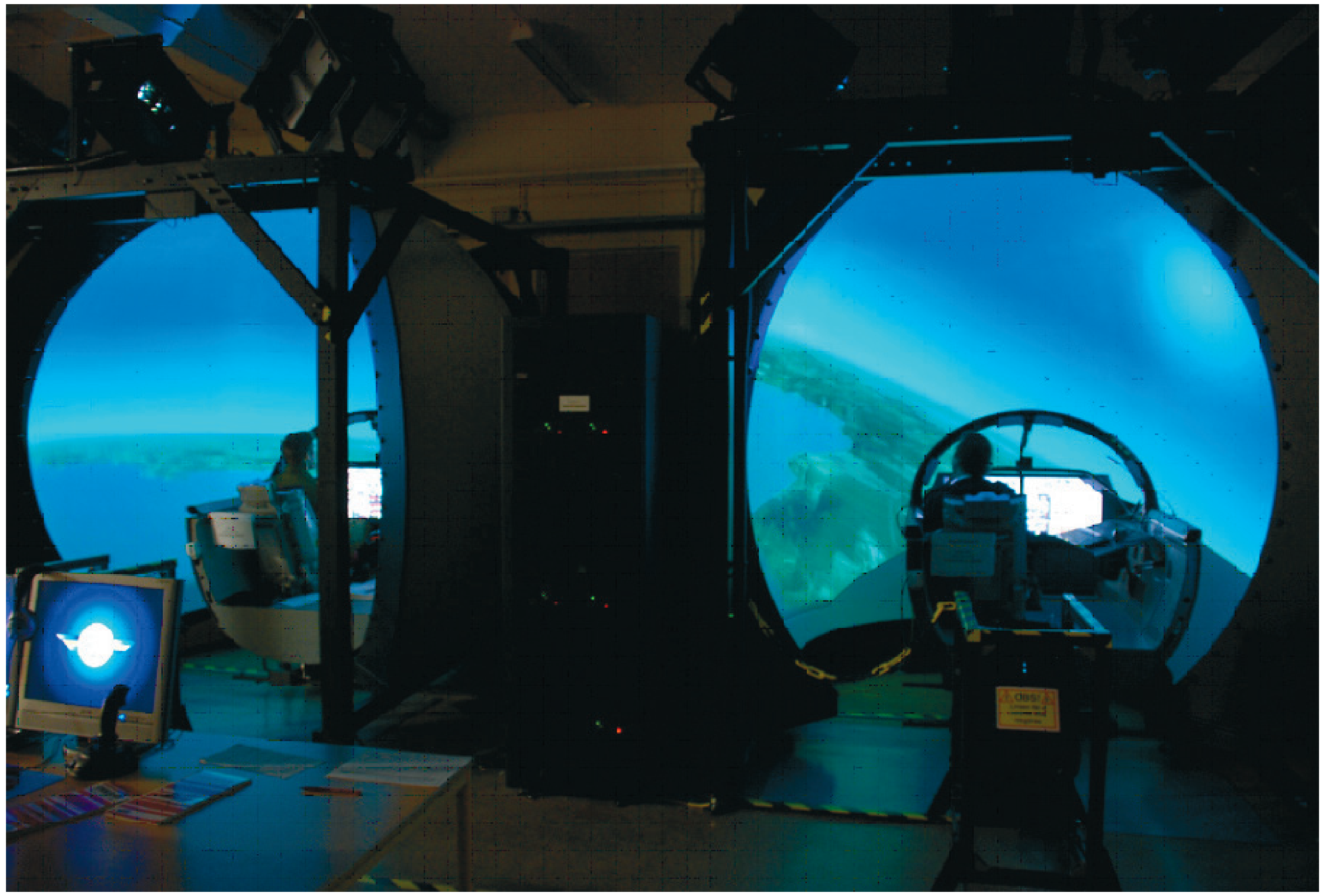

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Sammanfattning

Försvarsmakten använder en stor mängd av olika simulatorer för utbildning, träning och utvärdering. För att öka träningseffektiviteten borde erfarenheter från datorspel kunna användas. Projektets målsättning är därför att skapa och bidra med kunskap avseende hur erfarenheter från dataspel kan användas för ökad träningseffekt vid simulatorträning.

Först ges en teoretisk bakgrund, där olika synpunkter på simulator träning diskuteras. Exempelvis transfer of training, feedback och fidelity. Detta följs av en redogörelse av de aktiviteter som projektet har genomfört under året. Flera studier avseende simulatorträning har genomförts: Stridsvagn 122 simulator, Stridsfordon 90 simulator, Aktiv sonar simulator, Flightbook – flygsimulator, ACES – flygsimulator och MCM Wargaming – en stabsövning avseende ledning av ett internationellt minröjningsuppdrag. En studie avseende motiverande faktorer vid datorspel har också genomförts. Erfarenheter från två konferenser redovisas. Visa aktiviteter har, eller kommer att, presenteras separat. I dessa fall ges en kortare sammanfattning och referens till den separata publikationen.

Resultaten tyder på positiva träningseffekter vid simulatorträning. I två av studierna skattade deltagarna simulatorträningens effekt på deras prestation i verkligheten och på inlärning högre än vad de skattade hur väl simulatorn efterliknade det verkliga systemet (dvs. fidelity). Detta tyder på att hög fidelity inte är nödvändigt för positiva träningseffekter.

Deltagarna i simulatorstudierna hade överlag en mycket positiv inställning till simulatorträning. Flera ansåg att simulatorträningen var både motiverande och rolig. I två av studierna önskade sig deltagarna något mer simulatorträning än vad de fick.

Nyckelord:

Simulatorträning, transfer av träning, fidelity, motivation

Summary

The Swedish Armed Forces are using a large amount of different types of simulators for education, training and evaluation. To enhance training effectiveness, experiences from the gaming industry may be used. Thus, the aim of this project is to create and provide knowledge about how experiences from computer gaming can be used to enhance simulator training effectiveness.

Initially, a theoretical background is given, where different aspects of simulator training are discussed. For example, transfer of training, feedback and fidelity. This is followed by an account of the project activities performed during the year. Several studies of simulator training have been performed: tank 122 simulator, CV90 combat vehicle simulator, active sonar simulator, Fligthbook – flight simulator, ACES – flight simulator, and MCM Wargaming **-** a staff exercise of command and control of an international naval mine countermeasures mission. A study of motivating factors for computer gaming has also been performed. Experiences from two conferences are also given. Some of the activities have been, or will be, reported separately. In those cases, a brief overview and a reference to the separate publication is given.

The results indicate positive transfer of training. In addition, in two of the studies, the ratings of the effect of the training on real world performance and learning were higher than the ratings of the simulators' correspondence with reality. This implies that fidelity is not necessary for positive transfer of training.

The participants in the studies of simulator training generally had a very positive view towards simulator training. Many found the simulator training as both motivating and fun. In two of the studies, the participants wished somewhat more training in the simulators than they were provided.

Keywords:

Simulator training, transfer of training, fidelity, motivation

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1 Introduction

The Swedish Armed Forces are using a large amount of different types of simulators for education, training and evaluation. To enhance training effectiveness, experiences from the gaming industry may be used. Often training simulators are experienced as less positive than computer gaming. Therefore, it is important to getting an understanding of how engagement and motivation can be increased during simulator training. Most likely, education and training can be made more effective (reduced cost, increased learning), if the positive effects from computer gaming, and similar gaming activities, are taken advantage of. Computer games have a great capacity to creating engagement and motivation among players. People voluntarily spend large amounts of time with computer games, and often have the experience of being totally absorbed in a game. Increased engagement and motivation, most likely, also increase training effectiveness.

Thus, the aim of the project is to create and provide knowledge about how experiences from computer gaming can be used to enhance simulator training effectiveness. Previous reports are for example Nählinder & Oskarsson (2007, 2008). The project has cooperation with its sister projects at the Swedish National Defence College (FHS) and the Swedish Materiel Administration (FMV). Together with these partners, knowledge is spread by reports, demonstrations, lectures, and/or joint workshops (FOI, FHS, FMV).

The project has performed a number of different activities during this year. Studies at different simulator sites have been performed: tank 122 simulator, CV90 combat vehicle simulator, active sonar simulator, Fligthbook flight simulator, and ACES flight simulator. A study has been performed at MCM Wargaming - a staff exercise of command and control of an international naval mine countermeasures mission. A study of motivating factors for computer gaming has been performed. Experiences from two conferences are also given. All these activities are described in this report. Some of the activities have been, or will be, reported separately. In those cases, a brief overview and a reference to the separate publication is given.

Initially, a theoretical background is given. The focus is on simulator training and transfer of training to real world performance.

1.1 Military simulator training

In times of peace, safety regulations (not to mention moral considerations) often preclude regular training procedures that would most adequately target key aspects of skill acquisition. If dangerous maneuvers, as aerial combat or equipment failure, are trained in the real aircraft, this may lead to crashes resulting in huge material losses (and the pilot's life). However, many dangerous procedures can be both safely and cost-efficiently trained in the simulator.

Apart from the desire to avoid unnecessary risks on human life, simulator training can save large amounts of money. Since jet fighters bolt lots of fuel, transferring aerial training to simulators on the ground is both economically advantageous and has less negative consequences for the environment. Simulators can also provide more efficient training, since focus can be placed directly on the task that is to be trained. Flying the aircraft in the real world, on the other hand, requires coordination with numerous other services (such as air traffic control, maintenance), and appropriate weather and visibility conditions (Lee, 2005). Maintaining competence for adequate handling of unusual situations, which rarely occur in the real environment, is another important application of simulator training. For example, training of pilot skills of handling different types of equipment failure (e.g., engine, flares, landing gear).

In a simulator, it is also possible to hold different extraneous variables constant. In many cases, this makes it easier for instructors to get an adequate picture of the trainees' skills, or learning curves, on different procedures or maneuvers.

According to Stanton (1996), simulator training appear to be most appropriate for skill training in dynamic environments. That is, when the operator in real time has to interact with the simulation of the real system, and feedback from their actions is necessary. A typical example of a simulation of a dynamic environment is a vehicle simulator. In a military context, the ultimate dynamics is experienced when the vehicle (e.g. fighter jet, tank, submarine) is engaged in battle. However, there are other simulations with high levels of dynamic interaction, for instance a multi-user command and control system, operated in the context of dynamic decision-making.

Unfortunately, training simulators are generally not designed as good instruments for teaching. Modern flight simulators, all too often, lack the proper equipment necessary for providing pedagogical feedback. The simulator may provide a very realistic environment in which training can take place, but the simulator itself is often not built with the purpose of being a teaching device. It replicates a real world situation without providing pedagogical support that might facilitate learning (Nählinder, 2009).

However, attention has been paid to increased training efficiency by means of embedded pedagogical support in simulator training (e.g., Schmorrow et al., 2008; Cohn et al., 2003). ACES (Air Combat Evaluation System) is one example of a flight simulator with an extensive set of embedded training tools (Nählinder, 2004) (see Section 1.2.4 Embedded training tools).

1.2 Learning by training

1.2.1 Transfer of training

Transfer of training refers to how previous learning influences performance in a later situation. In this context, how simulator training influences skill acquisition in the real environment.

Transfer of training can be positive, nil, or negative. Positive transfer refers to improved real world performance of a given task following training in a training environment (i.e. simulator), nil to no effect, and negative transfer to degraded real world performance (Roscoe & Williges, 1980; Alexander, Brunyé, Sidman, & Weil, 2005). Negative transfer can be described as if the trainee reacts correctly according to practice and training, but incorrectly in relation to the real world (Liu, Blickensderfer, Macchiarella, & Vincenzi, 2008a).

Transfer of training can be estimated with somewhat different methods. The methods most commonly used are percentage of transfer, cumulative transfer, and incremental transfer. Percentage of transfer estimates the time saved during real world training that is preceded by simulator training, relative to real world training without prior simulator training. A drawback with the percentage of the transfer formulas is that the amount of prior practice in the simulator is not included. Thus, no conclusions about transfer effectiveness can be made. The cumulative transfer effectiveness function (CTEF) estimates the total time saved during real world training preceded by simulator training, in relation to the amount of prior simulator training. The term transfer effectiveness ration (TER) is also used for CTEF (e.g., Lee, 2005). The incremental transfer effectiveness function (ITEF) estimates the incremental savings of simulator training. For example, the time (trials or error) to reach the performance criterion after t_2 minutes of simulator training compared to t_1 minutes of simulator training, in relation to this difference in time ($t_2 – t_1$). Thus, ITEF can provide a measure of the value of increasing or decreasing the time in simulator with x minutes. Since both cumulative and incremental transfer take the amount of prior simulator training into consideration, cost-efficiency of the simulator training can be estimated (Roscoe & Williges, 1980; Roscoe, 1971).

A problem with these formulas for calculation of transfer of training is that they do not explicitly take into consideration that the difficulty is normally constantly increasing during training. Therefore, proper use of the above presented methods for estimation of transfer of training should be limited to training of well-defined skills in a limited period of time.

Transfer of training from one simulator to another is often referred to as quasi-transfer (e.g., Taylor, Lintern, & Koonce, 1993; Brannick, Prince, & Salas, 2005). The rationale for quasi-transfer is that specific situations that are not often encountered in practice are too dangerous, or less suitable for performance measurements in a real world setting. In pilot training, this can be training of combat or equipment failure. For example, training on a specific task in a PC based system can be evaluated, in a controlled setting, in a simulator with higher fidelity (Brannick et al., 2005).

1.2.2 Pedagogics

The choice of pedagogical method is of great importance. When a training aid is introduced, whether it is literature, study groups or simulators, choices have to be made regarding the pedagogical approach. A simulator, or any other training aid, is seldom of much use if it is just added to the training environment without consideration of how it should be used.

A simulator (as well as any training tool) must fit into the overall pedagogical environment. However, different pedagogical environments require different aspects of a training facility. If one believes that learning takes place inside the student and that teachers are their coaches, a simulator may well be designed to encourage students to explore the possibilities and test the effects of certain actions. On the other hand, in a behavioristic pedagogical environment, the teacher is more important to rule out what is good and what is not good performance and behavior (Borgvall, Castor, Nählinder, Oskarsson, & Svensson, 2007).

In Scenario-based Training (SBT), the training is embedded within an overarching scenario, which in essence becomes a dynamic curriculum. This means that in SBT the curriculum is the exercise (Oser, Cannon-Bowers, Salas, & Dwyer, 1999). This is distinctly different from the traditional classroom approach where training is delivered through a series of lessons, which together constitutes the curricula (Schmorrow et al., 2008). There are four basic tenets of learner oriented design (Oser et al., 1999) upon which the theory of underlying SBT is based (Schmorrow et al., 2008):

- Learning is a cognitive and behavioral process.
- A systematic approach to learning will facilitate skill acquisition and retention.
- Performance must be systematically measured
- Training for complex environments requires a scenario-based approach.

However, few simulator manufacturers – if any – consider building simulators based upon the pedagogical needs of the trainee. The pedagogical requirements can be substantially different from the requirements on physical and functional fidelity (Farmer, van Rooij, Riemersma, Jorna, Moraal, 1999). However, this reference is ten years old. Thus, more research about the present situation should be performed.

The Swedish Air Force, Air Combat Training School, uses a very specific, but established pedagogical model. It is based on the ideas of liberal education, and it differs markedly from the models used by other nations. The idea with this model is to build up the flight students' internal motivation. Other nations are putting pressure on the flight students, by dismissing those who do not meet certain criteria. Thus, one precondition for the Swedish model is a valid and reliable selection process that thoroughly sorts out candidates less suitable for fighter pilot education.

1.2.3 Feedback

Feedback is essential to supporting performance and motivation. Feedback provides the trainees with guidance on how they should adapt their behavior to reach desired goals. Thus, according to Garris, Ahlers, & Driskel (2002) feedback provides an assessment of progress towards goals that drives the motivated learner to expend more effort, to persists, and to focus attention on the task.

Debriefing is a critical part for transfer of learning from the simulator or game to real world performance. According to Garris et al. (2002), the role of the instructor in debriefing learners is a critical component. They indicate that games may be ineffective stand-alone training tools. Because people often have difficulty in abstracting general principles from concrete experience, they do not learn and understand complex relationships from simple exposure or experience alone.

Feedback can be provided after training during after action reviews (AAR). Simulators often support the instructional function of an AAR by replay. However, military flight simulator replays are often implemented in ways that help trainees to recall and learn the unit's overall flying mission, but not the specific parts of their own performance; for example, by presenting of a set of icons moving over a tactical map (Wiese, Freeman, Salter, Stelzer, & Jackson, 2008). On the other hand, flight simulators may very well provide detailed replay, with the trainee fully immersed in all relevant aspects of the replay. For example, Wise et al. (2008) mention an F-16 distributed debriefing system, which combines a central tactical view with instrument displays on each side; and the Dismounted Infantry Virtual After Action Review System (DIVAARS), which provides multiple viewpoints of the simulation space during replay. Another potent example of a complete simulator replay is the pedagogical tools implemented in ACES (see, Section 1.2.4 Embedded training tools).

There are several reasons for providing simulator-generated feedback. Students may train outside scheduled curricula, without the assistance of instructors. Furthermore, if simulators are used in deployed settings, there may be a lack of instructors (Schmorrow et al., 2008). This illustrates the value of autonomous intelligent tutoring systems, which automatically produce feedback and after action reviews. However, above all, simulator-generated feedback can support regular reviews given by experienced instructors, and elucidate course of events.

According to Wiese et al. (2008) simulator-generated replay can present events from multiple points of view, e.g. first-person view, third-person view, and God's eye view, which can provide context and perspective to trainees that otherwise would be difficult to obtain. Wise et al. claim that these types of simulator-generated replay of exercise events greatly facilitate diagnosis, recall, understanding, generalization, and assessment of trainee performance. An applied example of simulator-generated replay is given in the next Section 1.2.4 Embedded training tools.

1.2.4 Embedded training tools

In simulated systems, automated instructions can be given by intelligent tutoring systems or automated training tools. These systems provide the trainee with computer-generated feedback on their performance. Feedback can be given either dynamically or after training (e.g. Schmorrow et al., 2008; Cohn et al., 2003). If simulator training is performed autonomously without guidance from instructors, the training tools can support the learning process. Furthermore, during instructor guided training the training tools are very helpful to elucidating the instructor's views and feedback.

Simulator-generated feedback is the cornerstone of the pedagogical approach in ACES (Air Combat Evaluation System), a VR-based dogfight-training simulator tailored for research purposes. ACES is equipped with a set of specially designed embedded training tools that automatically provides feedback and after action reviews. The tools can be composed in three main categories: temporal, spatial, and analytical (Nählinder, 2004; Nählinder, Borgvall, & Svensson, 2004). However, these categories are partly overlapping. The most frequently used tools are:

- Temporal tools:
  - *Mistake correction* – the pilot starts all over from optional position in performed simulation.
  - *Playback* – replay of performed simulation (backwards or forwards).
  - *Slow/Quick flight* – faster or slower flight speed during simulation/replay (-0.5 to +1.5 times normal speed).
- Spatial tools:
  - *3D traces* – can be presented at optional time interval, dynamically or after the aircraft (see Figure 1).
  - *Altitude markers* – show dynamically aircraft altitude (see Figure 1).
  - *Change to opponent's aircraft* – at restart at an optional section of a performed simulation.
  - *Camera view* – at playback, the pilots can dynamically maneuver the camera view, and view the simulation from outside own aircraft.
  - *Backseat* – at playback, one pilot can view the simulation, including instrumentation, from the backseat of the other aircraft.
- Analytical tools, with presented graphics make it possible to dynamically follow the relationship between the two aircraft:
  - *Geometrical advantage*
  - *Energy advantage* (see Figure 1).
  - *Target angle* (see Figure 1), angles to and from the other aircraft.
  - *Turning speed versus loss of energy.*
  - *Turning radius versus loss of energy.*

A preliminary evaluation of the embedded training tools (Berggren & Nählinder, 2004), and an evaluation with military flight students and instructors from the Swedish Air Force Air Combat Training School (Nählinder, Bergren & Persson, 2005) has been performed. Both flight students and instructors had a positive view towards the training tools, and considered them having high potential for assisting tactical flight training. Moreover, a study has been performed where flight students at the Swedish Air Force Air Combat Training School's basic flight training program were provided training on specific maneuvers in ACES, prior to training the same maneuvers in the real aircraft (see Section 2.6 ACES – flight training simulator). The results indicate that the simulator training in ACES provided enhanced understanding of maneuvering, and in particular in relation to other aircraft.

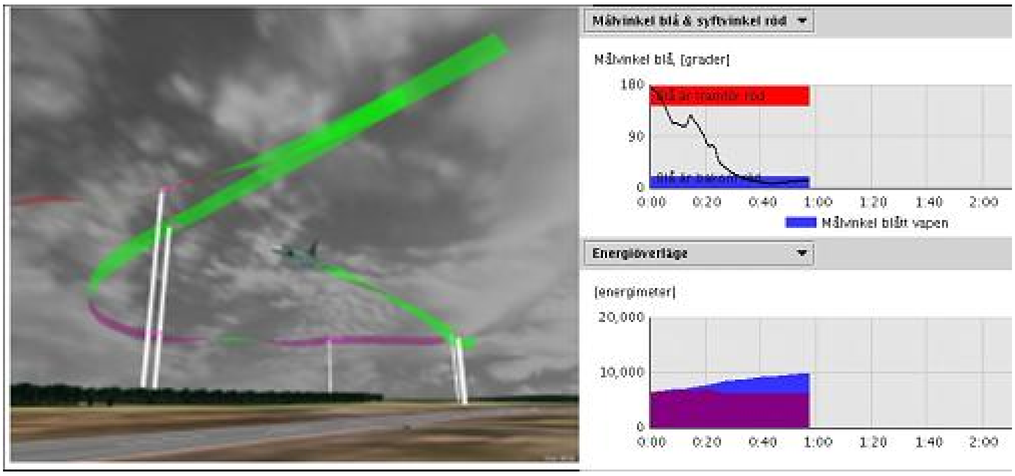

Figure 1. To the left, example of an embedded training tool with 3D traces and altitude markers after the aircraft. To the right, example of an analytic tool, presenting graphs with target angle and energy advantage.

1.2.5 Time

Amount of time spent on training in a simulator is, above all, dependent on the organization’s willingness to provide simulator time in the learning schedule. Thus, organizational factors and pedagogical approach are key factors for making simulator time available. However, motivational factors have a major influence on the willingness of the trainees to spend their time in the simulator.

Time of training in the simulator for a specific task is inversely proportional to training effectiveness. Thus, the first hours in the simulator provide the largest training effectiveness. To estimate a threshold for efficient number of hours in the simulator, for a specific task, the incremental or cumulative training effectiveness can be calculated (see Section 1.2.1 Transfer of training).

1.2.6 Motivation

Motivation is an important factor for learning. Motivation can be described as the willingness or desire to engage in a task. Motivated learners are thus more interested and involved, devote more time on a task, and are more committed to continued task activity. Motivated learners are enthusiastic, focused and engaged, and interested in what they are doing; and their behavior is self-determined, and driven by their own volition rather than external forces (Garris et al., 2002).

Effects of emotional involvement on performance have been shown in an experiment of war game playing (Delta Force OTS). Prior to playing the game, half of the subjects (the experimental group) watched graphically intense war scenes from the D-day invasion in *Saving Private Ryan*. The other half of the subjects (the control group) watched a non-stimulating black and white documentary of the beach invasion. After watching the film, the experimental group had higher levels of stress and arousal. They also had significantly better scores on mission success (Morris, Hancock, & Shirkey, 2004).

1.3 Simulators

1.3.1 Types of simulators

In general, simulators have been designed to meet user requirements in three areas: a) entertainment; b) personnel training, selection, and testing, and c) aircraft testing (Kaiser & Schroeder, 2003).

In this report, the focus is on simulators designed for training of military personnel. However, in simulators designed for entertainment, there are several appealing aspects, e.g. concerning motivation and amusement. These aspects are driving forces that induce participants to play for hours, and by free will compete for better results. To examine, and isolate, the importance of these factors, and if possible incorporating them in training simulators and training curricula might be a viable way of further improving the transfer of training from the simulator to the real environment.

The boundaries between computer games, entertainment, and training simulators can be rather fuzzy. Several commercial computer games have been used for training of co-ordination and command and control, of both military and civilian operations, and for studies of communication and common situational awareness and expertise (e.g., Hasewinkel & Lindoff, 2002). In addition, a number of commercial computer games can be modified, for instance by change of game world, which may be used to provide a specific study with the proper context. Thus, commercial computer games for training and research can provide a viable alternative to expensive development of specific simulations. Furthermore, some computer games are designed for training, a.k.a. serious games. For example, *The Rapid Decision Trainer* is a virtual and interactive game engine-based simulation developed for the US Army's Infantry Officer Basic Course; and *America's Army* is a serious internet based multiplayer game directed by US Army Office of Economic Manpower Analysis) (Nählinder & Oskarsson, 2007).

The Swedish Armed Forces are using a large amount of training simulators; for example flight simulators, helicopter simulators, combat vehicle simulators, simulators for marine vessels, and simulators for specific operator tasks. There are also simulations with focus on dynamic and cognitive decision-making, e.g. command and control and air-traffic control.

1.3.2 Fidelity

Fidelity is the degree of similarity between the simulator and the equipment that is being simulated, including scenarios, AI etc. Fidelity can be represented in several dimensions. The dimensions most commonly used are the degree to which the simulator looks like (physical fidelity), acts like (functional fidelity), and creates similar psychological reactions (psychological fidelity) as the equipment being simulated (Stanton, 1996).

Physical fidelity concerns the graphics of the simulation, such as screen resolution and type of display (e.g., CRT, LCD, plasma, projection, domes and VR displays). It also concerns the realism of instrumentation, flight stick, knobs, levers, and pedals, and the choice between motion-based and not motion-based (stationary or fixed) simulation. Thus, physical fidelity can be partitioned in several dimensions: e.g., visual-audio fidelity, equipment fidelity, and motion fidelity (e.g., Liu, Macchiarella, & Vincenzi, 2008b)

Functional fidelity concerns the presentation of proper scenarios, realistic environments, and relevant training tasks. It also concerns the realism and tactics of simulation models (e.g., behavior of computer generated forces, radar models, weapon models, and electronic warfare models).

Psychological fidelity concerns the degree to which psychological factors (e.g., fear, stress) that are experienced in the real environment are also experienced in the simulator. That is, if training in the simulator induces the same psychological reactions that are experienced in reality. Thus, psychological fidelity is ultimately a measure of how accurately the simulator engages the trainee. An example of psychological fidelity is if the psychological responses that are experienced in a real aircraft are also replicated in the simulator. Replication of psychological fidelity has been shown in a simulator study performed by the Swedish Defence Research Agency. During the attack phase of an air-to-ground mission, both heart rate and heart rate variability showed a very high association between training in the simulator and in the real aircraft. That is, the pilots' reactions in the simulator were very similar to what they were in the real aircraft. This indicates that the pilots were exposed to the same reactions in the simulator as in the real aircraft, thus validating the use of the simulator (Magnusson, 2002). The term cognitive fidelity is also used, referring to the extent the trainee is engaged in the same sort of cognitive activities in the simulator as in the real environment, e.g. juggling multiple tasks, supervising automated subsystems and maintaining situational awareness and an accurate mental model of air-craft dynamics (Kaiser and Schroeder, 2003; Liu et al., 2008b).

The separation of fidelity into separate dimensions is not unproblematic, for example, physical and functional fidelity are far from orthogonal. For instance, realistic radio communication in cockpit with air-traffic controllers (ATC) usually refers to functional fidelity, whereas equipment for sound generation, amplifiers, loudspeakers etc. usually refer to physical fidelity. However, if the sound system presents engine sound, the sound usually refers to physical fidelity.

Concerning physical fidelity, there is considerable disagreement of whether including motion in flight simulators contribute to transfer of training or not. Several studies have failed to show that motion based simulation increases the effects of training (e.g., Koonce, 1979; Roscoe, 1980; Lee & Bussolari, 1989; Bürki-Cohen, Soja, & Longbridge, 1998). Liu et al. (2008b) mean that the use of motion does indeed increase physical fidelity and realism, but with minimal and insignificant benefits concerning transfer of training. Moreover, for fighters performing extreme maneuvers, the motion errors in the simulation are considerable, and thus not practical for that application (Kaiser & Schroeder, 2003). On the other hand, there are arguments that studies of motion-based simulators have been performed on simulators with poor motion systems (e.g., Cardullo, 1991). This view is supported by Bürki-Cohen et al. (2003) who reports on a study that showed no training effects of motion. Objective measures of the motion characteristics of the FAA qualified simulator in this study showed that lateral acceleration stimulation was minimal. Furthermore, subsequent comparisons showed that attenuated lateral acceleration might be typical for the type of simulator that is used in airline training and evaluation. Kaiser and Schroeder (2003) consider the value of motion as strongly dependent on two factors – the task that is trained and the motion dynamics. However, according to Vaden and Hall (2005), the most important issue is perhaps not whether motion based simulation has effects on training or not, but if potential effects are large enough to motivate additional expenses and other drawbacks associated with motion based systems.

There is no unitary view of how much fidelity a simulator must have for achieving effective transfer of training. In part, the level is dependent on what type of training that is performed. For instance, perceptual-motor tasks require a higher level of physical fidelity than cognitive tasks (Stanton, 1966). However, the balance between cost and training efficiency is a matter of concern for all types of fidelity. Developing simulators with high fidelity generally incur great expenses. Thus, the common view is that simulators with excessive levels of fidelity may not be very cost-effective. Therefore, identification of certain key elements of fidelity that do not contribute much to increased transfer of training may lead to reduced costs of simulator production (e.g., Liu, et al., 2008b).

According to Alessi (1988), the optimal level of fidelity for learning is dependent on the expertise of the trainee. A novice flight student who encounters the highest possible level of fidelity (i.e. flying the real aircraft) may be so confused and stressed that no learning occurs at all. The experienced flight student who is exposed to high levels of fidelity in the simulator may learn more, but less with the highest level of fidelity in the real aircraft (but more than the novice pilot). The expert pilot, on other hand, may learn more, the more the fidelity is increased. In line with these arguments, learning as a function of fidelity seems to be u-shaped for novices and experienced pilots (lower learning with lower and higher fidelity), and asymptotically increasing for expert pilots (illustrated in Figure 2).

Thus, a delicate undertaking for simulator developers and training curricula composers is to balance the level of fidelity with regard to expertise and type of training. A problem is that if the fidelity for a novice is too low, learning might be high within the simulator, but with low transfer to the real world low. Alessi (1988) suggests that initial learning is emphasized for novices and transfer for advanced students. In line with this Alessi (1988) suggested varied levels of fidelity within individual phases, e.g. increasing fidelity by phase of instruction; and dynamic variation of fidelity based on student progress and performance. Alessi points out that the following questions are important, but remain to be answered. How low should the initial low-fidelity simulation for the beginner be before it causes decrements in later use with higher fidelity? How high should the fidelity be for more experienced students? What aspects of the simulation should be more or less realistic?

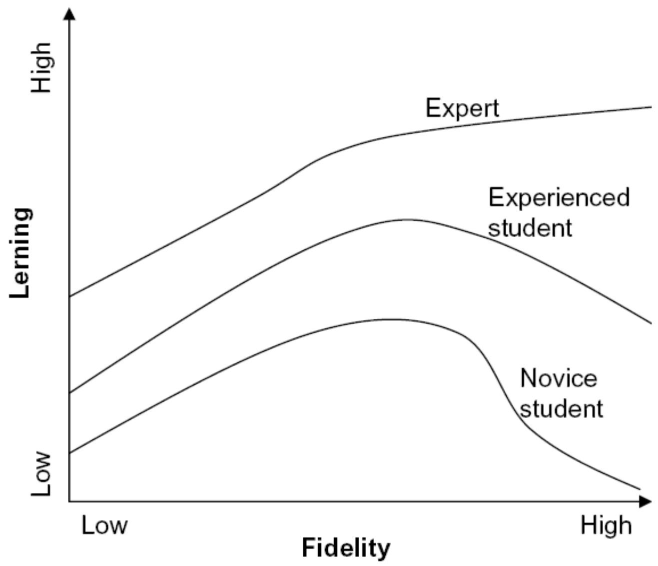

Figure 2. Hypothesized relationship of fidelity and learning (adapted from Alessi, 1998).

1.3.3 Presence

Presence is defined as the subjective experience of being in one place or environment, but physically situated in another (i.e., the simulator). Important factors for presence are degree of immersion in the virtual environment, involvement, and control over the task environment (Witmer & Singer, 1998).

Witmer and Singer (1998) have developed a presence questionnaire with the purpose of measuring presence in virtual environments. Researchers at the Swedish Defence Research Agency have adapted and translated the questionnaire to Swedish. It has been used in a validation study of ACES (Air Combat Evaluation System). The methodology has been briefly described (Berggren, Oskarsson, Nählinder, & Borgvall, 2005). The experienced presence was generally moderately high; the exception was the low ratings of the quality of the picture in the HMD (Oskarsson, 2005).

2 Project activities

The main purpose has been knowledge acquisition concerning factors related to simulator training effectiveness and motivation. One objective is to investigate how military simulator training can take advantage of concepts, like motivation and having fun, from the gaming industry. Thus, making simulator trainees more motivated and experience more fun during simulator training

The project has performed a number of studies of simulator training: the tank 122 simulator, CV 90 simulator, active sonar simulator, MCM wargaming, and ACES a VR based flight training simulator. The main focus of these studies has been motivation, fun, and training effectiveness. Except for the ACES study that had a somewhat different design, in principal, the same questionnaire has been used in these studies.

Project members have also supervised two academic essays. A flight student at the Swedish Air Combat Training School made a preliminary study of Flightbook, the school's pilot training simulator. A student at the cognitive science program at Linköping University made a study of motivating factors for commercial computer and video game playing. These studies have been reported previously, and are thus only cursory described in this report.

Project members have visited the Game Developers conference in San Francisco, and the Military Flight Training conference in London. Overviews of the most important impressions from these conferences are given.

2.1 Tank 122 training simulator

The tank 122 simulator (sw. BTA – Besättningsträningsanläggning) at the Swedish army's Land Warfare Centre (LWC) (sw. Markstridsskolan) consists of three tank simulators and one control station. There are four operators in each simulated tank: driver, gunner, loader, and commander. The environment in the simulated tanks is relatively realistically simulated (Figure 3). The simulated tanks can operate in the same simulated environment.

Figure 3. View from the tank 122 training simulator.

2.1.1 Methods

A questionnaire that consisted of both 7-point rating scales and open questions was used. The questionnaire was originally designed for Flightbook (see Section 2.5 Flightbook – flight training simulator).Two versions of the questionnaire were used, one for the instructors (72 questions) and one for the trainees 76 questions). In principal, the same questions were asked to instructors and trainees. The trainees were asked about their own view. The instructors were asked about their view of how the trainees experienced the simulator; except for correspondence with reality, fidelity, instructor control, and frequency of use for different types of training where they were asked about their own experience.

The questionnaire was answered in connection with performed training, during breaks in the training schedule.

Ten officers answered the questionnaire concerning simulator training. Of these seven were trainees and three were instructors at the simulator. The answers of one trainee were cancelled because of too little experience with the simulator (6 hours) and the real tank (0 hours). The age of the trainees was 35.0 ±4.2 (Mean ±SD) years and of the instructors 39.3 ±2.3 years. Number of years in the army of the trainees was 13.7 ±6.7 and of the instructors 18.7 ±2.1 years. Rated time of playing computer games (seldom – often) of the trainees was 3.7 ±2.2 and of the instructors 5.7 ±0.6. The instructors had served as instructors for 15.0 ±0.0 years (one did not answer) and at this simulator for 8.0 ±2.0 years. The trainees had driven a real tank 122 for 821 ±391 hours. Their experience of the CV90 simulator was 198 ±148 hours.

Their general attitudes towards simulator training as a complement to real world training (very negative – very positive) were very high and unanimous, for the trainees 6.7 ±0.5 and for the instructors 6.7 ±0.6.

2.1.2 Results

Since there were only three instructors, inferential statistics is not used for comparisons between the trainees and instructors. Thus, the results are only analyzed with descriptive statistics.

The ratings of the participants’ points of views of using the simulator and the training are given in Figure 4. Each mean value in Figure 4 is calculated from a number of underlying questions.

Both the correspondence with reality and the feeling of presence was rated high. However, one participant commented that the simulation of the driving task was not so good. One instructor commented that the feeling of being inside a tank could be better. However, another commented that the sound and graphics were good enough for its purpose.

The effects on real performance were rated very high. The participants commented improved performance on basic handling of knobs, levers, fire control system, shooting with programmable ammunition, communication both within the tank and between different units, order giving, controlling a tank platoon, understanding of fighting, and routines. One participant commented that “overlearning” always facilitates performance in real world situations.

Feedback was rated very high. Feedback both included amount of feedback provided from the simulator and the instructors, and the usefulness of this feedback. One instructor commented that the feedback is given by the functions in the simulator, and that a skillful instructor that uses the system in the right way can obtain very good effects.

Motivation of using the simulator is rated very high. Fun to using the simulator (very boring – very fun) was rated high by the instructors and very high by the trainees. This is the mean value of the different types of training illustrated in Figure 5. As can be seen on the small error bars (Figure 4), these ratings were very consistent. One instructor commented that the soldiers generally experience moments of fighting as fun – surviving and defeating the enemy – especially fighting against human opponents (the comrades in the other simulators during double-sided training). In these cases, the feeling of competition is very high.

The amount of learning when using the simulator for different types of training was rated high. This is the mean value of the different types of training illustrated in Figure 5 (the ratings of gaming, just for fun was excluded since its low frequency of use). One instructor commented that the simulator is just one tool by many for education. It is a very valuable, tool to quickly reaching a certain level of skill. After that level is reached, training in a real tank with live ammunition is necessary.

The usability of the simulator was rated moderately high by the trainees, and moderately low by the instructors. Usability concerned both questions about starting/stopping the simulator and questions about changing the conditions for the simulator. Concerning starting/stopping the ratings were relatively consistent between the trainees (means 3.2 – 4.0) and instructors (means 3.3 – 3.7). It was the ratings concerning changing the settings that differed most between the trainees (mean 5.2 – 6.2) and instructors (mean 2.7 – 3.0). However, as can be seen on the error bars (SD), the individual differences were large. Possibly the trainees had less understanding of changing settings, and overrated their ability. One instructor commented that it is an advanced training simulator, and that it is necessary to involve a system operator in order to get full effect of the training. One of the trainees commented that if a system operator was educated at the company, the availability would increase.

The instructor control of the training was rated high. One instructor commented that there are regulations for what the crew must learn, and that it is the responsibility of the instructors to choose proper training tasks. One of the trainees commented that a carefully considered training plan gives better effect of the training.

The availability of the simulator was rated relatively high by the instructors, but only on the middle of the scale by the trainees. The open questions showed that some of the trainees did not work at LWC. Thus, they have to travel to LWC in order to perform training. This may explain the lower mean ratings among the trainees, and their large error bars (SD), which reflect their differences in views. Those trainees that were working at LWC commented that the availability was no problem, but one of them commented that it was difficult to get time for training. One instructor commented that there is a lack of instructors, which implies problems for availability. Also, since the trainees in this study had great experience with both the real tank 122 and the simulator, they had no need for regular training.

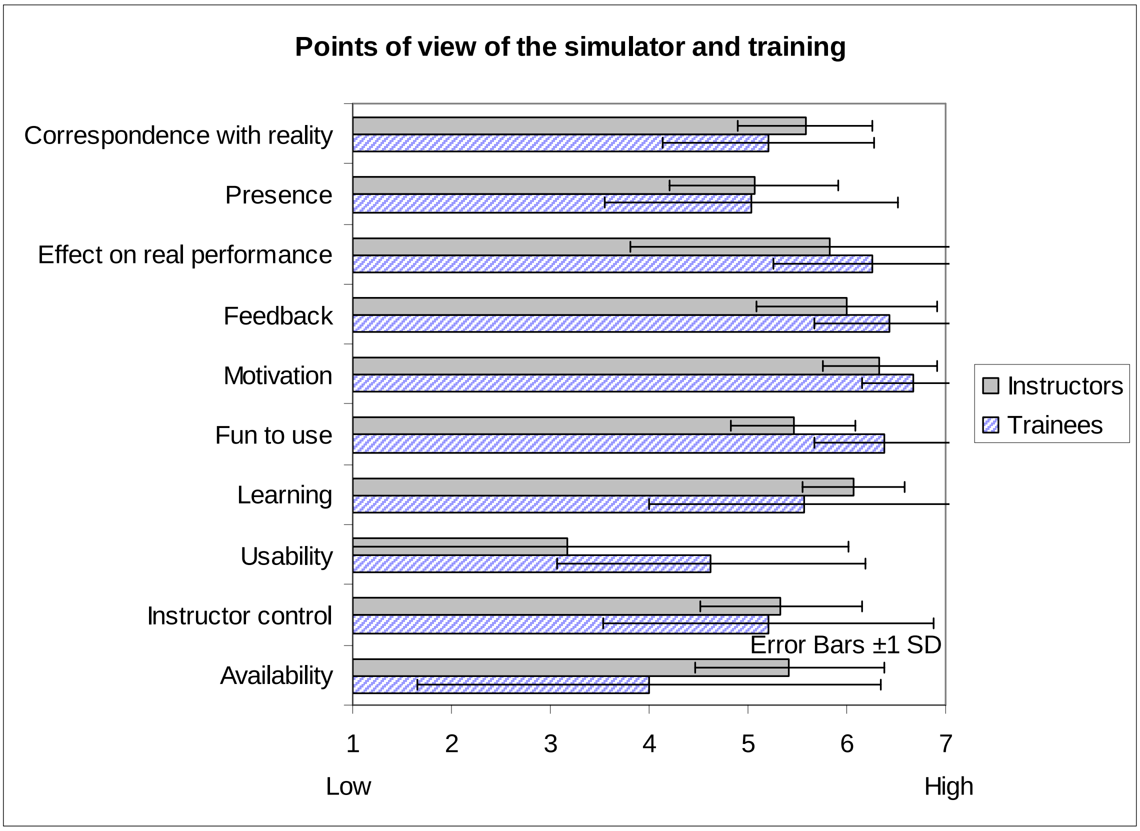

Figure 4. Ratings of points of view of the simulator and the training.

The ratings of how often the simulator is used for different types of training show that the instructors generally rate the frequency of use at higher than the trainees (Figure 5). However, even if the rated levels differ, the proportion is similar, i.e. the types of training that is rated as most/least frequent by the instructors is also rated as most/least frequent by the trainees.

Team cooperation, difficult actions, and things that cannot be trained in reality are rated as most frequent. Basic handling is rated as moderately frequent. Emergencies and preparation before training in reality is rated as intermediately frequent. Gaming, just for fun is according to the ratings occurring seldom. This is in line with the ratings of high instructor control over the simulation, which was illustrated in Figure 4.

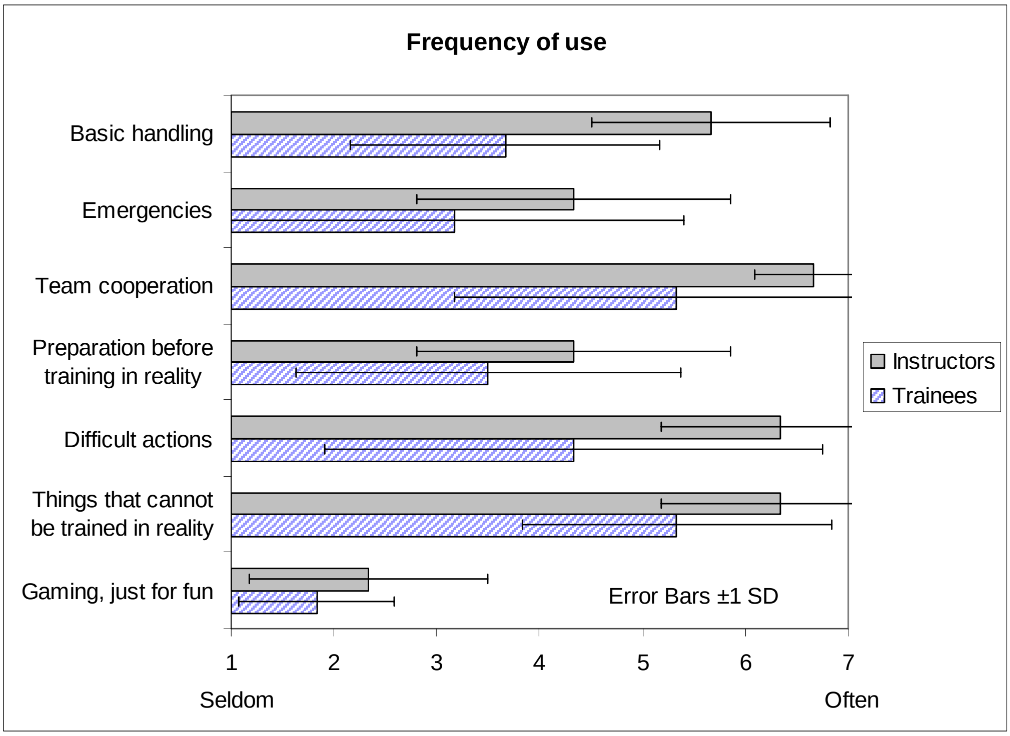

Figure 5. Ratings of how frequently the simulator is used for different types of training.

2.1.3 Discussion

All trainees were officers with rather a long period of service in the army, and great experience of both the real and simulated tank 122. In addition, the instructors had long experience with this simulator and as serving as instructors. This implies a good understanding of simulator training, and thus gives validity to their ratings of the simulator.

In principal, all ratings except usability and availability were high. This could be expected since the simulator is not supposed to be controlled by the trainees, and some trainees were from other military bases with no tank 122 simulator.

It is interesting that the ratings of how fun it is to use the simulator were higher by the trainees than by the instructors. Thus even if the difference is small, the instructors seem to have underrated how fun the trainees found the simulation.

It is also interesting that the ratings of effects on real performance and learning were somewhat higher than correspondence with reality and presence. Even if this difference is small, it supports the view that the simulation does not have to be a perfect copy of reality in order to provide positive transfer of training.

It is also interesting that the simulator was very seldom used for gaming just for fun. Nevertheless, the ratings of how fun it is with gaming just for fun were very high and consistent, by the trainees 6.7 ±0.5, and by the instructors 7.0 ±0.0.

2.2 CV90 training simulator

The CV90 (Combat Vehicle 90) simulator at the Swedish army’s Land Warfare Centre (LWC) (Markstridsskolan) can simultaneously train three CV90 crews; and will be enlarged to four crews. There are three operators in each CV90 crew: driver, gunner, and commander. They sit side by side in the simulator. They drive, shoot and interact with the simulator by PC based game controllers. In front of each crew member are three computer screens, which display instrumentation and simulated environment. The three CV90 crews are separated by walls in the simulator. The simulator is placed within a container, which can easily be moved by truck between training sites (Figure 6).

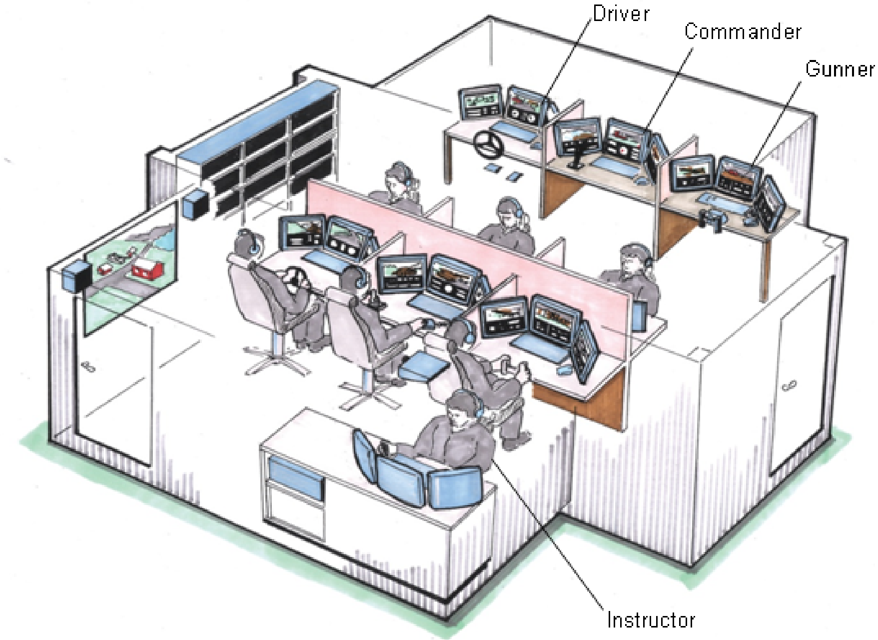

Figure 6. View of the CV90 simulator within the container. The three crew members in each of the three simulated CV90s (only two manned in the figure) sitting side by side.

2.2.1 Methods

The same questionnaire that was used in the tank 122 simulator study was used for the CV90 simulator. It consisted of both 7-point rating scales and open question.

Seventy-five questionnaires were sent to the simulator crew at the Swedish army's Land Warfare Centre (LWC). They distributed twenty-five questionnaires to each of three military bases, were training with the CV90 simulator was planned during the autumn 2009. When this report was published, we had only received the answers from one military Base (Revinghed).

Nineteen trainees (soldiers) and three instructors (officers) at Revingehed answered the questionnaire. The age or the trainees was 18.9 ±0.2 (Mean ±SD) years and of the instructors 31.7 ±3.5 years. Number of years in the army of the trainees was 0.5 ±0.0 and of the instructors 12.0 ±2.6 years. Rated time of playing computer games (seldom – often) of the trainees was 5.6 ±1.0 and of the instructors 2.7 ±1.5. The instructors had served as instructors for 6.0 ±2.6 years and at this simulator for 3.0 ±1.0 years. The trainees had not driven real CV90, except for two who had been driving for thirty minutes. Their experience of the CV90 simulator was 15.7 ±1.4 hours.

Their general attitudes towards simulator training as a complement to real world training (very negative – very positive) were high among the trainees 5.2 ±1.2 and very high among the instructors 6.7 ±0.6.

2.2.2 Results

Since there were only three instructors, inferential statistics is not used for comparisons between the trainees and instructors. Thus, the results are only analyzed with descriptive statistics.

The ratings of the participants' points of views of using the simulator and the training are given in Figure 7. Each mean value is calculated from a number of underlying questions.

The correspondence with reality was only rated moderately high, and the feeling of presence during the simulation was rated relatively low, just below the mean of the scale. The comments also indicate that for example sounds, graphics, and the driving task need to be improved.

The effects of the training in the simulator on real world performance were rated very high by the instructors and high by the trainees. Here it should be pointed out that the trainees had no experience of real world performance. Nevertheless, they commented positive effects of training, e.g. correct sequences of buttons to be pushed, target following, aiming with different types of ammunition. The instructors commented improvements concerning system understanding, e.g. fire direction system, and that mass training has effects.

The feedback was rated realtively high. In spite of this, one instuctor commented that there is no compilation of results.

Motivation was rated very high by the instructors, but only moderately high by the trainees.

Fun to use the simulator was rated moderately high by the instructors, but lower by the trainees, just above the mean of the scale. One trainee commented that it would be fun to try gaming just for fun.

The amount of learning from using the simulator was rated realtively high by the instructors, but somewhat lower by the trainees. Again, it should be called to attention that the trainees had relatively little experience of using the simulator.

The usability of the simulator was only rated moderately high, just above the mean of the scale. The trainees commented that they had not yeat been taught to handle start up and settings of the simulator, and that this was performed by the instructors.

The instructor control was rated moderately high by the instructors and high by the trainees. One trainee commented that more voluntary training would be good, for training on individual needs.

The availability was rated jus above mean by the instructors and moderately high by the trainees. Both instructors and trainees commented that training can only be performed on scheduled time. The instructors also commented that the simulator ought to be expanded to twelve places, to simultaneously train a platoon. The trainees used the simulator for 2.7 ±1.2 times a week, and wished to used for 3.1 ±1.2 times a week.

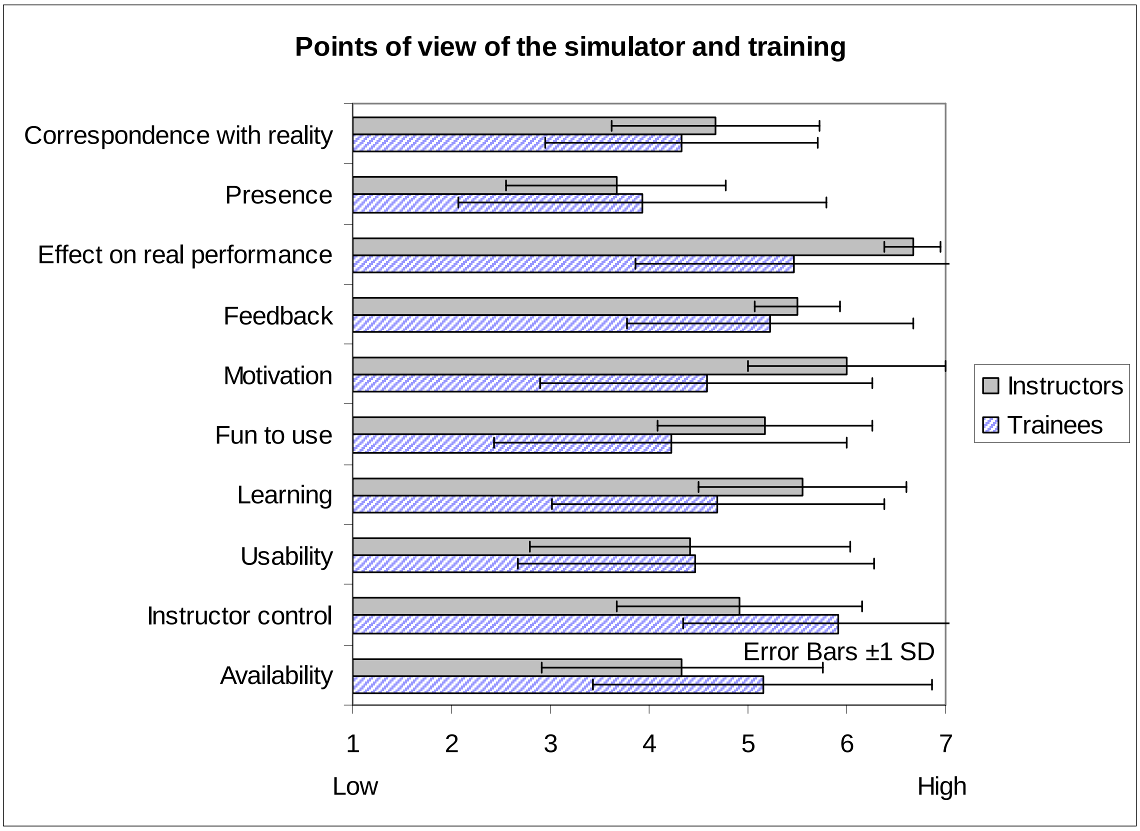

Figure 7. Ratings of points of view of the simulator and the training.

The ratings of how often the simulator is used for different types of training were very high for training of basic handling (Figure 8). The ratings were only moderately high for preparation before training in reality and training on difficult actions. Considering that the trainees had no experience of the real CV90, their ratings of frequency of training for preparation in reality are high. Perhaps they were thinking of their future training in reality? The ratings of frequency of team cooperation were high among the instructors, but very low among the trainees. Training things that cannot be trained in reality were rated low, and training on emergencies were very low. Gaming just for fun was rated very low (all instructors rated one). One trainee commented that gaming just for fun does not occur in the simulators.

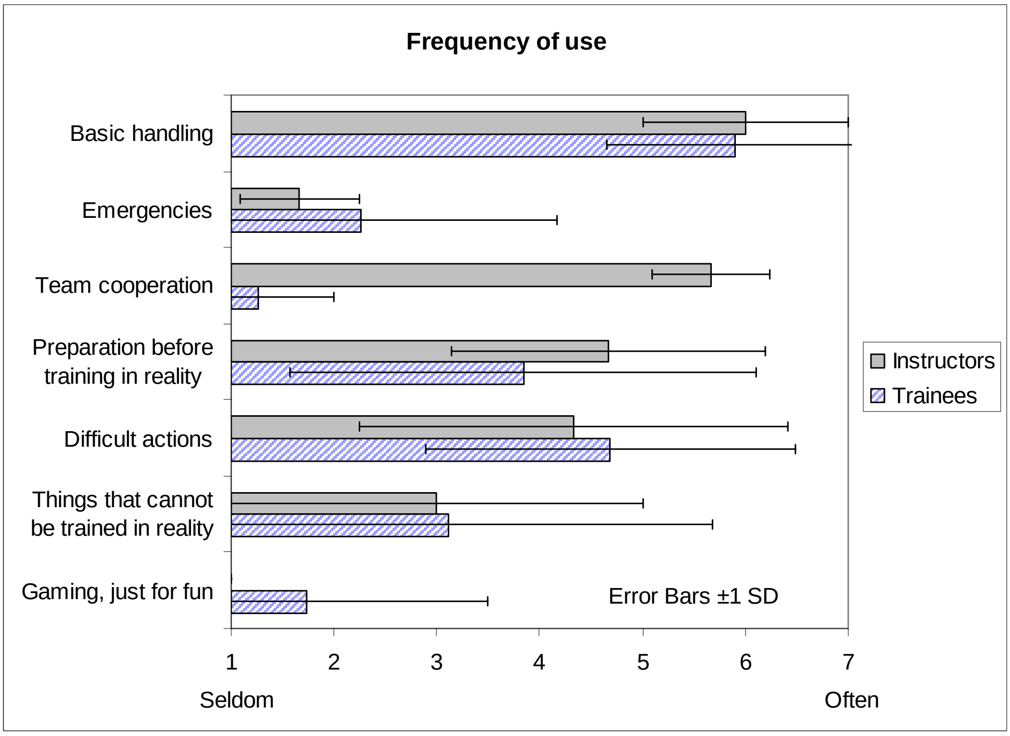

Figure 8. Ratings of how frequently the simulator is used for different types of training.

2.2.3 Discussion

The participants had, in principle, no experience of driving a real CV90 and their experience of the simulator was relatively low.

Considering that the trainees had no experience of the real CV90, their ratings of frequency of training for preparation in reality are high. Perhaps they were thinking of the effects on their future training in reality?

The relatively low ratings of correspondence with reality and presence can be explained by that the simulator is relatively simple. It was also commented sounds, graphics, and the driving task would need to be improved. However, the ratings of both effect on real performance and learning were higher than correspondence with reality and presence. This is in line with the results from the tank 122 simulator, and indicates that perfect correspondence with the real world is not necessary for positive transfer of training.

The instructors expected higher motivation and fun to use than the trainees experienced. This is contrary to the results from the tank 122 simulator. However, the trainees wished to use the simulator somewhat more often than what they were given the opportunity to do.

The ratings of how often the simulator is used for team training differed very much between the instructors who rated it as often, and the trainees as seldom occurring. One possibility is that the trainees had not yet received training on team cooperation; while the instructors were thinking of training in general with more experienced trainees.

2.3 Active sonar simulator

Hugin is an active sonar ASW simulator for anti-submarine warfare at the Naval Warfare Center. It consists of three separate training stations and one instructor station. That means that three teams of sonar operators can be independently trained at the same time. Two of the stations can be operated by three operators, and one by two operators.

2.3.1 Methods

The questionnaire that was used for tank 122 Simulator study was adapted for the sonar operator simulator. The questionnaire consisted of both 7-point rating scales and open questions. Seventy-one questions were asked to the trainees, and sixty-seven questions were asked to the instructors. In principal, the same questions were asked to instructors and trainees. The trainees were asked about their own view. The instructors were asked about their view of how the trainees experienced the simulator; except for correspondence with reality, fidelity, instructor control, and frequency of use for different types of training where they were asked about their own experience.

The questionnaire was answered in the afternoon, during our visit at the site. Simulator training had been performed in the morning on the same day. One instructor was on business journey and answered the questionnaire on the following week.

Seven trainees (soldiers) and three simulator instructors (officers) answered the questionnaire. The age of the trainees was 22.7 ±1.1 (Mean ±SD) years and of the instructors 40.3 ±9.6 years. Number of years in the Swedish Defence Forces of the trainees was 2.4 ±0.7 years and of the instructors 16.3 ±10.0 years. Rated time of playing computer games (seldom – often) of the trainees was 3.9 ±2.0 and of the instructors 2.0 ±0.0. The instructors had served as instructors for 7.0 ±6.9 years and at this simulator for 2.3 ±1.2 years. Two of the trainees had operated a real active sonar for 40 hours; the others had not operated a real system. Their experience of the active sonar simulator was 42.9 ±7.6 hours.

Their general attitudes towards simulator training as a complement to real world training (very negative – very positive) were very high and unanimous, for the trainees 6.6 ±0.8, and for the instructors 7.0 ±0.0.

2.3.2 Results

Since there were only three instructors, inferential statistics is not used for comparisons between the trainees and instructors. Thus, the results are only analyzed with descriptive statistics.

The ratings of the participants' points of views of using the simulator and the training are given in Figure 9. Each mean value is calculated from a number of underlying questions.

The correspondence with reality was rated relatively high. One instructor commented that the simulator is rather old, but that it is good enough for its purpose. However, they also commented that there are differences from reality that might render difficulties.

The feeling of presence and the effect on real performance were rated relatively high. The instructors commented positive effects on both functional and technical handling, and methodology.

Feedback was rated relatively high. One instructor commented that feedback is given after each training session.

Both motivation and fun when using the simulator were rated high by the trainees, but lower by the instructors. That is, the trainees experienced training in the simulator as more amusing than the instructors expected.

Learning was rated relatively high. One instructor commented that the simulator provides mass training, which may be difficult to achieve in reality.

The usability was rated low by the instructors and in the middle of the scale by the trainees. The low ratings were due to the need of an operating engineer to run the simulator, and no possibilities to saving the simulation.

The instructor control was rated relatively high. The availability was also rated relatively high. This means high availability according to scheduled learning plan. Thus, the simulator was only used on scheduled time. However, on averge the trainees used the simulator for 3.1 ±1.1 times a week, and wished to used for 3.6 ±3.2 times a week.

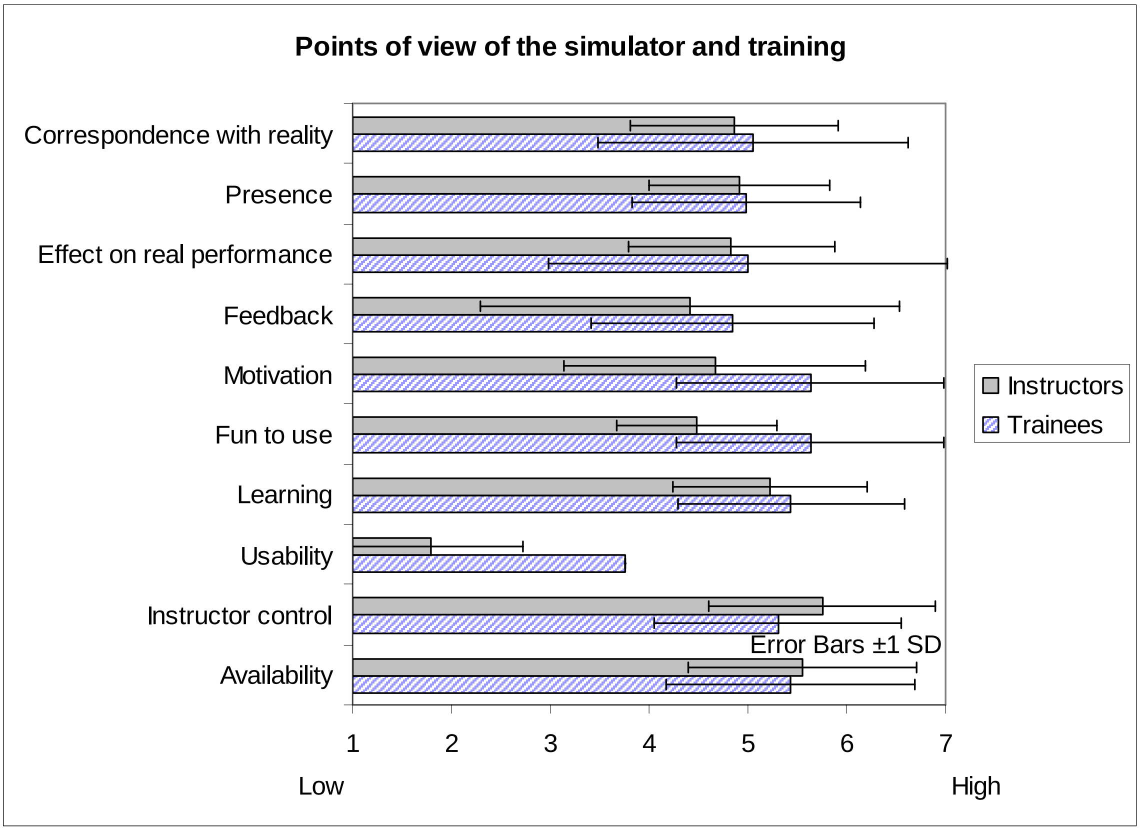

Figure 9. Ratings of points of view of the simulator and the training.

The rated frequency of using the simulator for different types of training is illustrated in Figure 10.

The simulator was mainly used for basic handling and cooperation within the team. The lower mean ratings by the instructors are dependent on low ratings by one instructor, illustrated by the large error bars.

Cooperation with other units was rated on the middle of the scale. However, both instructors and trainees disagreed with each other, two instructors rated often (six and seven), while one rated seldom (one); and three of the trainees rated often (seven), while three rated seldom (one).

Preparation before training in reality was rated as relatively infrequent. However, there was disagreement among the trainees.

Training on difficult actions was rated on the middle of the scale.

Things that cannot be trained in reality was rated as relatively seldom occurring. However, here it was disagreement among the instructors.

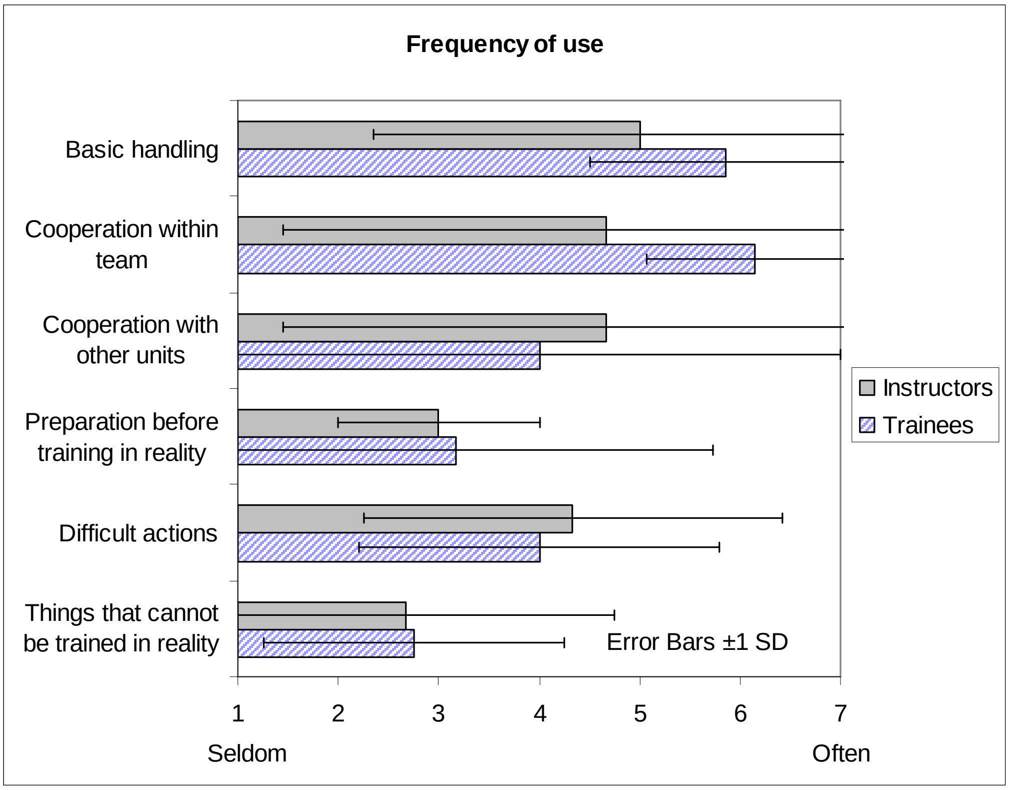

Figure 10. Ratings of frequency of use

2.3.3 Discussion

The trainees had in principal no experience with a real active sonar. In line with this, training for preparation before training in reality was rated as occurring relatively seldom. Thus, their ratings of correspondence with reality and effects on real world performance should be interpreted with caution. On the other hand, for these questions the ratings of the trainees were very similar to those of the instructors.

Learning was rated somewhat higher than correspondence with reality, which again indicates that positive transfer can occur without the highest level of fidelity.

It is interesting that both motivation and fun to using the simulator was rated higher by the trainees than by the instructors. Thus, the instructors seemed to underrate both the motivation and fun that the trainees experienced during the simulation.

2.4 MCM Wargaming

MCM Wargaming was a command and control staff exercise of an international naval mine countermeasures mission. The exercise was arranged by Belgian - Netherlands Naval Mine Warfare School, Eguermin. NATO.

2.4.1 Methods

The basis for the questionnaire in this study was the questionnaire used for the tank 122 simulator. Since, this was a very different type of simulation; several of the questions in the tank 122 simulator questionnaire were excluded. Other questions had to be reformulated, but as far as possible, the questions were retained for comparability. The questionnaire contained 41 questions, both 7-point rating scales and open questions. No questions were asked to the instructors. The main reason was that instructors belonged to a foreign institution; and would most likely have experienced the questionnaire as an evaluation of the value of there service. Furthermore, since they were only instructing the participating officers at this occasion, they would most likely not have had a well-founded view of their experience of the game.

Three staffs participated in the exercise. The three staffs were situated in different rooms, and they received the same tasks in the game. That is, they performed their task in parallel and did not interact with each other. The game was played during four days; which had been preceded by a planning phase. The questionnaire was answered during the game, when the participants had time to answer, in the afternoon of day three, and in the morning of day four.

Staff A was manned by five officers (four students and one students coach). Staff B and C were manned by four officers in each staff. All participants, except one in Staff B, answered the questionnaire.

The age of the participants was in staff A 29.4 ±1.3 years, in staff B 32.3 ±2.9 years, and in staff C 35.8 ±5.9 years (mean ±SD).

Number of years in the Swedish Defence Forces was for staff A 9.3 ±2.2 years, for staff B 11.0 ±2.6 years, and for staff C 14.5 ±4.5 years. The mean time for participation in staff exercises was for Staff A 175 ±171 hours, for staff B 173 ±142 hours, and for staff C 115 ±58 hours. As can be seen by the large standard deviations, the differences in experience of staff exercises were large in staff A and B.

Their ratings of how much previous practice they had for their position in the staff exercise (very little – very much) were rather low for all staffs. For staff A: 2.6 ±1.8, staff B: 2.3 ±1.5, and for staff C: 2.7 ±1.2.

Their ratings of how often they played computer games (seldom – often) were also rather low. For staff A 2.4 ±1.7, staff B 3.7 ±0.6, and for staff C 2.3 ±1.0

Their general attitudes towards simulator training as a complement to real world training (very negative – very positive) were very high and unanimous, for staff A 6.2 ±0.8, staff B 6.3 ±1.2, and for staff C 6.3 ±1.0.

2.4.2 Results

Since there were few participants in each staff, inferential statistics is not used for comparisons between the staffs. Thus, the results are only analyzed with descriptive statistics.

The ratings of the participants' points of views of the game and the training are given in Figure 11. Each mean value is calculated from a number of underlying questions.

The correspondence with reality was rated on the middle of the scale by staff A and C, and moderately high by staff B. One participant commented that there was a lack of credibility because of a simplified program. Another commented that the computer programs were difficult to work with without training.

The feeling of presence was rated moderately high. Some participants commented the time jumps, which entailed less time to consider the situation. That is, during the exercise the simulated time was compressed.

The effect of the game on real world performance was rated on the middle of the scale by staff A, just above the middle by staff C, and moderately high by staff B. One participant commented that the game did not completely reflect reality, where much more parameters would be necessary. Another participant commented that it was a good training of order writing and estimation of GOP (Guidelines for Operation Planning). Another commented that it was good training of understanding of the variety of signals used in an operation.

Feedback was rated moderately high. One participant commented that it is interesting to get input from other nations, since there are differences in working methods.

Learning was rated on the middle of the scale. Several participants commented that they would have learned more if they had been given more training before the game, with the computer programs that was used in the staff.

The motivation of the participants during the game was rated moderately high. Fun to play was rated just above the mean of the scale

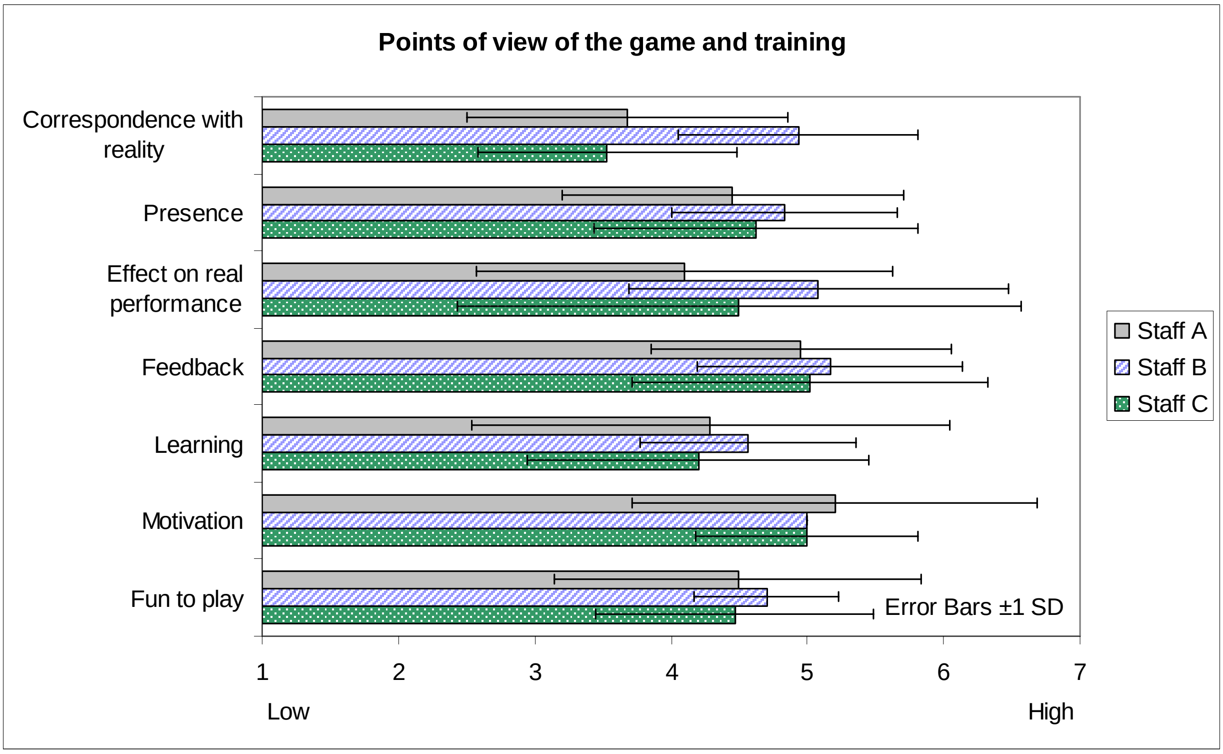

Figure 11. Ratings of points of view of the simulation and the training.

2.4.3 Discussion

The effects on real world performance, and learning were only rated just above the mean of the scale (except for staff B that rated correspondence higher). The main problem seems to have been too little experience with the computer programs and too little experience of their posts in the staff. One participant commented that he would have preferred to have an experienced chief of staff, who could have trained them during the game.

The ratings of how fun it is to play was rated lower, compared to the other studies in this report. This is not surprising, since this is a very different simulation, proceeding during several days. Even if the simulated time was compressed, there were periods with very little activity.

The highest ratings were on feedback and motivation. The relative high ratings of feedback are surprising, since the game was still going on when the questionnaires were answered.

Feedback and learning would most likely have been rated more reliably if the questionnaire had been answered after the completion of the game. Unfortunately, this was not possible.

Even if the ratings of how fun it was to play the game were not very high, we got the impression that most participants and other officers involved were rather satisfied and found it to be good training. It was mentioned as especially valuable to receive input from the game organizers from Eguermin, since they belonged to NATO. However, that the game was arranged by a NATO organization was also mentioned as a drawback. Since, this means that the game cannot, of practical and economical reasons, be played very often. In this context, it was mentioned that for continuous training it would be an advantage to acquire own game simulator capacity at the school for this type of staff exercises.

2.5 Flightbook – flight training simulator

The project had planned to use the same questionnaire at the Flightbook simulator at the Swedish Air Force Air Combat Training School. However, no training was performed in Flight Book during the autumn 2009.

Flightbook consists of two pilot stations (Figure 12). The cabins, including flight sticks and parts of the instrumentation, are built by parts from SK60 aircraft taken out of use. In each pilot station, the out of the window environment is displayed by projectors on a spherical display, with 270 degrees of horizontal view.

Figure 12. The two pilot stations in Flightbook. From the control station, at the table behind, a third person can act as air-traffic controller or air supreme commander.

Flightbook also consists of a PC-based flight simulator that each student has installed on a personal laptop computer.

The basic idea with Fligthbook is voluntary training. That the flight students mainly choose when, how, and in what extent they want to use the simulator. The purpose is to build up the flight students' airmanship by providing as many impressions as possible. For further description of this pedagogics, see Section 1.2.2 Pedagogics.

2.5.1 Preliminary evaluation of Flightbook

A flight student at the Swedish Air Force Air Combat Training School has performed a preliminary study of flight training with the flight simulator Flight Book and the pedagogics for its use. The work was supervised by a member of the project (Almquist, 2009).

The purpose was to investigate to what extent the flight students in the basic flight training program use Flight Book; their opinions of Flight Book, what type of training they use Flight Book for, their gain of using Flight Book; and the flight instructors' opinions of pilot training with Flight Book.

The participants were twelve flight students in the basic flight-training program at the Swedish Air Force Air Combat Training School. Data was collected with a questionnaire and with interviews. The questionnaire consisted of 80 questions, both ratings scales and open questions. The study was designed for three repeated measures. The reason for this was to investigate if the attitudes of the flight students changed over time of training.

After the first occasion of data collection, there were technical problems with Flight Book, and it could not be used during the rest of the period scheduled for data collection. Thus, the questionnaire was only answered at the first occasion, when the flight students only had used Flight Book for a relatively short period. Consequently, the results are confined to the flight students' preliminary opinions.

The results showed that the flight students were very positive to simulator training as a complement to real flight training. The flight students also had the view that prepared training profiles would provide more effective transfer of training, e.g. by more focused and serious training on important issues. However, they also wanted the opportunity to freely choose what to train. They also wanted a system for evaluation after training, i.e. the possibility to review their performance after training. Since the simulator training was often performed without guidance of instructors, they considered this as especially important.

The most frequent reasons the flight students gave for using Flight Book was testing new things that they had not yet learnt but were curious about; simply because it is fun; and training on something specific, as a preparation before training in the real aircraft.

Most frequently, they used Flight Book for training on things they are not allowed to train - or cannot train - in the real aircraft; training normal flying, to make themselves acquainted with the aircraft and environment; and as a preparation before practicing in the real aircraft, e.g. by flying together with another flight student (both aircrafts in the same simulation).

The same items of training that they stated as most frequently used were also the items that they considered having learnt most of from using.

2.6 ACES – flight training simulator

ACES (Air Combat Evaluation System), a VR-based dogfight training simulator tailored for research purposes. ACES is equipped with a set of specially designed embedded training tools (see Section 1.2.4 Embedded training tools).

A study of transfer of training from simulator training in ACES to the real aircraft was presented at the Human Factors and Ergonomics (HFES) European Chapter annual meeting 2009. This study will be published in the proceedings of the conference (Oskarsson, Nählinder, & Berggren, manuscript accepted for printing)

Flight students from the Air Force Combat School's basic flight training program participated in the study. Before training five maneuvers in the real aircraft, half of the flight students were provided instructor-based training on each maneuver in ACES, including after action review with the imbedded training tools. The results indicate that the simulator training in ACES provided higher situation awareness (SA) and enhanced understanding of maneuvering, and in particular in relation to other aircraft. This was most evident for the first maneuvers, thus indicating the highest training effects of the simulator in the initial training phases (see Figure 13, 14).The flight students that participated attached great value to the simulator training and considered it providing enhanced understanding of spatial understanding of maneuvering in the three-dimensional space.

This is especially interesting since ACES did not simulate the same flight model that was used in the real aircraft. Thus, the study demonstrates that positive transfer of training can be achieved for general maneuvering without high physical and functional fidelity.

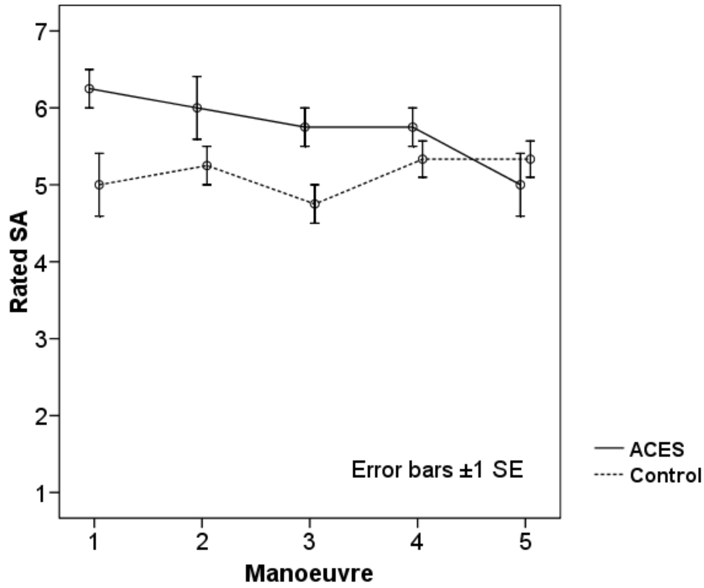

Figure 13. Rated situation awareness (SA), after each maneuver in the real aircraft, for pilots who had become simulator training in ACES, and the pilots in the control group who had not received previous training in ACES.

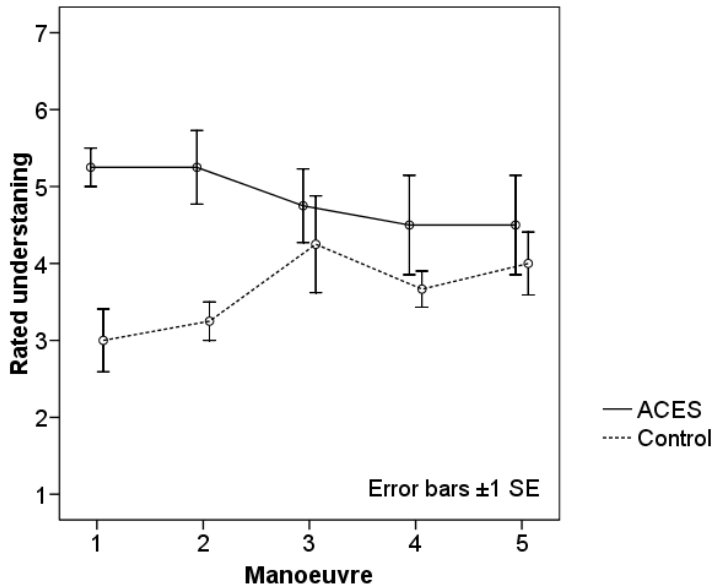

Figure 14. Rated understanding of maneuvering, after each maneuver in the real aircraft, for pilots who had become simulator training in ACES, and the pilots in the control group who had not received previous training in ACES.

2.7 The Naval Warfare Centre

Members of the project have visited the Naval Warfare Centre (Sw. Sjöstridsskolan, SSS) in Karlskrona. At this visit, studies were performed at an active sonar simulator (see Section 2.3 Active sonar simulator) and of MCM wargaming (see Section 2.4 MCM Wargaming). We also discussed different issues of simulator training with a number of officers.

The importance of simulators for education and training of soldiers and crews were emphasized. It is not economically defensible to go out with a ship with all its crew, if the purpose is to train single tasks with one of the crew. Furthermore, in some cases, there might be no ship available. In these cases simulator training was mentioned as very useful.

It was mentioned that it is important that a simulator replicate those parts of the reality that are necessary for the task. On the other hand, those parts of the reality that are not necessary for the training task do not have to be simulated with full detail. That is when a simulator is implemented; it is for cost-efficiency, and practical purposes, it necessary to decide when the simulator is good enough for its planned purpose.

The possibilities of using commercial and freeware simulators for training were mentioned.

Dangerous waters, by Sonalysts Combat Simulations, is a commercial naval simulator. http://www.sonalystscombatsims.com/dangerous_waters/

It was commented that the game is very good for example learning about the weapons that other nations use, recognizing the silhouettes of ships, and training on TMA analysis to find bearing. It is also very good for training on unconventional solutions, and tactics, but has too low fidelity on the scenario level. It was also mentioned that the game might be fun enough to attract the students' interest, in such extent that they play it on their spare time.

Seawolves Virtual Navy, is an on-line military command simulator. http://seawolves.org/svn/

It was commented that the simulation uses the same badges of ranks as NATO, and that it is very useful for training on NATO abbreviations.

A more extensive account of the visit at the Naval Warfare Center will be given separately.

2.8 Motivating factors for game playing

A student at the Cognitive Science Program at Linköping University has performed a study of motivating factors for game playing. The focus was on why people play and why they continue to play. The work was supervised by members of the project.

First, a semi-structured interview was performed with a focus group with four participants (students age 21 – 24). The participants were asked to think of a number of questions while playing video games. Then, the interview followed. The results from the focus group provided input to the construction of a web questionnaire.

The web questionnaire consisted of 42 questions, both rating scales, multiple choice and open questions. The questionnaire was sent by e-mail to 265 people; of these, 74 people answered (28 percent). The mean age was 25 years, ranging from 20 to 55 years (77 percent students and 23 percent employees; 59 percent men and 41 percent females)

The results suggest that people prefer playing together with others, and that they play mainly because of entertainment, fellowship and pastime. A majority of the participants considered the following five different characteristics of a game as important to make it fun to play: *a pleasant game feeling* (i.e. effects like sounds, characters and environments), *variation* in tasks, *successively* increased difficulty, an *exciting* story and that the game must be *understandable*. This study has been published in a separate FOI report (Jonsson, Nählinder, & Berggren, 2009).

2.9 Military Flight Training Conference

A member of the project has visited the annual Military Flight Training Conference, arranged in London by IPQC. The purpose of the conference is to having different actors from different countries presenting current topics and questions. As a rule, many presentations are given during two days.

The purpose of the project to cover the conference is to follow the development of flight training, in particular concerning simulator training and commercial software. The simulators at the training sites are often at a high technical level, are specialized, and are developed for specific platform training. However, the focus is often not to create effective training and education. Thus, the simulators are not often built to match a specific pedagogical model.

There is a great deal of on-going research areas concerning pedagogics and training simulators. It is becoming an obvious fact that effective training is only reached by both adequate technical and pedagogical conditions.

2.10 Game Developers Conference

Members of the project have attended the Game Developers Conference (GDC) (2009) in San Francisco. The purpose was educational and to be updated on what is currently going on within the field of game development. GDC is considered as the biggest and most important conference within the field of game development. The conference covers areas like programming, game design, sound, management, production, and graphics. Thus, GDC covers a very broad range of topics from describing algorithms at a very technical level to more business like presentations.

The conference also contained different summits, for instance on Artificial Intelligence (AI), Mobile Games, and Serious Games. These summits were held over two days and contained many presentations that focused on a specific field. The Serious Games Summit was specifically covered, since this is the main focus of the project. The summit contained presentations about how games and game technology are used for specific purposes like training and learning, for example within the military and medical fields

2.10.1 Trends

One of the more apparent trends at GDC reflected that more and more game platforms are built around multiprocessor hardware. For this reason, many algorithms and software solutions need to be adjusted. This affects many different areas, for instance graphics, physics, AI, and sound. Therefore, many hardware manufacturers were eager to get the game developers to adopt the technology and tools that they provide.

Another clear trend was the need for even more realistic AI characters with respect to appearance and behavior. When it comes to animating AI characters, a rather high level of realism has been achieved. Thus, new areas are explored in order to take the realism to a higher level. Biomechanics and increased accuracy of the interaction with the surrounding environment, through more advanced physics simulations, are two areas that are believed to push the level of realism even further. These areas have until recently almost been of interest to the academic domain, but are now also gaining interest within the game industry.

2.10.2 Interesting presentations

A summary is given of some of the more interesting presentations from GDC.

2.10.2.1 Animating in a complex world: Integrating AI and animation

This presentation was about the fact that characters in current games often are animated with an enormous amount of short animations. These short animations are put together to create longer animations, that work with the motions the player does with the character. However, it is necessary that the characters react properly to quick dynamic changes. Thus, it is very demanding for the AI-system to choose which of these animation pieces at a certain situations give a realistic impression. The selection process has to take many things in account such as biomechanics, collision handling, and the visual impression.

The presentation threw light upon these challenges and presented different architectures to solve them, for instance by separating the behavior models from the steering logic in parallel with different kinds of search graphs. This area is of very high interest to the game industry, since the visual impression often is as important as the characters' behavior in computer games today.

Presented by Christian Gyrling (Naughty Dog Inc.) and Alex J. Champandard (AiGameDev.com)

2.10.2.2 Breaking the cookie-cutter: Modeling individual personality, mood and emotion in characters

It has been increasingly common that AI characters in games interact in a greater extent with the gamer. Hence, it is important that each character is given a unique behavior, in order to mimic that the characters have their own personality. The problem is that the behaviors often are very specifically programmed. So when a digital environment is filled with AI characters, the shortcomings of the simulation become obvious if many characters share the same behavior and act in a similar fashion.

This presentation gave an example of how the people behind the game *Sims 3* solved this problem. Each computer-controlled character in the game was given its own personality, emotions and various moods, which lead to a great variation in how each of the characters will act.

The personality of each character in *Sims 3* was mainly created through data driven design. The characteristics of each character also changes over time, when the game is played, in order to enhance the gaming experience.

Presented by Richard Evans (Electronic Arts), Phil Carlisle (University of Bolton) and Dave Mark (Intrinsic Algorithm)

2.10.2.3 Characters welcome: Next steps towards human AI

This panel discussion was about the fact that computer game characters often are visually very realistic, but that their behavior does not have the same standard. The discussion tried to answer what human features the AI-characters are missing, and what challenges are left to be solved.

An important aspect was whether realistic behavior actually makes computer games more fun to play. An interesting concept discussed was symbol-based behavior, which cartoon movies often take advantage of, for example simple and obvious illustrations like a black cloud over the character's head when it is angry. These are very simple but effective ways of visualizing very subtle expressions and emotions.

The discussion was also about how much impact smaller details have on how trustworthy the characters appear, or if a more result-oriented approach to game AI should be applied instead of putting energy on the smaller details.

Participants in the panel was Richard Evans (Electronic Arts), Borut Pfeifer (Electronic Arts), Daniel Kline (Crystal Dynamics), Phil Carlisle (University of Bolton), Robert Zubek (Zynga), Dave Mark (Intrinsic Algorithm)

2.10.2.4 The story of Audi Odyssey & my journey through usability

This presentation was on a game that was created with the purpose that people regardless of physical impairment, for example impaired vision, should be able to compete with people with normal vision, without compromising the fun of the game.

Many games are created without any thoughts about that many people have some kind of perceptual impairment, for example impaired hearing or vision, and color blindness. For this reason, many games are not playable for a large portion of the population. When it comes to first person shooter games, it is very common when enemies sneak up on the player from behind, that feedback is only given through sound. Thus, if the player has impaired hearing, the attack is impossible to prevent and the game will quickly become boring. An important point in this presentation was that if game creators consider perceptual impairments already at the planning phase of game, the probability would be higher that more people will be given the opportunity to enjoy playing the game.

Presented by Eitan Glinert (Fire Hose Games)

2.10.2.5 MODs for Canadian Forces

This presentation discussed more traditional use of games in the sense of *serious games*, in this context how the Canadian Forces use computer games. Several applications were presented, where modified computer games were used in different kinds of training. It included both simple and complex simulations. An example of a simple simulation was a communication exercise where the personnel being trained communicated with characters in computer games through voice recognition. A more complex example was a simulator built with small funding and based on Microsoft Flight Simulator. It was used for training of air deployment of soldiers, when hanging in straps that imitated a parachute. The environment was projected on a dome and important equipment to solve the task, like GPS and compass, was integrated with the simulator.

Most impressive in this presentation was the large amount, and diversity, of applications that have been developed by utilizing computer games. With very small funding and a handful of developers, the Canadian Forces have created very useful applications that can be used to train a wide range of tasks.

Presented by Jeremy Macdonald (Canadian Forces).

2.10.2.6 Serious games Summit

A popular topic at the Serious Games Summit was social games. The keynote speaker hoped for more games with serious goals, and not only with focus on entertaining aspects; for instance on encouraging the player to conduct positive deeds, or get more socially aware.

There is a phenomenon called *pay it forward* where the goal is to make other people do good deeds for someone else, as a result of that you have done something good for them. The keynote speaker have created a game – *Akoha* – inspired by this concept, where the player according to instructions on playing cards do assignments in real life. This gives the player *Karma-points*, which get the player to the next level in the game. Tasks could be that the player should pay someone else’s coffee in a café, or pay a tank of gas for a stranger at a gas station.

The keynote speech was given by Austin Hill (Akoha)..

3 Discussion

In principal, both trainees and instructors in the studies performed had a very positive view towards simulator training as a complement to real world training. Officers at the Naval Warfare Center mentioned the necessity of simulator training as a complement to real world training, particularly of economical reasons. For example, it is much too expensive to go out with a ship in order train an individual crew member on a single task. In such cases, simulators can provide the training very cost-efficiently. The advantages of simulators for mass training were also mentioned.

In the tank 122 simulator, CV90, and the active sonar simulator studies both the effect on real world performance and learning were rated relatively high, or high. This implies positive transfer of learning. Furthermore, in both the CV90 and the tank 122 simulator studies, the effects on real world performance and learning were rated higher than the simulators' correspondence with reality. In the active sonar simulator, learning was rated somewhat higher than correspondence with reality. Even if the trainees with the CV90 and active sonar simulators did not have experience with the real systems, their ratings were very much in line with the ratings of the instructors (with great experience of the real systems); which implies reliability of the results. In this context officers at the Naval Warfare Center, involved in simulator training, emphasized the importance that a simulator replicates those parts of the reality that are necessary for the task that is trained. On the other hand, those parts of the reality that are not necessary for the training task do not have to be simulated in detail. That is, simulators must have high fidelity for those tasks that are important for the training task; but not necessarily for those tasks that are not important. This view is also supported from the ACES study, where positive transfer of training was achieved for general maneuvering without high physical and functional fidelity Thus, a high level of fidelity does not seem to be an unconditional demand for positive transfer of training. Consequently, when a training simulator is implemented it is, both because of cost-efficiency and of practical reasons, necessary to decide a level when the simulator is good enough for its planned purpose. However, a reservation is that we have not investigated how fidelity influences fun and motivation.

Today there are COTS (Commercial off-the-Shelf) game engines, for example VBS2 (Virtual Battlespace), that can be implemented in training simulators. In order to use an existing COTS game engine in a simulation application, it often requires that it support many features necessary in the simulation industry, for instance support for HLA and the possibility to use real geographic data, and not just fictive data. However, to exchange existing simulation engines with more inexpensive COTS game engines will most definitely entail large development costs, and thus should be carefully considered before implementation. On the other hand, when new simulators are developed, COTS solutions may be better suited. Furthermore, the gaming industry is always on the front edge when it comes to adopting new technologies and using them in a effective way. Thus, much can be learnt from the game development industry, which becomes obvious when attending game development conferences like for instance Game Developer Conference.

Motivation was rated relatively high, or high, in all of the studies performed. Fun to use the simulator was rated high in the tank 122 and the active sonar simulator studies. Besides, in the tank 122 and active sonar simulator studies the participants found the training as more fun than the instructors had expected. Fun was also mentioned as an important reason for training in Flightbook. Furthermore, in the studies where the question was asked (CV90 and active sonar simulator), the participants wanted more time for training in the simulator than they were provided.

Reasonably, more focus should be put on studying aspects of computer gaming that can contribute to both motivation and fun, and at the same time be transferable to military simulator training. Aspects, in this respect, found in this year's study of motivating factors for game playing were for example *fellowship* (i.e. interaction with others), *successively* *increased difficulty*, and *exciting story of the game* (i.e., scenarios), and *understandable* (i.e. appropriate level of difficulty).

The project believes that motivation and fun are important factors for enhanced training efficiency, and thus for transfer of training from the simulator to real world performance. However, several participants in the studies performed already found the training both motivating and fun. However, in this connection it should be pointed out that only relatively few simulator studies were performed; and that the ratings of fun where not very high in the CV90 simulator and in the MCM wargaming studies. Consequently, finding aspects from computer gaming that can further enhance motivation and fun during simulator training seems to be a challenge.

One important question is if relevant aspects from computer gaming can be identified, should they influence the simulator development, or the way training is performed in the simulators.

The question if commercial computer programs or online games can be used for training of specific skills is interesting. *Dangerous Waters* and *Seawolves* are examples of this type of games (see Section 2.7 The Naval Warfare Centre).

It was unfortunate that the planned study of Flightbook, at the Swedish Air Force Air Combat Training School, could not be performed. Since the Air Combat Training School uses a pedagogical model with a much lower level of instructor control of simulator training than in the simulator training studies in this report, it would be of great interest to compare simulator training in Flightbook with training in other simulators.

It would be interesting to perform the planned study of Flightbook next year. To get a better basis for comparisons, more studies at simulator sites should also be performed. Especially, other military flight simulators like PETRA (Planning, Evaluation, Training, Rehearsal, and Analysis) ought to be included.

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