PART II

INTRODUCTION

In the past decades, simulators have proven their benefit for training. Simulators have been implemented in a variety of training programmes, ranging from maintenance and fault diagnostics training to strategic command and control training. Technology has played an important role in the rise of simulators. The fast developments in processors, PC based graphics and auditory simulation systems have made it possible to build cost effective and efficient training systems. The availability of network technology has provided the opportunity to link simulators and construct a common synthetic environment in which several operators can practise simultaneously. The behaviour of opposing and own forces can be modelled in the form of intelligent agents allowing us to deliver team-training sessions individually.

Technical advancements were not the only boast to the widespread application of training simulators. At the same time, operational developments within the Armed Forces demanded a reflection on the way training was conducted. Missions were becoming more varied, complex and unpredictable. These missions had to be fulfilled with fewer personnel, in many different theatres and under many different circumstances. Education and training strategies had to be adapted to accommodate these changes. Differentiation in education and custom-made training programmes emerged. Mission rehearsal became more important, and concepts as 'just-in-time learning' and 'just-enough learning' gained popularity. Furthermore, the education and training community of our Armed Forces had to deal with more rules, regulations and restrictions concerning safety, environment, and working conditions. Simulators and synthetic environments provided an opportunity to conduct just enough training in a variety of tasks and circumstances, safely and just-in-time.

The introduction and application of simulation technology in education and training programmes was not without problems. Even today there are still numerous difficulties to overcome. Some of these problems can be resolved with sophisticated technology. However, technology alone cannot solve all problems. Maintaining and enhancing combat readiness and warrior capabilities requires the precise and accurate definition of critical competencies, clear specifications of the resources required to acquire these competencies, and smart application of the available technology to realise such effective simulator-based training environments. In this article we address interesting developments in the field of simulation-based training and present our view on issues that have to be tackled.

THE BASICS OF SIMULATION

In simulation based training, task behaviour is trained in a learning environment that, more or less, resembles the operational context. A simulation is the dynamic execution or manipulation of a model defining the behaviour of a system. The user interacts with this model through an interface. This enables the user to influence the simulation process (e.g. by pushing a button on the interface, by turning a steering wheel). The interface also informs the user on the changed status of the system. Simulations can vary widely in technical complexity and fidelity, but they consist of at least three elements: a model, a user-interface, and a scenario (Korteling, Kappé, Van den Bosch, Helsdingen, 1998). A simulation can therefore be regarded as a simplified copy of a real system (see **Figure 1**). This, of course, offers good opportunities for training. However, having a simplified and controllable copy of reality available is, by itself, not sufficient. In order to use a simulator as a training device, the instructor needs control of the learning environment. For example, he needs to be able to control the course of a scenario to make sure that the events intended to elicit target behaviour do actually occur at the right time; he needs to be able to measure trainee performance to monitor learning progress and to detect possible knowledge gaps reflected in continuous poor performance on certain aspects of the task; he needs to be able to provide tailored feedback to the trainee, and so on. Therefore, a train-

Fig. 1: Command Information Centre simulation at TNO Physics and Electronics Laboratory (TNO-FEL).
(All photos: TNO HUMAN FACTORS)

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Karel van den Bosch is researcher at the Modelling & Simulation group of TNO HUMAN FACTORS. He received a PhD from the University of Nijmegen for his work on visual word recognition processes. At TNO he is performing fundamental and applied research on the opportunities of simulators for acquiring skill in perceptual-motor and cognitive tasks (e.g. driving, unmanned vehicle operation, command & control). His current work is in the domain of tactical training. More specifically, he works on the development and validation of new concepts for training (e.g. critical thinking), identifying the requirements for effective utilisation of simulation technology, and the deployment of human behaviour models (cognitive agents) in synthetic training environments.

ing simulator necessarily needs 'Instructional Facilities' that serves these functions.

We can distinguish many types of simulators, but the following classification is customary:

1. live simulations,
2. virtual simulation, and
3. constructive model or simulation.

Live simulations involve real people operating real systems. Live simulation thus comes close to the operational tasks, but do often require large financial and logistic investments and have substantial practical and didactical drawbacks. *Virtual simulations* involve real people operating simulated systems (human-in-the-loop). These simulations can play an important role in learning motor control skills (e.g. flying an aeroplane, see **Figure 2**), decision skills (e.g. committing fire control resources to action), or communication skills (e.g. as members of a C4I team). *Constructive model or simulation* involve simulated people operating simulated systems. Real people stimulate (make inputs) to such simulations, but are not involved in determining the outcomes.

All three types of simulation are used in naval combat systems training, usually in combination. Virtual simulators are often used for the training of individual operators, or for a team of operators. Exact replicas of the operator stations are used for training of complex procedures. Command and control teams receive training in their operational environment (live simulation), with lower and higher level teams being played by a war game engine or by role players (constructive simulation).

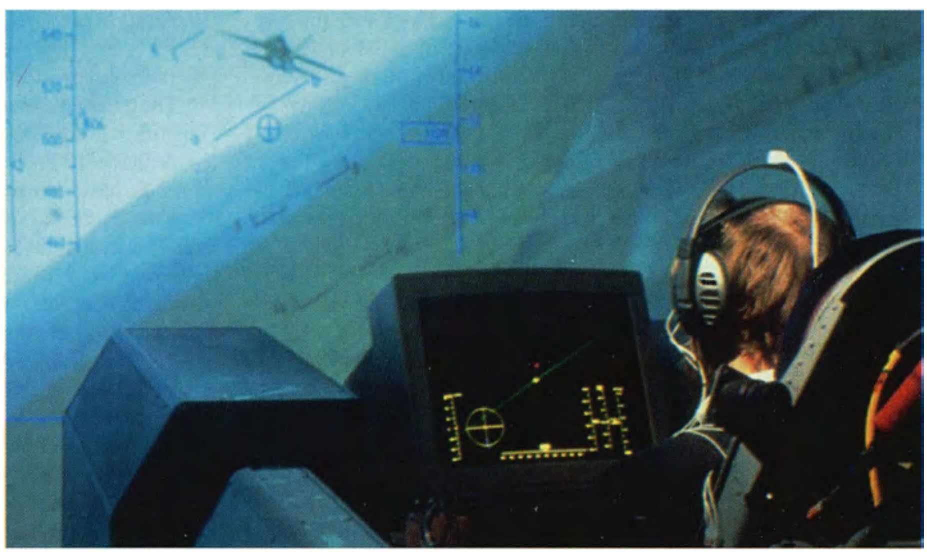


Fig. 2:
Flight Simulator at TNO HUMAN FACTORS.

There are two new developments in simulator-based training, embedded training and game-based training. *Embedded training* has the advantage of delivering training on-the-job, using operational equipment, with the control associated with simulation based training. In order to fully benefit from this type of training, capabilities have to be integrated into the operational systems (e.g. software for scenario generation, cueing and performance registration) to prevent drawbacks of traditional on-the-job training. The need to attach specific capabilities to the operational system to make the most out of training is not shared by everyone: "Dividing lines between operational applications and training applications and the systems that support them are going to fuzz out", says Ron Kruk, manager Technology Analysis, Research and Development at CAE (Kauchak, 2002/2003). The question is whether this is desirable, since operational systems are not designed for training purposes and can therefore be too rigid to conduct effective training. The increasing capabilities of simulation and networking technology make is possible to use *commercial-of-the-shelf (war)games* for training purposes. It is believed that training with war games will positively affect the effectiveness of commander and staff training because of its increased realism and scope. A positive feature of war gaming is that it may enhance motivation by inducing challenge, curiosity and fantasy. This may, in effect, foster the retention of learned knowledge and skills. Fowlkes, Dwyer, Oser, & Salas (1998) argue however that the factors making war games exciting (complex, dynamic and unpredictable) make it troublesome from a training standpoint. Control of task content is a fundamental requirement of training. This requirement is clearly at odds with the intentionally dynamic nature of war fighting that is simulated in war games. One should keep in mind that games are developed for fun. If used for training purposes, adaptations have to be made. And that might be problematic since manufacturers are usually not willing to freely provide the necessary software to adapt games and be able to gain insight into the underlying processes and procedures of the game.

QUALITY, EFFECTIVENESS AND EFFICIENCY OF SIMULATORS

Using simulators for training has many potential advantages over deploying the real equipment, such as cost reduction, availability, safety, and instructional facilities. However, these advantages can only be achieved if the simulator accomplishes the purpose for which it was developed. This is the issue of *validity*. Validity refers to the extent to which skills acquired in the simulator transfer to the operational equipment. Validity is affected by fidelity, quality of training (i.e., the training methods, the contents of training, the way in which feedback is provided, etc...), type of task, and trainee level. Two types of validity need to be distinguished: face validity and functional validity. *Face validity* is the subjectively experienced similarity between the simulator and the real-life situation. *Functional validity* refers to the extent that skills learned on a simulator transfer to the real task (ToT: transfer of training) (Verstegen, Barnard

TNO HUMAN FACTORS

TNO HUMAN FACTORS is one of the 15 institutes that constitute TNO, one of the largest organisations for Applied Scientific Research in Europe, with over 5000 employees.

TNO HUMAN FACTORS is focussed at human behaviour and performance in a technical environment. Through innovative research we improve performance, safety and comfort. We work for the Netherlands' Armed Forces and worldwide for private enterprises and Governments.

TNO HUMAN FACTORS is a market-oriented research institute, striving for the benefit of its clients. TNO HUMAN FACTORS is a scientific research institute, operating at the front line of scientific developments in close co-operation with our clients. TNO HUMAN FACTORS is part of TNO Defence Research; our primary mission is to develop and apply human factors expertise in a high-tech military environment and to promote efficient deployment of personnel and materials. In addition, TNO HUMAN FACTORS focuses on a number of specific civil markets which include traffic behaviour, public safety, and ICT. As a TNO Institute, we seek to serve society worldwide with our unique research expertise.

TNO HUMAN FACTORS participate in a wide network of collaborative arrangements within TNO, NATO, EUCLID, the European Union and the academic world.

TNO HUMAN FACTORS has a multidisciplinary staff of 165: Physicists, engineers, psychologists, biologists and doctors work closely together.

In 2002, TNO HUMAN FACTORS had a turnover of 15 million Euro. Fifty per cent of this turnover involved projects for the Netherlands' Ministry of Defence – explorative research and dealing with concrete projects. Fifty per cent came from other projects.

Our primary activities include:

- *Perception:* Vision and Imaging, Speech and Hearing
- **Cognitive Ergonomics:** Decision Making and Support, Human System Interaction, Usability and Experience
- **Skilled Behaviour:** Steering and Control Tasks, Traffic Behaviour
- **Work Environment:** Workplace Ergonomics, Thermal Physiology, Equilibrium and Orientation, Aerospace Medicine
- **Instruction and Training:** Learning Technologies, Team Training, Modelling and Simulation
- **Team Solutions:** Team effectiveness and Organisation, Social Influence and Capabilities

TNO HUMAN FACTORS possesses a number of unique facilities for experimental research, such as Vision & Display Laboratory, Hearing Research Laboratory (virtual acoustics, anechoic room), Experimental Command & Control Laboratory, Colab (3D visualisation, tele-presence, electronic board room), Driving Simulator, Flight Simulator, Climatic Chambers, Vestibular Laboratory (3D Rotation chair, tilting room, ESA Space SLED), Virtual Environment lab.

Doing business with TNO HUMAN FACTORS

Ruled by law, a large part of TNO HUMAN FACTORS' capacity is set apart for the Netherlands' Ministry of Defence. The Ministry of Defence attaches great importance to permanent scientific support. This is expressed in a rolling-budget relationship with TNO Defence Research. TNO HUMAN FACTORS has become a strategic partner of the Royal Netherlands Army, Navy, and Air Force, and has built up military domain expertise which is applicable to many other domains.

Great care is given to the definition of new research projects. Doing business with TNO HUMAN FACTORS begins with thorough discussions on what the 'problem' really is, how it will be approached, and what kind of solution will be delivered. Contracts are accepted on the basis of rates per hour or for a fixed price.

Quality Assurance

The quality system of TNO HUMAN FACTORS is certified, meeting the requirements of ISO 9001.

A quarter of TNO HUMAN FACTORS' research capacity is used for pure basic research and development of knowledge and methods in order to maintain a frontline position. This basic research programme is oriented towards actual and future military need and requires approval by the Ministry of Defence. Of course, civil funding of basic research is equally welcome. TNO HUMAN FACTORS considers this policy as an important contribution to quality assurance.

TNO HUMAN FACTORS co-operates closely with a number of 'sister' Institutes and Universities. TNO HUMAN FACTORS' scientists are therefore able to integrate all available knowledge in their research and consultancy. If not limited by commercial or security reasons, TNO HUMAN FACTORS strives for publication in the open literature. In agreement with TNO's general policy, TNO HUMAN FACTORS introduced a formalised Quality Assurance System. Through inspection of the corresponding Quality Handbook clients can inform themselves about the efficient and skilful performance of their projects.

Technology Position

For TNO HUMAN FACTORS auditing the quality and market relevance of the technology portfolio through technology position audits is a crucial component of quality management, as are employee and customer satisfaction audits. Independent committees comprising international experts in their respective fields carry out technology position audits. The last audit of TNO HUMAN FACTORS was carried out in January 2001 resulting in a very positive judgement regarding the technology position in comparison with comparable research institutes. This judgement provides an underpinning of the position of TNO Human Factors as a world class human factors institute.

Fig. 3: The Action Speed Tactical Trainer (ASTT) at the Operational School of the Dutch Navy.

and Van Rooij, 1999; Korteling & Sluimer, 1999). Unfortunately, in the process of simulator specification and acquisition, face validity usually has priority. One reason for this may be that assessing a simulator's ToT is complex and time consuming and only makes sense if functional aspects are taken into account such as purpose, tasks, trainees, training methods and additional training aids (Korteling & Sluimer, 1999). Nevertheless, various examples of negative ToT (training on a simulator deteriorated performance on the real system) (Van Breda and Boer, 1988; Korteling, Van den Bosch & Van Emmerik, 1997) demonstrate the importance of functional validity.

Another important concept in simulation is *fidelity*. Fidelity is the amount of similarity between the simulator and the real-task equipment. Again, there is a distinction between physical fidelity and functional fidelity. *Physical fidelity* denotes to what extent the simulator mimics the real equipment and environment in terms of physical measurable characteristics (e.g. the resistance on controls). *Functional fidelity* is defined as to what extent the behaviour of a person resembles his or her behaviour on the real task under the same conditions (Korteling, Van den Bosch & Van Emmerik, 1997). Measuring the physical fidelity is the most precise and reliable validation method because it is based on objective measurements. However, with these kinds of physical data one cannot predict the behavioural characteristics of humans in the simulator (Korteling & Sluimer, 1999).

Aiming to maximise their effectiveness, simulator facilities have often been instrumented at high costs to represent the operational equipment as realistically as possible. Ironically, when the training procedures from the operational system are implemented on the simulator as well, the simulator might lose much of its additional training value and possibly yield sub-optimal training results as a consequence. Shortly, the simulator is used as a rigid substitute for the operational system rather than as an effective training device (Hays, Jacobs, Prince, & Salas, 1992; Lintern, Sheppard, Parker, Yates, & Nolan, 1989).

Efficiency is an aspect of training simulator that is often neglected. Even if cost-benefit analyses are conducted in the acquisition and application process, usually only few cost components are considered. Very often, organisations acquire training systems as an added feature of the operational system. The implicit assumption is that because the supplier has the know-how of designing and producing a system that meets the operational demands, he will also be able to design and produce a system that meets the training demands. Unfortunately, there are ample examples where this assumption proved to be false, leaving the customer with an expensive but worthless training tool.

SCENARIO GENERATION AND INSTRUCTION METHODOLOGIES

In scenario-based training, trainees prepare, execute, and evaluate exercises that are simplified simulations of the real-world. *Scenario-based training* is considered to be a more appropriate approach for training competencies required in complex task environments (e.g. Fowlkes, Dwyer, Oser, & Salas, 1998, Oser, 1999). Scenarios are a simplified version of the operational course of events. A scenario has a starting point and depending on the type of scenario, specific events are specified in time and space. Scenario's can be very structured in the sense that all events are scripted, or have a free play character. Also, scenarios can differ in complexity: they may be simplified, leaving out many aspects; they may also be complex and realistic.

Investigation of the present methods and strategies for scenario based training has shown that military training often is based on the educational principle: 'train as you fight' (van den Bosch and Helsdingen, 2000). The latter pertains to the idea that to warrant transfer, the nature and content of training should correspond as much as possible to the operational environment. The consequence of that principle is that training sessions are planned and executed like operational missions. However, the objectives differ. The goal of operational missions is to minimise failure, while the goal of training is to learn and improve knowledge and skills (Farmer, Van Rooij, Riemersma, Jorna, & Moraal, 1999).

Literature reports a number of methods supporting the process of event specification and scenario generation (e.g. Campbell & Deter, 1997; Fowlkes et al., 1998; Prince, Oser, & Salas, 1993; Oser, Gulateri, & Dwyer, 1998; Stretton & Johnston, 1997). All rightly emphasise the relationship between the learning goal, scenario event and performance measure. However, they tend to remain rather vague and not related to a specific domain (Van den Bosch and Helsdingen, 2000). For example, the guideline 'link missions, training objectives, performance measures and events' (Stretton & Johnston, 1997) although valuable, gives little insight in how it could be implemented. There is a need for more detailed rules and guidelines for scenario-based training development.

The design of scenarios is important, and so is the execution. A concern of current scenario-based training is that the dynamic and interactive nature of high-fidelity simulator training sometimes provides too little opportunity for instruction, interim feedback, reflection and critical task performance. This can be overcome by preparatory paper-and-pencil exercises, role-playing scenarios, and by introducing pauses in the simulator-scenarios (Van den Bosch & Helsdingen, 2002).

Very often, feedback is provided only at the After Action Review (AAR). Instructors tend to focus on the overall outcome of a training exercise and not to reflect on individual task behaviour. Instead, performance measurement and feedback should be aimed at both individual and team behaviour, and should not only address the outcomes but also the processes of performance.

LINKED SIMULATORS IN SYNTHETIC ENVIRONMENTS

Developments in network technology, open architectures and ever faster calculating speeds of processors result in the possibility to link simulators and create synthetic environments in which many different trainees can practise simultaneously. During the seventh annual Advance Planning Briefing to Industry (APBI), Rear Admiral Lindell Rutherford, Commander of the Navy's Carrier Strike Force and Carrier Group Four, emphasised that "in the future, a ship needs to return to port, plug into a data stream that allows its crew to operate its combat systems in a virtual training environment to train and rehearse joint combat missions with the Navy, Marines Air Force and Army in the same virtual world" (Weirauch, 2002). However compelling this scenario might be, we will elaborate on why this type of training is likely to be ineffective.

Linking simulators into one common synthetic environment may be detrimental to the benefits of the individual training systems. For example, an appropriate scenario for a radar operator requires the presentation of many contacts in a limited time frame. This is necessary to provide the operator the opportunity to practise his procedures and image-processing skills. When the simulator for radar operator training is linked to a larger simulated exercise (e.g. an air defence exercise), involving many other higher and lower level simulators (e.g. other sensor or weapon systems, C2 simulation, other frigates), then there is a good chance that the radar operator spends most of his time waiting for contacts to appear on his screen. Although knowledge and awareness of the relevance of your performance in a larger perspective is certainly important, we feel that waiting is not an efficient use of training time at the individual level.

Another problem with linked simulators is the increase in complexity, uncertainty and unpredictability. Firstly, increasing the number of simulators in a simulated environment, the number

UPDATED SOFTWARE TO ASSIST PROJECTION THEATRE DESIGN AND SET-UPA

3D Perception a.s has, in its release of CompactControl and CompactDesigner software, included several new features that allow the end users and projection theatre designers to set-up and design accurate theatres in minutes.

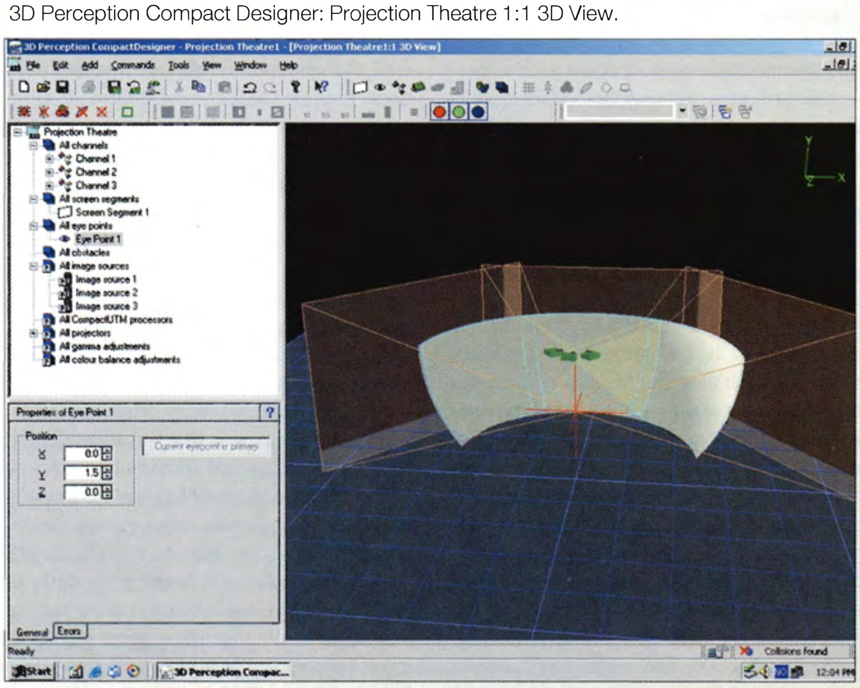
In CompactControl, there is a new feature called AutoCalc. Based on accurate modelling of the screen geometry and measurements along with definition of where in space the lens of the projector is located, the definition of the eye-point and accurate definition of Image Generator Pyramid of View (from the eye-point), the software will automatically calculate the correct distortion correction needed for the projection system. In products such as any projector in the CompactView family with built-in 3D Perception warping technology, or the external solution Compact UTM, the parameters for correct set-up will be automatically fed to the system.

This new feature of the system ensures a correct and accurate linearity in the imagery as seen from the eye point. To further ensure that the system can be aligned 100 %, as one is not always able to measure all parameters of screen, lens, eye position and IG view, the addition of a second mesh is possible for manual correction and fine tuning.

In the CompactDesigner, it is possible to include the above and another new feature: A Projector Editor. 3D Perception acknowledged that with the introduction of the Compact UTM, end users would opt to use projectors of other makes or the Compact XX E series. To enable the comprehensive design software package to be widely used in this manner, a new and easy-to-use projector editor is available. Measures or data about the projector to be used can be modelled into the software. Parameters include physical measures, optical data on the lens, depth focus limitations e.t.c.

Other features such as import of geometry distortion correction from external files and the possibility to import objects in 3D Studio format into the theatre design package, along with the AutoCalc feature, enables the designers to finalise projection theatre studies and investigate parameters for placing projectors, light beam interception of objects, definition of pyramid of view for the image generators as well as all physical limitations of the theatre both in 3D and 2D formats.

3D Perception Compact Designer: Projection Theatre 1:1 3D View.



of independent actors (the trainees on these simulators) increases and the training session will be far more unpredictable because of all these actors behaving freely. Secondly, each simulator is designed for specific purpose and with specific limitations. Although technical limitations are usually considered, the functional limitations are often ignored when simulators are included in a network of training systems. The unpredictable character might resemble real world situations but it does not provide a good training environment. Instructors can't be sure that all trainees will have the opportunity to practise their skills. Trainees can't know if and how they have to adjust their task behaviour since they don't know how their performance influenced the course of events. Training can even have detrimental effects if the simulator, due to the uncertain and unpredictable character of the scenario, assigns an error to accurate performance, and the trainee decides to change his task behaviour (Van den Bosch and Riemersma, in press).

Network centric warfare is an important development for future combat. Military units at all levels will be connected and form a network. This means that information which today is available only to a few headquarters can be made available to all units at all levels. For example, all ships will have access to exactly the same information as the naval headquarters. As a consequence, actions can be taken more quickly. If we have the operational networks up and running, and we have embedded training systems, why not use the network to design a comprehensive combat training? It provides a challenging and motivating training environment, and trainee motivation is an important factor in the quality of training. But the challenging character of linked simulators can also be a drawback: it could trigger competitive behaviour within trainees. Competition leaves no room for mistakes and sometimes tempt trainees to employ task strategies that may lead to victory but are inappropriate from a training point of view. Whether trainees will perceive winning, rather than learning, as the primary objective of networked training depends upon the way it is designed and whether or not pre-instructional information is provided to induce the desired attitude.

Before setting up network-based training, it is very important to consider the goals, the benefits, and the costs. When the goal of training is to teach teamwork capabilities to members of (distributed) teams, then linking simulators to create one common learning environment can be very effective. This presupposes that trainees have reached a sufficient level of competence in their individual tasks. It is also important to be specific in defining the training objectives: who needs to learn what skills, and who should be involved in the training thereof? It is often implicitly assumed that when training a team (e.g. CIC-team), the other players involved in the scenario (e.g. a helicopter pilot), will also profit from the exercise. This is not very likely, since the scenario, the instruction, the instructional support, the performance measurement and the feedback are not designed according to their training needs. It is probably more efficient to define the actions of supporting players as scripted events in the scenario or to simulate their behaviour by means of intelligent agents.

Fig. 4: Command and Control Room at TNO HUMAN FACTORS.

ARTIFICIAL INTELLIGENCE IN SIMULATORS

In scenario-based training, trainees prepare, execute, and evaluate exercises in simplified simulations of the real-world to acquire task-essential competencies. Scenario-based training can be very effective, provided that it meets the fundamental principles of training. For example, selected training scenarios must be tuned to the training needs of the individual or team, scenarios should provide ample opportunity to practise the target behaviour, appropriate measures of performance need to be logged, trainees need to have knowledge of results, and trainees need adequate feedback. These functions are now performed by the instructor, who often also needs to act as scenario leader and role player. Consequently, the work load of instructors is often too high, resulting in sub-optimal training profits. Artificial Intelligence can be used to develop models that support instructors in these important tasks, or that take over some of the functions all together. Such a model is called a 'virtual instructor'.

In the training of a command and control task, a virtual instructor may be used to compare trainee performance to the behaviour generated by an expert model. The outcome of the comparison is used to identify mistakes, to diagnose the underlying causes of mistakes (e.g. knowledge gap, implausible assumption), to deliver feedback, to adapt the scenario to the trainee's level of competence, and to select appropriate follow-up scenarios. Off-line virtual instructors are already used in computer-based training programmes. Developing virtual instructors that can work on-line in open tasks (e.g. military command) require substantial R&D investments, but will produce huge returns in training value.

The awareness that successful application of human models will bring about immense progress in research, training, policy making and system acquisition has yielded attention for this topic in the scientific world (Pew & Mavor, 1999). There are many different human models available: models of motor behaviour, models of social behaviour, models of cognitive behaviour, models of speech or human language, and so on. The functional demands on models differ, of course, according to application. For example, a human model developed for study-ing organisational problems requires different demands than a human model to be used for training purposes. However, Chandrasekaran and Josephson (1999) observe growing support for the view that, with the improvements in computing power, there is no longer any need to be concerned about the different requirements on human models. The cost of computing and the quality of modelling tools are supposed to have gotten to the point that we can have one model of agents that can answer all questions. With Chandrasekaran and Josephson, we believe that this view is the result of over-generalisation of a useful insight: that indeed we don't need to handcraft from scratch models for each simulation set-up or exercise, and that a large part of what is in human models can be shared across exercises. But even partial models could be successfully combined into one universal model, it would still be good to understand which details and dimensions must be represented in such a model to answer all current needs, which are of marginal value, and which are superfluous. The expansion of human factor knowledge will allow for capturing more elements, and more interdependencies among elements, into models. However, it is unnecessary and inefficient to consider elements that are irrelevant to the question or application. In addition, it may also have adverse effects. If human models are combined to construct a larger, more comprehensive model, the basic assumptions of the individual models may be violated. Research efforts should therefore focus on developing models that are intelligent, adaptive and dedicated to their purpose.

Another area of application of human behaviour models is 'team training'. Human models can be used to generate the behaviour of team mates. This enables the training of individual team members in team skills in the context of a systematic and controlled simulated team. Using human models in team training has huge potential benefits, such as lower costs per training session, accessibility of training, and improvement of training quality. There are still some challenges to overcome for successful application, however. Virtual team mates are still based on limited models of human behaviour and thus have limited range of behaviours. It is therefore necessary to specify exactly which tasks can, and which tasks can-not be trained with virtual teammates. The training of verbal communication skills, for example, is still difficult. Although automatic speech recognition systems become better and better, they still require the use of standard communication protocols. And every experts knows that in reality, communication deviates from that protocol, especially in the more challenging scenarios.

Another problem is the differences between teams that perform the same tasks. Not every frigate command team has the same working methods or social structure, although the tasks they have to perform and the operational environment are the same. This might cause problems and prevent broad applicability of virtual team-mates. Even if taking these problems into account, virtual team-mates are still a very promising area of technology, especially since there is so much to gain from their application. The focus, for now, should be on defining simulated team members for well-structured task environments, in which communication procedures are reasonably well defined (Schaafstal & Lyons, 2001).

Fig. 5: The basic T-workstation layout developed for the Dutch Navy.

CONCLUSION

The rapid technological developments in weapon, sensor, and communication systems have changed the character of military missions substantially. The demands on personnel in terms of information processing capabilities, decision making skills and team functioning have increased accordingly. Education and initial training are the appropriate means to acquire the essential competencies, which can later be expanded by advanced training and operational experience.

In order to be able to meet the high standards of military expertise, training should exploit the available resources as effectively as possible. Recent technology enable us to realistically simulate the task and operational environment. However, a high-quality representation of the operational environment does not, by itself, constitute a high-quality training tool. In this paper we addressed some key requirements to make a simulator effective in terms of training.

First of all, it must be made sure that trainees learn the knowledge and skills that are actually needed in the operational environment. This is not achieved by just conducting free play exercises. The learning objectives (derived from task analyses) must be taken as starting point for developing (a series of) training scenarios. Events in the scenarios must be linked to learning objectives, and performance measures must be defined for each event. Instructional facilities must be attached to simulators in order to support instructors in keeping track of the exercise, to guide and correct trainees, to provide feedback.

Secondly, trainees must be able to apply the knowledge and skills acquired in the simulator in operational conditions. This is the issue of "transfer of training". It can not be stated often enough that high face validity (the expert's subjectively experienced similarity between the simulator and the real-life situation) is, by itself, not sufficient for achieving transfer of training. In fact, introducing all complexity of real life into training may sometimes even be counterproductive. A simulator's validity is a function of simulator fidelity, the quality of training (i.e., the training methods, the contents of training, the way in which feedback is provided, etc…), the type of task, and trainee level.

The requirement to increase operational availability of personnel brought about new concepts of training, like "just-in-time" learning and "just-enough" learning. New concepts of simulator-based training emerged to accommodate these concepts. In the future, training will be delivered to the trainee rather then the trainee coming to the training facility (embedded and networked training). This requires us to design and develop systems and methodologies for appropriate training in the workplace. Technology is providing us with ever better, faster, and more comprehensive systems. Close consideration to the training demands is needed to ensure that technological solutions will be effective in solving the challenges. NAFO

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