Fire Control Application for Technical Control of Artillery Fire – Data Binding

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ABSTRACT

The Czech Republic, as a member of international organizations (NATO, EU, UNO), with respect to current global security neighborhood, employs the units of the army both at its own state territory and outside the Czech Republic, in multinational forces operations. The article focuses on Data Binding Issue of future Automated Command, Control, and Information system (C2I) in conditions of the Army of the Czech Republic.

The issue of automated command, control, and information systems is of high importance in the solving of asymmetrical operations tasks today and in the upcoming future. The authors define ground for designing a new and by the Army of the Czech Republic required, sophisticated Automated Fire Support Control System of Artillery meeting NATO standards in Network Enabled Capabilities (NEC) conditions. Final assessment of the particular issues is determined by analysis. The software model contains derivation, definition and reasoning of data which are essential for the effective artillery fire in condition of modern software tool - Data Binding.

The Czech Artillery units need to have intuitive system for mathematical computations which assures prediction capabilities for adequate fire support provision - PVNPG-14M. This software should be the best choice in current conditions. The article represents section of a huge defensive research project of Ministry of Defence of the Czech Republic and the Army of the Czech Republic solved by leading scientists of the University of Defence in Brno.

Keywords: Artillery, Decision-making process; software development; Command, Control, and Information System; C2I; Artillery.

1. INTRODUCTION

The basic task of artillery weapon systems is an indirect firing, thus keeping fire on targets kilometers away and beyond the line of sight. Calculation of the fire elements is a lengthy process based on the mathematical apparatus of several disciplines such as Ballistics, Meteorology, Geography and Theory of probability. Automation of the entire process of calculation of fire elements accelerates and reduces the likelihood of errors.

The Czech University of Defence has initiated a project to develop a proposal for an interoperable automated Command and Control (C2) system for the Czech Army's Artillery systems. This paper provides a framework for the project through the establishment of strategic and conceptual context and the examination of Network Enabled Capability (NEC) activities and Interoperability Standards, makes proposals for engagement with NATO and coalition agencies, programs and projects, and offers starting point for project and moreover set up the new artillery full-automated system for fire control – PVNPG-14M (Figure 1). [6] [12]

Figure 1 – Main screen of PVNPG-14M

The software model of PVNPG-14M contains derivation, definition and reasoning of data which are essential for the effective artillery fire in condition of modern software tool - Data Binding.

At the same time, the user of the new system removes the necessary knowledge of basic principles and procedures for calculating the fire elements of fire and creates the illusion of correctness of himself. Because of the destructiveness of artillery fire, the feelings of perfection cannot be relied upon. The basic operating rule of tactical using of artillery fire is supervised calculated of fire elements for fire at a target before real start. [3] [4] [5]

PVNPG-14M software utilizes digitized tables of firing for 152 mm ShKH model 77. The method of assembled of firing tables does not completely define the fire elements for artillery firing. In some cases it is necessary to perform interpolation between the values which are entered in the firing tables. To do this it was necessary to adjust the automated calculation via PVNPG-14M and implement the interpolation method into software.

Interpolation is further used in the preparation of fire control in determining targets in an alternative manner and within the meteorological preparation of artillery.

PVNPG-14M software uses an interpolation method for determining values of corresponding distances for the individual bullets and cartridges, then interpolates when it is necessary to determine additional correction deliberate angle for each bullets from the table of additional correction deliberate angle. [15] [18]

From the perspective of the application, software must be open for easy deployment of internal adjustments and additional functions, use common programming language and allow install and run on modern touch platforms with the Windows operating system, which is implemented in the Czech Army. One of the key prerequisites is a good map view. Modern mapping tools and imaging environments are a basic application requirement (Figure 2). [16]

Figure 2 – On-line map view in PVNPG-14M condition

NEC framework in the Czech Republic Artillery
The Czech Artillery units can realize specific tasks of fire support which can help to fulfill Czech military forces commissions in the multinational operations in new, turbulent conditions. In accordance with presupposed artillery functionality and future development can be assumed that artillery will act lethally at enemy troops and non-lethally at its information and communication systems, sensors, and awareness. Artillery can also contribute to joint planning process and perspective operations commanding in NEC conditions through its specific integrated sensor systems.

NEC conceptual framework including capabilities of Czech Republic Artillery can be determined in the following way:

Decision Ascendancy Achievement presupposition
Effective Artillery Command, Control, and Communication System, which ensure all functions of command, control and communication of the Czech Artillery reconnaissance system and the executive elements. This system must be able to fulfill complex fire support in NEC conditions.

Operational Effectiveness Achievement presupposition
Effective Artillery Reconnaissance (sensor) system – recognition abilities about enemy objects, effective using of Targeting cycles system and ISTAR system for adequate reaction suggestion of friendly forces including criteria evaluation effect. Effective lethal and non-lethal artillery fire – artillery join connection operations capabilities which means capabilities of power demonstration, fire for effect etc. Resistant artillery units – active and passive defence equipment using. [5] [20]

Achievement of Deployment Presumption
Well-time artillery unit's attainability – to be able to accord the fire support in the operation area.
Artillery positioning and mobility – Artillery deployments capabilities.
Effective Supply – logistics support capabilities of artillery units. [21] [22]

The last point (Achievement of Deployment Presumption) is not Fire Support Control System problematic and that is why it is not in detail resolution on next text.

2. WHAT IS DATA BINDING…

Very simply expressed, data binding (DatB) creates a connection between "data" and "user interface" (UI) without any controller, so called "business logic. Data binding, as the name suggests, is purely data-oriented. If DatB is properly used then it allows you to create dynamic and responsive applications.

Thus, a data change caused by an asynchronous process is propagated automatically to the UI, and DatB itself provides an event handler that was triggered by a change of data. Without using the DatB, the new function would have to be programmed to set the relevant data and then called up for another function to make the appropriate changes to the UI.

With full DatB, the changes are propagated from UI to the internal application model. In this way we can omit the function to handle such event. Thanks to DatB's features, it is very advantageous to use this technique to create dynamic-length lists where each list item has a defined structure in the UI. The data are then injected only into this structure.

Advantages of DatB
- Simplify the structure of the resulting application.
- Implementation of responsive elements.
- Enabling the connection between model and UI, on the other hand shielding of business logic.
- Enable full UI control over an object containing the data.

Disadvantages of DatB
- Too complicated and built-in Data Binding is unclear in terms of development.
- The introduction of elegance in the design

of the application using the Data Binding brings greater demands on the documentation, conception and clarity of the application model.
- Ensuring heterogeneous dynamic lists filled with DatB leads to the creation of other control variables used only for the DatB control.

3. USING DATA BINDING IN THE PVNPG-14M APPLICATION

The PVNPG-14M application is written in the old version of the Windows application framework for Windows 8.1. This is the reason why we use only the basic DatB. With the new Universal Windows Platform (UWP) framework, DatB would be more comfortable.

Because of the combining this technique with the elements of the framework which is used (the elements are adapted to be used for this presentation technique), it is easier to create functions such as drag&drop or modeling of dynamic UI structures.

PVNPG-14 uses DatB mainly in sections where dynamic application behavior is required. These functional areas are the definition of the combat form, where items such as cannons, observers and targets are growing and decreasing dynamically. Moreover, there are also adjust firing sections where the lines of the adjust fire process are dynamically increasing – Figure 3.

Figure 3 - Example of the Data binding in the adjust fire process

As a detailed example, here is the DatB shredding process, which is probably the most complex DatB in the application:
- The individual lines of the process represent the observation of the impact of a missile fire out of a cannon. In general, this number firing is unknown, so it cannot be said that the cannon will shoot twice. Thus, there is a factor of dynamic number of items here.
- Each of these lines is modeled as a container of item and using the DatB are the data injected into application.
- Another dynamic element is that the above-mentioned modulated item consists of other dynamic items (columns) that are displayed based on the configuration of the combat form (number of cannons, number of observers...). Viewing or not viewing the columns is also done using DatB. So there is multiple DatB.
- Another complication of DatB is the ability to create commands that are created either by ad-hoc by user or dynamically from previous commands. To create a commands is used dialog box (also uses DatB) and using DatB is injected into a given line of the adjust firing process.
- The main issue here is that the application needs to access to the upstream UI element. However, since DatB is anonymous, it cannot simply access the UI elements created through DatB. This is solved through internal events handlers that can distinguish the source of the event and thus distinguish the individual UI elements from each other.

This entire DatB is encapsulated using one class that represents a given process line and also provides DatB control (what to see and what does not).

4. REFACTORING

At the time the application started to develop, only the Windows 8.1 framework was available, and it was a progressive approach to application development that could be run on both desktops and mobile devices. However, Microsoft has recently begun to favor UWP applications based on Windows 10 that bring new features and a better multiplatform solution than Windows 8.1 (An example of application support for users - Figure 4 and 5).

As Windows 10 seems to be a standard for the next few years, it has been decided that the next phase of development will start working on converting PVNPG-14M into the UWP framework and introducing DatB to the fullest extent, allowing for dynamic changes to the behavior of the application or presenting its behavior to the user. The migration to UWP is not only considered due to DatB, but mainly due to the limited support of Windows application 8.1 mentioned above.

Figure 4 – Display of results in graphs

One example is global change of units in which the application counts without having to reprogram all functions. The model will remain the same, and will still internally count the application in the units it has used up to now. Only through full DatB will display the results to the user in the given units or transfer the inputs from the user to their internal units.

Figure 5 – Display of user forms

5. CONCLUSION

The global environment changes, threats and new tasks require new approach of the Czech Republic defence strategy. Future security environment will be characteristic by dynamic changes of situation. The threat of terrorism causes changes of strategy, which turns from using massive armed forces to effectively using modern, sophisticated forces with quick Command, Control and Decision process supported by information technologies. [8] [9]

The aim of this article was not to describe in detail design of the new software PVNPG-14M, his develop, approach, concept and other issue but to introduce the most important system of the Artillery Battalion Fire Control System of the Artillery of the Army of the Czech Republic and highlight significance of perfect communication system of today and future fire control system or command and control operational tactical systems.

This article tries to describe a process of developing and refactoring the basic design and data binding issues that is used within the PVNPG-14M software.

The above mentioned issues and solutions are the necessary changes the Czech Automated Artillery Fire Support Control System represent absolutely basic conditions for approach to the NATO standard (NEC Capabilities). [8]

The perspective fire control system, which is developed at the University of Defence, must assure fire control at first. In near future there may be circumstances for the advancement of the current system to a higher level.

Automation of processes of preparation of fire control is key issue to meeting the increasing demands of the tasks of artillery fire support. They are especially associated with accurate and timely fulfillment of firing tasks in the modern battlefield.

Modern substitute and control software PVNPG-14M is developed to streamline the specific process during the preparation of fire control. It will also serve as a possible starting platform for the development the national perspective artillery automated fire control system. [1] [18]

Software PVNPG-14M working with digitized tables of firing of 152 mm ShKH model. 77. Because of the way of assembling firing tables, it is necessary in an automated calculation of fire elements used interpolation method.

The perspective system must assure Command, Control and Artillery Reconnaissance Connection, Coordination and Fire Control of effectors (Weapon Sets) on the brigade level with Mechanized Forces Control System. The Czech Artillery units need to have intuitive system for mathematical computations what assures prediction capabilities for adequate fire support provision - PVNPG-14M should be the best choice in current conditions. It is necessary to connect Future Artillery Fire Support Control System to the NATO network philosophy system within the Network Enabled Capabilities. [4] [17]

6. REFERENCES

[1] AArtyP-3 – **Artillery Procedures for Automatic Data Processing (ADP) System Interoperability.** NATO: NSA, 2009.

[2] STANAG 4119 Ed. 2 "**Adoption of a Standard Cannon Artillery Firing Table Format**", NATO: NSA, Feb 2007.

[3] K. Šilinger, M. Blaha, "Conversions of METB3 Meteorological Messages into the METEO11 Format" **ICMT 2017**. In press.

[4] M. Blaha and K. Šilinger, "Setting a Method of Determination of Fire for Effect Firing Data and Conversion of the METCM into the METEO-11", **International Journal of Circuits, Systems and Signal Processing**, 2015, no. 9, 2015, pp. 306–313.

[5] BLAHA, M., SOBARŇA, M. Principles of the Army of the Czech Republic Reconnaissance and Fire Units Combat using. **In The 15th International Conference „The Knowledge-Based Organization"**. Sibiu (Romania): Nicolae Balcescu Land Forces Academy, 2009, pp. 17-25.

[6] BLAHA, M., BRABCOVÁ, K. Decision-Making by Effective C2I system. **In The 7th International Conference on Information Warfare and Security**. Seattle (USA): Academic Publishing Limited, 2012, pp. 44-51. ISBN 978-1-908272-29-4.

[7] Joint Forces Command, Training. **Shooting Rules and ground artillery fire control (gun, platoon, battery compartment).** Pub-74-14-1. Prague: 2007. 256 p.

[8] **Military Strategy of The Czech Republic**. Praha: MO CR, 2008.

[9] **Long-Time Scheme of Ministry of Defence**. Praha: MO CR, 2008.

[10] **NATO Capabilities/Statements -** 2018. Brusel, 2007.

[11] **Doctrine of the Army of the Czech Republic**. Praha: MO CR, 2005.

[12] POTUŽÁK, L. **Control and Realization of Fire Support - The Cooperation of Artillery and Units of Artillery Reconnaissance during Fire Support of Forces.** Partial task - Specific research of FEM. Brno: University of Defence, 2006.

[13] AD-6.1 **Doctrine of Communication and Information systems.** Praha: MO CR, 2003.

[14] AAP-6 **NATO Glossary of Terms and Definitions** (english and french). 2009.

[15] BLAHA, Martin. Communication as a basic for future Artillery Fire Support Control System. **In The European Conference of COMMUNICATIONS (ECCOM'10).** Tenerife: WSEAS Press, 2010, p. 140-142. ISBN 978-960-474-250-9.

[16] BLAHA, Martin; POTUŽÁK, Ladislav. Decisions in the perspective Automated Artillery Fire Support. In: **Recent Researches in Applied Informatics & Remote Sensing**. Penang: Wseas Press, 2011, p. 87-91. ISBN 978-1-61804-039-8.

[17] NATO Standardization Agency. AArtyP-1 (A) – **Artillery Procedures.** Brussels, Belgium, 2004.102 p.

[18] NATO Standardization Agency. AArtyP-5 (A) – **NATO Indirect Fire Systems Tactical Doctrine**. Brussels, Belgium, 2013. 121 p.

[19] Chulsilp, P.; Charubhun, W. & Nuktumhang, N. Investigating and iterative method to compute firing angles for artillery projectiles. **In the 2012 IEEE/ASME International Conference on Advanced Intelligent Mechatronics.** Kaohsiung, Taiwan, 11-14, July 2012, pp 940-945.

[20] Taeho, L., Sangjin, L., Seogbong, K. & Jongmoon, B. **A distributed parallel simulation environment for interoperability and reusability of models in military applications.** Def. Sci. J. 2012, 62 (6), 412-419.

[21] MAZAL, J., STODOLA, P., at al. Math modelling of the basic defensive activities. **In: Proceedings of the International Conference on Applied Physics, Simulation and Computers (APSAC 2015).** Vienna, Austria: Institute for Natural Sciences and Engineering (INASE), 2015, p. 116-120. ISSN 1790-5109. ISBN 978-1-61804-286-6.

[22] Stodola, P., & Mazal, J. Tactical and operational software library. **In Military Technologies (ICMT),** 2015 (pp. 1-4). IEEE.