International Journal of Electrical, Electronic and Communication Sciences
ISSN: 2517-9438
Vol:5, No:7, 2011

Using Simulation for Prediction of Units Movements in Case of Communication Failure

J. Hodicky, P. Frantis

***Abstract*—**Command and Control (C2) system and its interface-the Common Operational Picture (COP) are main means that supports commander in its decision making process. COP contains information about friendly and enemy unit positions. The friendly position is gathered via tactical network. In the case of tactical network failure the information about units are not available. The tactical simulator can be used as a tool that is capable to predict movements of units in respect of terrain features. Article deals with an experiment that was based on Czech C2 system that is in the case of connectivity lost fed by VR Forces simulator. Article analyzes maximum time interval in which the position created by simulator is still usable and truthful for commander in real time.

***Keywords*—**command and control system, movement prediction, simulation

I. INTRODUCTION

NOWADAYS, Command and control (C2) system is main mean that support commanders in its decision making process. First C2 system was designed in 1995 when the US army deployed Force XXI Battle Command Brigade and Below (FBCB2) system. From that time the main interface that provides the idea of current situation to the commander at the battlefield is the Common Operational Picture (COP). COP is based on Geographic Information System approach and visualizes military information related to geographic data resources. It creates the real time view of the battlefield and shows mainly friendly and enemy units on particular terrain in two or three dimensions [1]. To get the right information about friendly unit position the C2 system must be interconnected with all friendly units on the battlefield via tactical network. In case of communication failure COP uncertainty is increased.

II. EXPERIMENT PHILOSHOPY

Common operational picture is created by C2 system and is updated when new information from battlefield is available. This information is sent via tactical data links that are based on radio or satellite connectivity. If there is no connection failure the commander gets the real time picture with no uncertainty. If there is a problem of a data link, the commander looses the possibility to get the right information about unit position in near future. To overcome this drawback a dead-reckoning algorithm can be used, but only for a very short period of time [2]. This algorithm is based on a unit movement history. The vector of the unit movement is counted from historic data and it is used to predict the future position of the unit. This approach is not suitable for long period of time, because units in the real world control their movements according to terrain, battlefield situation and its behavior settings.

The main goal of our experiment is to define the time interval in which the simulated movement of units or vehicles can be still taken as applicable in C2 system. Thus we used simulation environment to predict unit movement in the real battlefield and we correlated the obtained simulation results with the real ones.

III. EXPERIMENT ARCHITECTURE

The three main components were used in the experiment:

- Tactical simulator VR Forces,
- Czech Command and Control System (CC2S),
- New presentation layer of CC2S.

MÄK VR Forces product was chosen as a tactical simulator. VR Forces can generate and execute various battlefield scenarios. Tactical simulator was used for modelling units' behaviour - to add a model based on artificial intelligence that would generate expected movement of units

CC2S is used to get the last available real information about unit positions at the battlefield [3].

New presentation layer of CC2S is capable of 3D visualization of the real situation at the battlefield. The output of this presentation layer is real-time 3D visualization of the terrain with aerial or satellite imagery, 3D models of buildings generated from vector shape files, polygon or full 3D tree representation of woods, forests and tree lines, 3D road network, power lines and obstacles [4]. Real time visualization in 3D brings commander another means to support decision-making process.

VR-Forces, CC2S and the new presentation layer support High Level Architecture (HLA) for distributed simulation [5]. This architecture was used to interconnect all system and it allows using any suitable tactical simulator.

Each component works with correlated terrain databases. It was vital to prepare the terrain database from the same data sources. DTED format for the digital elevation model and ESRI Shapefile files for the vector features were used.

When the communication line failure is detected the CC2S send the current situation (positions of units at the battlefield)

J. Hodicky is with the University of Defense, Brno, Czech Republic, (phone: 00420-737875288; e-mail: jan.hodicky@ unob.cz).

P. Frantis is with the University of Defense, Brno, Czech Republic (e-mail: petr.frantis@unob.cz).

and expected scenario to the simulation environment (represented by the VR Forces simulator). VR Forces loads the scenario via HLA and execute it. The simulated results – the expected unit positions are sent back to the CC2S and they are visualized in 3D in the new presentation layer of CC2S. The question is for how long the simulated results can be used to overcome the shortage of the real information.

The overall architecture is showed on Fig. 1.

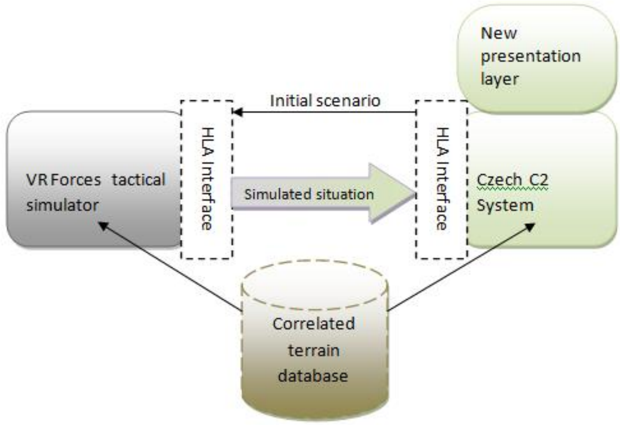

Fig. 1 Experiment architecture

IV. EXPERIMENT SCENARIOS

The main question that we need to find the answer is: "How long the simulated environment can substitute the real data from the battlefield?" To answer this question we executed an experiment. We took the records of a real exercise and compared it with the results obtained by simulation. We used records from the Network Challenges 2009 exercise. The three main categories of input were selected:

- Unit movement on the road.
- Unit movement in the built up area.
- Unit movement in other terrain.

Each of these categories contained more than 2 hours of records. These records were divided into 20 minutes parts. Thus the each category contains 10 parts with 20 minutes of real record of unit movement. The convoy of four vehicles was selected as the main reference mean. To measure the divergence between real and simulated vehicle position the variable difference position error (DPE) was defined (1).

$$DPE = \frac{\sqrt{(X_{RP} - X_{SP})^2 + (Y_{RP} - Y_{SP})^2}}{2v_v t} 100 \quad (1)$$

X_{RP} –real position of vehicle in axis x,
X_{SP} –simulation position of vehicle in axis x,
Y_{RP} –real position of vehicle in axis y,
Y_{SP} –simulation position of vehicle in axis y,
v_v – average velocity of vehicle in defined terrain (in one of our three category),
t – time is equal for simulation and for real system as well, third dimension was omitted, the flat projection was used.

Maximum difference between real position and simulated position must be doubled (2* v_v *t) because of possible opposite movement. That situation corresponds with 100% value of DPE as we can see on Fig. 2.

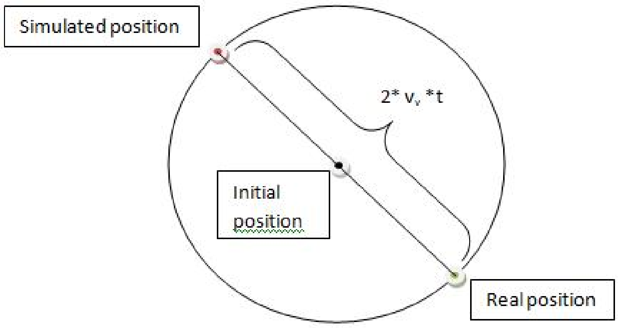

Fig. 2 Maximum value of DPE

V. EXPERIMENT RESULTS

Three categories were individually analyzed:

- on road movement,
- movement in built up area,
- movement in other terrain.

Every category contained 10 intervals that corresponded to different initial positions of vehicles. The measurement of difference between real position and simulation position was done in period of 30 seconds. Measured values of DPE were averaged and results referenced to time as can be seen on Fig. 3.

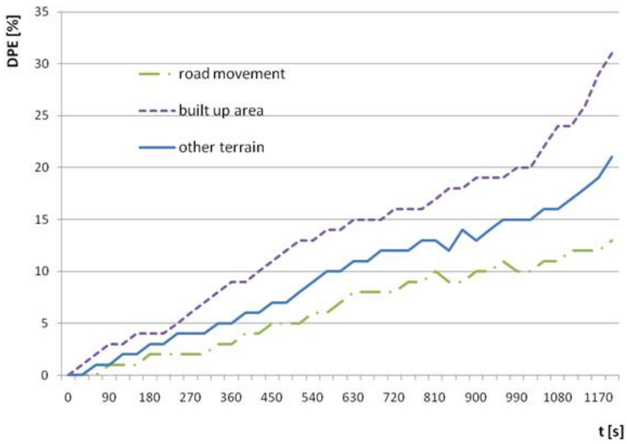

Fig. 3 Experiment results – DPE reference to time

Based on the discussion with commanders at the particular levels of command the maximum acceptable error between real position and calculated position by the simulator was chosen as 5% (DPE = 5%). This value is the threshold value that decides if the simulator delivers correct information from the military decision point of view or not. From Fig. 3 the followed results can be obtained. If the connection between C2 system and real units is broken, the simulation can deliver the future position of units only if the time interval of connection failure is less then:

- 240s in the case of unit movement in the built up areas.
- 450s in the case of unit movement on the roads.
- 330s in the case of unit movement in other -non specified terrain.

If these times are exceed the estimated position cannot be taken as usable.

VI. Conclusion

The connection failure in C2 system is frequent issue in the military environment. Commander needs to have the real units positions at all time. To overcome this inconvenience we implemented the interconnection between the tactic simulator and Czech C2 system. In the time of connection failure the simulator can feed the real system by predicted (simulated) positions. Our experiment involved only vehicles moving in specific category of terrain. It reveals that simulator can deliver usable results in limited time interval. In the case of movements in the built up areas is this method almost inapplicable. Next step in our experiment will be focused on prediction of unit movement that can be affected by enemy forces. Our approach is not only limited to the military domain but can be also employed in civil domain. The Geographic Information System that support crisis management can be fed by special simulator.

References

[1] T. Johansen, "Requirements for a Future COP-Display Based on Operational Experience," in *Proceedings of RTO Information Systems Technology Panel (IST) Workshop*, Totonto: RTO IST, 2005, pp. 10-14.
[2] S. J. Yu, Y.C. Choy,, 2005. *An adaptive dead reckoning algorithm using update lifetime*. Revue of Virtual Reality. New York: Springer London, 2005.
[3] V. Jindra, J. Kotas, "Modernized conception of Czech Command and Control System, " *in Proceedings of ITTE 2006*, Brno, 2006, pp. 34-39.
[4] Prenosil, V., et al., 2008. *Virtual reality devices in the modernized conception of Czech C2*. [Research report of military project: VIRTUAL]. Brno: MU Brno.
[5] NATO, STANAG 4603: *Modelling and simulation architecture standards for technical interoperability-High Level Architecture*. Brussels, NATO Standardization Council, 2009.