Fundamental Requirements for the Automated Fire Control System for Field Artillery

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Abstract **-** This paper in introduction defines concept of automated fire control system for artillery support (ASRPP-DEL) and further divides into chapters according to the requirements that the system had to fulfil, including standardization agreements. First are mentioned general system requirements then all necessary data, which we put into the system. Other chapters deal with supporting commander´s action, tactical and technical fire control, calculating firing data and the already mentioned standardization. Conclusion contains a summary of the requirements and recommendations for ASRPP-DEL arising from this work.

Keywords **-** Automated system, fire control, artillery support, fire support.

I. INTRODUCTION

PERSPECTIVE automated fire control system for artillery support (ASRPP-DEL) should fulfil set of requirements to ensure its expected functions within the Task force command and control system of fire support. [1], [2], [3], [4].

This work contains definitions of requirements the ASRPP-DEL has to fulfil in order to successfully function within the Task force command and control system of fire support.

II. GENERAL SYSTEM REQUIREMENTS

Basic requirements for the automated fire control system for artillery support (ASRPP-DEL) are descript in Place and Task of ASRPP-DEL. [1], [2], [8], [12]. Among them are:

a) ASRPP-DEL must fulfil the role of automated instrument supporting commander's decision making by gathering and processing information, suggesting standard solutions and providing calculations necessary for implementation of tactical and technical fire control for artillery fires while keeping the option to choose non-standard solutions by the commander respecting his responsibility for his decision.

b) ASRPP-DEL must be able to operate independently without the necessity to confirm suggested solutions, from the input of target data to the fire order issued to weapon systems.

c) ASRPP-DEL must be able to receive process, store and distribute data from work-stations, weapon systems and sensors automatically.

d) ASRPP-DEL must be connected to automated command and control systems of the Task force (OTS, BVIS) [5], [8], [9]. It must be able to receive and distribute orders, directives, signals and information intended for the elements of fire support system automatically, using free form or formalized documentation, graphical documents included.

e) ASRPP-DEL must be connected to C2 systems of other military branches in order to enable processing unified combat support plan for the Task force at any situation or any combat phase [14].

f) All work-stations participating in artillery units command or fire control processes will be equipped with ASRPP-DEL devices, including all elements of combat service support. The system must be variable enough and provide operation of reinforcing artillery forces and assets within any organisation structure created, including employment of artillery assets assigned from the superior level. In case of carrying out specific tasks or operating detached, the system must enable commanding artillery units in any order of battle including several independent groups. Listed requirements are valid for fire units, artillery reconnaissance assets, fire support coordination, fire control, meteorological preparation, topographical-geodetic preparation, combat secure and logistics assets [20].

g) In terms of points c), d) a f) must ASRPP-DEL automatically replace sender or addressee, which is missing in actual task force structure and cannot send or receive any information. It means that the system of sending orders, commands, signals and reports must have substitute elements for fire control system work-stations. That applies to situations, when standard elements are eliminated, not incorporated in the Task force, or not functional for other reasons.

h) Single elements of the system must be able to work autonomously in case of total or partial elimination of the system as a whole (e.g. connection interruption). After restoring operation, the system must be able to continue fluently.

i) ASRPP-DEL must be created in a way, which ensures the capability of continuous updates, editing, expansion and customization according to actual needs of ACR. [21], [22], [23].

j) In case of automatic execution of given operation, which is lacking necessary data, ASRPP-DEL must notify relevant operator with specific request to input missing data.

k) During execution of fire missions the system will store all data concerning actual fires and will do so chronologically. It means it will be possible to determine exactly who, when and what was put in the system and what action followed based on that input.

l) ASRPP-DEL must have hardware resilient to climate anywhere on Earth, excluding polar areas. It must also be adapted to operation in military vehicles

while on the move. The user interface must be arranged clearly in a way, which enables an artillery specialist to navigate easily in protocols after short training.

m) ASRPP-DEL must be resistant to interception and jamming. This requirement focuses on communication devices, which will provide data transfer. Communication devices must ensure 100% information transfer at required range using phonic communication or data transfer. [18].

n) ASRPP-DEL must meet requirements for information security. The degree of confidentiality shouldn`t be too high concerning the practical use. Since the system is intended for tactical level command and control, the confidentiality level should be "RESTRICTED" at highest.

III. Data put in ASRPP-DEL

ASRPP-DEL must enable input of all necessary data in advance and storing it in memory while other data (acquired later, altered or supplemented) can be put in continuously:

a) First of all, it concerns characteristics of weapon systems, ammunition, artillery reconnaissance assets and other sensors, or information about the actual equipment of the reconnaissance elements and all the data. [14], [15], [25], [26].

b) ASRPP-DEL must include grid location precision for fire emplacements and for artillery reconnaissance assets as well as the precision of orientation direction or the method of their determination. [6], [7], [10], [24].

c) ASRPP-DEL must be equipped with necessary map sources of the area of operation. That means a digital model of the battlefield. The system must enable quick loading of digital maps and their updates. On this digital map layer, it will be possible to display actual order of battle of all artillery elements.

d) ASRPP-DEL must have permanently saved these weapon system data:

• rate of fire in rounds per minute ($v_{stř}$);
• maximum firing range of the weapon system;
• change of initial projectile velocity caused by attrition of the barrel, based on fired shots count (Δv_{od}^{R});
• grounds for computing the decrease of initial projectile velocity [%] from the extension of the chamber [mm];
• evaluating the capability of the weapon systems to accurately determine position and orientation;
• elevation range for firing solutions.

ASRPP-DEL must be able to input new actual data, if needed, or to use another method of determining the decrease of the initial projectile velocity. [11], [13], [16], [23].

e) The ASRPP-DEL must have data from all range tables for each weapon system used and every ammunition type used. [17], [19], [23], [24].

f) In ASRPP-DEL there will be stored forms for a complete combat documentation, which will be used during the planning process and available after the approval by the officer responsible. Mainly comprising of:

• OPORD of the superior task force commander with appendixes, particularly the Fire support appendix;
• OPORD of the booster artillery units commander with appendixes;
• OPORD of subordinate commanders with appendixes;

The most important appendix for the ASRPP-DEL function is „Target list", which will function in several ways:

• it will be an appendix of superior commander's OPORD (in the „Fires plan");
• it will be a source of data for calculations;
• it will serve as a report document and overview of targets found and targets eliminated. [14], [17], [23], [24].

IV. Supporting commander´s actions

To support commanders at all levels ASRPP-DEL must:

a) during the tactical and technical fire control choose from the list of possible solutions a standard variant and offer it as a solution to the commander responsible.

b) ASRPP-DEL must provide access to documents and information for all command, coordination and fire support control elements. It's necessary to specify, who processes the information and who is it send to. During the fire control the receivers will be determined in advance and it won't be necessary to further specify addressees during requesting fire procedure. However the sender must be able to add a new addressee or exclude a preset-one.

c) Combat documents must be passed to all interested elements of the command, coordination and fire control system in a form, which enables them to create their own orders and other combat documents quickly, easily and without further transcription [2].

d) ASRPP-DEL must supply all fire control system elements with all resources, including printed data for alternative fire control methods. Charts from schemes of operational tactical tasks can be utilized.

e) ASRPP-DEL must register exact title of the element within the coordination and fire control system and in case of requesting printed output for any document with official header, it must fill in the author based on his 4 digits login in the system. The system must automatically fill in other data, like date, time, location of the document creation and it is serial number. To achieve this, the system must be able to automatically determine exact local time, location of the element of the coordination and fire control system, which creates the document.

f) The system must automatically add missing data in all documents, with stress on converting rectangular and polar coordinates in the document „Target list" [8], [9]. [14], [17].

V. Tactical fire control

Within the tactical fire control ASRPP-DEL must fulfil following requirements:

a) ASRPP-DEL must have information about the exact location of all elements of the system. At the same time it must register the accuracy of determining the location of reconnaissance assets and

artillery weapon systems and their orientation. It uses this data to suggest the method of firing data determination.

b) ASRPP-DEL must register all inputted lines and areas, which will be recorded with rectangular grid reference and evaluate movement of elements of the order of battle related to these coordinates. In case of exceeding area restrictions, the system will automatically respond with warning message [26].

c) ASRPP-DEL must register target priority in each period, task or phase of combat activity. This function becomes crucial in case of delegating the competence of the task force commander and switching to sensor – effector fire control method, when fire support coordination elements are excluded from the fire control system and targets are engaged based on their assigned priority. [8].

d) In order to determine ammunition for the fire solution, ASRPP-DEL must automatically receive ammunition information from the weapon systems, including count, types of projectiles, fuses and cartridge case. Based on this ASRPP-DEL will provide actual summary of ammunition state by type. In case of lowering the ammunition count under desired level, the system will automatically request resupply by sending report to the artillery unit‘s logistics element.

e) While choosing units, assets, etc. the ASRPP-DEL must check automatically, if unit or asset in question is available for given mission. To achieve this, the system must be capable to automatically receive reports on actual activity of the weapon systems.

f) ASRPP-DEL will automatically compute time of the start and the end of the fire mission based on data from OPORD or superior’s command.

g) After requesting fire, ASRPP-DEL will suggest fire mission command, which comprises:

• firing unit determined;
• target number;
• fire mission;
• method of determining Firing data;
• restrictions caused by dangerous distance between protected elements and the aiming point;
• fire duration;
• fire solution method.

VI. Technical fire control

a) The system will automatically choose grid zone, which will contain most of the artillery order of battle elements (based on planning). Other points will be automatically converted to coordinates in the chosen grid zone. The coordinates of all points will be stored in full format.

b) ASRPP-DEL will compute shoot over distance as well. Depending on actual artillery equipment will the shoot over distance calculation follow standard methods or it will be calculated for each projectile separately.

c) ASRPP-DEL will automatically receive and process meteorological messages for the needs of field artillery. Processing a meteorological message contains also evaluation of spatial and time validity of the message and timely automatic warning, when meteorological data need to be updated. The device monitoring meteorological conditions must be connected to ASRPP-DEL. Before any combat activity time needed for the preparation of probing until the input of the results in ASRPP-DEL must be calculated. ASRPP-DEL will compare time passed until the invalidation of the actual meteorological message and the time needed for gathering data for new meteorological message. ASRPP-DEL will warn responsible commander, to make necessary arrangements to obtain valid meteorological conditions for fire,

d) ASRPP-DEL must have the capability to continuously detect the temperature of propellant charges stored in weapon systems, or obtain information about propellant charges being stored in normal – table temperature conditions.

e) Main direction bearing and all other values needed for alternative fire control methods must be registered by the system. The system must be able to work with these data.

f) System must enable determining position of the target and target measurements.

g) ASRPP-DEL must ensure that inputting values about the target position will not lead to mistake. So, rectangular coordinates expressed in 10 m (EEEENNNN) won’t be mistaken for polar coordinates expressed in form of $\alpha_c\alpha_c\alpha_c\alpha_c$ $d_cd_cd_cd_c$ [8], [9], [23], [24].

h) ASRPP-DEL will offer pre-made alternatives of target description depending on their characteristics and will offer optimal decision. Yet there will always be a possibility to insert new characteristics, while keeping option to insert relevant parts of the command manually. In case of requesting fire at two different targets at the same time and inability of the artillery unit to engage both targets simultaneously, ASRPP-DEL will choose the target with higher priority. [19].

i) Based on data inputs will ASRPP-DEL derive following grounds for the Fire for effect:

• Firing unit;
• fire solution method;
• fire mission;
• projectile trajectory;
• type of projectile;
• fuse and it’s setting;
• method of engaging the target [17].

j) ASRPP-DEL will compute ammunition consumption for observed and unobserved targets. ASRPP-DEL will calculate ammo consumption for weapon system, range and direction. In accordance with task force commander’s request the system sets rate of fire.

k) Based on possibility of battle damage assessment, target dimensions, character and location of the target, actual fire conditions, range, unit dispersion and chosen firing unit ASRPP-DEL will determine method of engaging the target, meaning number of ranges of fire and directions of fire [26].

l) In case of any protected elements being situated in areas endangered by artillery fire, ASRPP-DEL will automatically calculate coordinates of new aiming point, which is in safe distance [14].

m) During fire adjustment and fire for effect corrections ASRPP-DEL converts corrections reported form observer post to corrections for fire position. The system also provides option to input data for correction calculations directly from the cooperating artillery reconnaissance assets.

VII. Calculating firing data

During calculation of firing data ASRPP-DEL carries out following actions:

a) ASRPP-DEL suggests the most suitable charge, depending on chosen weapon system, type of projectile, type of cartridge case, fuse and desired projectile trajectory. The system will consequently check angle of safety [8], [9], [13], [14].

b) ASRPP-DEL will calculate the calculated range and direction, and then use those values in fire control process. The calculated direction determination system incorporates multiple of splash fan interval for aiming the weapon systems at centres of their target sections.

c) ASRPP-DEL will always use the most precise method of firing data calculation from available data. When resources for complete preparation are unavailable, the system will notify the operator about specific missing data. The operator can take measures to complete the data or he can refuse the notification and system will use another, less precise method of firing data calculation

d) In case of determination of firing data using adjustment gun, ASRPP-DEL automatically determines decrease of initial projectile velocity for platoon master guns (δv_{od}) compared to battery master gun, which created fictional auxiliary target used for shifting fire [19], [20], [23], [24].

e) When determination of firing data by complete preparation or using fictional auxiliary target is impossible, fire adjustment is necessary. In that case ASRPP-DEL suggests fire adjustment method based on type of sensor, which detected the target and inserted target data in the system.

f) ASRPP-DEL will calculate firing data for each weapon system and each shell, fuse and cartridge case separately. That enables precision fire with different ammunition characteristics in single fire mission.

VIII. Standardization

ASRPP-DEL must fulfil standardization agreements, above all AArtyP-1, STANAG 4144 and AOP-55. Other publications related to the project are listed in Mott MacDonald study from 2010. [8], [14] Utilization of standardized NATO software marked S4 is assumed as well.

Content and form of the reports respect principles set by standardization agreements NATO at full scale. Differences occur only in situations required by ASRPP-DEL processes.

In case of reaching NEC, ASRPP-DEL must enable inserting call signs and data for reconnaissance assets of combat units and other military branches.

IX. Conclusion

ASRPP-DEL must be developed in a way, which will support and fasten activities of commanders and all other elements of artillery fire control system during all activities concerning task force combat support coordination, technical and tactical fire control and logistics. It must also contribute to cooperation with superior and cooperating task forces including military branches. It must not restrict combat support command, control and coordination elements in any way. It must provide standard solutions for any situation.

The system must be capable of relatively autonomous operation, especially in fire control method „sensor - - effector“.

ASRPP-DEL must support all task force organization structure variants.

Individual components must be able to operate independently when needed.

The system must be resistant to stress and conditions it will face in field conditions defined by politico-military ambitions of ČR.

ASRPP-DEL must communicate both sides with artillery systems.

During ASRPP-DEL development close cooperation between the programmers and artillery specialist will be absolutely necessary

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LIST OF ABBREVIATIONS

AČR	Army of the Czech Republic
ASRPP-DEL	Automated fire control system for artillery support
BVIS	Combat Vehicle Information System
ČR	Czech Republic
FFE	Fire for Effect
NATO	North Atlantic Treaty Organization
NEC	Network Enabled Capability
OPORD	Operation Order
OTS	Operational Tactical System