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Virtual Reality Devices in C2 Systems

Topic: Track 8 – C2 Architectures

Abstract

The situational awareness and decision making support is the main objective of C2 system. Thus, the presentation layer architecture of C2 systems is one of the most important features for common understanding of a battlefield situation. The commander should have the option to choose the appropriate form of data presentation and interaction in the C2 system. The current state of the art in presenting of information is set by the US Force XXI Battle Command Brigade and Below (FBCB2) system and its new presentation layer component Command and Control in 3 dimensions (C3D) that renders the battlefield information into a 3 dimensions (3D) environment in real time.

The paper deals with the Czech approach to the improvement of presentation layer in the currently used C2 system. It involves using an existing virtual reality presentation engine (designed for virtual simulators) as an additional presentation layer. This work has already been started as a defense research project that plans to deliver results in 2008. The currently developing presentation layer extends the 3D visualization of the battlefield situation and adds virtual reality (VR) device integration, supporting an interaction within the C2 system. The architecture utilizes head-mounted display, data gloves and motion tracking systems.

The paper describes the current situation in this outgoing project, and then discusses the technical aspects of the solution.

Introduction

The main objective of outgoing projects in the C2 field is to increase the situational awareness of a commander by maintaining a common tactical situation picture. The main concept of C2 systems is to equals the commander's mental awareness to the actual tactical battlefield situation. It can be mainly achieved by using the means of new technology in “appropriate” way. The meaning of word appropriate is essential. The high tech solutions usually create new forms of confusion and misunderstandings from the user point of view.

Thus, the architecture concepts in C2 domain that brings new Human Machine Interfaces (HMI) may reduce the uncertainty at the high level of command (i.e brigade), but only if the used technology is verified by years of a usage.

A new architecture approach with virtual reality devices in the C2 field is based on the idea of leveraging the army commander's experience with innovative means of visualization such as Head Mounted Displays (HMD), data gloves and tracking devices.

Current state of HMI in the C2 context

The brigade commander should have the possibility to support his own decision making process by selection of suitable HMI in the C2 context. The current HMI in the C2 systems at brigade level are based on two dimensions (2D) desktop solutions. The only way of communication is using a mouse, headphones and microphone. Figure 1 shows the FBCB2 interface that is used at tactical level up to the brigade. This system is based on VMF messages. These are used for the transmission of orders, reports, and data in a timely manner.

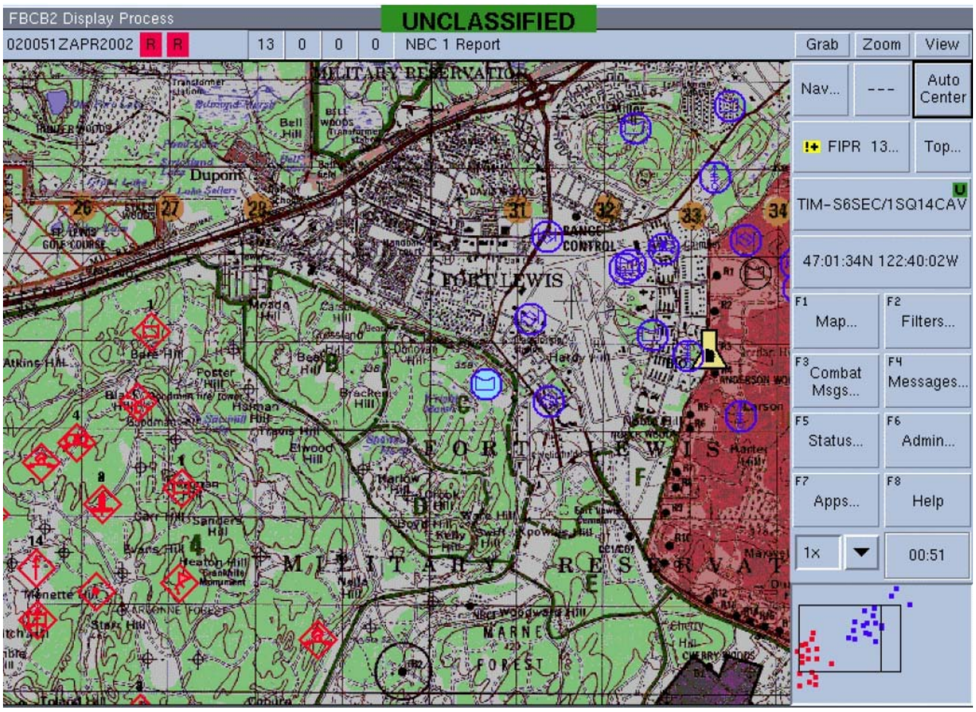

Figure 1. Snapshot of FBCB2 in 2D Desktop Application

The validity of new approaches in improvement of the user interface of the C2 systems and simulators is confirmed by new products from the main companies in these fields. For example, CG2 COMPANY and its new software product C3D[1] are considered to be at the current state of the art. This opens a new possibility of real-time view of the battlefield environment by including 3D terrain.. Figure 2 depicts snapshot of C3D that was employed in the U.S. Army Air Assault Expeditionary Force (AAEF) C4ISR On-The-Move experiment at Ft. Benning in fall 2007. However, one should keep in mind that it is only a simple 3D engine without the addition of VR devices such as HMD, data gloves or tracking systems to manipulate it.

[1] C3D uses FBCB2 VMF message parsing, a Quantum3D GeoScapeSE(TM) COTS McKenna MOUT terrain database, high-resolution digital map imagery and Mil-Std-2525B symbols.

Figure 2. Real-Time Snapshot of C3D Application

Current state of the Czech C2 system

The first design project of the Czech C2 system - Ground Forces Tactical Command and Control System (GFTCCS) was introduced in the Army of the Czech Republic in 1997. GFTCCS offers shared common picture of the battle space, displays with friendly and enemy unit locations, ADatp3 messaging, documents support for planning and decision making process, visual visibility, radio visibility, etc.

The presentation layer of GFTCCS solves visualization of common operational picture but only in 2D, with reduced resolution and low speed of communication between operator and system (Figure 3).

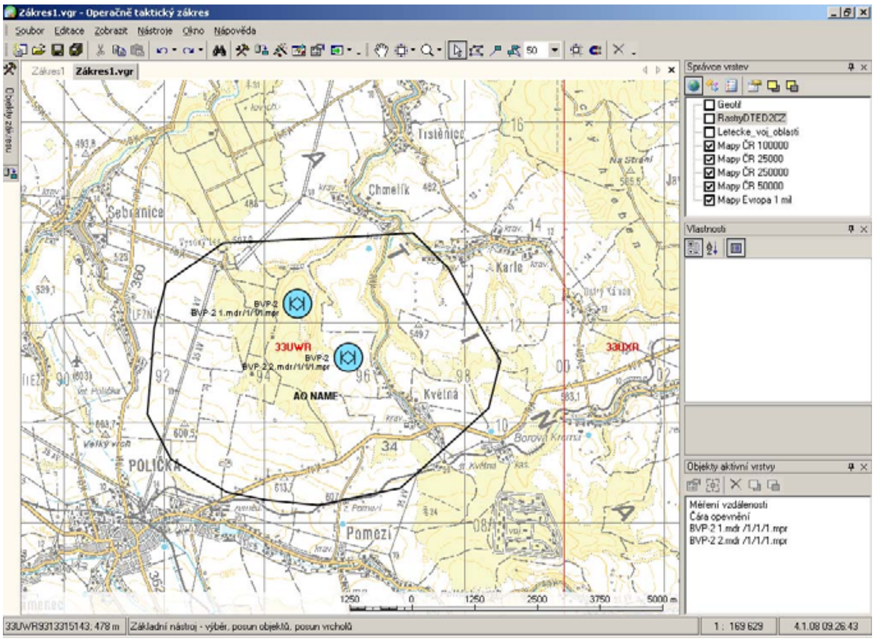

Figure 3. Snapshot of GFTCCS Presentation Layer

These features were sufficient in that time but now the requirements are totally different. The reality level of the battlefield situation is the key factor and understanding of battlefield situation is essential. All these factors led to a new project to improve the new presentation layer of Czech GFTCCS.

New presentation layer in the Czech C2 system

The Army of the Czech Republic defense research project goal is to provide a new interface to the current C2 system through a pilot project for the integration of the virtual reality technologies into the C2 processes. One part of this project was the creation and evaluation of questionnaires to assess the utility of basic ideas. The 59 respondents were from current users of the GFTCCS at the brigade level.

As a summary of questionnaire the respondents indicated that:

1. The new presentation layer with VR devices can be used as a new way to communicate with GFTCCS but the main interaction must remain via the current presentation layer.

2. The idea of a new presentation layer is strongly supported by users of GFTCCS.

3. The new presentation layer for brigade commander should show the units at the company level.

The questionnaire also helped to expose the importance of how information about a unit is displayed by the presentation layer. The position information is consider to be the most important category, followed (in order) by combat effectiveness, velocity, movement direction, ammunition and fuel amount. The information from these categories can be displayed using predefined data glove gestures.

Figure 4 shows the software architecture of the new presentation layer for the GFTCCS.

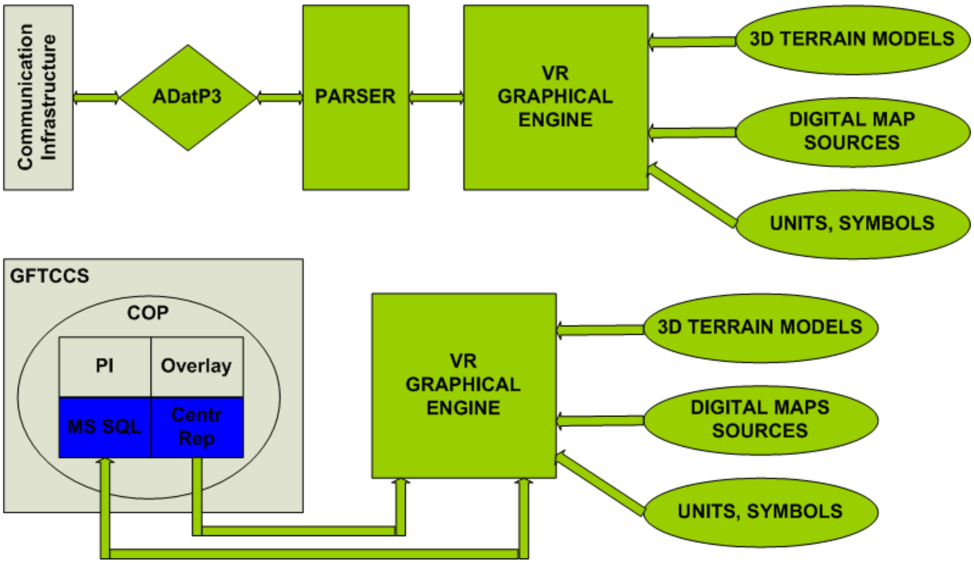

Figure 4. Presentation Layer of the Architecture

The VR presentation layer is implemented as a stand-alone application. This application is connected to the unit database server and central overlay repository of the GFTCCS system. From these sources it is getting real-time unit positions, symbols and tactical lines. The application is also connected to the digital terrain data sources of the GFTCCS (or uses a local copy). The input layer of the application handles the VR input devices – 6DOF sensors and data gloves. The application processes all the input data and generates real-time 3D image that is sent to the HMD or data projector.

The implementation of the VR presentation layer as a stand-alone application is so it will be independent of the C2 system. The input data from any C2 system can be pre-processed by a parser module and can be then processed by the VR presentation layer.

User interface

The user interface is based on standard commercial virtual reality devices. The user uses a head mounted displays (HMD) coupled with 6 degrees of freedom (6DOF) sensor. The interaction with the VR environment is made by VR gloves with 6DOF sensor on each one glove. A user of the VR system can move in the sensor range.

Figure 5 shows a base station placed above the user's head in the center of the delimitative circle. It serves as a reference point for the motion sensors and also as a bus place for all the data cables for the visualization device, data gloves and sensors (or receiver for an optional wireless solution). The user's motion range is restricted by a fence that delineates the maximum sensor range.

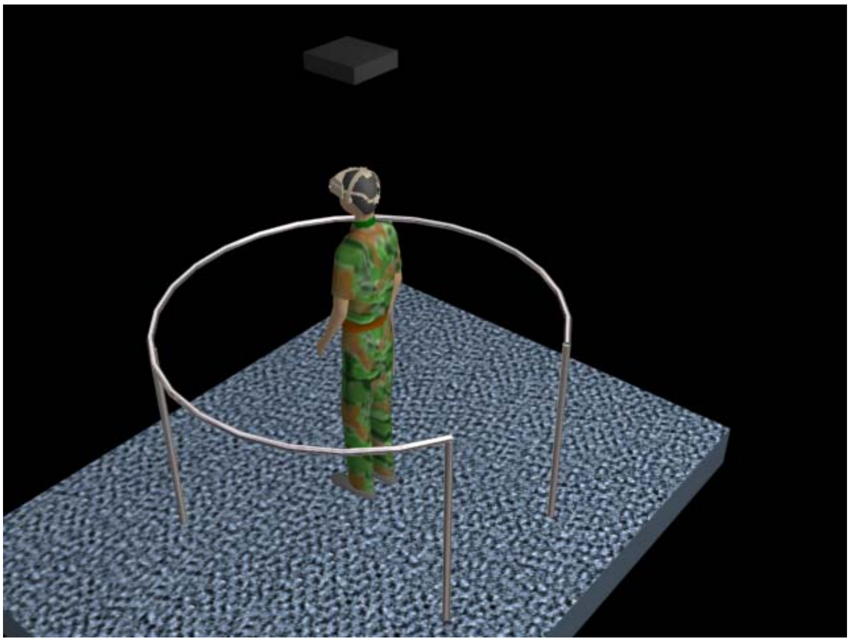

Figure 5. VR Working Area on the Battalion Level

The data from the VR data gloves and its 6DOF sensors are processed by the input layer and correlated with the 3D data from the presentation layer. The user uses gestures to send commands to the presentation layer. The user can control the movements over the 3D terrain and can perform basic operations above the map and the displayed units. The HMD and 6DOF head sensor handles the free lookout.

Terrain database generation

The terrain database generation process is a key process for data preparation of Modeling and Simulation (M&S) applications. Traditional M&S applications use dedicated terrain databases that are human controlled and take lots of time to prepare.. On the contrary, the M&S applications integrated into operation and tactical systems need to automatically generate the required data at short notice. This raises the requirement to develop a mechanism to generate terrain databases using the standard digital maps.

In our situation we needed to develop a simple system capable of generating full 3D terrain database from standard vector terrain sources in order to expand the functionality of GFTCCS. The requirement was to use the digital terrain data that are used in the GFTCCS, to ensure no additional data sources are needed.

The terrain generating system must combine aerial photos or satellite images with vector map data and grid terrain model. The system must deal with different resolution of the data sources and also with low resolution of the satellite images. The missed details must be reconstructed from the vector data sources and the resulting database must be optimized for used image generators.

Special algorithms are then used for adding high-detailed topographic lines and contours – such as roads, railways, rivers and lakes to low-resolution satellite or aerial image to look visually correct.

The terrain database can handle full 3D objects such as power lines, trees, bushes, fences and buildings according to the real topographic object database. All objects have correct dimensions and positions. Figure 6 contains an example of what happens when all this data is merged together.

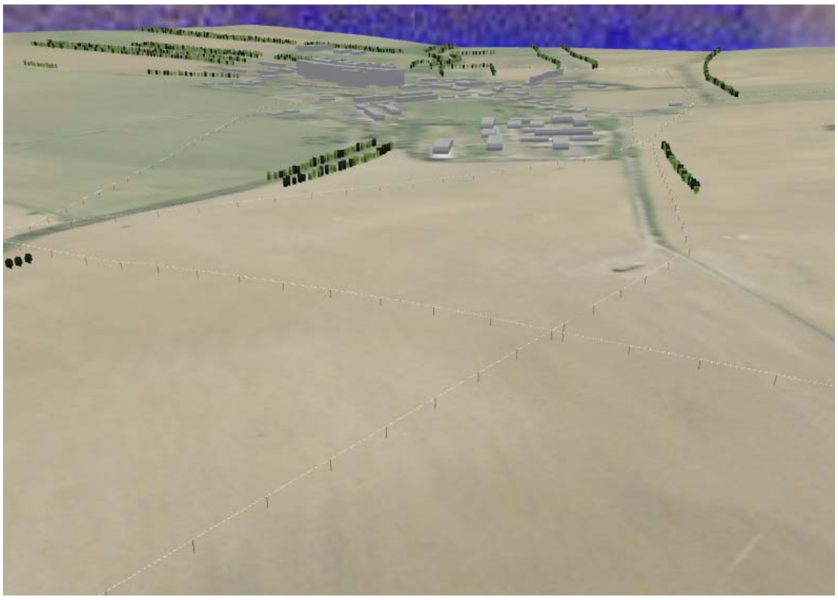

Figure 6. Sample Screenshot of High-Detail Version

The resulting database is in WGS-84 coordinate system so it is fully compatible with navigation systems such are GPS and military paper maps. Also the resulting terrain database correlates with digital maps used in GFTCCS.

Tactical symbol representation

The GFTCCS uses military tactical symbols according to APP6a standard but there remained an issue of how to properly represent them in 3D environment. Firstly, we tried to represent them as a 2D billboard object (i.e. a sign along a roadway). For us the billboard is a picture of a military symbol applied as a texture to a rectangular primitive. The primitive is rotated so that it always faces the user. The problem with this representation is that the symbol represents only a single place in the 3d terrain. It is fine for representing single weapons, vehicles, points of interest or headquarters but for aggregated units like squads, platoons, battalions that are located across a large area makes this representation inaccurate and distorted. There is also uncertainty of where to position the billboard object;– is it the geometric center of the military object (platoon, battalion), or commander's vehicle?   This confusion resulted in a decision to use a different representation of tactical symbols.

The selected format was a military symbol presented as a square block that has a picture of the military symbol mapped on all its faces (Figure 7). The picture is semi-transparent so the user can see the area under this military symbol and the user can change the transparency value. The dimensions of this square block represent an area covered by the unit. It can be taken from the unit database - the exact numbers for the particular unit or some general unit type dimensions.

Figure 7. Real Time Tactical Situation Created by New Presentation Layer of GFTCCS

The above solution is not final; in fact our recent questionnaire showed that the commanders would prefer a bit different tactical symbol representation. They suggested using tactical symbol as a billboard object placed in the geometric center of the unit and show outlines of the unit covered area only for units that are close to the observer or are selected. We are now considering how to implement this approach and test it.

Tactical line representation

The 3D visualization brings new challenges into tactical lines representation in a full 3D environment. There is a problem in representing a pure 2D object such as a line to be clearly visible from different angles of view. After few experiments we decided to make the line from two rectangular primitives placed along the line and rotated 90 degrees of each other. These primitives are mapped by the line texture and rendered as a two sided set of triangles. These lines then float in a specified height above the 3D terrain (Figure 8). These 3D lines represented by such a technique are visible from various angles. Its thickness can be modified by the user to increase visibility from longer distances.

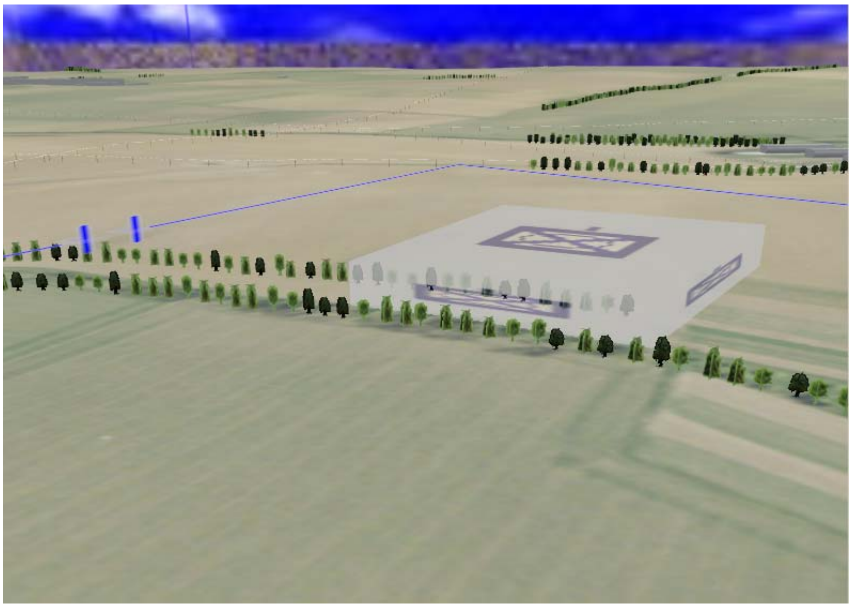

Figure 8. Sample Screenshot of Unit and Tactical Line Representation

Conclusions and Way Ahead

Human interactive interface with the VR devices will enable brigade commander to significantly reduce the C2 decision-making process time and effort on the battlefield.

Users want a new presentation layer for the GFTCCS but insist that its role must be as an additional information source. They want to leave the current 2D presentation of information and interaction with the GFTCCS unchanged because the commanders are used to it. The consensus this that VR devices used for C2 should be introduced as a step-by-step process in order to give the commanders time to adapt to the changes caused by the new way of perceiving the battlefield.

Many issues remain to be solved before the new presentation layer can be considered to be operational. The answer to most of the questions should be resolved during the extensive testing of the first prototype of this VR presentation that is scheduled before the end of this year.

References

CG2 Inc, CG2 C3D Demonstration Application Employed in U.S. Army AAEF Exercise Tests Real-Time 3D Visualization of Onthe - Move C4ISR Data from FBCB2 VMF Messages. www.cg2.com

Glossary of Acronyms

2D	Two Dimensional
3D	Three Dimensional
6DOF	Six Degrees of Freedom
AAEF	Air Assault Expeditionary Force
C2	Command and Control
C3D	Command and Control in 3 Dimensions
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
COP	Common Operational Picture
FBCB2	Force XXI Battle Command Brigade and Below
GFTCCS	Ground Forces Tactical Command and Control System
GPS	Global Positioning System
HMD	Head Mounted Display
HMI	Human Machine Interface
VMF	Variable Message Format
PI	Position Identification
VR	Virtual Reality
WGS	World Geodetic System