The New Automated Fire Control System for Artillery Units based on Interoperability and Standards

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Abstract: This paper is focused on the new automated fire control system for artillery units - PVNPG-14M, especially on interoperability and standards. Artillery units of the Army of the Czech Republic, reflecting the current global security neighbourhood, can be used outside the Czech Republic. The paper presents principles, evolution and functionality in the 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. 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.

1 INTRODUCTION

The basic task of artillery weapon systems is an indirect firing, thus keeping fire on targets kilometres 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 Defense 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 (Blaha, Sobarňa, 2009), 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 (Blaha, Brabcová, 2012) – PVNPG-14m.

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 (Doctrine of Communication and Information systems, 2003). 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 (Shooting Rules and ground artillery fire control, 2017).

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.

2 INTEROPERABILITY

Interoperability is an operational problem not a technical problem. The need for technical interoperability between C2 Information Systems (C2IS) is driven by the greater need for operational interoperability between the national force elements within a coalition military force.

Interoperability that is enabled by Communication and Information Systems (CIS) is

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defined as "the ability of systems, units or forces to provide services to and accept services from other systems, units or forces and to use the services so exchanged to enable them to operate effectively together" (ACP 167J, March 2008). Interoperability enabled by CIS contributes to better information sharing and better shared understanding. This in turn leads to better decisions, actions and effects (NATO Capabilities/Statements – 2018, 2007).

In the context of an Artillery system, this implies a need for two-way flow of information between all elements of the system and between the system and higher echelons of C2, whether operating as part of a national or Allied/Coalition force, so that accurate and timely direct and indirect fire support can be provided, to deliver the effects required by the Command (Potužák, 2006).

Whether developing a national bespoke system or procuring an 'off-the-shelf' system from an international defense company, the Czech Army will need to decide what level of interoperability is required (Military Strategy of The Czech Republic, 2008). This will be dictated by the likely scale of deployment of Artillery forces in national defense operations or deployed Allied or coalition operations, and the level of integration within the Command structure (Doctrine of the Army of the Czech Republic, 2005).

Assumptions about the scale of operations and level of integration required will be determined by national policy and strategy (Blaha, Sobarňa, 2010).

3 CONCEPTUAL CONTEXT

3.1 Effects based Approach to Operations

The University of Defence project specifically seeks to make proposals for an Artillery C2 system that will support an Effects Based Approach to Operations (EBAO). This is an evolving philosophy that is defined as "the coherent and comprehensive application of the various instruments of the Alliance, combined with the practical cooperation along with involved non-NATO actors, to create the effects necessary to achieve planned objectives and ultimately the NATO end state" (AJP-3.9).

At the operational level, an effects based approach involves the selective combination of actions, coordinated with the activities of other organizations to create lethal and non-lethal effects in order to achieve operational objectives in support of this end state. Operations are still executed through the time-tested manner of applying operational art, design and management. Operational art, supported by the targeting process, seeks to analyse and then direct activity to defeat or neutralise an adversary. It integrates recent developments, for example, Information Operations, with more traditional methods.

Understanding the adversary's operational objectives, capabilities, and intentions through analysis enables the use of capabilities to be focused on key components of the adversary's systems. This analysis is an integral part of the Operational Planning Process. The Joint Force Commander (JFC) establishes the operational objectives to be achieved. Targeting is focused on creating specific desired effects to achieve the JFC's objectives and/or subordinate commanders' supporting objectives.

3.2 Joint Action

Effects are delivered through Joint Action, designed to influence any actor, whether opponent, friend, neutral, belligerent or spoiler. An actor's ability to use force or to threaten force, to achieve a desired outcome is dependent upon his will to act, his understanding of the situation, and his capability to act decisively. Together, these elements determine an actor's military effectiveness (Doctrine of Communication and Information systems, 2003).

- Will - At the strategic level, will is influenced by factors such as national culture, ideology and political resolve; at the operational and tactical levels it is based upon the social unity of communities of interest or armed groups, their morale, esprit de corps, and cohesion. Once an actor loses the will to act, he relinquishes his ability to actively influence events.
- Understanding - An actor's understanding of his situation originates from the information he receives, but is shaped by his thoughts, experience and senses. As a result, an actor's perception of his situation is as important as reality in determining his actions and, indeed, in affecting his will to act at all.
- Capability - An actor's capacity for action is dependent upon his physical capabilities and their utility in a particular situation. Although quantity and quality tend to confer advantage, a variety of other factors also impact upon effectiveness. Some, such as geospatial factors, are situation-dependent but others,

such as prioritised resource allocation to achieve competing tasks, are subject to a commander's discretion and influence.

Cohesion within an organization is also an important facet of operational effectiveness. For example, it is collective will or resolve, ranging in strength from tacit acceptance through to absolute allegiance, which mobilises a group of individuals in pursuit of a common goal. A group's cohesion reflects the extent to which those motivations bind individuals together, and inspire them to act in unison.

Joint Action, then, involves the deliberate use and orchestration of military capabilities and activities to realise effects on other actors' will, understanding and capability, and the cohesion between them. It is implemented through the coordination and synchronization of:

- Fires - Fires are the deliberate use of physical means to realise, primarily, physical effects. They are focused on another actor's capability (to destroy someone or something, including that which enables understanding); fires may also influence indirectly behaviour, attitudes or decisions. Fires would include Artillery systems.
- Influence Activities - Influence Activities seek to affect understanding and thus the character or behavior of an individual, group or organization. They do so by manipulating information ahead of its receipt, or perceptions of that information once received. Artillery systems could be used in influence activities, perhaps to strengthen understanding of friendly force capabilities.
- Manoeuvre - Manoeuvre gains temporal and spatial advantage. It places those seeking to create either physical or psychological effects, or frequently both, in the most appropriate time and space to do so. Manoeuvre can also realise a variety of effects in its own right, and may be used to supplement the impact of fires and influence activities. Artillery systems are often used in conjunction with manoeuvre.

3.3 Joint Action Enabled by Network Enabled Capability (NEC)

The aim of NEC is to link sensors, decision-makers, weapon systems and support capability to achieve enhanced military effect through improved exploitation of the information available (AArtyP-5, 2013). Therefore, NEC should be viewed as delivering Networked Enabled 'Capabilities', ie, a pervasive attribute, or a characteristic, desired of all capabilities and having applicability to all personnel across Defence.

All capabilities rely on the integration of the Lines of Development (eg DOTMLPFI). Similarly, NEC has three dimensions that provide the ways and means – Networks, Information and People – that support the end effect; Joint Action. With Networks acting as the arteries of the NEC 'body', Information as the blood supply and People as the brain, Joint Action may be most easily likened to the senses and the muscles – the effectors, realizing the physical effects engendered by the three 'supporting' dimensions.

NEC delivers 'enablers' that facilitate communication between platforms, sensors, decision makers and support services within a nation's Armed Forces and with Allies and coalition partners. As such, it is a force multiplier that can offer decisive advantage in terms of improved situational awareness, more efficient sharing and exploitation of information, better-informed decisions, more effective command and control and greater precision and speed in the application of appropriate force.

The diagram below shows the NEC 'Benefits Chain':

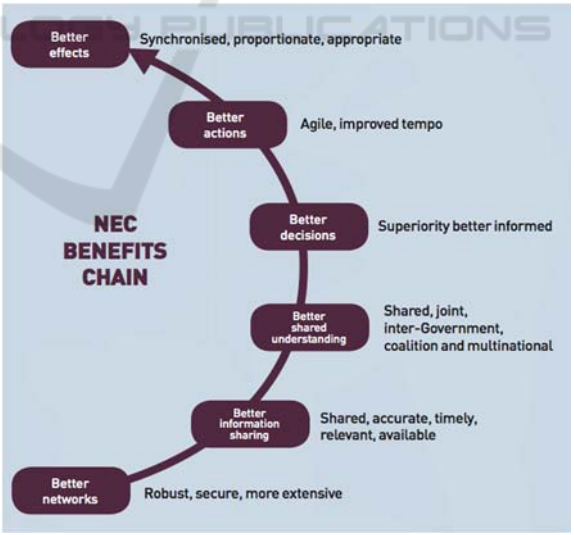

Figure 1: NEC Benefits Chain.

In other words, NEC enhances operational capability by helping to get the right information to the right people at the right time. As far as Artillery is concerned, it uses information and communications technology to get information from the sensor to the

shooter more quickly and more effectively than in the past. The use of Artillery systems as an effective component of Joint Action may therefore be enhanced by NEC.

4 INTEROPERABILITY STANDARDS

Operational, procedural and technical standards within NATO are developed through Standardisation Agreements (STANAGs) and Allied Publications (APs). A STANAG is defined as "A normative document recording an agreement among several or all NATO member nations, which has been ratified at the authorized national level, to implement a standard, in whole or in part, with or without reservation." (AAP-42) An AP is defined as "A NATO standard established and approved by several or all NATO member nations at tasking authority level."

STANAGs and APs are produced by groups and committees under the direction of their various Tasking Authorities; senior NATO bodies with the authority to task their subordinate groups to develop new standards. Of these, the most relevant to the development of Artillery C2 interoperability are the NATO Committee for Standardisation (NCS), the Conference of National Armaments Directors (CNAD) and the NATO Consultation, Command and Control Board (NC3B). Committees and groups working to other Tasking Authorities may have some relevance, for example the NATO EW Advisory Committee under the Military Committee, but only peripherally.

Under the NCS, the Army Branch of the NSA (NATO Standardisation Agency) provides support to 9 working groups and 34 panels, responsible primarily for the development of tactics and procedures published in APs (such as AArtyP-1 and AArtyP-5). Of these, the most important are the Artillery Working Group, Interservice Ammunition Interchangeability Working Group and the Land Operations Working Group.

Under CNAD, the NATO Army Armaments Group's (NAAG) 'Level 2' group on Fire Support, Land Capability Group 3 (LCG/3), is the main focus for Artillery systems. LCG/3's Sub-Group 2 on Accuracy and Ballistics is especially important for the development of the SG/2 Shareable (Fire Control) Software Suite (S4).

NC3B is the authority with expertise in C4ISR capabilities, including Land C2IS, Deployable CIS, the Information Exchange Gateway (IEG), Secure Joint Tactical Chat Services (JChat) and the NATO Messaging System (compliant with STANAG 4406).

Following a reorganization within the structure of the CNAD Main Armaments Groups in 2006, the Battlefield Digitization Group (LG/1) was disbanded, and it was expected that NC3O would continue the work of the group. However, funding cuts have impacted on the capacity of NC3O, so NAAG is now establishing a C2IS Quick Reaction Team (QRT – due to report to NAAG in Spring 2011) to clearly define Land Force C2IS operational requirements at Battlegroup level and below across the Level 2 Groups' tactical capability domains, as well as the interfaces to the Air and Naval components. The analysis will result in the definition of the C2IS requirements and in the presentation of an action plan that can be used by NAAG to prioritize the shortcomings and gaps.

The resulting C2IS Operational Requirements and action plan will be presented to the International Staff, NHQC3 Staff, RTA, and other NATO organizations and agencies for them to address the required development of tactical C3 architectures and standards necessary to achieve the necessary level of interoperability (Chulsilp et al., 2012).

4.1 SG/2 Shareable Software Suite (S4)

The S4 is an umbrella NATO cooperative program with five individual cooperative projects, all under the auspices of NAAG, LCG/3 SG/2. Each project develops one or multiple software products. The suite is comprised of the separate software products, designed to be embedded in the executive level software of a fire control computer, which when combined will provide most if not all of the basic capability required by a fire control computer for mission planning and accurate fire except for communication and the soldier-machine interface.

The five individual software projects are the NATO Armaments Ballistics Kernel (NABK), NATO Armaments Geophysical and Information Kernel (NAGIK), NATO Armaments Meteorological Kernel (NAMK), NATO Indirect Fire Appreciation Kernel (NIFAK), and the NATO Armaments Support Services (NASS). The NABK project produces the NABK product. The NAGIK project produces the Terrain Elevation Data Manager (TEDM), Global Land-Usage Manager (GLUM), and NAGIK Common products. The NAMK project produces the Meteorological Data Manager (METM), Gridded Meteorological (Message) Verification software (GMVerify), and CI products. The NIFAK project

produces the NIFAK product. The NASS project produces the NASS product.

The umbrella or parent programme is managed by SG/2 through the S4 Configuration Control Board (SCCB). This level has oversight of all projects, manages key requirements and product-to-product interfaces, suite quality assurance, technology generation, and independent software/safety audits. Each project is managed by a project lead from a lead nation and the project team at a minimum has the key roles of software development, quality assurance, and configuration management. STANAG 4537, AOP-37 and AOP-49 guide the program organization and operation.

4.2 Multilateral Interoperability Program (MIP)

MIP is an interoperability organization established by national C2IS system developers with a requirement to share relevant C2 information in a multinational/coalition environment. As a result of collaboration within the program, MIP produces a set of specifications which, when implemented by the nations, provide the required interoperability capability. MIP provides a venue for system level interoperability testing of national MIP implementations as well as providing a forum for exchanging information relevant to national implementation and fielding plans to enable synchronization. MIP is not empowered to direct how nations develop their own C2IS.

Key points:

- MIP focuses on interoperability of command and control (C2) systems, which includes the Land view of Joint operations, but encourages contributions from Air, Maritime and other Communities of Interest (CoIs).
- MIP specifications are based on operational requirements developed into a fieldable interoperability solution.
- MIP assures the quality of the specification through operational and technical testing of national implementations.
- The MIP solution refers to two or more national C2IS exchanging information by employing their respective implementations based upon the agreed MIP technical specifications and supporting procedural and operational documentation.

A conceptual illustration of how the current MIP interoperability solution works is shown below.

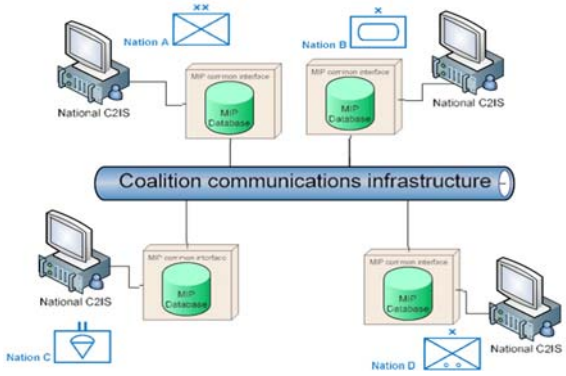

Figure 2: MIP interoperability solution.

The MIP Solution supports the ability to exchange information between national C2IS in order to facilitate the improved situational awareness and collaboration among commanders that will lead to and support common understanding. The MIP Solution satisfies the information exchange requirements between forces employing dissimilar C2IS and which, during an operation, have a command, support, or proximity relationship. The MIP Solution contributes to the creation of a Common Operating Picture (part of Situational Awareness) and the Plans and Orders by providing effective management and dissemination of information being exchanged between national C2IS. This is achieved by the implementation of a common data model and common exchange mechanisms (messaging and data replication).

The Common Operating Picture is created through a predefined set of information exchanges with other HQs. The information exchanges include: Blue force locations, operational graphics, significant activities (as defined by the Lead Nation), the correlated enemy picture and uncorrelated enemy picture. In general terms it encompasses all relevant information within a given commander's Area of Interest. Operations staffs are responsible for identifying specific information to be exchanged in order to create the default common operational picture. This information sharing is accomplished via the Data Exchange Mechanism (DEM). The DEM is the automated exchange of information between related forces.

This diagram shows how MIP-JC3IEDM supports a call for fire message and subsequent action:

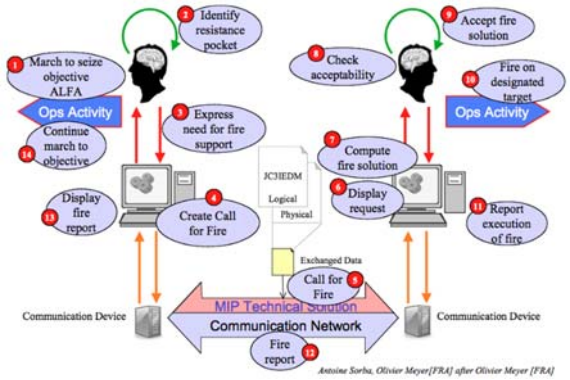

Figure 3: Diagram MIP for fire message and subsequent action.

4 CONCLUSIONS

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.

The aim of this article was not to describe detailed interoperability and standards issue for fire control system running 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 (Mazal, Stodola, 2015). The above mentioned requirements on necessary changes the Czech Automated Artillery Fire Support Control System represent absolutely basic conditions for approach to the NATO standard (NEC Capabilities).

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.

This higher level requires compliance with principles and standards presented above in the paper. 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.

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