SimNEC: Research Platform for Studying Human Functioning in NCW

Dr. Hendrik-Jan van Veen, Dr. Bernd de Graaf, Dr. Peter Essens
TNO Defence, Security and Safety
Business Unit Human Factors
P.O. Box 23
3769 ZG Soesterberg
THE NETHERLANDS

hendrik-jan.vanveen@tno.nl

ABSTRACT

SimNEC is TNO's grand scheme for experimentally studying human factors issues related to NEC/NCW. The research platform SimNEC consists of multidisciplinary expert teams, long-term research programmes, and a local network of state-of-the-art simulator modules. SimNEC does not focus on technology, but is purposely designed to study the functioning of humans in future network-centric warfare. This distinguishes SimNEC from typical technology-focused concept demonstration and experimentation approaches. Note, however, that SimNEC is designed with the capability to couple with and involve external parties, simulators, simulation networks, and potentially even life systems.

Several individual simulator modules have been created in-house over the past few years as the result of originally separate long-term research programmes, such as ICO, MSC, UMV, and FAC. ICO stands for an Integrated Command environment for the bridge, command centre and engine room of a naval frigate. MSC is a Mission Simulation Centre consisting of four F-16 cockpits (one on the high-end motion platform Desdemona). The UMV is a ground station for Unmanned Military Vehicle operations. FAC is a Forward Air Controller (or dismounted soldier) who communicates with MSC or a helicopter of the air manoeuvre brigade. C-unit is a RNLA command post for land operations within a NATO Response Force. Cannibal Hector is a joint operational centre for the supreme staff during an operation (hector is an acronym for human in command, and cannibal stands for maximally reduced manning). The network of simulator modules allows for the use of sensors and actors from one unit in any other unit. This part is currently under construction.

The aim of SimNEC is to facilitate experimental studies in each of the domains concerned, and additionally to provide the platform for joint/combined operations with multiple levels involved. We believe that real insight in the human aspects of NEC/NCW requires complex scenarios and a complex interconnected environment. We will discuss the approach taken and the studies that are under way and planned in the coming years.

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1.0 NCW/NEC DIMENSIONS

Military policy makers, including NATO, see network-based Command and Control (either NCW or NEC) as the key-enabling concept for future operations. The international efforts in this area provide the evidence that the network-based concept of operations is more than just an idea of some visionary thinkers. It's also meant to be more than digitisation of the force. It's aimed at linking and integrating all capabilities required to show and apply the decision powers and the means to achieve the desired effects.

Key components of a network-based capability are networks, information systems, the human system, and the organisation. In Figure 1, we show the four dimensions as key entities in the interaction model of a network-based structure. We take information as a separate entity in the model. The networks link sensors, systems, and humans in an integrated set of grids; the information systems gather, process, store, and distribute the information; the human system selects, decides and coordinates; and the organisation represents the distribution of roles, authorities and responsibilities, and the distribution of means and resources. From our perspective, which is the 'human in command' perspective [4, see also 7], the human is the driver of this system as pro-active user of information, and collaboration with other people. The human dimension represents the individuals and groups in the social network. The availability of information and of robust networks is the essential supporting component. The organisation component provides the support for collaboration between individuals and teams in the network of soldiers. All four components require new conceptual and applied development, in order to fully realise the network-based potential for joint concepts of operations.

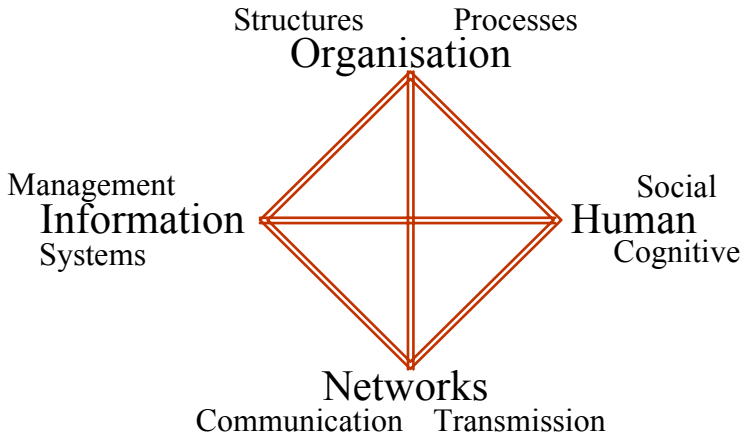

Figure 1: The Four Dimensions with their Main Components of a Network-Enabled System.

An essential element in the development of NEC and its four dimensions is the integration within and over services towards a 'seamless force' (see for instance, Australia's NCW Roadmap). This means not only that the systems are fully interoperable, but rather, while the joint parties each have their roles in the operation, a seamless force will share the higher intent and goals of the operation and at each level commanders should think in achieving joint effects. This, what we call, 'network-based thinking' on top of own tasks and responsibilities, will provide a basis for self-synchronisation of effects, which means, synchronisation with other parties without being pre-planned and directed by higher command [2].

2.0 HUMAN DIMENSIONS

What are the human dimensions of network enabled operations? From the open literature one can conclude that there is not yet a well established view on what the critical human aspects are of NEC -

many questions are raised, few answers are given, some questions are mere rephrases of old questions. At a recent conference at Shrivenham on this topic [8], themes presented were skills and attributes of NEC warriors, trust, command styles, collaborative working, situation awareness support architecture, and cultural differences. We note that often general statements and grand schemes are presented. However, actual behaviours using network capabilities are rarely discussed. What behaviours, skills and attitudes are required to realise the potential of the network? What are the opportunities and threats to human performance? Data on actual behaviours is a critical requirement for developing concepts and theories in this human domain. In addition, understanding emerging behaviours is crucial for understanding the potential of the network and its impact. For this reason, discovery experiments and building practical experience with network enabled ways of working are crucial.

We have started two lines of research using the empirical cycle approach towards building theory (observation, hypothesis building, testing, evaluation) [6]. One line is the gathering of data from naturalistic situations ('field data') and the second line is experimentation with realistic scenarios in complex command environments in the laboratory (SimNEC). We will give two examples of studies that focus on gathering field data.

In a recent study on competencies of future commanders in network-based operations, military commanders were interviewed on their perspectives on how command will develop using the network for communication and information gathering [1]. Typical characteristics of the network-based operation are increased information flows with multiple dimensions, larger area's of deployment, reduced freedom of movement, and sudden changes of operational conditions. There was a common understanding that distributed command will be the standard way of working in a network-based operation, with virtual collaboration between individuals and teams that are geographically, temporally and/or hierarchically dispersed. This will require effective 'distanced' and 'distributed' forms of military leadership. Teambuilding, cohesion, and trust are the challenged issues in such conditions. What was established before by face-to-face interaction now has to be build and maintained on a distance. The commanders were explicit about the idea that face-to-face interaction ('looking in the eyes') is conditional to command people when putting them into harms way. Operating in a network context will demand extra qualities in leadership, conveying meaning and clear intent, and explicit attention to social-emotional factors.

A second study of operational behaviours in naturalistic conditions is a current collaborative study between Canada, Sweden and The Netherlands, which addresses network-based thinking in a joint operation [5]. The issue studied here is the effective use of information coming from all parties in the joint operation. In a joint operational picture the tactical information of all military parties in theatre is presented. Which means that besides the information of your own troops and resources, such as geographic location and tactical properties, similar information of the others is presented. The idea of network-based thinking is that, due to direct insight into the status and conditions of the other parties, a commander can synchronise the execution of his own tasks with those of the other commanders. This enables him to better adapt to the operational conditions and augment joint effects. Moreover, the commander might make use of resources that are not under his command, which might be more adequate in terms of speed and effect in the particular operational conditions at that moment. In a peace keeping operation an air defence and navy force are tasked to protect an island from being infiltrated and taken over by an increasingly hostile nation. Multiple command levels are involved. In the scenario several situations arise in which for instance the use of navy resources by the air defence commander would be much more adequate (such as use of a navy helicopter for a fighter down rescue, or a naval radar to compensate for a black out condition). First observations revealed, for instance, the problem of thinking outside the own scope of tasking and including the other joint intent in the own intent. The utilisation of available capabilities as identified in the joint operational picture is a problem. While the tactical information is available, it is a large step to apply this in the own solution space. This field experiment has many of the known problems of field experimentation, despite the level of control of the scenario. In particular the measurement of the behaviours is difficult in a naturalistic condition.

These two studies provide data that add to our insight in what behaviours are required to fully exploit NEC. A classic problem in trying out new concepts in a naturalistic context is that current ways of working are often in the way. It takes time before new possibilities are fully exploited by the operators and soldiers in the new situation. For instance, one could argue that the commanders in the competencies study have a particular mental model and way of working that prevents adapting to a new situation and exploit the new possibilities provided. So despite the commanders' conclusion that face-to-face is conditional, this should not prevent exploring what configuration of media, protocols, and attitudes might resolve these issues of leadership and team quality, and still be operationally feasible. Also in the air-navy study on the effective use of the joint information provided, the observed problems demonstrate what problems there are in the transition from current thinking to network-based thinking. These problems are realistic and in the development of the seamless force, in particular in a coalition force, this will always be a problem with joint (coalition) parties that are not used to working together. The challenge is now to study how to alleviate these problems, in terms of technology, new ways of working, new protocols, capabilities, training. For this research program to realise, we need a simulation environment that allows a complex variation of operational scenarios with multiple levels of command.

3.0 C2 SIMULATION ENVIRONMENTS

The development of simulation environments for command and control studies reflects the separation of the forces in the past. In our Human Factors laboratory most recent developments of command environments address six environments:

- ICO - an Integrated Command Environment for the bridge, command centre, and engine room of a naval frigate.
- MSC - a Mission Simulation Centre consisting of four F-16 cockpits (one on the high-end motion platform Desdemona).
- UMV - a ground station for Unmanned Military Vehicle operations.
- FAC - a Forward Air Controller (or dismounted soldier) who communicates with MSC or a helicopter of the air manoeuvre brigade.
- C-unit - a RNLA command post for land operations within a NATO Response Force.
- Cannibal Hector - a joint operational command suite for the supreme staff during an operation (hector is an acronym for human in command, and cannibal stands for maximally reduced manning).

Some of these environments were developed from long term studies on how to integrate radar information, augment situation awareness, and support decision making. A good example is the development of the Basic-T workstation, which was developed first as a stand alone concept (see figure 2). After testing and demonstrating the added operational value, this formed the basis for a whole ensemble of stations for complete integration of all command and control functions on board of a frigate.

Figure 2: Integrated Workstation for Raw Data Presentation, Augmented Situation Analysis, and Effect Consequence Analysis ('Basic-T').

A recent development was the joint operational command suite 'Cannibal Hector'. This concept has four future premises: 1. operational commanders will share one central workspace, where they discuss, solve, and plan jointly; 2. by rotating their seat into their personal cave, they will command their force using high level communication media that provide virtual presence with their lower commanders; 3. they will be able to directly interact and command lower tactical levels and talk to the so called 'strategic corporal', if situations require this; 4. there are no local staffs around these commanders, staff support is at a reachback position (see figure 3). This challenging command concept will allow for very fast decision making and agility in strategically and politically complex situation. One of the major fears military commanders express with the NEC developments is that higher level command will use the 'long screwdriver' to control the lower levels. They fear that instead of mission command, micro-management will take over and will leave little freedom of action for lower level commanders to solve operational problems with the extended local knowledge they have. This fear is not an anecdotal observation, but is brought forward by many of the military commanders we have spoken since NCW/NEC became popular [1], and is reported by many other authors [3]. The Cannibal Hector command environment will allow us to study what the real limitations in human behaviour are, if the right support, adequate training, skills and attitudes, and information presentation is given to commanders.

Figure 3: Cannibal Hector Command Suite with the Joint Operational Commanders Table and their Personal Command Niches with Sample Images.

4.0 SIMNEC: AN INTEGRATED EXPERIMENTATION PLATFORM

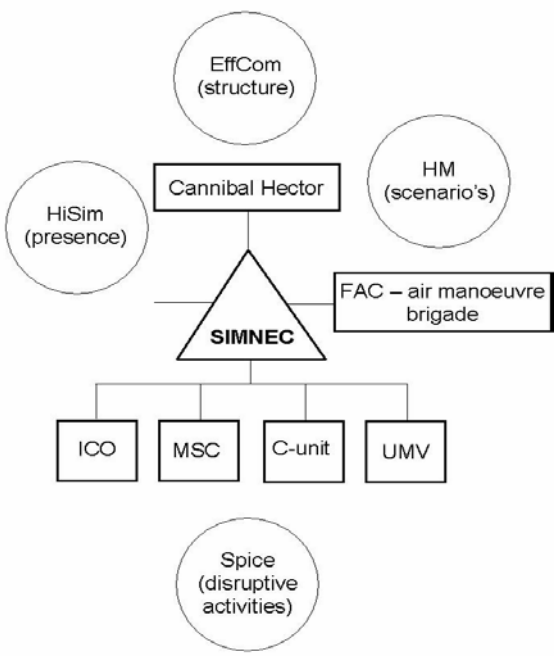

Figure 4: Scheme of Research Platform for Network Centric Warfare: SIMNEC.

Figure 4 shows a schematic lay-out of our research platform for Network Centric Warfare: SIMNEC. It consists of a network of modules, each of which is build for an individual long-term research program. ICO (see figure 5) is an Integrated Command environment for the bridge, command centre and engine room of a frigate. ICO has evolved from the Basic-T (see figure 2) and is being developed together with the Royal Netherlands Navy in a long-term research progamme. MSC (see figure 6) is a Mission Simulation Centre consisting of four F-16 cockpits (one mounted on the high-end 6-DOF motion platform Desdemona, and three with a fixed base). MSC is the primary research tool for the Pilot Factors research programme together with the Royal Netherlands Airforce. C-unit is a Royal Netherlands Army command centre for land operations (BMS) within the NATO Response Force. The UMV is a ground station for Unmanned Military Vehicle operations. FAC is a Forward Air Controller (or dismounted soldier) who communicates with MSC or a helicopter of the air manoeuvre brigade. Cannibal Hector (see figure 7) is a joint operating centre for the supreme staff during an operation (hector is an acronym for human in command etc., and cannibal stands for maximally reduced manning). While the former modules act mainly on a tactical level, the latter is primarily on an operational, and a bit on the strategic level. With the exception of C-unit and FAC, all these modules are located next to each other in one dedicated building.

Figure 5: ICO: Integrated Command Environment for the Bridge, Command Centre and Engine Room of a Frigate.

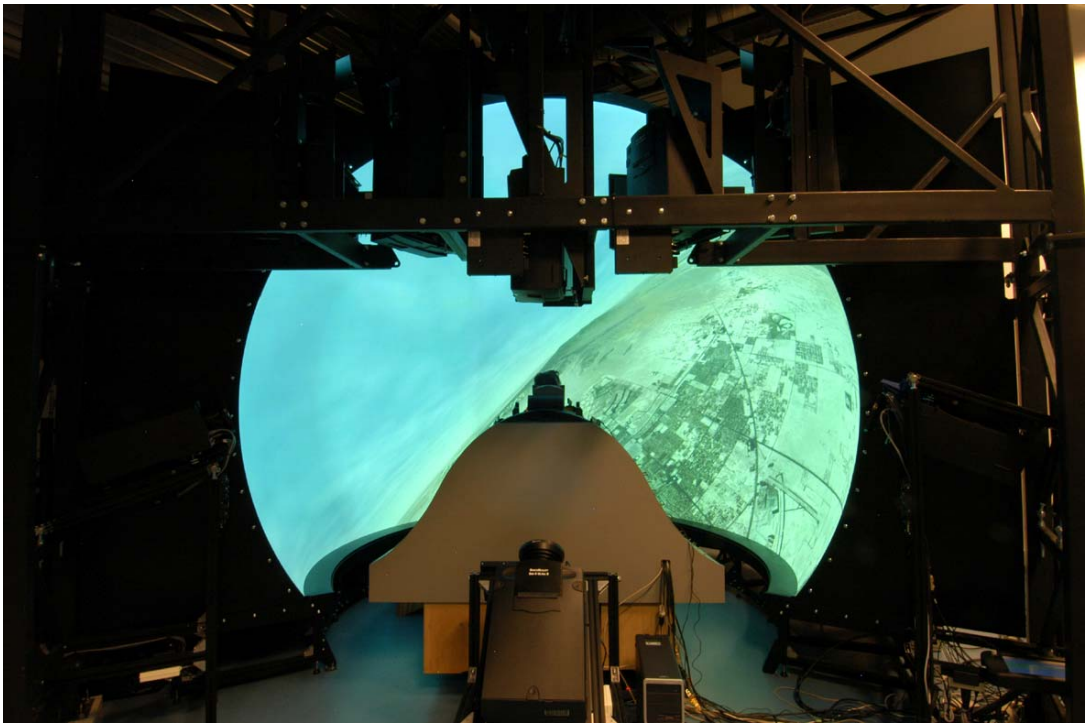

Figure 6: MSC: Mission Simulation Centre Consisting of Four F-16 Cockpits. Shown here is a one of the three fixed-base cockpits and its dome projection system.

Figure 7: CH: Cannibal Hector, a Joint Operating Centre for the Supreme Staff. The left panel depicts an early CAD-model showing the basic lay-out of four "cubicles" draped around a central workspace. The panel on the right is a photograph of the current situation. Two of the four commanders are working in their personal workplaces, interacting with staff members at a reachback position. Also see figure 3.

SimNEC does not focus on technology, but is purposely designed to study the functioning of humans in future network-centric warfare. When fidelity requires us to introduce technological limitations (e.g., effects of bandwith) or possiblities (e.g., seamless use of sensors from one unit in any other unit), we will use all available tricks to simulate them. This distinguishes SimNEC from typical technology-focused concept demonstration and experimentation approaches. Note, however, that SimNEC is designed with the capability to couple with and involve external parties, simulators, simulation networks, and potentially even life systems.

The aim of SimNEC is to facilitate experimental studies in each of the domains concerned, and additionally to provide the platform for joint combined operations with multiple levels involved. We believe that real insight in the human aspects of NEC/NCW requires complex scenarios and a complex interconnected environment and that SimNEC can provide this.

Four multidisciplinary expert groups shape SimNEC's appearance and research future. EffCom (effectiveness of command and control) is responsible for the structure and flow of the C2 processes in SimNEC, HM (human modelling) is responsible for the content of the scenario's played, including cognitive agents, and HiSim (human integrated simulation) guarantees for the ecological validation, the "presence" or immersion, of the experiences of the participants. The fourth group was created only recently and is called SPICE. This team has a dark image. While the first groups have a positive role in building an NCW environment and investigating it for its improvement, the latter group has to find ways and measures to disrupt the command processes by identifying the vulnerability of its organisation and of the man in the loop (PsyOps, etc.). Together, these groups build SimNEC and use it as a controllable experimental NCW environment with high ecological validity.

Several research programmes are under way to exploit human functioning in NEC. On the organisational dimension one research focus will be on the dynamic reallocation of functions in a network-based command structure driven by operational conditions. Another issue studied will be a reachback staff that supports multiple levels of command, in stead of one level. This will reduce the size of staff even further. The question of course is what the informational, cognitive and social boundaries are of such a system. Other research issues will be the positive utilisation of direct command with a long screw driver, while avoiding the downsides. Also, the issue of trust in command on a distance will be studied in the SimNEC

context. On the informational dimension we will study the essential NEC aspect of sharing and understanding of information over command levels and between different service and coalition partners. Another study will be launched to prepare and train soldiers in quickly adapting to the network-based thinking using the simulation and gaming facilities, rapidly integrating new technology-provided functions into their concept of operation. A further issue will be the graceful degradation of working in a network environment if the network fails to work. We think that in principle the network-based thinking does not depend on the technology. Soldiers should also be able to apply the same thinking in all operational conditions, as a better way of effectively operating in dynamic situations. We will test those conditions once network-based thinking has proven to deliver the decision superiority it is supposed to have.

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