Some research results obtained with DKE: A dynamic war-game for experiments

Jan Kuylenstierna, Joacim Rydmark and Hans Sandström

Jan Kuylenstierna
PhD, Psychology
Researcher, C^3I studies
Swedish National Defence College
Department of War Studies
Valhallavägen 117, Box 27805
SE-115 93 STOCKHOLM
Sweden
Tel: +46-8-788 9822
Fax: +46-8-788 9588
E-mail: jan.kuylenstierna@fhs.mil.se

Joacim Rydmark
PhLic, Political Science
Research assistant, C^3I studies
Swedish National Defence College
Department of War Studies
Valhallavägen 117, Box 27805
SE-115 93 STOCKHOLM
Sweden
Tel: +46-8-788 9592
Fax: +46-8-788 9588
E-mail: joacim.rydmark@fhs.mil.se

Hans Sandström
MSc, Computer Engineering
Research assistant, C^3I studies
Swedish National Defence College
Department of War Studies
Valhallavägen 117, Box 27805
SE-115 93 STOCKHOLM
Sweden
Tel: +46-8-788 9592
Fax: +46-8-788 9588
E-mail: hans.sandstrom@fhs.mil.se

Abstract

The decision task facing a military commander in battle can be characterized as a dynamic decision making task. An efficient way to study dynamic decision tasks is to conduct experimental laboratory research with the aid of so-called microworlds. Microworlds are low-fidelity computer simulations of real world decision-making environments and for research on military decision-making it seems reasonable to use computerized war-games. Although many war-games are available on the commercial market, few are suitable for experimental research. A dynamic war-game for experiments called DKE (Dynamiskt Krigsspel för Experiment) has therefore been developed within a project entitled "The need for information in future wars". Two experiments have been carried out with the aid of this war-game. According to a widespread opinion the value of information superiority is unrelated to the absolute level of certainty about the situation in the battlespace. In line with the research group's earlier findings the results from the first experiment failed to support this opinion. The results from the second experiments suggest that a "need-based operational picture" can be an alternative to a "role-based" operational picture.

Introduction

A military commander in battle is facing a dynamic decision task and such a task has four properties (Brehmer, 2000).

- It requires a series of decisions.
- The decisions implemented are not independent.
- The state of the environment changes both, autonomously (for example as a consequence of enemy actions of enemy actions) and as a consequence of the decision maker's own actions.
- Time is an important factor.

An efficient way to study dynamic decision-making is to conduct laboratory experiments with the aid of so called microworlds. Microworlds are computerized simulations of real world decision-making environments. They are not intended to be high-fidelity simulations however. Instead, they represent the environments in the same sense that woodcuts represent scenes – it is possible to recognize what is being represented, but there is very little detail. The use of microworlds is an attempt to preserve the "ecological validity" of field research without losing the experimental control of laboratory research (Brehmer, 1992; Brehmer & Dörner, 1993). For research on military decision-making it seems reasonable that the microworlds employed are computerized war-games. Many war-games are available on the commercial market but they normally have too many limitations to be really useful as research tools. As a rule they cannot meet the demands for experimental control and data registration required for experimental research. A dynamic war-game for experiments has therefore been developed within a project entitled "The need for information in future wars". It is called DKE (Dynamiskt Krigsspel för Experiment). The purpose of this paper is to present DKE and also to present some findings made with this game.

DKE

DKE is a computerized war-game based on GECCO (Game environment for Command and Control Operations), a construction environment for dynamic microworlds developed at the Royal Institute of Technology in Sweden (Brynielsson & Wallenius, 2001). DKE is written in JAVA and runs under a GPL-license. The latter feature is what makes DKE attractive as an experimental tool; users of the game are free to re-programme it at will. Three versions of DKE have been developed so far, one of which is available on the web.

At least two players are required to play the web version of DKE; it is not possible to play in a single player mode. Many commercially available war-games are turn-based games. For each turn the clock stops, the players enter their orders, and then the clock starts again and a player who wants to give a new order must wait until the clock stops again. DKE on the other hand is played in real-time; new orders can be entered when needed.

In the game each player has access to a number of military units that can move over a map and fight each other. However, the task is not to annihilate the adversary's units but to capture terrain. The terrain to be captured is marked by symbols on the map. The game has two types of units: Armored units for combat and artillery units for distant engagement. They differ with respect to efficiency values for armored attack, artillery fire, defense, protection, endurance and mobility. Advantages can be reached by combining the efforts of the two types of units. There are also several types of terrain: Open, covered, woods, villages, bypaths, narrow roads, broad roads, motorways, narrow rivers and broad rivers. The various types of terrain differ with respect to their effects on unit speed, unit defense efficiency and unit the efficiency of unit protection. Figure 1 shows a screenshot from the game.

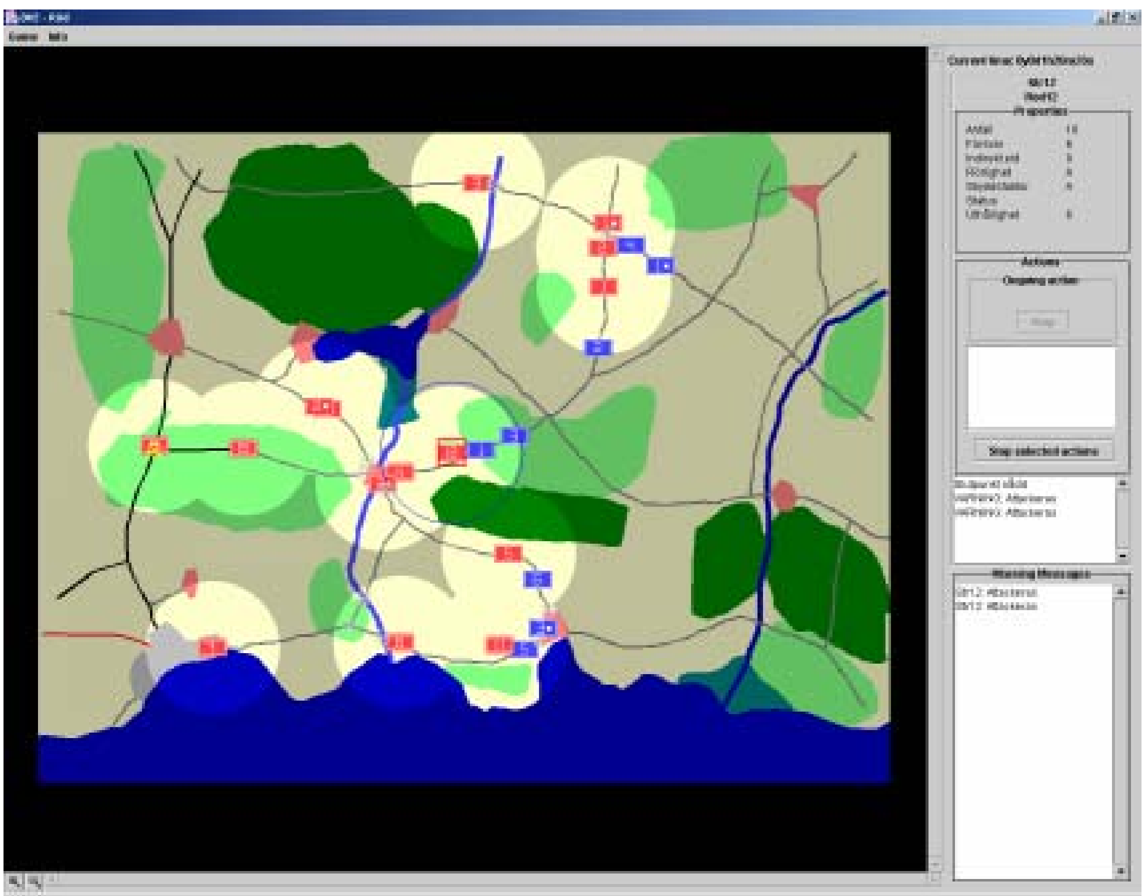

Fig 1. The figure shows a screenshot from DKE.

To the left in Figure 1 is the map with the units and to the right of the map is a message area. The latter can display the status of marked units, ongoing actions and various types of warning messages. Marking units and selecting from a menu enter orders and marking points in the terrain chooses the units' destinations. Units can advance either by going straight to the destination through the terrain or by taking the shortest way possible confining to the roads. The game also has a "zoom-function" for close-up pictures.

It is possible to redraw the map, re-position the victory points and change the number of units as well as the units' efficiency values without re-compiling the program; other changes require reprogramming.

Experimental findings

So far two experiments have been carried out with the aid of DKE. Both were concerned with a key question for the development of network centric warfare; how to create superior command and control. One way to accomplish this is to use advanced information technology in order to establish information superiority against an adversary. However, also with the best technology the "fog" of war is expected to remain and lead to an unclear view of the battle space, but according to a widespread opinion this need not be very serious for the possibilities to create efficient information superiority (e.g. Alberts, Garstka, Hayes & Signori, 2001). If the information situation is perfect or not is assumed to be of lesser importance; what counts is the information situation as compared to the adversary's. The purpose of the first experiment was to test this assumption (Kuylenstierna, Rydmark & Sandström, 2003 a). The participants in the experiment (56 persons) were randomly divided into two groups and the participants in each group were subdivided into pairs. Each pair played one game. In each pair one player had two and a half times longer sensor range on his units than what the other player had. The two groups played under different conditions. The respective sensor ranges were twice as long in the first condition than the sensor ranges in the second condition. Each player with superior sensor range was scored one point for a win, a half point for a draw and zero points for a loss. The group means were compared and the result failed to support the assumption that the information situation as compared to the opponent's is the only thing that counts. Increasing the fog by shortening the sensor ranges made it much more difficult to defeat the opponent although the sensor-range ratio between players in the same pair was the same in both conditions. This result is in line with earlier results obtained by the research group (e.g. Kuylenstierna, Rydmark & Fahraeus, 2000). These findings indicate that it may be difficult to create superior command and control only by using technology to lift the fogs of war. Other measures in order to establish superior command and control need also be taken.

One such measure could be to improve the selection of information for the commander's decision making. Modern information technology can provide military commanders with enormous amounts of information about the situation in the battlespace. So much information can lead to "information overload" and thereby to delays in the decision making process. A central problem in the development of military information systems is therefore how to select information for planning and execution of military operations so that the amount of information is kept down, but still provides for an operational picture that is sufficient as a basis for good decisions. Literatures within the field suggest two principally different solutions to this problem (e.g. Kahan, Worley & Stasz, 1989; Builder, Banks & Nordin, 1999; Brehmer, 2002). The first solution, here designated "role-based operational picture" means that a unit is assigned a role and its commander is provided with information that is pre-selected as appropriate for this role, and that access to other information is strongly restricted. The other solution, here called "need based operational picture", means that the commander has potential access to all information available about the situation in the battle space, and makes his own decisions about what information to select. Which solution is to be preferred? The second DKE experiment was designed to investigate this question in more detail (Kuylenstierna, Rydmark & Sandström, 2003 b). Participants in the experiment (32 persons) were randomly divided into two groups and the groups were in their turn also randomly subdivided into pairs. In each pair one of the players had access to all information that could be provided, whereas the other player had access to an expert based sub-selection of information. The player with access to more information had access to some 130 information variables more than their opponent. The groups played under different conditions. The players in the first condition could choose between three different speeds for their units whereas the player in the other condition could choose between five speeds. The top speed in the second condition was twice as fast as the top speed in the first condition. Each player with the need-based operational picture was scored one point for a win, a half point for a draw and zero points for a loss. The condition means indicated no differences between the two selection methods in any of the conditions. In this experiment strong efforts were made to optimize the role-based information for the scenario used. However, to optimize the role-based information may not always be possible. It can in many situations be difficult to specify in advance what kinds of decisions that are going to be made and hence what kinds of information that will be required. If the need-based alternative should prove to be equal to the role-based alternative in a situation where the role-based information is optimally selected, it can be expected to be superior in situation where the role-based information is suboptimal. From this perspective the outcome of the experiment can be interpreted as support for the need-based alternative. However, interpretation of a "no-effect" result is always fraught with risk and more research is needed to get a conclusive answer.

Concluding remarks

DKE has proven to be a valuable tool in the conduct of experimental research on dynamic decision-making in adversarial situations. A version of the game can be apprehended from the GECCO homepage at www.nada.kth.se/tcs/gecco.

References

Alberts David S., Gartska John J., Hayes Richard E., & Signori David A. (2001), *Understanding Information Age Warfare*, CCRP Publication Series, Washington.

Brehmer Berndt (1992), ”Dynamic Decision Making: Human Control of Complex Systems” i *Acta Psychologica 81*, s 211-241.

Brehmer Berndt & Dörner Dietrich (1993), ”Experiments With Computer-Simulated Microworlds: Escaping Both the Narrow Straits of the Laboratory and the Deep Blue Sea of the Field Study” in *Computer in Human Behavior* (1993), Vol. 9, s 171-184.

Brehmer Berndt (2000), ”Dynamic Decision Making in Command and Control” in *The Human in Command: Exploring the Modern Military Experience*, Eds. McCann, Pigeau & Kluwer, Academic/Plenum Publishers, New York.

Brehmer Berndt (2002), *Ledning i NBF*, Rapport från projektet NetWork Warfare, KVI-F, Försvarshögskolan, Stockholm.

Brynielsson, J. & Wallenius, K. (2001), "Game Environment for Command and Control Operations (GECCO)" in *International Workshop on Cognitive Research with Microworlds*, Granada, Spanien, 12-14 november 2001 (http://www.nada.kth.se/theory/gecco)

Builder Carl H., Banks Steven C. & Nordin Richard. (1999), *Command Concepts: A Theory Derived From the Practice of Command and Control*, National Defence Research Institute RAND: Santa Monica CA.

Kahan James P., Worley D. Robert & Stasz Cathleen (1989), *Understanding Commanders Information Needs*, RAND Corporation, Santa Monica.

Kuylenstierna Jan, Rydmark Joacim & Fahraeus Tonie (2000), ”The Value of Information in War: Some Experimental Findings” in *Proceedings of the 5th International Command & Control Research & Technology Symposium (ICCRTS)*, 24-26 okt 2000, Canberra, Australien.

Kuylenstierna Jan, Rydmark Joacim, & Sandström Hans (2003 a), ”Betydelsen av överlägsen sensorräckvidd vid olika nivåer på osäkerhet om läget i stridsrummet” in *Informationsbehov i framtida krig: Experimentrapport, Rapport nr 12,* KVI-F, Försvarshögskolan, Stockholm. Bilaga 2 till FHS 21 105:60998.

Kuylenstierna Jan, Rydmark Joacim, & Sandström Hans (2003 b), ”Urval av information och tempo i striden” in *Informationsbehov i framtida krig: Experimentrapport, Rapport nr 13,* KVI-F, Försvarshögskolan, Stockholm. Bilaga 1 till FHS 21 105:61305.