european social fund in the czech republic
EUROPEAN UNION
MINISTRY OF EDUCATION, YOUTH AND SPORTS
OP Education for Competitiveness
UNIVERSITY OF DEFENCE
INVESTMENTS IN EDUCATION DEVELOPMENT

Course: **FIRE CONTROL**

Author: prof. Ing. Ladislav POTUŽÁK, CSc.
mjr. Ing. Mgr. Martin BLAHA, Ph.D.

Contents

1 Adjusting fire without utilization of artillery survey

1.1 Targets

Management of Fire (fire and effective fire) is an essential attribute of ground artillery. This part of the rules of fire based on the requirement to specify options to current technical means of reconnaissance and artillery at the same time be able to fire when the fire is necessary to prepare traditional (alternative manual) way.

To obtain the most effective elements for fire targets directly observable (in terms of observing efficiency of firing can be observed and unobserved) observation of artillery used fire. Use is subject fire target accuracy of the starting elements for firing. Fire to take the shortest time and is used to target where there is a crucial element of surprise. When determining the elements for fire full training usually does not fire, even targets observable from observatories. Fire elements may be specified in the first rounds (1st and 2nd rounds) or wound an effective fire.

Determining elements for effective fire is done:

- to determine the starting elements for fire a shortened training (in addition to Article 174 and simplified training;
- for small size targets and shooting at various targets very important;
- if the specific conditions of performance firing task.

Fire is done with or without recovery of (technical) resources survey.

For fire are selected track missiles, missile type, lighter, and the series number of cartridges to be used as guidance for effective shooting.

It is allowed to perform fire and other projectiles or missiles with other lighters, when tabular correction for changes in conditions for firing the missiles and the missiles, designed for effective fire management are the same. In these cases, the elements of sight for the effective management of fire determined by fire distance.

1.2 Accuracy fire is provides a reliable observation of explosions

At the same time:

- define (evaluate) the individual deviations from the target explosions in the distance in meters or signs (characters in the group rounds explosions) and in the direction of the divisions;

– evaluate the kinds of explosions when using lighter bullets with non-contact (bursty, shock) and when shooting for reflection and measured height bursty.

Instead of an explosion is determined when a flash occurs, and a puff of smoke, according to the crater after the explosion or the impact of the fragments. Rate explosions by a puff of smoke overblown is unacceptable.

The first explosion is observed free eye or a device with a large field of view. The first place determined by explosion, and then measure the deviations from the target.

Unless the first explosion observed fire the second shot with the same elements or be suitably changed so that the explosion occurred in the observed field.

When shooting in rugged terrain is the first observation to ensure efficient explosion fire launch missiles with non-contact (timer, proximity) lighter and lighter with a timer for timing a table and spirit level (sight distance) increased by 10 to 20 dc, or you can use smoke (mark) missile.

An artillery observer during fire obligated personally or through subordinate observers and reconnaissance to observe and evaluate deviations explosions and, if necessary, continue fire according to the results of his observations.

Explosions that cannot be reliably evaluated when fire ignored.

Deviations from the target explosions (center of the group targets) in the distance in meters to determine the rangefinder and favorable conditions of observation and estimation.

If you cannot determine the size of deviations from the target explosion in the distance in meters, assessed as the morning "short" with marking "-" or "long" with marking "+".

When shooting for reflection and fire missiles with non-contact or proximity timing lighter deviations are determined by cloud bursts bursty (shock) and on flat ground by the impact of the fragments.

Deviations in the direction of explosions and bursty height is measured from the center of the target usually in divisions.

Repairs distance direction can be determined by a computer (the program PVNPG 95 automatically), the apparatus for fire control and the viewing angle in 5-00 addition and calculation.

The correction distance in meters to determine the distance sighting repair (vials) in the divisions.

To determine the corrections calculated during fire effective during shooting uses the reduction ratio *Rp* and lateral jump *Ss.* Repairs are determined with an accuracy which allows to set the sights.

Reduction ratio is calculated with an accuracy of 0,1 according to the formula:

$$Rp = \frac{d_C}{D_t^C}$$

where:

- d_C viewing distance target*;*
- D_t^C topographical distance target*.*

To determine the direction of the repairs and bring an explosion in line with the observational deviation areas (middle of the group blasts) in the direction taken with the opposite sign and multiplied by the reduction ratio.

Lateral jump serves to keep the explosions on the line when changing the viewing distance shooting.

Side step to change the shooting distance of 100 m is calculated with an accuracy of 1 component by the formula:

$$Ss_{100} = \frac{i}{0{,}01 \cdot D_t^C}$$

where:

- *i* viewing angle (angle*,* constricted viewing line and shot*).*

To determine the direction of repair, resulting from a change in the distance, the distance multiplied by a hundredth repair lateral jump according to the equation:

$$\Delta S = 0{,}01 \cdot \Delta D \cdot Ss_{100}$$

The direction towards correcting the lookout for shortening the distance to the opposite side and extending the distance.

Fire begins calculated elements of the target (the center of the target group). If the destination is located in close proximity to friendly troops, elements of the fire to determine the point, which is far from the target by 200 to 400 m in the opposite direction than his own troops.

The number of units that need to gain weight to set fire to the target, and under the terms of the technical and tactical fire control can be carried fire batteries (squad) or Section.

Battery (platoon) can calibrate target with or without the use of technical means artillery survey.

If the battery is placed in the firing position on the whole, fire target gun control, if deployed in platoons can calibrate target gun control either one (usually the first) platoon or two platoons control guns.

Fire gun control one squad can only be used when the following conditions:

- topographic-geodetic control connection cannon are carried out under the terms of ÚP;
- aiming cannon are carried out using the bearing of one landmark direction or one compass*;*
- Both fire crews keep fire cartridges of the same series*;*
- Elements are determined for shooting PC (program PVNPG 95) or the fire control unit for controlling gun crews of both the inclusion of corrections for the mutual inconsistency of control cannon*.*

Fire control guns each firing platoon must be used if it is not to be met if only one of these conditions and also in cases where the time is a crucial task.

When fire goals include gun control one for all repairs cannon battery at fire objectives governing each cannon firing squads, each squad includes only their repair.

Artillery can calibrate target once or gradually each battery with or without the use of technical means artillery survey.

Fire one battery can be used when the following conditions:

– battery firing positions are distributed in its entirety;
– topographic-geodesic connecting the firing position is done with precision, fully meeting the conditions of preparation, or is made to one point common to all batteries;
– Battery emplacements are located in one section firing position;
– Include the repair cannon of the inconsistency of control due to the battery management cannon, which performs fire;
– Shooting is conducted in a series of fillings or fillings when shooting different series included corrections for changes in their initial speed.

Fire gradually each time the battery is used, if not satisfied to be just one of these conditions and also in cases where the time tasks are not critical and it is necessary to obtain the most accurate elements for effective shooting.

If the firing batteries deployed in the whole section, then at each successively fire batteries goal fire gun control each battery. When deployed in platoons, then from each battery fire aimed either gun control only one platoon or two platoons gun control. When I drive fire target gun only one platoon from each battery must be complied with in article 211.

When fire one battery section includes all the fixes for battery compartment.

At each successively fire batteries battery repairs include the following:

– when fire target gun control batteries (one platoon) includes each battery repair the gun control;
– aims at controlling guns fire two platoons, each platoon comprises repairing his gun control.

1.3 Fire by the use of artillery survey – general rules

Fire means of artillery survey is the main way fire observed and unobserved targets (observable from observation posts or reconnaissance). It is used as needed to accomplish tasks both direct and general fire support regardless of the size of the inclusion of the firing unit (department).

When fire, or even observation and renovation (evaluation) of the active fire can cooperate:

- Intended for observation combined with surveillance device (KPzP) - with a laser rangefinder;
- integrated observation system LOS - with a laser rangefinder;
- for observation (two) - with protractor device;
- reconnaissance and observation SNĚŽKA – with a laser rangefinder or radar; radar ARTHUR (fire rules are part of a separate policy for the determination of combat use).

The Army of the Czech Republic can be the part of the military operations with Brigade Task Force, Battalion Task Force and Company Task Force. Every military unit all over the world consists of combat units and support units. The basic combat support provides aircraft and artillery.

The main element most of task forces will be mechanized unit with combat (fire) and the non-combat support. Not long history was the most important aim for artillery massive using of weapon systems. Today is the most important accurate and timely Fire for Effect with effective selection and coordination of weapon systems.

Success premise for this trends encompassment new intelligence and weapon systems, application of Standards Operation Procedures to the profession and to the fire control system. In current time Czech Artillery specialists working on new Artillery Fire Support Control System and his connection to higher level system for Network Connection Capabilities (NEC).

Same important is perfectly cooperation between control and coordination elements witch dependence on the communication.

1.4 Military Communication in the framework of the Artillery Fire Control System

The most sophisticated resources are necessary for manipulation with huge databases which inputs to the Artillery Battalion Fire Control System. It means to use of the modern communications and information technologies (systems).

It´s necessary to have sophisticated technologies which will be more friendly uses and friendly interface integration with the applications for working with maps (topographical data) and realization of difficult mathematical and physical science operations etc.

No less important for all systems are command posts. On the battalion level is the Battalion Coordination Center (figure 1), which is the part of the Battalion Main Command Post (or Battalion Tactical Command Post). The main tasks of this command post is analyzed of the information about targets and suggest to the Battalion Commander the using of Fire (Artillery) Support Units for eliminated of enemy. Responsibilities of suggestions are of course on the Battalion Commander.

On the brigade level is the Brigade Fire Direction Center (figure 2), which is the part of the Brigade Main Command Post. The main task of this command post is similar as Battalion Command Post. Different are in the level of control.

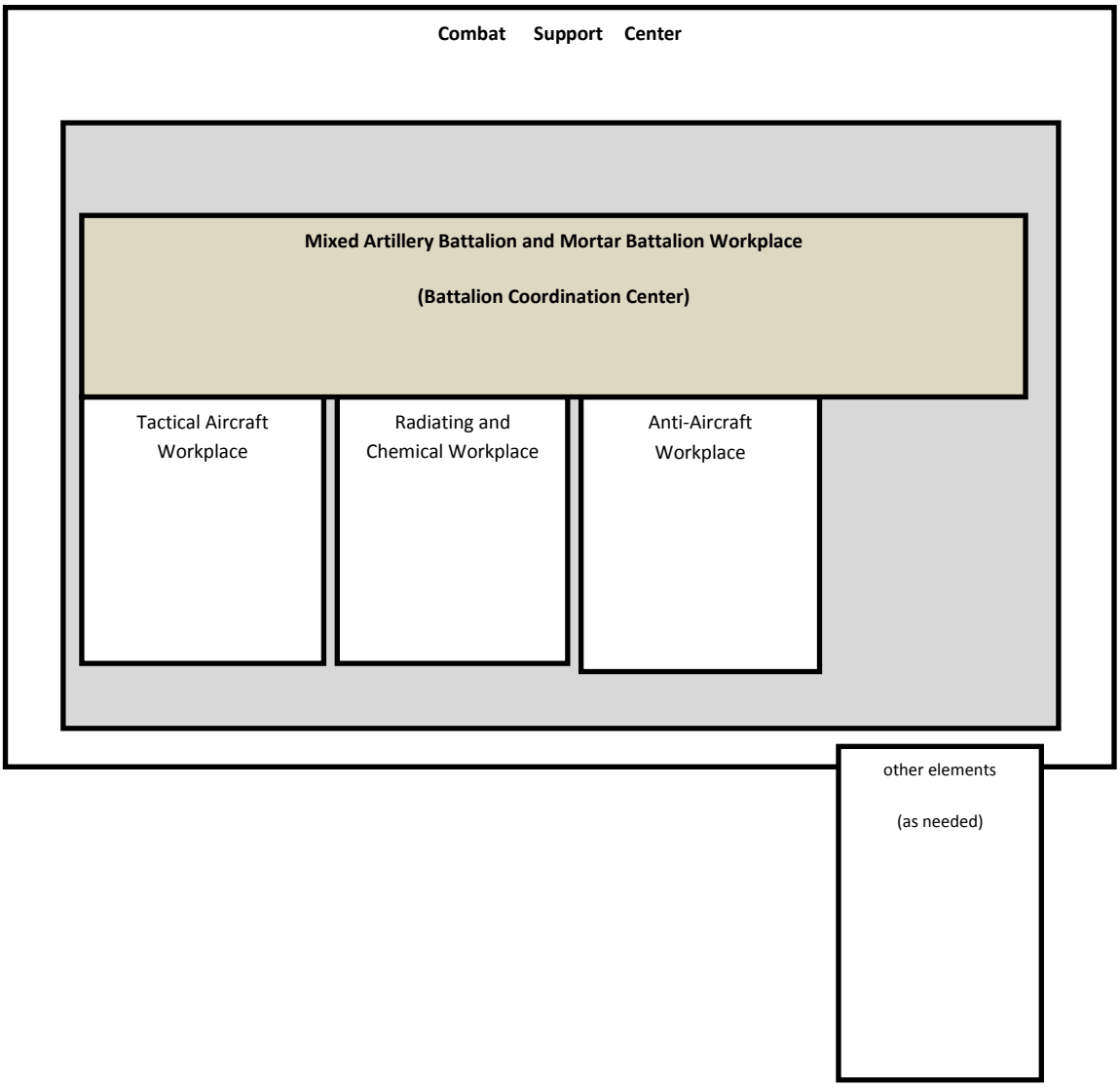


Figure 1: Battalion Coordination Center

It´s necessary to remember the fact, that computer fire control system will not to be ready for using in every time. Communication system is addicted to the function of the Artillery Battalion Fire Control System and the information technologies.

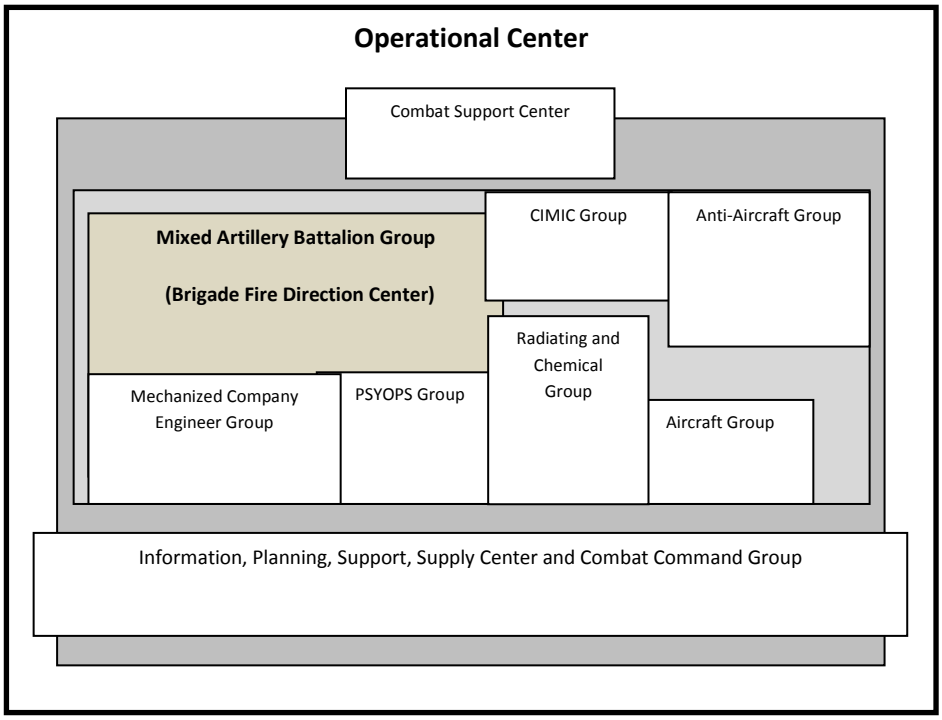


Figure 2: Brigade Fire Direction Center

In this time artillery specialists define functional and effective command posts of command and control and adequate software applications (Fire Control System), which will not be able to resolving only the fire tasks but will be able to be connected with command and control systems of higher level (Land Forces Control System and Aircraft Control System).

Every level of the control system must be covert by data.

Brigade Task Force has these elements of control system:

Brigade Fire Direction Center (Figure 1), Battalion Coordination Center (Figure 2).

1.5 MATH

From the figures result, that the elements for the Fire Support are implemented to the Operational Centers which integrating every experts for combat and non-combat Task Force elements.

It´s necessary to provide the special software modification to these elements included effectors. This reality supports a device to approximate the Artillery Battalion Fire Control System to C4ISTAR model.

The best variant, in my opinion, is creating one big “super system” consists of elementary special sub systems for every specialist combat and non combat support. This model is represented by Command and Control Operational Tactical System which is created in the Army of the Czech Republic in this time. The Artillery Fire Control System fillings-up fires separately and super system guarantee checking and coordination by superior level, see Figure 3.

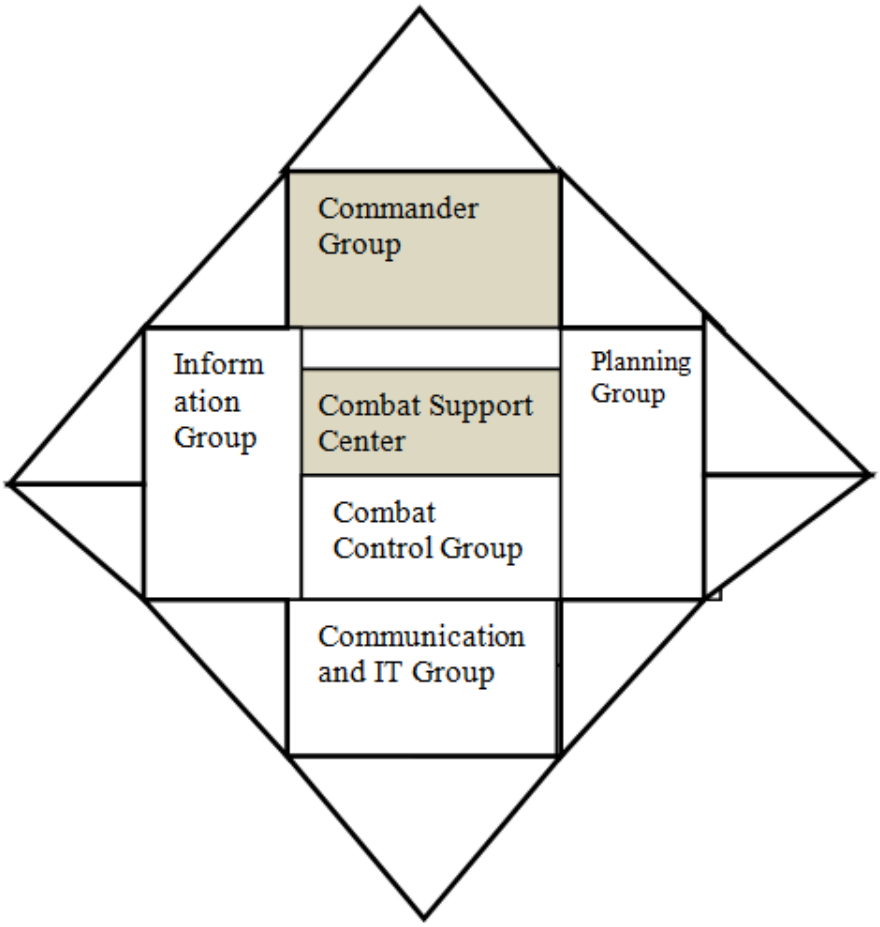


Figure 3 Artillery Fire Control Systems

The main method of communication and data exchange in this system is digital data transfer.

Resolution of technical and technologies of communication and data transfer isn´t the aim of this article. Practice using of the Artillery Fire Control System of Artillery of the Army of the Czech Republic displayed, that is serviceable to have some alternative kinds of communication, because digital connection can be broken. The alternative kind of communication is voice mode (radio stations).

Both systems are built on the procedures of “Artillery Rules of Fire and Control Fire” (Czech Artillery Doctrine), what is the main manual of using of Artillery of the Army of the Czech Republic. The disadvantage of this system is necessity of artillery experts a knowledge’s of the standard operational procedures and rules of the using of the Czech Artillery. The most important is to sustain permanently connection of every elements of the fire control systems, include Forward Observer which will cooperate during the adjustment and surveillance of results of the Fire of Effect (figure 4).

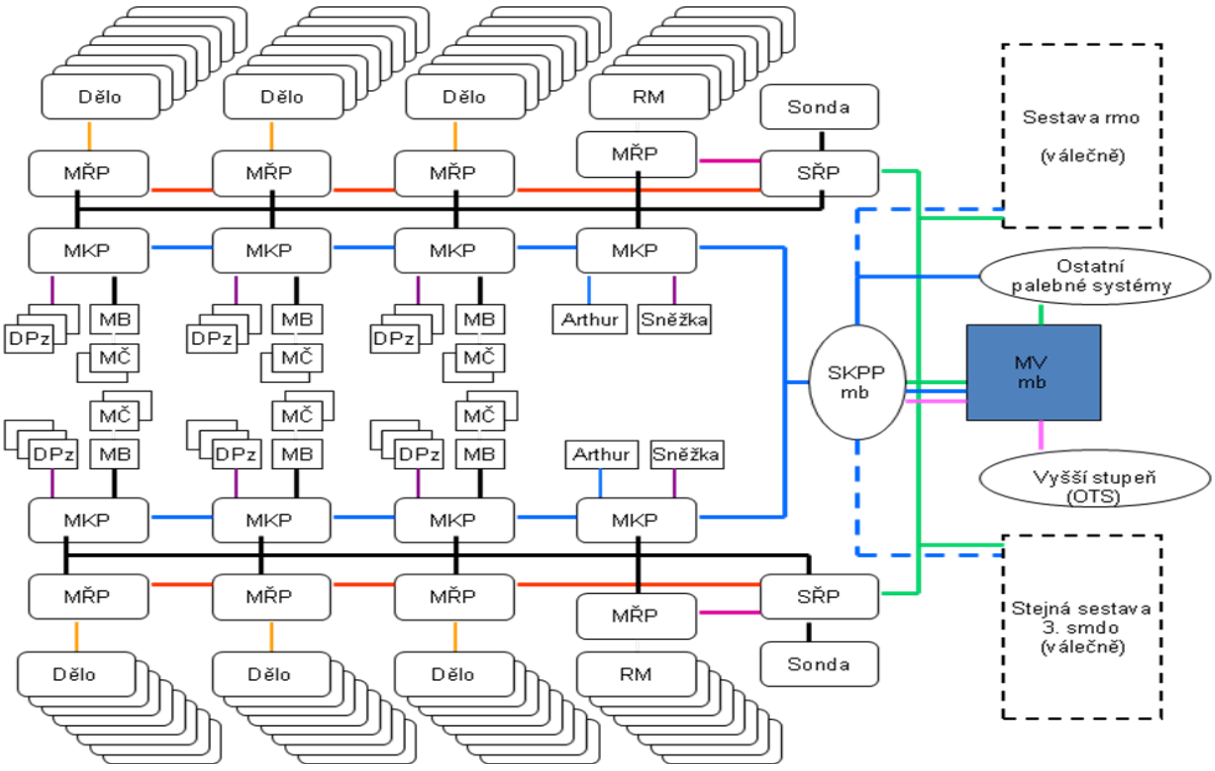


Figure 4 Elements of Artillery Fire Control Systems

The global environment changes, threats a new tasks required new views of the Czech Republic defense strategic. Future security environment will characteristic by dynamic changes of situations and connection by many factors.

The terrorist's problems occasioned strategy changes from massive Armed Forces using to effective using of modern, sophisticated forces with quick Command, Control and Decision process supported by information technologies.

The aim of this article wasn´t described details of principles of fire control system elements working, described every data of communication flow, or difficult linkages and priorities but introduced the most important system of the Artillery Battalion Fire Control System of the Artillery of the Army of the Czech Republic and highlight significance perfectly communications system of today's and future fire control system or command and Control operational tactical systems. The basic necessary changes which were defined mentioned above are absolutely basic conditions for approaching to the NATO standard (NEC Capabilities).

Very big limiting conditions, especially in current time of financial crisis, are financial means. But, for achievement of NATO standard investments in the army are necessary.

1.6 Call for Fire Procedure

Fire support assumes a key role in modern warfare and often even in non-combat operations today. It could be expected that in the future, its share in the achievement of objectives of the operations conducted by Task Force will only increase. Fire support realized only by artillery is called artillery support. At lower levels of command (company, battalion, brigade) artillery is major and often the only mean of performing tasks of fire support. Artillery has the unique ability to reduce the combat potential of several groups of enemy elements i.e. the artillery can destroy different targets by using manoeuvre of fire in a short time. In order to exploit the capabilities of artillery as a whole, all relevant elements of groups fighting task force's must have ability to request artillery support. This process is called "Call for Fire CFF". CFF includes: target acquisition, processing and transmission of information serving as the basis for the firing of artillery.

This procedure can be divided into several parts:
a) make a connection;

b) providing information about the target;

c) specification.

The content of this article is to derive, definition and justification documents that are necessary for effective artillery fire and fire control system are placed in the „Call for fire".

1.7 Principles of communications at the call for fire

Content and realization of communication at the call for fire and during the firing task is governed by the principles of communication and rules of communication which should comply with the principles of management of radio operations of NATO. These principles are included in the publication AArtyP-1 Artillery Procedures.

Transmission of orders, commands, messages, information and signals must be fast and totally accurate. Flawless communication increases the security of transmission, reducing the possibility of confusion and reduces the time required for the realization of artillery support. In the case of use of automated artillery command and fire control system (ASRPP-DEL) through the communication using data transmission, which significantly reduces the transmission time, eliminating the possibility of garbled text. It also allows secret transmission, reducing the risk of interference, etc.

ASRPP-DEL provides automatic transmission of information to predetermined elements of artillery fire control system. Recipients in the system will be determined in advance, so it will not be necessary to set whom the message should be sent to. However, the sender will be able to add a new recipient set or removed. Received message will not be repeated. It is necessary to ensure automatic information about the adoption of report. This means that the system will provide feedback that a message was sent and the recipient was included.

1.8 Transmission of information about the target

Target information can be divided into three groups:

a) target position;

b) description of target;

c) additional information about the target.

For the effectiveness of artillery support is also important that all the necessary information will be identified and submitted.

Location of targets

Target position is given by Cartesian coordinates or polar coordinates. Cartesian coordinates can be used without having to know the location of reconnaissance authority. The target position indicating polar coordinates, it is necessary to know the location of reconnaissance authority from which the coordinates are measured.

The accuracy of the detected coordinates of a destination depends on the effectiveness of fire. In the case of incorrect destination coordinates must be followed fire adjusting, which reduces unexpectedness of fire and the enemy will take step to reduce the effects of fire. Existing rules of fire given to the start effective shooting without fire adjusting need to find the coordinates of targets with a circular probable error of 50m or less (CEP $\leq$ 50 m). In the case of determining the polar coordinates of targets are established the accuracy topographic connections, orientation and measurement of reconnaissance device.

The position of artillery fire target can be determined in the following ways:

a) enter the target to map and read the target coordinates;
b) read the previously registered target coordinates, which restored the activity or the new target discover on an already familiar place;
c) to estimate the distance of the new target from the previously registered target along the axis E and N and the estimated distance attributed to (with the sign) to the coordinates of previously entered target;
d) determine the coordinates of the target using reconnaissance device.

Determination of target coordinates on the map

Artillery observers enter a target with touch screen and digital map by comparing maps with terrain into the system. The system automatically deduces Cartesian coordinates and altitude. This process is vague and requires subsequent fire adjusting. This is a case without the use of artillery reconnaissance devices. Reconnaissance authority which is able to use some of the possible ways of fire adjusting and is trained in conjunction with the artillery firing units and has links with the fire unit may cooperate during the fire adjusting.

Read the previously registered target coordinates

In cases where the target resumes or the target will appear at the place which was already known. This target is possible to determine using the list of targets. In this case report only the number of target. ASRPP-DEL looks set target in the target list and automatically defines coordinates. In this case effective fire can be started immediately.

To estimate coordinates of the target according to previously registered target coordinates

In the event that the new target will appear near the target, which was already being destroyed, it is possible to estimate the deviation from the target coordinates. The position we can mark by the number of old targets and a horizontal and vertical tolerance coordinates of the new target. Example: "target CZ1025, E +200, N -400. Due to estimate of distances and directions of the horizontal and vertical coordinates in the terrain will be required fire adjusting.

Determination of coordinates of the target using

Reconnaissance devices greatly reduce the possibility of error in determining the coordinates of targets due to human error. Completely eliminate human error in aiming the device can only be achieved by using devices that seek enemy targets themselves. In the arsenal of artillery of AČR it is radar ARTHUR and PzPK SNĚŽKA. Both these devices require activity of targets. Optoelectronic devices do not require activity of targets, but the accuracy of collected data is affected by human factor.

Contemporary reconnaissance devices measure the required values with sufficient accuracy and edit them in the time horizon of seconds. Numeric values can be directly sent to an automated system or to read and work with them. Sending and reading values greatly reduces the determination of target coordinates.

The reconnaissance authority must insert the information about accurately or inaccurately target coordinates. When using ASRPP-DEL it is advisable to insert the information about reconnaissance devices and their accuracy. After logging into the system and calling for fire ASRPP-DEL automatically assess the coordinates of target accurately or inaccurately and if it is possible to lead an effective fire by using complete preparation or fire adjusting.

Description of target

Exact description of the target influences the effectiveness of artillery fire particularly in terms of effects of projectiles in target position. It is not possible to fire without some of the data. In Call for fire it must be stated:

a) the type of target;

b) the character of target;

c) the location of target;

d) activity of target;

e) if the target is observed or not.

ASRPP-DEL will offer pre-loaded options describing the target in each individual characteristic. After that, options evaluation system will provide an optimal decision in the form of the following part of fire command: determining the size (number) fire unit (fire units), method of firing, firing task, trajectory, projectile type and lighters settings. it is Always possible to insert another characteristic option manually.

Type of target

Type of target is the most important basis for the commander for assessment of the importance of target and its elimination. In addition, there is a basic description of the object. Type of target is basis for the firing command. Type of target is important for

the chosen firing unit (number of firing units), the way of firing. Possible types of targets are divided into categories and will be stored in the automated system permanently. For each type of target system is assigned a standard unit, which will eliminate specific target and choose the best firing possibly.

Character of target

The character of target expresses its resistance to fire in terms of its cardinality. It can be concluded that this characteristic does not change in space or in time. Based on the character of target it is possible to assess the firing unit (number of firing units) for the firing, the trajectory and lighter set.

Location of target

The exact description of the target location is needed to assess the trajectory. Generally, the targets located behind cover or in urban areas leads to a steep fire track and on target located in the objects rounded trajectory. The choice of trajectory on the targets located elsewhere will affect their character.

Activity of target

Description of current activity of target is important for commander's decision. The commander's decision can assess work of subordinate units. Task force commander can decide about immediately fire or just prepare of fire and realize later, or not realize.

Observed / unobserved target

According to this data, in some cases it is possible to assess the size of the target, method of fire, consumption, and consequently way of fire, choice of species and possibly determine the number of firing units. Generally, we can establish the principle that the group of target which cannot reliably determine the activity of their elements (because of their number, location in hiding, etc.) are considered to be unobserved.

Additional information about target

Additional information is being used in call for fire in cases, where it is necessary to specify the size, shape and orientation of target, or specify its number, set limits, seek the firing task, set trajectory or set a specific type of ammunition for adjusting fire or effective fire.

Size, shape and orientation of target

Size of the target is given only to group targets. If it is a rectangular group of target, it is necessary to set the width and depth, usually rounded to tens of meters. By linear group target are given only the width. ASRPP-DEL to calculate the exact dimensions just signposts measuring distances and a front, rear, right and left bearing of the target. The system will be able, based on these data to calculate the exact location of those points and then the exact dimensions of the target. This will set a different target than the rectangular shape. This will require an appropriate mathematical framework, which allows the calculation of the positions of deliberate firing sets of points on the irregular surface in complying with the requirement of an equitable distribution of missile explosions.

A special case of group target is a circular target. When using ASRPP-DEL it is possible that the system assesses the shape like a circular target. This will affect only intentional deployment points and it will be given the same principles as the targets of irregular shape, as described in the previous paragraph.

Standard information during call for fire on the group's target is its orientation, which is bearing of the longer side of rectangular group target (bearing linear target) rounded to the hundreds of miles. This information is applicable only when using an automated fire control system, because it is calculated on the basis of elements for fire on individual points of fire units.

Number of target

Number of target is a data for navigate in the list of targets especially if it is useful to use data about previously identified targets or eliminated targets. Number of targets is composed of two parts provided by allied publications. If ASRPP-DEL will be available to combat orders, automatically assigns the first three characters of target number. The remaining three characters of the target identified by category and so far the number of targets identified in this category.

1.9 Specifications

Limitations

One of the fundamental limitations that are often used is warning "Danger Close". This is for combat support and coordination of fire control authority and fire units aware of the fact that the target is at a distance from friendly forces, which is in conflict to the existing security measures.

When using ASRPP- DEL must be a digital model of the battlefield with the current location of all own units and objectives that may not be threaten by the effects of artillery fire (these objects are defined by international treaties). The system calculates the coordinates of point of aim, which is located at a safe distance from the protected element. Then specify the elements for an effective fire, depending on the reconnaissance devices in accordance with the rules of firing.

a) Automated system calculates the distance from the nearest established targets to the protected element ($D_{v\text{-}c}$), based on information from the digital model of the battlefield and calculates bearing connectors this point and target ($\square_{v\text{-}c}$).

b) System calculates the safety distance from the point of aim of the protected element:

$$L_{MBV} = 4 \times (Ex^2 + úd^2)^{½} + r_{str}$$

where: L_{MBV} is the minimum safety distance of the point of aim from the protected element.

E_x is probable long error of elements fire.

If the elements fires for effective fire are designed by:

- complete preparation, then: $E_x = D_t$ [m] x 0,008
- transfer of fire from assistant target, then: $E_x = D_t$ [m] x 0,006
- using adjusting gun, then: $E_x = D_t$ [m] x 0,01
- reduced preparation, then: $E_x = D_t$ [m] x 0,037
- Simplified preparation, then: $E_x = D_t$ [m] x 0,09

where: D_t [m] is the topographic distance from firing position to the target in meters, ASRPP-DEL calculating the topographic distance;

0,008; 0,006; Etc. are constants and the average values probable long errors of fire preparation for effective fire in percentage of topographical distance;

úd is a deviation distance corresponding to the firing by specific cartridge on specific distance that ASRPP-DEL to get out of from pre-inserted firing tables;

r_{str} is the maximum radius of the fragments of projection and it is placed in ASRPP-DEL permanently with other data about the ammunition.

c) Compare the distance of own troops from the target (D_{v-c}) and minimum safety distance (L_{MBV})

$$\Delta L_{MBV} = D_{v-c} - L_{MBV}$$

where: ΔL_{MBV} is the difference between the distance of the protected element to the nearest identified target and safety distance from the point of aim to the protected element;

D_{v-c} is the distance from the nearest protected element to identified target;

L_{MBV} is the minimum safety distance from the point of aim to protected element.

d) If the distance D_{v-c} from the protected element to target greater than or equal to safe distances L_{MBV}, the coordinates of target are not adjusted.

e) If the distance D_{v-c} from the protected element to target less than the safety distance L_{MBV}, it is necessary to calculate the correct coordinates of the point of aim:

$$\Delta E = \sin \Delta_{v-c} \times | \Delta L_{MBV} |$$

$$\Delta N = \cos \Delta_{v-c} \times | \Delta L_{MBV} |$$

where: ΔE is a correction of horizontal coordinates of the point of aim;

Δ_{v-c} is bearing measured from the nearest protected element to identified target;

□L_{MBV} is the difference between the distance of the protected element to the nearest identified target and safety distance from the point of aim to the protected element;

□N is repair of the vertical point of aim.

f) The system at the same time attention of all fire control authorities by the words "DANGER CLOSE!".

g) The calculated values of correct coordinates are added to original coordinates of the target. This gives the new coordinates of the point of aim, which is located at a safe distance from friendly forces:

$$E_{bezp} = EC + (\pm\square E)$$

$$N_{bezp} = NC + (\pm\square N)$$

where: E_{bezp} is the horizontal coordinates of the new point of aim;

E_C is the horizontal coordinates of the target;

ΔE is a correction of horizontal coordinates of the point of aim;

N_{bezp} is the vertical coordinates of the new point of aim;

N_C is a vertical coordinates of the target;

ΔN is a correction of vertical coordinates of the point of aim.

h) ASRPP-DEL calculates the new fire elements for the new point of aim.

Firing task

Determination of firing task by reconnaissance authority is one of the ways how to obtain the degree of exclusion targets or specific realization of fire. If the reconnaissance authority does not set firing task, it must set one of the coordinating combat support authority or fire control authority. The general principle is to respect the requirement of reconnaissance authority in determining the firing task, because it expresses the need of the supported task force commander.

Trajectory

Trajectory is determined by general rules of the firing rules. In exceptional cases, the reconnaissance authority can require a steep fire (on the basis of an exploratory evaluation of target position and its cover and fire units).

When using ASRPP-DEL, which will be updated by digital model of the battlefield, the trajectory will be determined automatically. The system compares the altitude of the trajectory points with altitude terrain points, which are situated below this distance.

The type of ammunition for adjusting fire and effective firing

Reconnaissance authority may in specific cases also require the adjusting fire or effective fire by non-standard types of ammunition and lighter set. When is ASRPP-DEL using that the system will determine firing elements for each shot separately.

MARK SHEET

Task				ε'_C		α_{CL}		α_{CP}		ε'_R	
D_t^C		So_t^C		A_P		d_L		i_L		ΔX_{dc}	
				A_C							
				A_B		d_P		i_P		t_C	
ΔD_P^C		ΔS_P^C		ΔA		ΔN_{dc}		γ		úd	
				ε_C		$\Delta D = ...L - .....P$				ÚV	
D_P^C		So_P^C		$\Delta\alpha_z$		$\check{S}_C$		Ss		Rp	
				$\Delta\varphi$		H_C					

Directive, report:

Command number	COMMANDS	Distance Timing	Telescope level ($\Delta\varphi$)	Side deviation	Surveillance 5d	Surveillance 4d	Note

Time (operating time)		Effective firing data accuracy: - in distance - in direction		Error count in performance of fire tasks		Overall evaluation	
Evaluation		Evaluation		Evaluation			
Commander´s conclusion:							

2 Artillery observer

An artillery observer during fire obligated personally or through subordinate observers and reconnaissance to observe and evaluate deviations explosions and, if necessary, continue fire according to the results of his observations. Explosions that cannot be reliably evaluated when fire ignored.

Deviations from the target explosions (center of the group targets) in the distance in meters to determine the rangefinder and favorable conditions of observation and estimation.

If you cannot determine the size of deviations from the target explosion in the distance in meters, assessed as the morning "short" with marking "-" or "long" with marking "+".

When shooting for reflection and fire missiles with non-contact or proximity timing lighter deviations are determined by cloud bursts bursty (shock) and on flat ground by the impact of the fragments.

Deviations in the direction of explosions and bursty height is measured from the center of the target usually in divisions.

Repairs distance direction can be determined by a computer (the program PVNPG 95 automatically), the apparatus for fire control and the viewing angle in 5-00 addition and calculation.

The correction distance in meters to determine the distance sighting repair (vials) in the divisions.

To determine the corrections calculated during fire effective during shooting uses the reduction ratio *Rp* and lateral jump *Ss.* Repairs are determined with an accuracy which allows to set the sights.

Reduction ratio is calculated with an accuracy of 0,1 according to the formula:

$$Rp = \frac{d_C}{D_t^C}$$

where:

- d_C viewing distance target;
- D_t^C topographical distance target.

To determine the direction of the repairs and bring an explosion in line with the observational deviation areas (middle of the group blasts) in the direction taken with the opposite sign and multiplied by the reduction ratio.

Lateral jump serves to keep the explosions on the line when changing the viewing distance shooting.

Side step to change the shooting distance of 100 m is calculated with an accuracy of 1 component by the formula:

$$Ss_{100} = \frac{i}{0{,}01 \cdot D_t^C}$$

where:

- *i* viewing angle (angle, constricted viewing line and shot).

To determine the direction of repair, resulting from a change in the distance, the distance multiplied by a hundredth repair lateral jump according to the equation:

$$\Delta S = 0{,}01 \cdot \Delta D \cdot Ss_{100}$$

The direction towards correcting the lookout for shortening the distance to the opposite side and extending the distance.

Fire begins calculated elements of the target (the center of the target group). If the destination is located in close proximity to friendly troops, elements of the fire to

determine the point, which is far from the target by 200 to 400 m in the opposite direction than his own troops.

The number of units that need to gain weight to set fire to the target, and under the terms of the technical and tactical fire control can be carried fire batteries (squad) or Section.

Battery (platoon) can calibrate target with or without the use of technical means artillery survey.

If the battery is placed in the firing position on the whole, fire target gun control, if deployed in platoons can calibrate target gun control either one (usually the first) platoon or two platoons control guns.

Fire gun control one squad can only be used when the following conditions:

- topographic-geodetic control connection cannon are carried out under the terms of ÚP;
- aiming cannon are carried out using the bearing of one landmark direction or one compass*;*
- Both fire crews keep fire cartridges of the same series*;*
- Elements are determined for shooting PC (program PVNPG 95) or the fire control unit for controlling gun crews of both the inclusion of corrections for the mutual inconsistency of control cannon*.*

Fire control guns each firing platoon must be used if it is not to be met if only one of these conditions and also in cases where the time is a crucial task.

When fire goals include gun control one for all repairs cannon battery at fire objectives governing each cannon firing squads, each squad includes only their repair.

Artillery can calibrate target once or gradually each battery with or without the use of technical means artillery survey.

Fire one battery can be used when the following conditions:

- battery firing positions are distributed in its entirety;
- topographic-geodesic connecting the firing position is done with precision, fully meeting the conditions of preparation, or is made to one point common to all batteries;
- Battery emplacements are located in one section firing position;
- Include the repair cannon of the inconsistency of control due to the battery management cannon, which performs fire;
- Shooting is conducted in a series of fillings or fillings when shooting different series included corrections for changes in their initial speed.

Fire gradually each time the battery is used, if not satisfied to be just one of these conditions and also in cases where the time tasks are not critical and it is necessary to obtain the most accurate elements for effective shooting.

If the firing batteries deployed in the whole section, then at each successively fire batteries goal fire gun control each battery. When deployed in platoons, then from each battery fire aimed either gun control only one platoon or two platoons gun control.

When fire one battery section includes all the fixes for battery compartment. At each successively fire batteries battery repairs include the following:

- when fire target gun control batteries (one platoon) includes each battery repair the gun control;
- aims at controlling guns fire two platoons, each platoon comprises repairing his gun control.

2.1 Reconnaissance and fire units

The Military Strategy of the Czech Republic brings forth a set of basic principles for defence of the state and for development of the Armed Forces of the Czech Republic. The Military Strategy reflects upon the current and future global security environment while building upon security interests and defence as well as foreign policy defined in the Security Strategy of the Czech Republic. Furthermore, this

document keeps true to the fundamental principles of the NATO´s Strategic Concept and Comprehensive Political Guidance, and the EU´s European Security Strategy.

The basic principle of defence of the Czech Republic against present or rather future threats is her active participation in the NATO´s system of collective defence founded on a strong transatlantic link. Units of the Army of the Czech Republic can be used (respect current global security neighborhood) outside of the Czech Republic or more precisely outside of NATO and EU territory. The Army of the Czech Republic can be the part of the military multinationals operations with Brigade Task Force, Battalion Task Force and Company Task Force. Main element of every task force will be mechanized unit with the combat and noncombat support. The basic combat support provides air force and artillery.

Not long history was a more important aim for Artillery massive using of weapon systems. Nowadays is a more important accurate and timely Fire for Effect with effective selection and coordination of weapon systems. Success premise for this trends encompassment new intelligence and weapon systems, application of Standards Operation Procedures to the profession and to the fire control system.

2.2 Command and Control System

Command and Control System in current time is a modern sophisticated computer network especially Command and Control Operational Tactical System. C2 System is defined as the group of the equipment and apparatus (including sensor) for using by weapon systems (effectors) or by some groups of this system. In more detail is defined as process of the target (information) acquisition and tactical using of the combat power of effectors.

Requirements of the future C2 System are tasks and responsibilities of each system elements, which is defined by classical diagram (Figure 1). If we discuss about the future command and control systems, we will have to effective inputs (reconnaissance), data processing resources (Command and Control System) and outputs (Guns). All this facts are necessary condition for optimal C2 system.

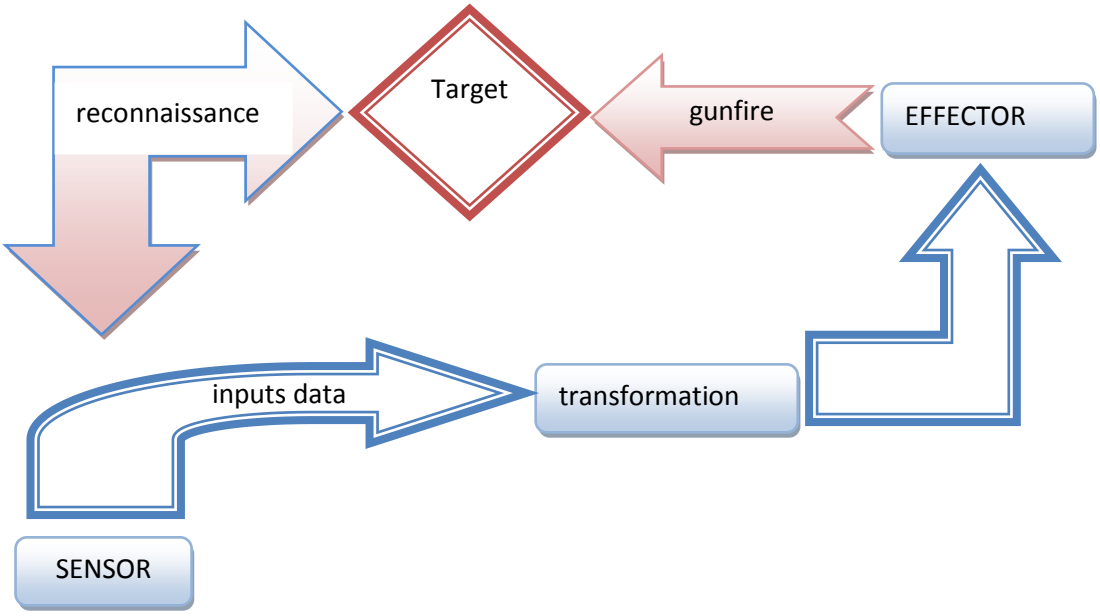


Figure 1: General System

Reconnaissance part

Reconnaissance devices are parts of ISTAR (Intelligence, Surveillance, Target Acquisition and Reconnaissance), which integrates sensor output in Targeting processes. Requirements to ISTAR system are published in NATO Capabilities/Statements.

Lowest element of this system is Forward Observer. Forward Observer is the main element of the artillery recon in the company level. Czech Army disposes of the light reconnaissance and observation system (LOS).

Next important is Artillery Technical Recognize Squad with the special technical equipment marked SNEZKA (Figure 2). This reconnaissance and observing system is a mobile device with high cross-country mobility and optimum protective features. It´s designed especially for artillery reconnaissance with smart computer support. The system can perform detection, recognition and identification during all day's and night's conditions. SNEZKA measures and calculates target coordinates, makes automatic processing of the data and transmits it to the headquarters with radio. The system is in the service of the Czech Army, and it is included in artillery fire control system ASPRO. Main task is target detection of course.

Figure 2: Reconnaissance and observing system SNEZKA

Czech Artillery has the use of three ARTillery HUnting Radars (ARTHUR WLS modB), which is determinated for detection of enemy artillery. ARTHUR (Figure 3) is on the Brigade level. The basic necessary changes for effective reconnaissance are:

- online target review (real time target database),
- inter connecting capabilities (connection with other sensor),

Artillery reconnaissance target detection ability over 40km every time, every weather or every terrain.

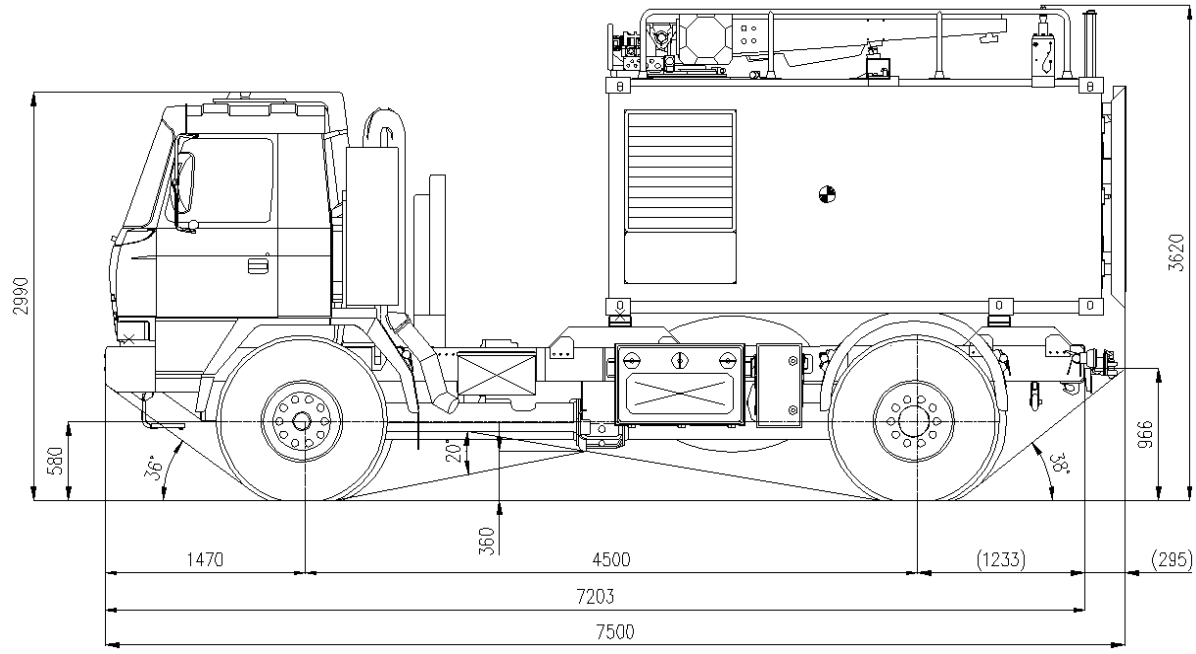


Figure 3: ARTHUR WLS mod B

Firing part

Efficient element of the Artillery Fire Control System is Weapon System – Effector (Self Propelled Howitzer, Rocket Launcher, and Mortar). Artillery platoon consists of four effectors and two artillery platoon forms the artillery battery (mortar battery is consist of three Mortar Platoons). Current Artillery of the Army of the Czech Republic is represented by 13th Artillery Brigade consist of two Artillery Battalions.

Today's trends are uniquely determined. All-weather weapon have to be autonomous with uniformly caliber all over the NATO. The basic necessary changes for effective Gun System are:

- every gun systems with inertial navigation system,
- self propelled gun with gunshot over 40 km and rocket launcher with gunshot over 60km,
- self propelled gun with caliber exactly 155 mm and rocket launcher with caliber exactly 155mm.

In the current security environment, collective defence within NATO is the only effective, efficient and credible means of defence of the Czech Republic. The Armed Forces fulfil their core task of preparing for defence of and defending the Czech Republic against external attacks in this context. The Czech Republic also assumes sharing of responsibility for security and defence of her allies and for protection and advancement of common security interests of NATO member states.

From the conclusions of the last conference “Perspective of Artillery Fire Control System 2008” on University of Defence results necessary of modernization of the Artillery Fire Control System in the Artillery of the Army of the Czech Republic, included communication system and implementation of NATO standards.

Units of the Armed Forces shall be built so as to be able to compose required task force through mutual combinations in accordance with the operational requirements.

The basic necessary changes which were defined mentioned above are absolutely basic conditions for approaching to the NATO standard (NEC Capabilities). Artillery of the Army of the Czech Republic with weapon systems will come of the lethal effect on enemy and non lethal effect on enemy´s information and communication system, sensors, etc. Artillery special sensors will pertain to joint planning and perspective operation control in integrated interface of Network Enabled Capabilities.

Very big limiting conditions, especially in current time of financial crisis, are financial means. But, for achievement of NATO standard investments in the army are necessary.

3 Call for Fire Procedure

Fire support assumes a key role in modern warfare and often even in non-combat operations today. It could be expected that in the future, its share in the achievement of objectives of the operations conducted by Task Force will only increase. Fire support realized only by artillery is called artillery support. At lower levels of command (company, battalion, brigade) artillery is major and often the only mean of performing tasks of fire support. Artillery has the unique ability to reduce the combat potential of several groups of enemy elements i.e. the artillery can destroy different targets by using manoeuvre of fire in a short time. In order to exploit the capabilities of artillery as a whole, all relevant elements of groups fighting task force's must have ability to request artillery support. This process is called "Call for Fire CFF". CFF includes: target acquisition, processing and transmission of information serving as the basis for the firing of artillery.

This procedure can be divided into several parts:
a) make a connection;

b) providing information about the target;

c) specification.

The content of this article is to derive, definition and justification documents that are necessary for effective artillery fire and fire control system are placed in the „Call for fire".

3.1 Principles of communications at the call for fire

Content and realization of communication at the call for fire and during the firing task is governed by the principles of communication and rules of communication which should comply with the principles of management of radio operations of NATO. These principles are included in the publication AArtyP-1 Artillery Procedures.

Transmission of orders, commands, messages, information and signals must be fast and totally accurate. Flawless communication increases the security of transmission, reducing the possibility of confusion and reduces the time required for the realization of artillery support. In the case of use of automated artillery command and fire control system (ASRPP-DEL) through the communication using data transmission, which significantly reduces the transmission time, eliminating the possibility of garbled text. It also allows secret transmission, reducing the risk of interference, etc.

ASRPP-DEL provides automatic transmission of information to predetermined elements of artillery fire control system. Recipients in the system will be determined in advance, so it will not be necessary to set whom the message should be sent to. However, the sender will be able to add a new recipient set or removed. Received message will not be repeated. It is necessary to ensure automatic information about the adoption of report. This means that the system will provide feedback that a message was sent and the recipient was included.

Transmission of information about the target

Target information can be divided into three groups:

a) target position;

b) description of target;

c) additional information about the target.

For the effectiveness of artillery support is also important that all the necessary information will be identified and submitted.

3.2 Location of targets

Target position is given by Cartesian coordinates or polar coordinates. Cartesian coordinates can be used without having to know the location of reconnaissance authority. The target position indicating polar coordinates, it is necessary to know the location of reconnaissance authority from which the coordinates are measured. The accuracy of the detected coordinates of a destination depends on the effectiveness of fire. In the case of incorrect destination coordinates must be followed fire adjusting, which reduces unexpectedness of fire and the enemy will take step to reduce the effects of fire. Existing rules of fire given to the start effective shooting without fire adjusting need to find the coordinates of targets with a circular probable error of 50m or less (CEP $\leq$ 50 m). In the case of determining the polar coordinates of targets are established the accuracy topographic connections, orientation and measurement of reconnaissance device.

The position of artillery fire target can be determined in the following ways:

e) enter the target to map and read the target coordinates;
f) read the previously registered target coordinates, which restored the activity or the new target discover on an already familiar place;
g) to estimate the distance of the new target from the previously registered target along the axis E and N and the estimated distance attributed to (with the sign) to the coordinates of previously entered target;
h) determine the coordinates of the target using reconnaissance device.

Determination of target coordinates on the map

Artillery observers enter a target with touch screen and digital map by comparing maps with terrain into the system. The system automatically deduces Cartesian coordinates and altitude. This process is vague and requires subsequent fire adjusting. This is a case without the use of artillery reconnaissance devices. Reconnaissance authority which is able to use some of the possible ways of fire adjusting and is trained in conjunction with the artillery firing units and has links with the fire unit may cooperate during the fire adjusting.

Read the previously registered target coordinates

In cases where the target resumes or the target will appear at the place which was already known. This target is possible to determine using the list of targets. In this case report only the number of target. ASRPP-DEL looks set target in the target list and automatically defines coordinates. In this case effective fire can be started immediately.

To estimate coordinates of the target according to previously registered target coordinates

In the event that the new target will appear near the target, which was already being destroyed, it is possible to estimate the deviation from the target coordinates. The position we can mark by the number of old targets and a horizontal and vertical tolerance coordinates of the new target. Example: "target CZ1025, E +200, N -400. Due to estimate of distances and directions of the horizontal and vertical coordinates in the terrain will be required fire adjusting.

Determination of coordinates of the target using

Reconnaissance devices greatly reduce the possibility of error in determining the coordinates of targets due to human error. Completely eliminate human error

in aiming the device can only be achieved by using devices that seek enemy targets themselves. In the arsenal of artillery of AČR it is radar ARTHUR and PzPK SNĚŽKA. Both these devices require activity of targets. Optoelectronic devices do not require activity of targets, but the accuracy of collected data is affected by human factor.

Contemporary reconnaissance devices measure the required values with sufficient accuracy and edit them in the time horizon of seconds. Numeric values can be directly sent to an automated system or to read and work with them. Sending and reading values greatly reduces the determination of target coordinates.

The reconnaissance authority must insert the information about accurately or inaccurately target coordinates. When using ASRPP-DEL it is advisable to insert the information about reconnaissance devices and their accuracy. After logging into the system and calling for fire ASRPP-DEL automatically assess the coordinates of target accurately or inaccurately and if it is possible to lead an effective fire by using complete preparation or fire adjusting.

3.3 Description of target

Exact description of the target influences the effectiveness of artillery fire particularly in terms of effects of projectiles in target position. It is not possible to fire without some of the data. In Call for fire it must be stated:

a) the type of target;

b) the character of target;

c) the location of target;

d) activity of target;

e) if the target is observed or not.

ASRPP-DEL will offer pre-loaded options describing the target in each individual characteristic. After that, options evaluation system will provide an optimal decision in the form of the following part of fire command: determining the size (number) fire unit (fire units), method of firing, firing task, trajectory, projectile type and lighters settings. it is Always possible to insert another characteristic option manually.

Type of target

Type of target is the most important basis for the commander for assessment of the importance of target and its elimination. In addition, there is a basic description of the object. Type of target is basis for the firing command. Type of target is important for the chosen firing unit (number of firing units), the way of firing. Possible types of targets are divided into categories and will be stored in the automated system permanently. For each type of target system is assigned a standard unit, which will eliminate specific target and choose the best firing possibly.

Character of target

The character of target expresses its resistance to fire in terms of its cardinality. It can be concluded that this characteristic does not change in space or in time. Based on the character of target it is possible to assess the firing unit (number of firing units) for the firing, the trajectory and lighter set.

Location of target

The exact description of the target location is needed to assess the trajectory. Generally, the targets located behind cover or in urban areas leads to a steep fire track and on target located in the objects rounded trajectory. The choice of trajectory on the targets located elsewhere will affect their character.

Activity of target

Description of current activity of target is important for commander's decision. The commander's decision can assess work of subordinate units. Task force commander can decide about immediately fire or just prepare of fire and realize later, or not realize.

Observed / unobserved target

According to this data, in some cases it is possible to assess the size of the target, method of fire, consumption, and consequently way of fire, choice of species and possibly determine the number of firing units. Generally, we can establish the principle that the group of target which cannot reliably determine the activity

of their elements (because of their number, location in hiding, etc.) are considered to be unobserved.

3.4 Additional information about target

Additional information is being used in call for fire in cases, where it is necessary to specify the size, shape and orientation of target, or specify its number, set limits, seek the firing task, set trajectory or set a specific type of ammunition for adjusting fire or effective fire.

Size, shape and orientation of target

Size of the target is given only to group targets. If it is a rectangular group of target, it is necessary to set the width and depth, usually rounded to tens of meters. By linear group target are given only the width. ASRPP-DEL to calculate the exact dimensions just signposts measuring distances and a front, rear, right and left bearing of the target. The system will be able, based on these data to calculate the exact location of those points and then the exact dimensions of the target. This will set a different target than the rectangular shape. This will require an appropriate mathematical framework, which allows the calculation of the positions of deliberate firing sets of points on the irregular surface in complying with the requirement of an equitable distribution of missile explosions.

A special case of group target is a circular target. When using ASRPP-DEL it is possible that the system assesses the shape like a circular target. This will affect only intentional deployment points and it will be given the same principles as the targets of irregular shape, as described in the previous paragraph.

Standard information during call for fire on the group's target is its orientation, which is bearing of the longer side of rectangular group target (bearing linear target) rounded to the hundreds of miles. This information is applicable only when using an automated fire control system, because it is calculated on the basis of elements for fire on individual points of fire units.

Number of target

Number of target is a data for navigate in the list of targets especially if it is useful to use data about previously identified targets or eliminated targets. Number of targets is composed of two parts provided by allied publications. If ASRPP-DEL will be available to combat orders, automatically assigns the first three characters

of target number. The remaining three characters of the target identified by category and so far the number of targets identified in this category.

3.5 Limitations

One of the fundamental limitations that are often used is warning "Danger Close". This is for combat support and coordination of fire control authority and fire units aware of the fact that the target is at a distance from friendly forces, which is in conflict to the existing security measures.

When using ASRPP- DEL must be a digital model of the battlefield with the current location of all own units and objectives that may not be threaten by the effects of artillery fire (these objects are defined by international treaties). The system calculates the coordinates of point of aim, which is located at a safe distance from the protected element. Then specify the elements for an effective fire, depending on the reconnaissance devices in accordance with the rules of firing.

a) Automated system calculates the distance from the nearest established targets to the protected element (D_{v-c}), based on information from the digital model of the battlefield and calculates bearing connectors this point and target ($\square_{v-c}$).

b) System calculates the safety distance from the point of aim of the protected element:

$L_{MBV} = 4 \times (Ex^2 + úd^2)^{½} + r_{str}$

where: L_{MBV} is the minimum safety distance of the point of aim from the protected element.

E_x is probable long error of elements fire.

If the elements fires for effective fire are designed by:

- complete preparation, then: $E_x = D_t$ [m] x 0,008
- transfer of fire from assistant target, then: $E_x = D_t$ [m] x 0,006
- using adjusting gun, then: $E_x = D_t$ [m] x 0,01
- reduced preparation, then: $E_x = D_t$ [m] x 0,037
- Simplified preparation, then: $E_x = D_t$ [m] x 0,09

where: D_t [m] is the topographic distance from firing position to the target in meters, ASRPP-DEL calculating the topographic distance;

0,008; 0,006; Etc. are constants and the average values probable long errors of fire preparation for effective fire in percentage of topographical distance;

úd is a deviation distance corresponding to the firing by specific cartridge on specific distance that ASRPP-DEL to get out of from pre-inserted firing tables;

r_{str} is the maximum radius of the fragments of projection and it is placed in ASRPP-DEL permanently with other data about the ammunition.

c) Compare the distance of own troops from the target (D_{v-c}) and minimum safety distance (L_{MBV})

$\Delta L_{MBV} = D_{v-c} - L_{MBV}$

where: ΔL_{MBV} is the difference between the distance of the protected element to the nearest identified target and safety distance from the point of aim to the protected element;

D_{v-c} is the distance from the nearest protected element to identified target;

L_{MBV} is the minimum safety distance from the point of aim to protected element.

i) If the distance D_{v-c} from the protected element to target greater than or equal to safe distances L_{MBV}, the coordinates of target are not adjusted.

e) If the distance D_{v-c} from the protected element to target less than the safety distance L_{MBV}, it is necessary to calculate the correct coordinates of the point of aim:

$\Delta E = \sin \alpha_{v-c} \times | \Delta L_{MBV} |$

$\Delta N = \cos \alpha_{v-c} \times | \Delta L_{MBV} |$

where: Δ E is a correction of horizontal coordinates of the point of aim;

□v-c is bearing measured from the nearest protected element to identified target;

□L_{MBV} is the difference between the distance of the protected element to the nearest identified target and safety distance from the point of aim to the protected element;

□N is repair of the vertical point of aim.

f) The system at the same time attention of all fire control authorities by the words "DANGER CLOSE!".

g) The calculated values of correct coordinates are added to original coordinates of the target. This gives the new coordinates of the point of aim, which is located at a safe distance from friendly forces:

E_{bezp} = EC + (±□E)

N_{bezp} = NC + (±□N)

where: E_{bezp} is the horizontal coordinates of the new point of aim;

E_C is the horizontal coordinates of the target;

ΔE is a correction of horizontal coordinates of the point of aim;

N_{bezp} is the vertical coordinates of the new point of aim;

N_C is a vertical coordinates of the target;

ΔN is a correction of vertical coordinates of the point of aim.

h) ASRPP-DEL calculates the new fire elements for the new point of aim.

Firing task

Determination of firing task by reconnaissance authority is one of the ways how to obtain the degree of exclusion targets or specific realization of fire. If the reconnaissance authority does not set firing task, it must set one of the coordinating combat support authority or fire control authority. The general principle is to respect the requirement of reconnaissance authority in determining the firing task, because it expresses the need of the supported task force commander.

Trajectory

Trajectory is determined by general rules of the firing rules. In exceptional cases, the reconnaissance authority can require a steep fire (on the basis of an exploratory evaluation of target position and its cover and fire units).

When using ASRPP-DEL, which will be updated by digital model of the battlefield, the trajectory will be determined automatically. The system compares the altitude of the trajectory points with altitude terrain points, which are situated below this distance.

The type of ammunition for adjusting fire and effective firing

Reconnaissance authority may in specific cases also require the adjusting fire or effective fire by non-standard types of ammunition and lighter set. When is ASRPP-DEL using that the system will determine firing elements for each shot separately.

In the case of using ASRPP-DEL will be exclude human error, which could adversely affect the accurate and rapid transmission of messages. An automated system will also contribute to a significant reduction in radio operation and reliability.

Identify the target position can be in several ways. When using of imprecise methods must be effective for firing identified by adjusting fire. These methods of determining the target coordinates are appropriate for authorities that are able to cooperate with an artillery unit in adjusting fire.

The authority, which will require the artillery fire, they must know the issues of cooperation with artillery.

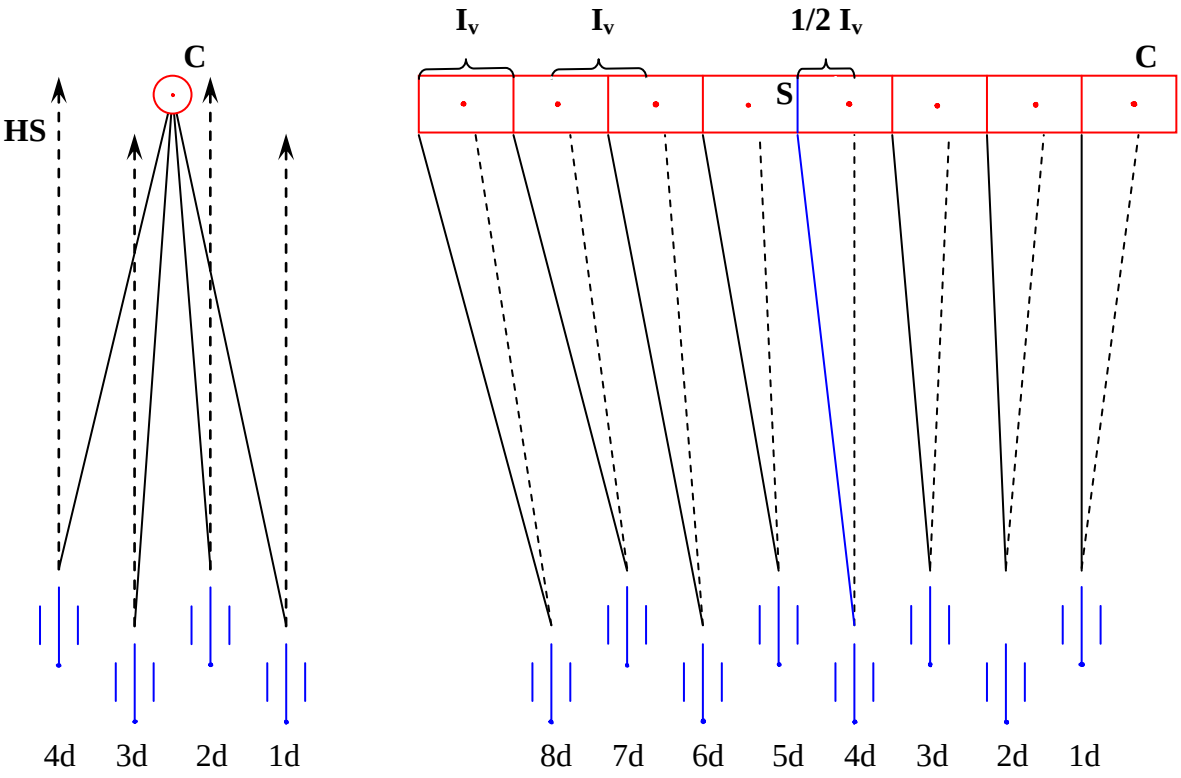
ASRPP-DEL to determine the precise dimensions of group targets, and more accurate calculation of the consumption of ammunition, more precise determination

of the point of aim and using of other elements, which directly affecting the effectiveness of fire support.

Using ASRPP-DEL is also a more reliable security of friendly forces and objects protected by international treaties. For this will ASRPP-DEL need a digital model of the battlefield and the current location of all protected objects. Linking to command and control system of task force allows immediate transfer of information about the position of interest elements.

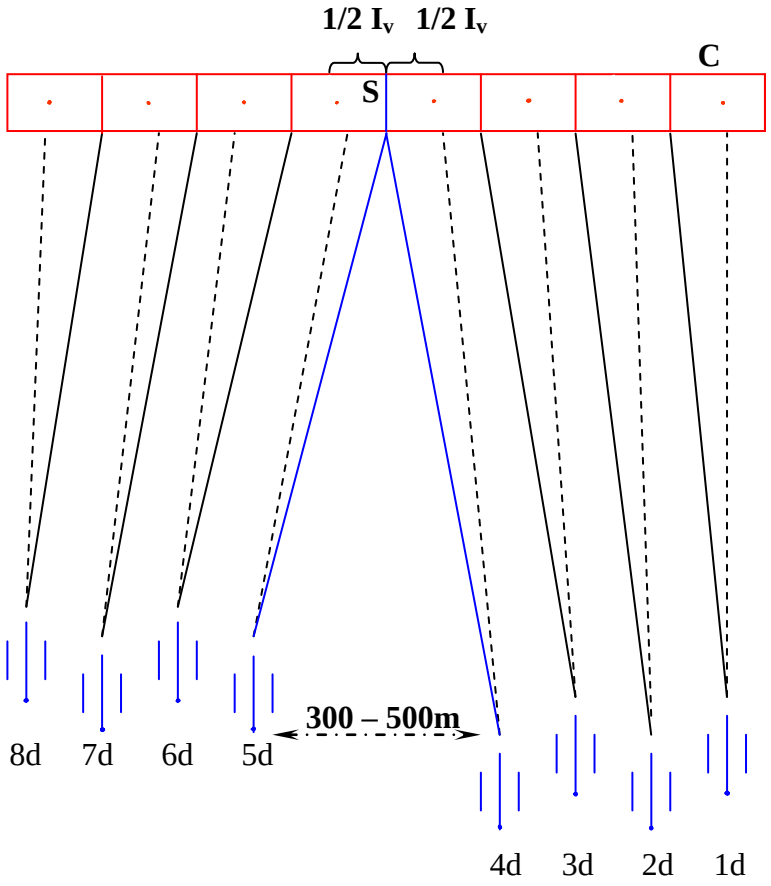
Achieving full automation of command and control of artillery fire in conjunction with automated command and control combat units and units of other types will increase the scope and effectiveness of artillery fire support.

Sheaf



a) Tight sheaf (vjs) parallel sheaf

b) sheaf on width of target (vjc)



c)sheaf on width of target(vjc) – gun tiers by platoons

4 Maximal and minimal sizes of group unobserved targets

Maximal sizes of group unobserved targets, barrel artillery and small caliber mortars

Unit, command	**Unit, command (allocation, amount of guns, mortars)**	**Size of target (area) [m]**		
		Width $Š_{Cmax}$	Depth H_{Cmax}	Radius R_{Cmax}
Platoon	3 – 4	200 (200)	100 (150)	50 (75)
Battery	In whole (6 – 8)	300 (300)	150 (200)	75 (100)
	By platoons (6 – 8)	400 (400)	200 (300)	100 (150)
Small (medium) cal. mortar battery – 3 platoons	In whole (12)	400 (400)	250 (300)	125 (150)
	By platoons (12)	500 (500)	300 (400)	150 (200)
Battalion	Two batteries (batteries in whole)	400	300	150
	Three batteries (batteries in whole)	400	400	200
	Two batteries (bateries by platoons)	500	300	150
	Three batteries (batteries by platoons)	500	500	250

Minimal sizes of group unobserved targets, barrel artillery and small calibre mortars

Range of fire	**Unit, command (allocation)**		**Size of target (area) [m]**		
			Width $Š_{Cmin}$	Depth H_{Cmin}	Radius R_{Cmin}
To 6 km	Platoon		100	100	50
	Battery	In whole and by platoons	150	150	75
	Battalion	Batteries in whole and by platoons	200	200	100
Above 6 km	Battery	In whole	150	150	75
		By platoons	200	200	100
	Battalion	Batteries in whole and by platoons	200	200	100

Maximal areas for application of defensive (barrage, preventive) fires, barrel artillery and small (medium) calibre mortars

Unit, command (amount of guns, mortars)		**Maximal width of area [m]**	
		Defensive immobile barrage fires - NPP	**Defensive mobile barrage fires - PPP**
Batteries (8)		400 (600)	200 (280)
Small (medium) calibre mortar battery (12)		600 (900)	300 (420)
Battalion	Two batteries (by 8)	800	400
	Three batteries (by 8)	1200	600

Maximal and minimal sizes of group unobserved targets – rocket launchers

Count of batteries	**Maximal size**			**Minimal size**		
	Width $Š_{Cmax}$	Depth H_{Cmax}	Radius R_{Cmax}	Width $Š_{Cmin}$	Depth H_{Cmin}	Radius R_{Cmin}
One	2000	400	200	400	400	200
Two	2000	700	350			
Three	2000	1000	500			

5 Development of formula for calculation of range correction with adjustment fire with given look-out posts

Explosion **V** spotted right observer on the left from target (displacement error **P)**, left observer on the left from target (displacement error **L)**.

Correction of direction:

· for the right: $P \cdot Rp_P$ (to the right to point A)

$Ss_P \cdot 0{,}01\Delta D$ (to the right to point C)

because: $Rp_P = \frac{d_P}{D}$, $Ss_P = \frac{i_P}{0{,}01D}$

$$Ss_{P\Delta D} = \frac{i_P}{0{,}01D} \cdot 0{,}01\Delta D = \frac{i_P}{D} \cdot \Delta D$$

then: $$\boxed{P \cdot \frac{d_P}{D} + \frac{i_P}{D} \cdot \Delta D} = \Delta S$$

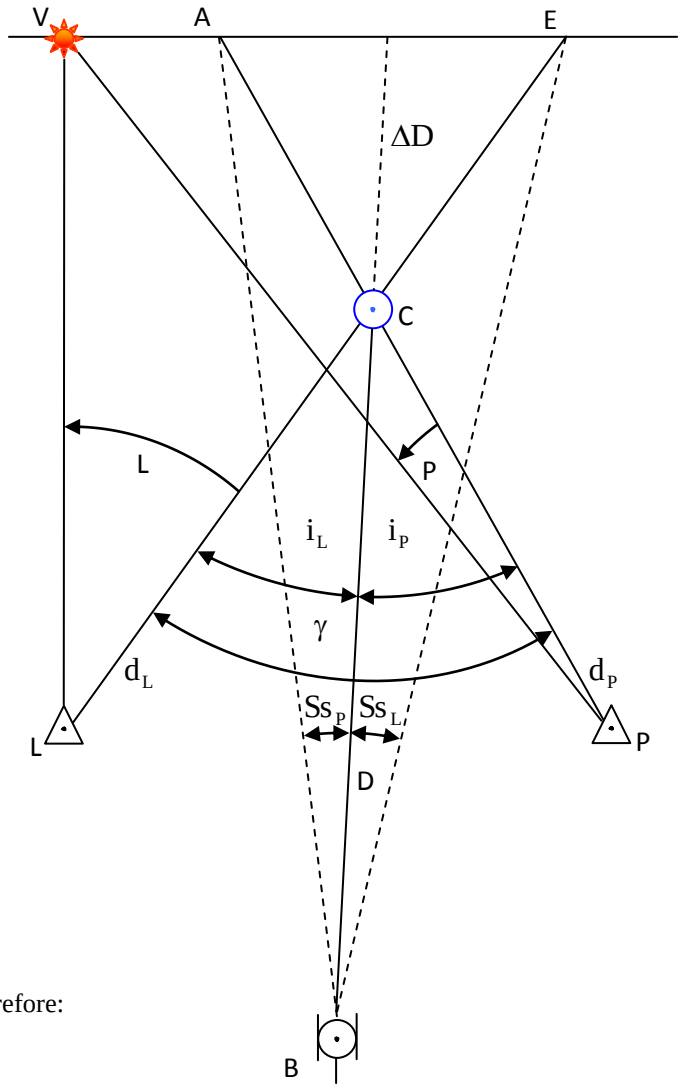
· for the left: $L \cdot Rp_L$ (to the right to point E)

$Ss_L \cdot 0{,}01\Delta D$ (to the left to point C)

because: $Rp_L = \frac{d_L}{D}$, $Ss_L = \frac{i_L}{0{,}01D}$

$$Ss_{L\Delta D} = \frac{i_L}{0{,}01} \cdot 0{,}01\Delta D = \frac{i_L}{D} \cdot \Delta D$$

then: $$\boxed{L \cdot \frac{d_L}{D} - \frac{i_L}{D} \cdot \Delta D} = \Delta S$$



Correction of direction has to be the same for both observers, therefore:

$$P \cdot \frac{d_P}{D} + \frac{i_P}{D} \cdot \Delta D = L \cdot \frac{d_L}{D} - \frac{i_L}{D} \cdot \Delta D / \cdot D$$

$$(P \cdot d_P) + (i_P \cdot \Delta D) = (L \cdot d_L) - (i_{L\cdot} \cdot \Delta D)$$

after adjustment: $i_P \cdot \Delta D + i_L \cdot \Delta D = L \cdot d_L - P \cdot d_P$

further: $\Delta D \cdot (i_P + i_L) = L \cdot d_L - P \cdot d_P$

because $i_P + i_L = \gamma$,

then $\Delta D \cdot \gamma = L \cdot d_L - P \cdot d_P$

$$\Delta D = L \cdot \frac{d_L}{\gamma} - P \cdot \frac{d_P}{\gamma}$$

6 Determining elements for firing full, shortened and simplified preparation

Artillery firing in the performance of tasks fire rectangular (linear) objective:

- fully loaded batteries;
- Scale batteries;
- The allocation of goals between the battery;
- The allocation of target segments (lines) between the batteries.

When extracting circular targets are subject to special rules and executes only in calculating the elements for shooting computer assisted or automated it ASPRO fire control system.

Firing batteries firing in the performance of tasks fire rectangular (linear) objective:

- fully loaded squads;
- Squads scale;
- The allocation of goals between the platoon;
- The allocation of target segments (lines) between the squads.

Fire target fully loaded batteries are used when shooting high-jerky shots with occasional lighter.

Fire target batteries scale is used when shooting with a non contact lighter and shooting streams.

Fire target with the objectives of the division between the battery is used in targets, that is, from a tactical point of view, necessary to exclude the same time period.

Fire target with the distribution of target segments (lines) between the battery is used

for objectives which are detected coordinates of the most important features and defense firings.

Depending on the type and size of target partition fire can target one or more distance and one or two directions.

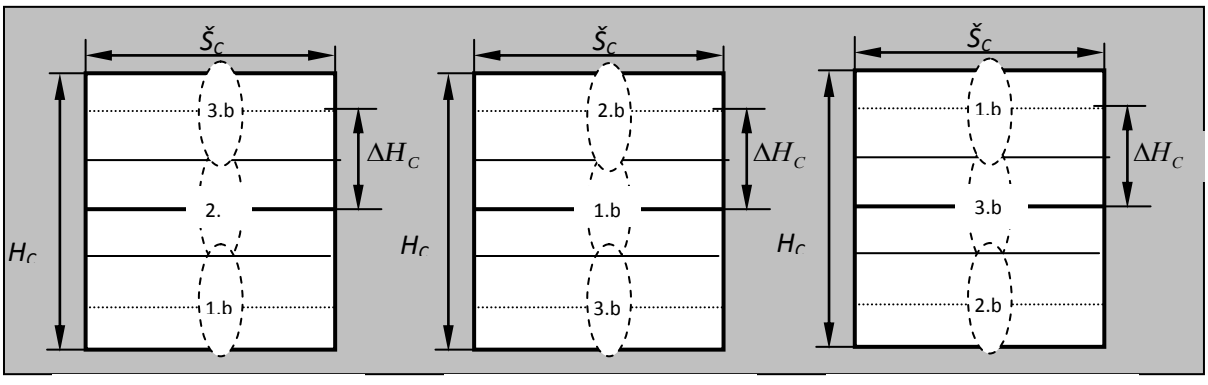
26th The order of distance changes in the conduct of effective shooting section at a rectangular target group "batteries fully loaded" is expressed in the following tables and diagrams. Each battery fires one-third of the planned missile battery consumption to 1st sight distance and separately open fire on the 2nd and then for 3rd sight distance. In section two batteries to fire half the distance of each planned missile battery consumption.

Table: T-1.2 Fire manner and order of distances - the section on three batteries

Number of batteries	The order the change of distance		
	1st length of sight	2nd length of sight	3rd length of sight
first	$D_P^C - \Delta H_C$	D_P^C	$D_P^C + \Delta H_C$
second	D_P^C	$D_P^C + \Delta H_C$	$D_P^C - \Delta H_C$
third	$D_P^C + \Delta H_C$	$D_P^C - \Delta H_C$	D_P^C

Note: D_P^C – calculated sight distance to center target;

ΔH_C – size of the jump in the distance in meters sights ($\Delta H_C = \frac{1}{3} H_C$).

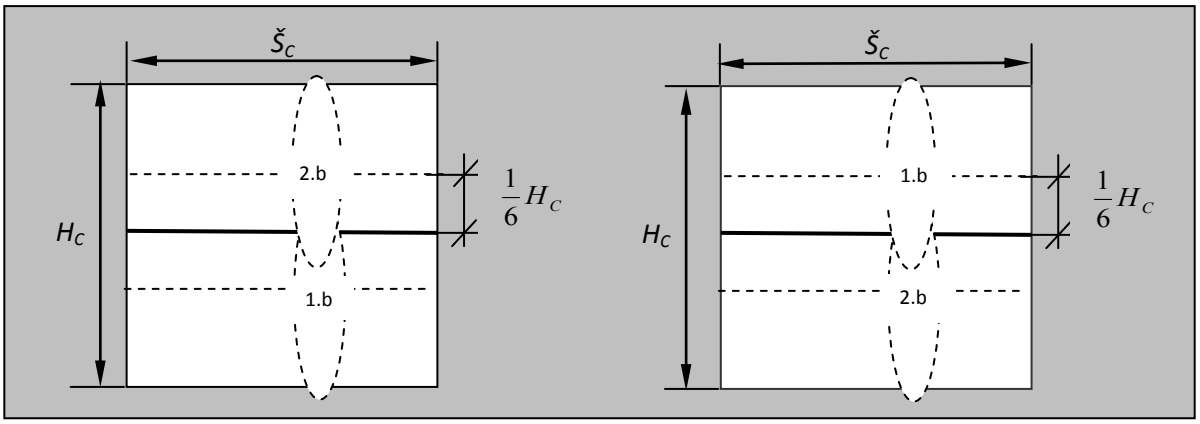


a) Fire 1st distance b) Fire 2nd distance c) Fire 3rd distance

Fig. 1.5 The scheme aids fire group rectangular section „fully loaded batteries“ (3 distance, 1 direction, control guns first platoon)

Table: T-1.3 Fire manner and order of distance **– a section on the two batteries**

Number of batteries	The order the change of distance	
	1st length of sight	2nd length of sight
first	$D_P^C - \frac{1}{6} H_C$	$D_P^C + \frac{1}{6} H_C$
second	$D_P^C + \frac{1}{6} H_C$	$D_P^C - \frac{1}{6} H_C$



a) Shooting 1st sight distance

b) Shooting 2nd sight distance

Fig. 1.6 The scheme aids fire group rectangular section with two batteries „fully loaded batteries“ (2 distance, 1 direction, control guns first platoon).

In the firing line section with the division between the sections objectives change batteries every battery sight distance in the same way as on a separate firing batteries.

When a rectangular target group of firing section "batteries scale" leads each battery firing on only one sight distance, and jump in the distance $\Delta H = \frac{1}{3} H_C$ and battery on the distance thein entire consumption, i.e. – 1/3 power section (Fig. 1.7).

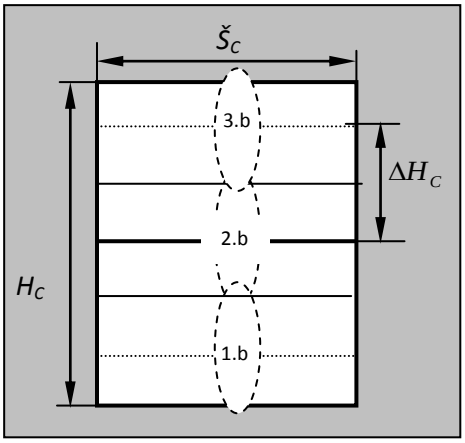


Fig. 1.7 The scheme of a rectangular target grou fire section „scale batteries“ (3 distance, 1 direction, control guns first platoon)

Artillery (mortar) Battery (platoon), fulfilling the task of independently firing fire each observed once a target distance in one direction, fan tight.

The unobserved orthogonal group and some individual goals firing on three batteries each distance and one or two directions.

The observed rectangular target group fire Battery (platoon) as follows:

- Sight distance fire one goal, which depth is less than 100 m;
- two sight distance fire target (on a separate firing squads fully loaded battery), whose depth is 100 m and more. Changes to sight distances platoons are made in the same order as the battery section on two batteries (Table T-1.3);
- three distance sight fire target, which depth is 100 m and more. Changes to sight distances platoons are made in the same order as the second battery

section of the three batteries in fire "batteries fully loaded" (Table T-1.2);

- Two directions leads to an indoor firing batteries and armored targets, if the fan blasts interval greater than 25 m and exposed unarmored targets, if the interval fans explosions greater than 50 m for the gun.

When shooting in two directions leads Battery (platoon) fire first counted towards any sight distances, then changes direction by half the interval fans explosions leads to the right and fired a second direction, the same way as when shooting the first direction.

In determining how firetarget (target segment) with battery (platoon) determines:

- Number of sight distances;
- The size of the jump distance (scale), and timing;
- Number of directions (if two);
- Interval fans explosions and fix the direction of the fan to the right half of the interval when shooting in two directions;
- Consumption of bullets for the gun in pieces, distance and direction.

6.1 Jump in the distance

Jump in the distance and the interval is determined fans rounded on all parts of lower value.

Established ways fire ensure even distribution of eruptions on the whole surface of the target (section), when size targets (section) shall not exceed the figures shown in Table T-1.4.

Fire linear targets are realized as lead defense (mobile and stationary) or prevent firings. Group goal-oriented linear shape of the fan at the fire angle once the distance in one direction with an interval of fan 50 (25) meters for cannon.

1st Front movement

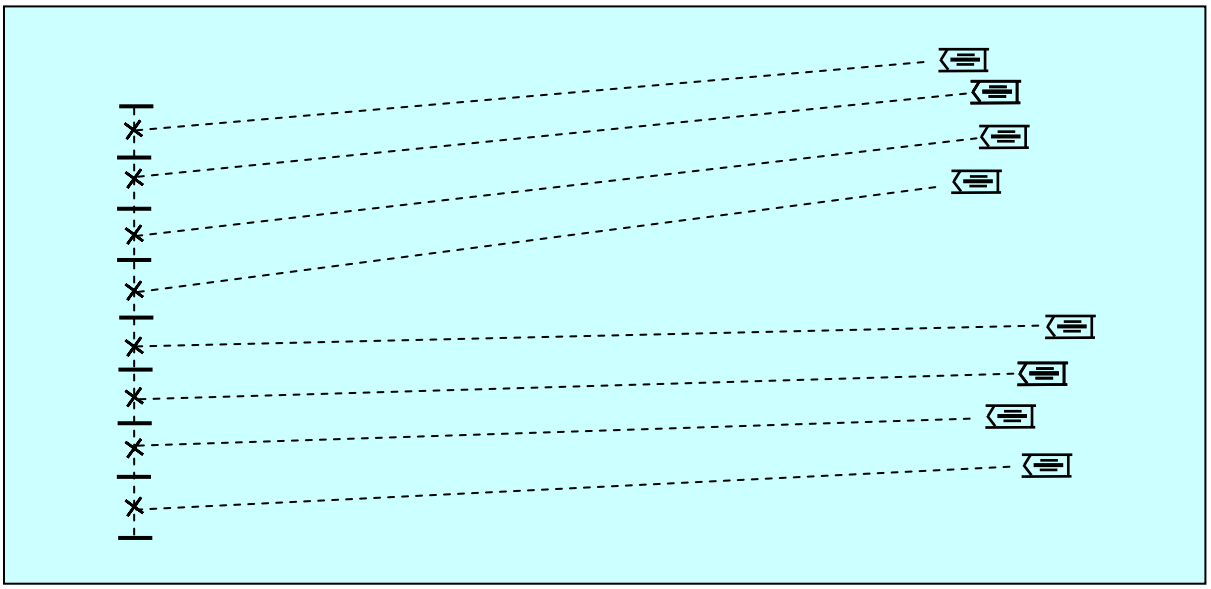


Fig. 1.8 Fire defensive front barrage

2nd Lateral movement

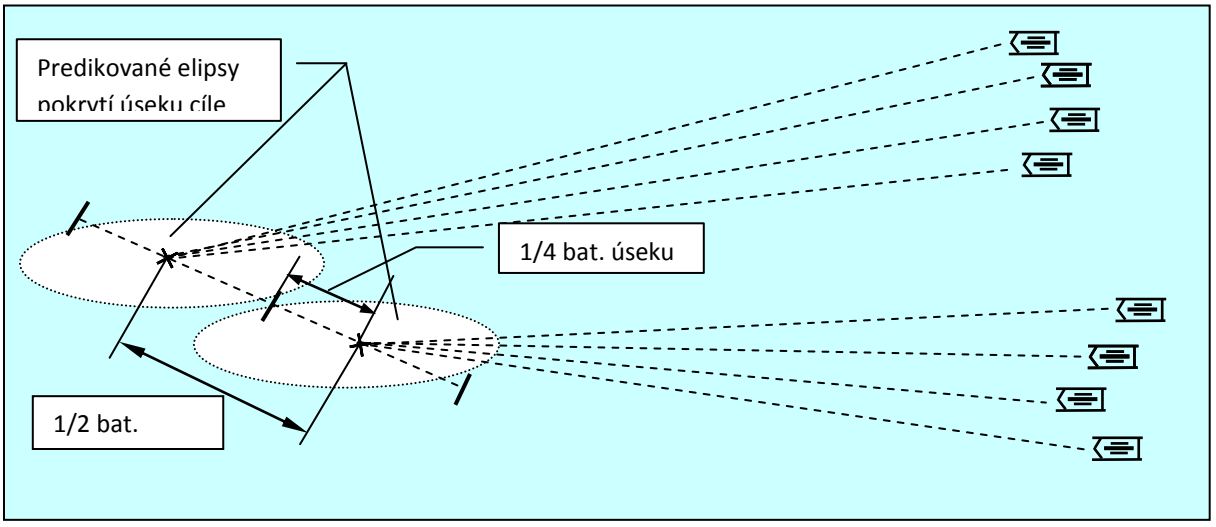
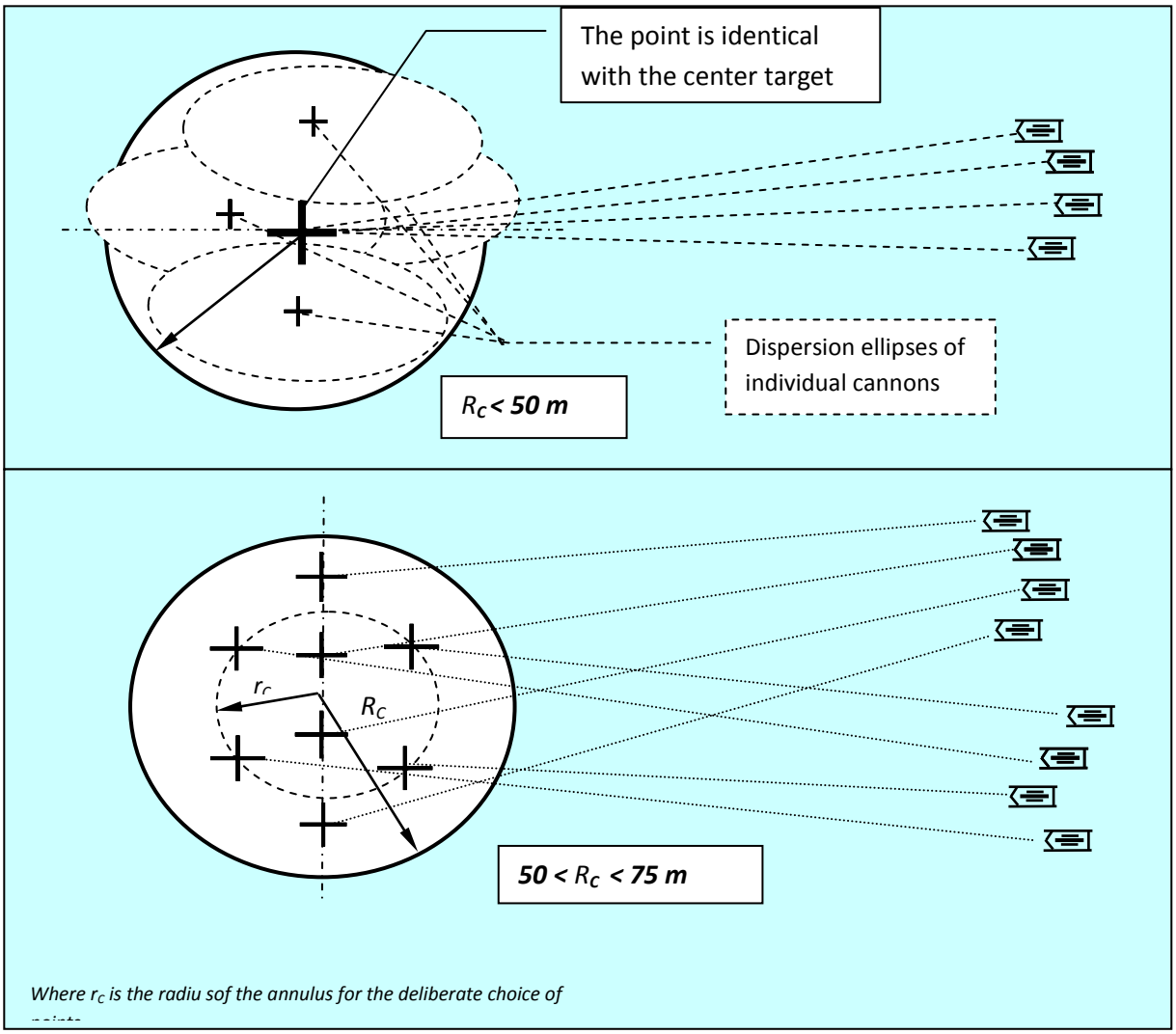


Fig. 1.9 Fire defensive side barrage

Group goal linear form oriented laterally with respect to fire squads fan tight to the deliberate points platoon, with a distance of 1/2 section of battery. Calculated distance to the center of the targets for platoon increases (decreases) by 1/4 section of battery according to the relative positions of targets and firing platoons.

Method and methodology aims at fire linear sections equipped with fire control system ASPRO are described in the 5th section, Chapter 1, Article 345.

Group target of circular shape with a radius of 50 m fire platoon or battery. Components are prepared for shooting at an aiming point, which is the center of the target (circle). In preparing the elements for shooting traditional way with a circular target with a radius greater than 50 m fire rarely, according to a specific methodology.



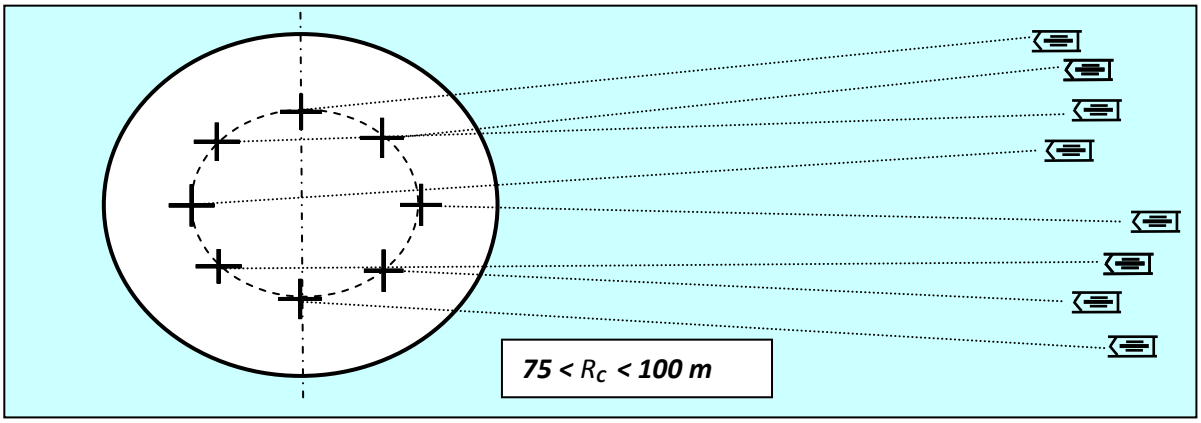


Fig. 1.12 Fire circular target battery (option B)

Target circular shape with a radius of 50 < RC < 75 meters in manual (either classic manner - PUO) for determining the elements of fire squads fire fan tight at one distance, with elements designed for shooting at the center of a circular target with a shift first platoon to the right, second platoons left about 1/4 width of target (1/2 RC).

When determining the elements for shooting using PVNPG 95 elements are determined for shooting algorithm automatically determined (Figure 1.11).

Target circular shape with a radius 75 < RC < 100 meters fire batteries (two batteries or partition). Elements for shooting are determined using PVNPG 95 in accordance with specified algorithm automatically (Figure 1.12).

In the firing line two batteries at hand (classical) method of determining elements for the target shooting fire batteries fan tight at one distance for shooting with elements designed to shift the center of the target with the first battery to the right and second battery left about 1/4 width of target (1/2 RC).

Method and methodology fire circular targets on sections equipped with automated fire control system ASPRO are described in the 5th section, Chapter 1, Article 345.

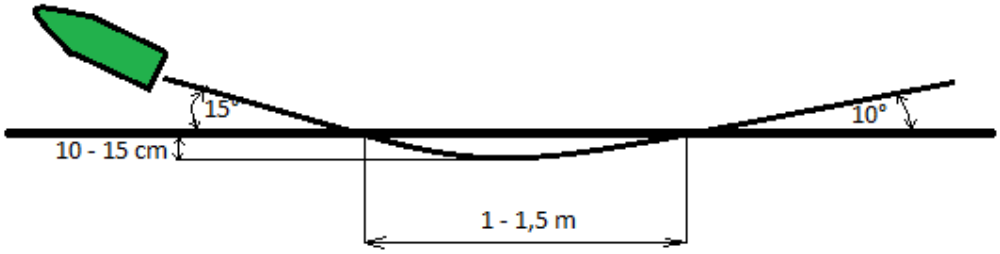


Fig. 2 Ricochets at angles of impact from 0° to 10°

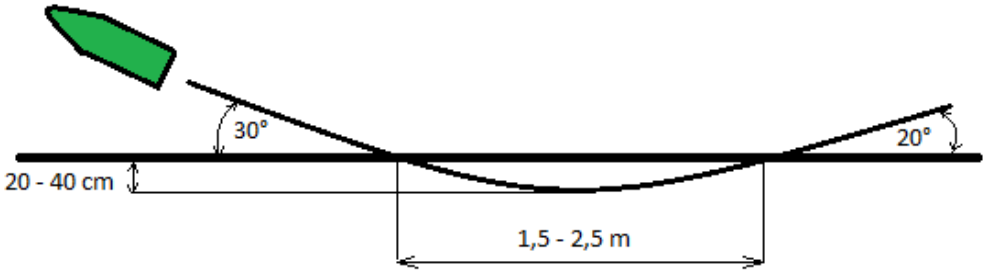
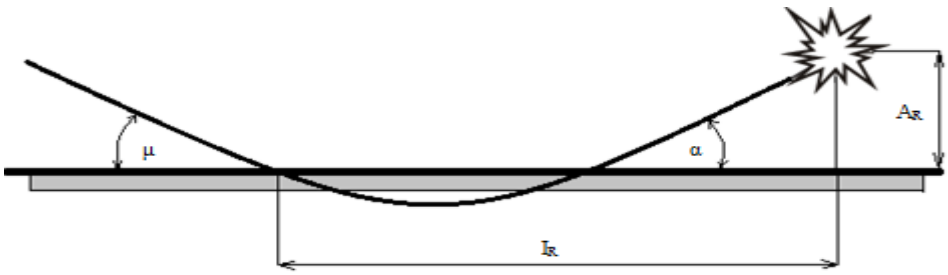


Fig. 3 Ricochets at angles of impact from 10° to 20°

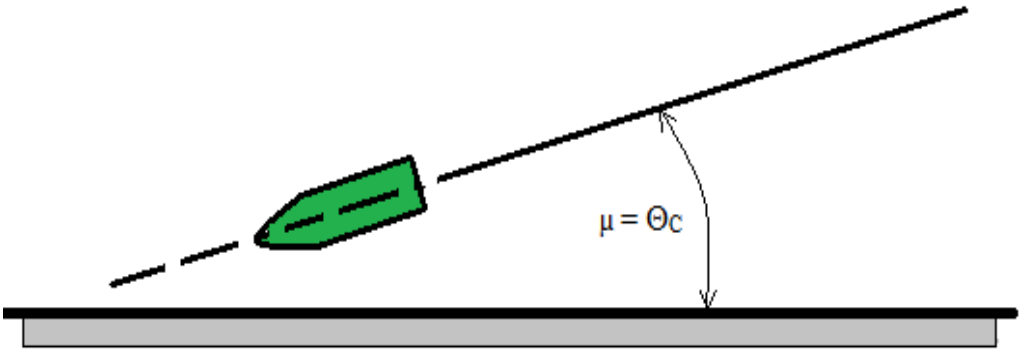


A_R – height of burst, I_R – interval of burst, μ - angles of impact, α – angles of reflection

Fig. 4 Reflection shots from the field, interval and height of burst

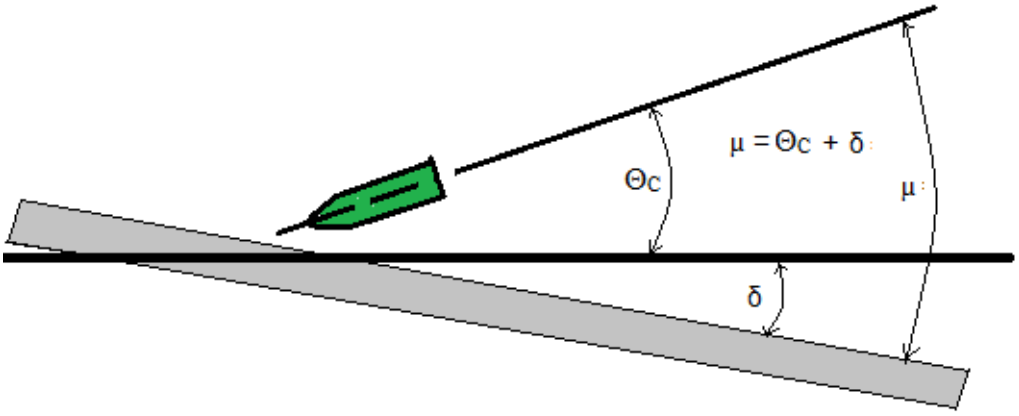
Tab 3 Values range and height of burst.

angles of impact (°)	Interval of burst (m)	height of burst (m)
2 – 6	50	3 – 8
6 – 20	20 - 25	4 – 15



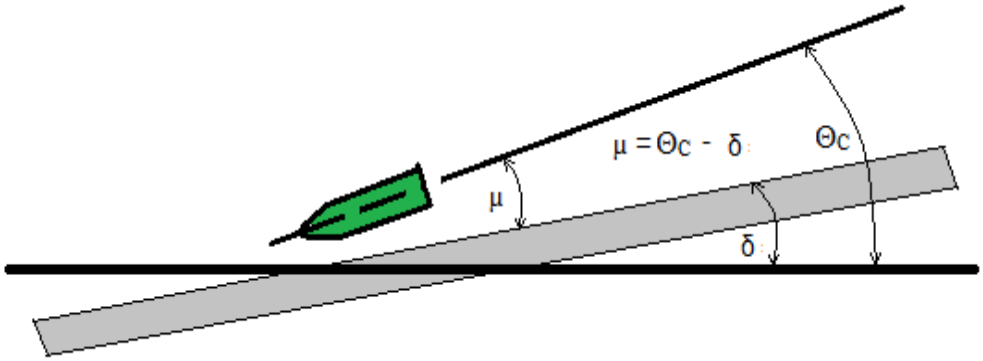
Θ_C – angles of impact, μ - angles of reflection

Fig. 5 Angles of impact from when firing at a horizontal terrain



Θ_C – angles of range, μ - angles of impact, δ – angles of hill

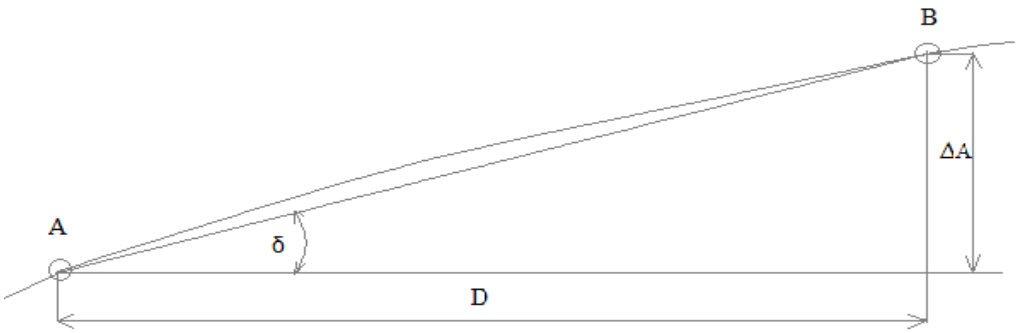
Fig. 5 Angles of impact from when firing at a facing terrain



Θ_C – angles of range, μ - angles of impact, δ – angles of hill

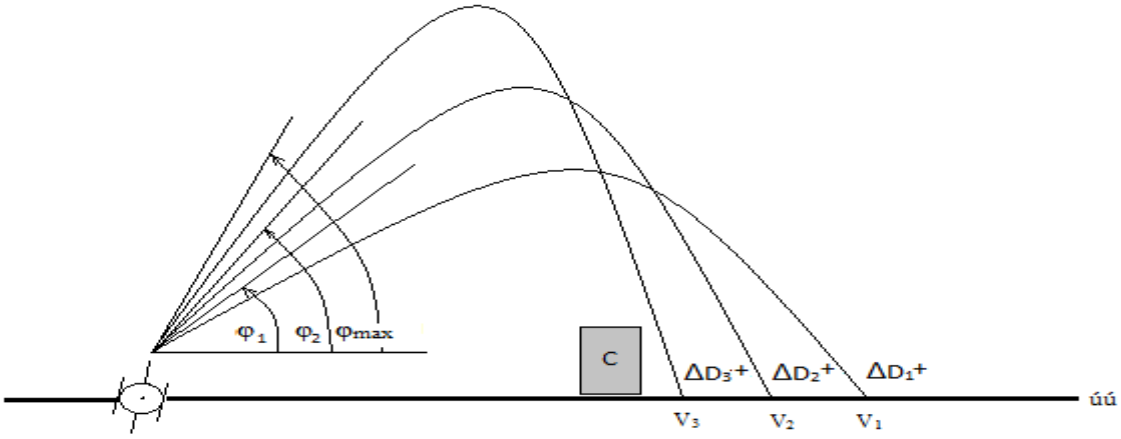
Fig. 6 Angles of impact from when firing at a retrograde terrain

$$\delta = \Delta A/D \cdot 60°$$



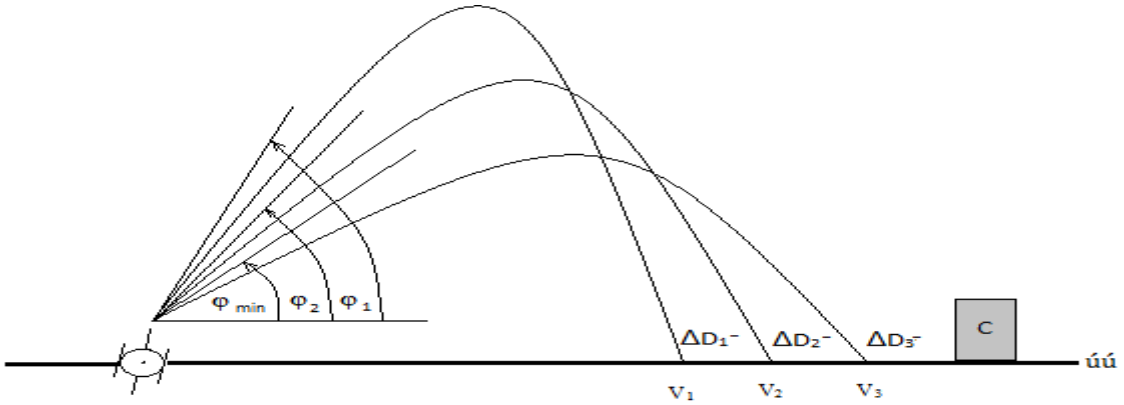
ΔA – a cant, D – distance between contours, δ – angle of slope

Fig. 7 Diagram determine elevation and distance between contours



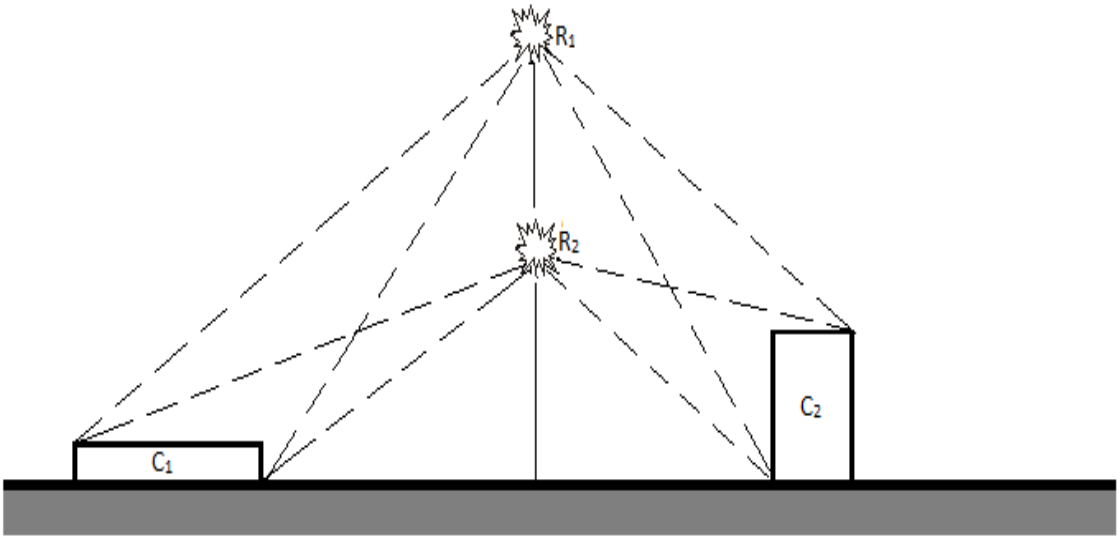
úú – level estuary, φ max – the angle of elevation for the explosion V3, φ 1 – the angle of elevation for the explosion V1, φ 2 – the angle of elevation for the explosion V2, C – target

Fig. 8 Renovation (reducing) the firing range by increasing elevation (sight distance)



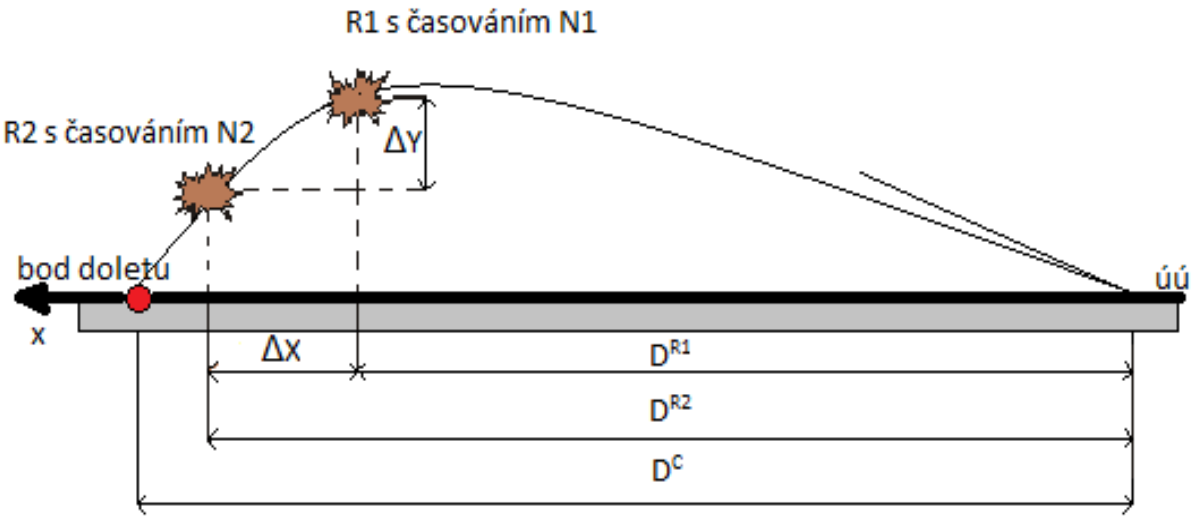
úú – level estuary, φ min – the angle of elevation for the explosion V3, φ 1 – the angle of elevation for the explosion V1, φ 2 – the angle of elevation for the explosion V2, C – target

Fig. 9 Renovation (reducing) the firing range by increasing elevation (sight distance)



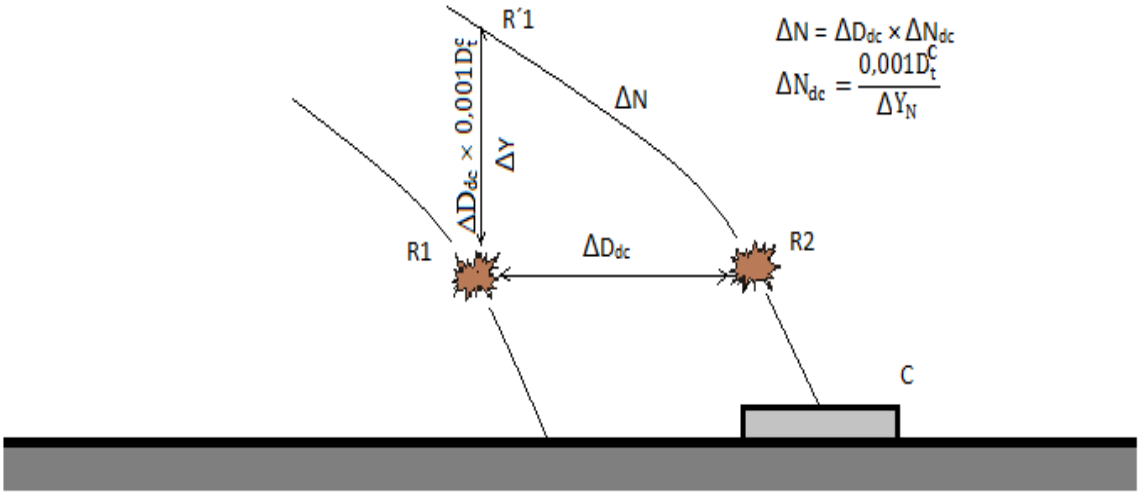
R1,2 – scattering, C1,2 – target

Fig. 10 The influence of the height of burst at high and low target



ΔX – difference distances, ΔY – height difference, DR1.R2, C – distance burst R1,R2 and objectives, úú – level estuary, x – direction

Fig. 11 The repair height of burst by timing change



R1 – bursty, R2 – burst after changing distance and timing, R´1 – burst after changing the distance, ΔY – height difference, ΔN – fix timing, ΔNdc – coefficient of variation of timing, ΔYN – change table burst height (m), ΔDdc – repair sight distance, C – target

Fig. 12 The repair distance of burst by timing change

6.2 Determining elements for firing full, shortened and simplified preparation

Elements for shooting full or shortened preparation are determined to support a laptop computer (PC) using program PVNPG 95 or substitute graphically on the device for fire control (PUO) or calculation (using the firing tables).

Elements for simplified shooting training are determined graphically on the device for fire control or on the map scale 1 : 50 000 or greater, using artillery protractor.

The procedure for calculating the elements of fire, with the support computer is listed in the manual program PVNPG 95.

To determine the elements for the shooting device for fire control (calculated) must first calculate the correction for distance and direction of changes in ballistic and meteorological conditions and if necessary, and geophysical conditions for shooting.

The organization of determining elements for shooting full or abbreviated preparation is determined by the type of track missiles, missile type, and usually *two charges* for which will calculate repair. One of the selected contents to allow shooting at the greatest distance, shooting the reflection (angle range θ_C to 20 degrees) and shooting with a non-contact lighter. The second charge is chosen so as to achieve the best tracks the missile and thereby maximize the shrapnel effect.

Corrections are calculated for standard supporting distance, the main direction of shooting and directions, differing from the main direction of the shooting 8–00. In the narrow space targets can be determined only 1 to 2 directions. Corrections for one direction can be used in a range from $\pm$ 3–00 in this direction.

The standard distance for supporting calculation of the corrections are determined in advance, with a maximum interval of up to 4 km for guns and rocket launchers and up to 2 km for mortars and when shooting a steep path cannon.

Corrections for changes in distance ballistic firing conditions are calculated for:

- *the total initial rate of change of control works batteries (platoon) –* $\Delta v_{0\Sigma}$ *;*
- *temperature change cartridges –* ΔT_n *;*
- *change in other characteristics of ballistic missiles, which were not included in the determination* Δv_0 *(eg. type cartridge etc.).*

Correction for changes in the direction of ballistic conditions, the only fix for the derivative ΔZ .

Corrections for changes in distance shooting meteorological conditions are calculated for:

- *a change in ground pressure –* ΔH_v *;*
- *ballistic air temperature change –* ΔT_v *;*
- *longitudinal component of ballistic wind –* w_x *.*

Correction for changes in the direction of fire weather conditions only fix for the transverse component of ballistic wind – w_z .

Repairs distance and direction for geophysical conditions are calculated according to the provisions listed in the tables in the shooting distances of the shooting 25 km and larger.

Changing the air pressure specified in the meteorological report is converted to the height of the firing battery. To do this, for every 10 m altitude meteorological station team (patrols) due to the correct position fire pressure change mentioned in a weather report about 1 Torr. Fix the sign "+", if the firing position below and sign "-" if the firing position above the weather station crews (patrol).

Ballistic change of air temperature, wind direction and speed of ballistic wind searches for the weather report, according to the relative height, which is determined from the shooting tables.

Ballistic wind is decomposed into longitudinal and transverse component as follows:

– *calculate the angle of ballistic wind* A_w *according to the relation:*

$$A_w = \alpha_S - \alpha_w$$

where:

– α_S *bearing the shooting;*

– α_w *bearing wind.*

If the bearing is less than the firing bearing wind ($\alpha_S < \alpha_W$), increases by 60–00. The result is rounded to 1–00. The angle and ballistic wind speed using a special table in the Tables shooting searches or calculated analytically transverse w_x and longitudinal w_z component of the wind through relation:

$$w_x = w \cdot \cos A_W \text{ a } w_z = w \cdot \sin A_W$$

Merging fixes for ballistic, meteorological and geophysical conditions are determined by overall shooting distance and direction of repair. The overall correction distance and direction of the fire control unit for constructing graph calculated corrections. Topographic distance to construct a diagram is determined by dividing the standard

by supporting distance, for which repairs have been calculated, deducted (signed) summary repairs distance.

When using a computer and program PVNPG 95 to calculate shooting elements for implementing the method of successive approximations. The program automatically registers all the values inserted into the program forms and use them according to the setting of organizational protocol. Elements for the shooting is determined for each cannon directly at the point of destination, or to control cannon platoons (batteries).

Determining elements for the calculation of classical shooting (manual) method is performed as follows:

- *determine the topographical distance target –* D_t^C*, topography lateral deviation –* So_t^C *and elevation (position angle) target –* Δh_C (ε_C)*;*
- *according to topographical distance target and topographic lateral deviation is determined from the diagram calculated corrections for the repair filling distance and direction, which interpolates between the lines timetable. Beyond the extreme directions is allowed to determine the correction in the 3–00;*
- *repair distance is to be added (with sign) to topographical distance and distance will be calculated;*
- *repair direction is to be added (with sign) to the topographical lateral deviation and will be calculated lateral deviation;*
- *according to the calculated distance for the charge to find the calculated firing tables sight distance;*
- *Determine the repair for elevation target* $\Delta\varphi$ *and credits (signed) to the basic position of vials and vial will be counted.*

At 152mm ShKH mod. 77 the correction for excess target counted always in sight distance.

Topographic distance and topographical targets lateral deviation is determined graphically on the device for fire control or by calculation using the table in Annex No. 6.

Exceeding target shall be determined as the difference between target height and height of firing position. The position angle of the target ε_C is determined by the formula:

$$\varepsilon_C = \frac{h_C - h_B}{0{,}001 D_t^C}$$

and the absolute value of the result is reduced by 5 %.

Repair for height target $\Delta\varphi$ is calculated as the sum of the positional angle of target ε_C and additional repairs deliberate angle $\Delta\alpha_\varepsilon$.

Additional repair deliberate angle is determined from tables computed by the shooting distance finder (deliberate angle), corresponding to the calculated distance shooting and positional angle. When shooting a steep path to repair target for the elevation determined from the tables computed by the shooting distance (sight distance calculated) and the target altitude.

If the targets established in the area instrumental target whose creation was done at about the same time it was compiled meteorological report (difference not more than two hours), shall be determined and calculated differences fire repairs distance and direction. These differences are considered *repairs improving* distance and direction.

They can add (with sign), the counted elements ready for shooting at target, provided that the following conditions are met:

- *auxiliary coordinate target and targets are the same reconnaissance vehicle and from the same habitat;*
- *the difference bearing on the target and auxiliary target is not greater than 6-00, and the difference reaches of topographic target and service target does not exceed 4 km;*
- *battery emplacements are geodetically connected, with GPS or from topographically one (common) starting point.*

After moving into a new firing position area after receiving a new weather reports or to change the terms of ballistic shooting the elements for a *renewed* fire. New data on the battle group is inserted into a computer, the ballistic and meteorological conditions. The apparatus for fire control shall be made, a new battle group, calculate a new cumulative patch distance and direction and plot a new graph calculated corrections, which is used to determine the new features for shooting at targets.

7 Complete preparation

Preparation of elements for the shooting is deemed complete if the following conditions are met:

- *firing position coordinates are determined geodetically using GPS, topographically by maps of geodetic data and using devices, and topographic tagger;*
- *bearing the orientations directions for aiming cannon are determined gyro, astronomically or geodetically and transfer current aim bearing on the celestial body or directional show and, together with a magnetic compass for repairs within a distance of 5 km from the firing position and, together with a KPzP grivace to the destination;*
- *coordinates of targets are determined according to Table T-2.1 with a degree of precision 1 and 2;*
- *meteorological conditions of fire are determined from the weather report METCMQ for sections with the fire control system ASPRO, METEO– MEDIUM, METEO– MEDIUM –APPROXIMATE, and their temporal and spatial validity is in terms of table T-2.8;*
- *are intended ballistic shooting conditions, in particular the total change of the initial speed;*
- *geophysical conditions are shooting (if necessary);*
- *at rocketlauncher batteries are included corrections for ballistic winds on the active section of the trajectory the rocket charge.*

7.1 Shortened preparation

Preparation of elements for the shooting is considered to be shortened, if not satisfied if only one condition laid down in article.

Preparation of elements for the shooting is considered to be shortened if he has to define the elements of fire use the data gained through the establishment of auxiliary targets and their age is from 3 to 8 hours.

After preparing the elements for shooting a shortened preparation is usually necessary to artillery and mortar batteries and artillery units carried fire target. Rocketlauncher units can result in effective shooting without fire.

Elements for effective shooting for shortened preparation, can be used to guide artillery fire compartment without fire only to silence the group (unobserved)

objectives are to coordinate the targets identified one of the methods listed in table T-2.1 and the requirements of article 172 are not currently met the most in two points.

It cannot exceed the following limits:

- *firing position coordinates are determined by topography topographic maps of scale 1: 50 000 and using instruments;*
- *bearing the orientations are magnetically with the inclusion of repairs identified within 10 km from the firing position;*
- *Coordinates of targets are determined according to Table T-2.1 with the degree of precision 1, 2, 3;*
- *meteorological conditions of fire are determined from the weather report "METEO– MEDIUM –APPROXIMATE ", that is not older than 1 hour when used up to 1600 m;*
- *includes only change the initial velocity of the pellet, mainly caused by worn barrel, and repairs are included for changing the characteristics of ballistic missiles, which are listed in tables shooting.*

7.2 Preparing of Fire in the Automated Artillery Fire Support Control System

Massive armed forces using has been substituted by effective using of modern, sophisticated forces based on quick Command, Control, and Decision process supported by information and communication technologies.

Units of the Army of the Czech Republic, reflecting current global security neighborhood, can be used outside the Czech Republic, or more precisely outside the NATO and EU territories.

On the present the Czech Artillery specialists develop a new Artillery Fire Support Control System (AFSCS) and its connection to higher level system for Network Enabled Capabilities (NEC).

Main details about the Process of Preparing of Fire

For fire control system, tactical and technical, it is necessary range of information that must be available before and during firing, even after its completion. These are primarily for information about the elements of a military deployment involved the detection targets or the fire. These data are important not only for the authorities of fire control system, but also for other parts of the task force, especially for logistics.

Default information for fire entering to the system through permanent data that

are unchangeable in the system and are permanently available (by reporting on the current status of the elements fire control system, which is changing in the course of combat operations).

Permanent information is for example the data from tables of shooting, tactical and technical data selected for weapon, ammunition, etc. The reports contain the necessary changing information about the elements of fire control system (artillery observation post, weapon set), time to ready to fire, number of ammunition on the set, and the end of fire.

This information must be available irrespective of the fire control mode. It is two possibilities: the fire control in automated mode (supporting AFSCS) or alternate (manual) mode. This means that fire control authorities must keep records with the necessary documents to allowing the fire to perform tasks even if AFSCS will be dysfunctional.

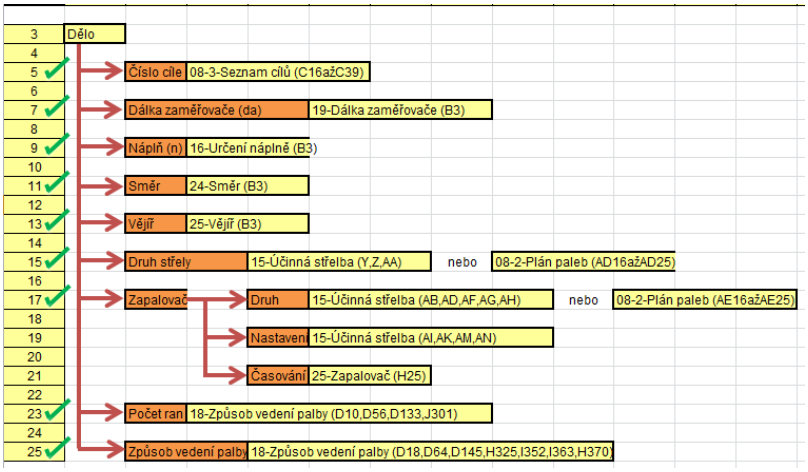


Fig. 1 - Information for weapon set

Permanently embedded (unchangeable) information

The basic embedded information for calculating the fire elements are in tables shooting. For the alternative (manual) mode of fire control it's the documentation in printed tables of shooting, but for automated fire control system is more convenient to specify the individual permanently information using mathematical functions.

Values, or functions that will be needed to insert to AFSCS will be determined by software that will use the system. The output will be primarily distance of gun sight, or timing of gun sight and other values needed to aim the weapon set. (Figure 1 - Information for weapon set)

Information about the weapon set

Information about the weapon set in terms of fire control system is necessary in the following range:

1. Changing the initial velocity caused barrel wear (Δv0d), which is needed to calculate the elements of effective preparation and shooting using sighting cannons. In the first case will be used to calculate the distance repairs for a total change of the initial velocity. In the second case will be used for elimination of irregularity of the cannon due to the control cannon.

2. Rate of fire in wounds per minute (vstř), which is necessary to determine the type and number of firing sets to use in specific task of firing. (Figure 2 - Selection the type and number of firing sets)

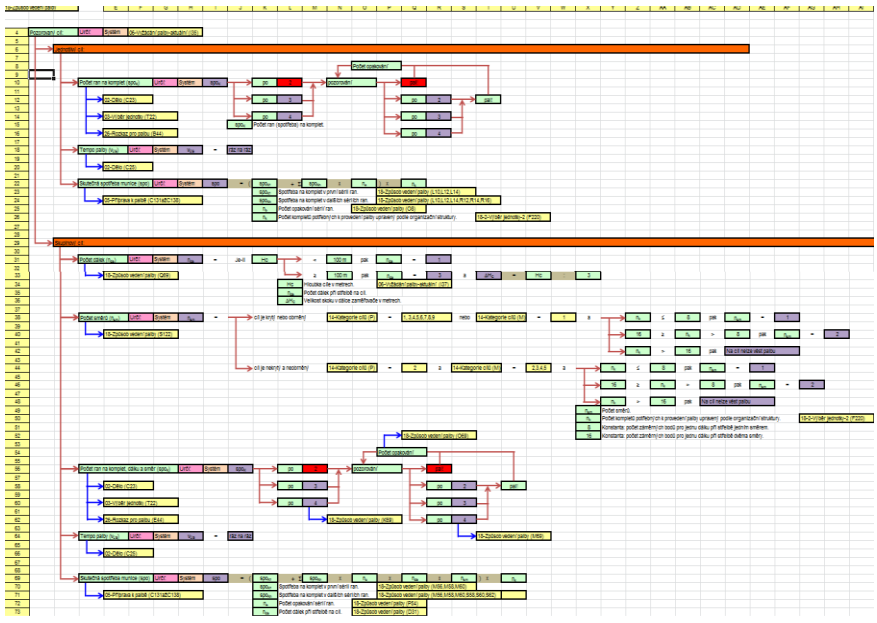


Fig. 2 - Selection the type and number of firing sets

3. The value of the maximum range of weapon set, which will be used when selecting the type of firing set for the realization fire on the detected target. (Figure 3 - Selection of Unit, Weapon set which can accomplish the firing task).

Information about the ammunition

To calculate the fire elements are needed the following information about the ammunition:

1. The value of the maximum radius of the fragments of projection. This information is essential to calculate the coordinates of a new point of target in the event that fire on target will lies so close to own troops, it is for their safety.

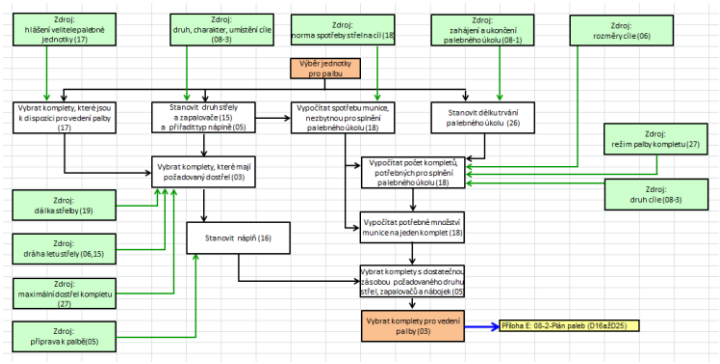
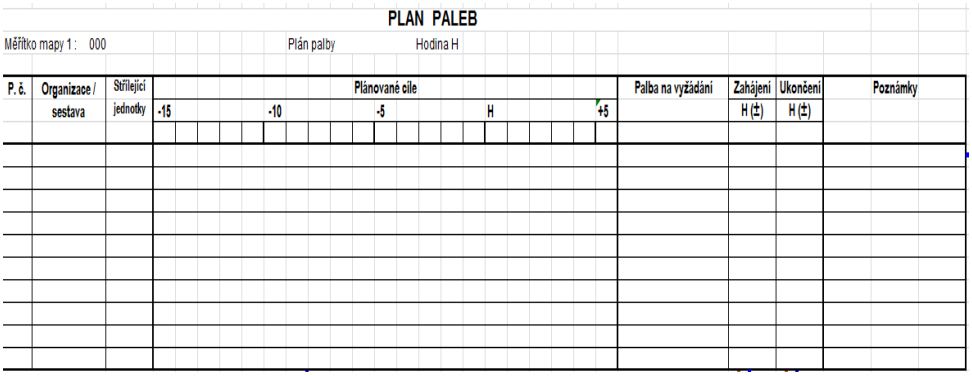


Fig. 3 - Selection of Unit

2. The standard consumption of ammunition to specified types of targets. This information is essential for determining the number of weapon sets to accomplish the firing task. Commanders and staffs use this information when planning and artillery support. This is one of the major limiting factors during the implementation process of targeting. When planning the artillery support is it necessary to bear in mind the quantity of ammunition, which is for the operation and its duration available. With standard consumption of ammunition we can establish the types, quantity and degree of elimination targets. Based on comparison of available quantity of ammunition and ammunition needed for the elimination the targets and the result is the absence of ammunition, it will be necessary to adjust the logistics challenges in the supply of artillery ammunition or number of targets for artillery fire. The results of artillery fire planning are among other tasks for subordinate units, expressed by firing plan. (Figure 4 - Firing plan)



PLAN PALEB

Měřítko mapy 1 : 000 Plán palby Hodina H

P. č.	Organizace / sestava	Střílející jednotky	Plánované cíle					Palba na vyžádání	Zahájení	Ukončení	Poznámky
			-15	-10	-5	H	+5		H (±)	H (±)	

Fig. 4 - Firing plan

The standard consumption of ammunition is also used when:

- calculating the adjusted consumption of ammunition on target,
- number of shots on weapon set, distance and direction,
- real consumption of ammunition on a target,
- the rate of fire (if the firing is determined by length overflow).

3. The maximum range in kilometers is a basis in the selection process for choosing weapon set for specific firing task. Maximum firing range of weapon set is dependent on the type of missiles and Cartridge.

4. Maximum width of the fire section on the covered, uncovered, armored and non-armored target is a information which is used in calculating the number of firing points in relation to the character (armored, non-armored), location (covered, uncovered) and the width of the target.

7.3 Reports

The information (which is changing in the course of combat and non-combat activities) is usually transmitted in the form of reports. Reporting within AFSCS do not transmitted, but is available as a source of information for the each element of the system. In case of alternative fire control is necessary to forward the actual information on all elements of the system. At present, this information is most often transmitted by radio stations. Staff members record information in the documentation,

usually in the form of tables. In case of failure AFSCS is necessary that all the information for fire control were available in all workplaces involved in fire control. This means that AFSCS must provide also all materials for fire control in an alternative manner in printed form for all elements of the fire control system. For this reason, the information is already completed into tables in operational schemes and tactical tasks, which after printed can be used in fire control by alternative means.

To the fire control system continuously enter the information from:

- reporting about passion observation,
- reporting about ready to fire,
- reporting about ammunition at weapon set,
- reporting during combat operations,
- call for fire report,
- reporting about end of firing,
- combat orders,
- sketches topographic-geodetic connection,
- and meteorological reports.

Contents of combat orders, sketches topographic-geodetic connection and meteorological reports in this paper does not described in detail, because these documents are discussed in another paper.

Reporting about passion observation

Reporting about passion observation inserted into AFSCS every commander of artillery reconnaissance squad immediately after standing observation. Reports must be available to senior chief and combat support coordination center and the chiefs of all the places of fire control (gun and mortar units) and center of fire control. The content and form of reporting is based on the publication AArtyP-1 Allied Artillery Procedures. The first is the call sign of called unit and followed his own call sign. Then follows information about passion new observation, then rectangular coordinates, altitude and accuracy of coordinates. Accuracy of coordinates is compared AArtyP-1 extra entry information. However, it is necessary to evaluate whether it is possible to determine the fire elements for effective preparation,

or adjusting fire. This information is possible to replace with the agreed format, for example, coordinates observation:

1. If the coordinates of observation given the accuracy of meters or tens of meters (format: EEEEENNNNN or EEEENNNN), it means that the observation was connected with a precision that meets the level of accuracy for determining the target position.

2. If the coordinates of observation given an accuracy of hundreds of meters or worse (format: EEENNN or EENN), it means that the observation was connected with a precision that does not meets the level of accuracy for determining the target position.

Continuous specification of all information given by artillery units provides background for planning further activities of task force units. This means for example that artillery observer does not change position even though during combat operations but the commander of artillery reconnaissance squad must report a change of all other information contained in the reports about passion observation.

Reporting about ready to fire

Reporting about ready to fire process and inserted in AFSCS by artillery commander of each unit when it reaches the ready to fire at the start of combat operations or in a new firing position. Reports must be available to the supervisor of fire unit and chief of places and center of fire control and coordination of combat support. The content and form of document based on the needs of automated and alternative fire control system (Figure 5 - Reporting about ready to fire)

Principles of message transfer are the same as in chapter 3.1. The first information is the number of weapon sets in the fire unit. The number of weapon set is obtained from report from the commanders of guns (mortars), each of which marks the number of his set. Based on this information the system will automatically calculate the number of weapon set by platoons, batteries and battalion. In fire control system works only with weapon sets and units, which are known in this way.

Other information describes the firing position.

It is:

- distances between guns in meters, which are the basis for adjusting the fan wide for targets,
- the method of deployment of fire battery (on the whole, by the platoons), this information is needed for sizing of individual and group unobserved targets and select the fire unit,
- information for the calculation overshooting, values for individual basic bearing that fill commanders of firing sets.

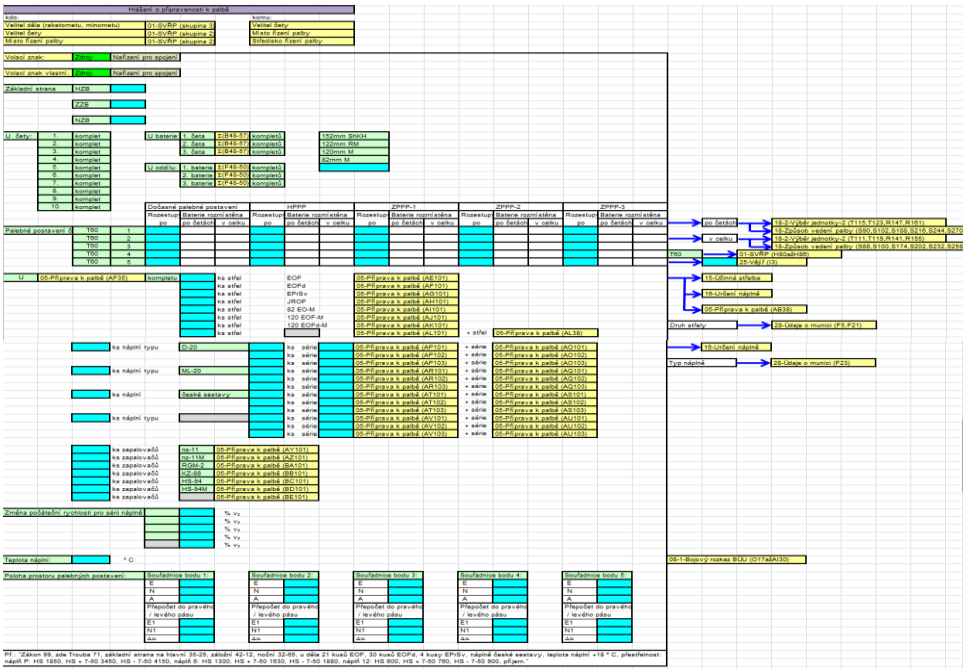


Fig. 5 - Reporting about ready to fire

In reporting about ready to fire also states:

- the number and type of missiles,
- cartridge,
- and lighters after each set.

Reporting about ammunition at weapon set

Reporting about ammunition at weapon set process and inserted into AFSCS commander of weapon set. The content is based on the needs of automated and alternative fire control system. The report provides all information about ammunition at weapon set:

- the type of missile,
- weight characters,
- painted bullets,
- cartridge type,
- series,
- change its initial speed,
- and type of lighter.

Overview of ammunition for firing set is processed that the established types of ammunition are in the system in advance and it is possible also insert a new type of missile or lighters, or type of cartridge. The table is created for inserting up to 60 pieces of ammunition, which corresponds to average firing of 152 mm ShKH vz. 77. In AFSCS condition is virtually unlimited amount of ammunition.

Overview of ammunition is conducted according to a specific location with a specific missile, lighter and type of cartridge in specific place in weapon set. This means that line 1 corresponds to No. 1 in the bed of the conveyor of shots and No. 1 in the bed of the conveyor of cartridge in 152 mm ShKH vz. 77. This also applies to other firing sets. Such a review can result that any bullet choice in fire, without the need to identify the type of ammunition in a charging machine.

Before the acquisition of a new weapon set in Army of Czech Republic will be desirable to set the condition that the ammunition will have all the necessary data indicated (e.g. bar code) and firing will have a complete equipment for automatic reading of the data. After charging the new ammunition in weapon set will complete all necessary data is automatically transferred to AFSCS. This method will accelerate operation during charging of weapon set, refining the fire, allowing selection of a particular shot, lighters and type of cartridge for excluding possible operator error and provide a current overview of ammunition for all firing sets at any time. AFSCS will count for firing elements for each set and for each shot, lighter and cartridge separately. This allows accurate firing with ammunition with various ballistic characteristics.

Reporting during combat operations

In terms of fire control is important during combat operations overview of the current activities of fire units and weapon sets. Therefore, the unit commander must report any change in the activity of his subordinate elements. During the fire control using AFSCS to use summary table of activities weapon sets in figure 6 - Commander reports. The data used for an automated system that selects them based on specific weapon systems currently being prepared for firing.

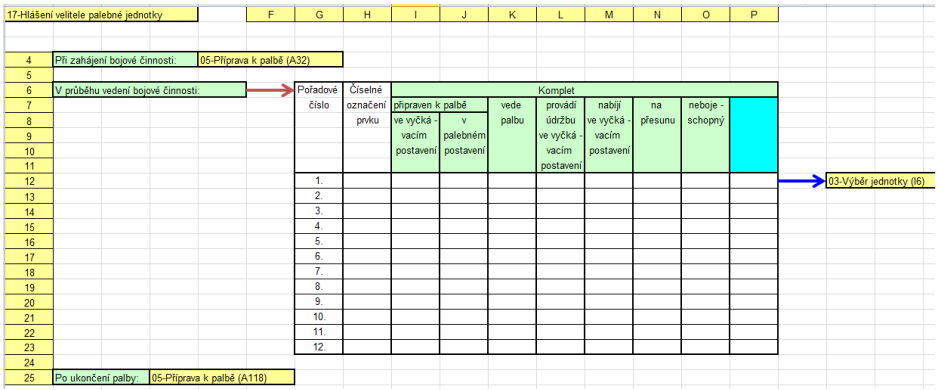


Fig. 6 - Commander reports.

Reporting about end of fire

Reporting about end of fire process and inserted into AFSCS artillery fire commander of each unit when it reaches the end of firing task and ready to fire mode. The report is intended for a senior commander of the unit and the chief of places and center of fire control and coordination of combat support. Principles of message transfer are the same as in chapter 3.1. The report contains only information about the quantity and type of ammunition consumed in fire at a specific target.

Overview of ammunition in the unit will be lead in two ways:

1. Number of missiles, lighters and cartridge mentioned in the report about end of fire will be deducted from the number which was reported at the start of combat operations. It is necessary for replenishment of ammunition to send reports of charging weapon sets. This can be done either by new reports about the status of ammunition at the weapon set or a special message, which will contain only the supplied quantity of ammunition. This way of keep overview of ammunition is more suitable for fire control by alternative means.

2. Number of missiles, lighters and cartridge mentioned in the report about ammunition at weapon set. In case of weapon sets are equipped with automatic detection of data on ammunition, will be overview of the types of ammunition always available in the AFSCS condition. This way of keep overview of ammunition is only possible when using the fire control by automated means.

Overview of the amount of ammunition in the fire unit

Overview of the amount of ammunition in the fire unit continuously processes and inserted into AFSCS artillery fire commander of each unit, the chief of places and control centers and fire places and coordination of combat support centers and also by the chief of logistics. Content meets the needs of fire control system in both ways, as well as artillery ammunition supply. The form may be the same at all levels. The commander maintains an overview of the types of ammunition for each subordinate unit and total for your unit. For example:

- commander of the firing battery keeps records of ammunition for the first and second firing squad and collectively for their battery,
- chief of place coordinate combat support battalion task force, which is reinforced by artillery battery from the battalion, keeps records of ammunition for organic mortar battery and reinforced artillery battery. In this case, records two overviews, because it is not possible to add up the numbers for ammunition of the 152 mm ShKH vz. 77 and for 120 mm Mortar.

Fire control authorities must always be ready to realize fire control by alternative means in case of failure AFSCS. They must handle documents that are substantively identical to most documents embedded in AFSCS. The exceptions are the information that results from differences in fire control in the automated mode and alternative mode.

Before acquisition software for calculations within AFSCS will be necessary to define the output data, including units of measure, format, etc.

Depending on the selected software will be needed to identify the same for input data. It is likely that for this reason the amount of information that will be put into AFSCS will be greater than indicated in this paper. This can be avoided by using a standardized software NATO labeled S4.

Before introducing new weapon sets and ammunition is required to establish their characteristics, which will AFSCS needed for full activity. This information is indispensable for many calculations and decision making activities.

For every report or overview, it is necessary to define exactly processors and recipient. In automated condition this information indicates an officer with allowed access to the database element of the fire control system and is entitled to obtain necessary data. In alternative fire control is defined reporting system between the elements of fire control system.

The content and form of reporting respect the principles laid down by NATO agreements in the maximum extent possible. They differ only in cases where it requires a process of AFSCS.

An element of fire control system does not provide information only for fire control, but also for senior commanders to support the decision or for authorities to plan logistics supply ammunition, etc.

AFSCS using overview and reporting system provide a considerable simplification of the preparation of fire. Automated system will reduce the time to use more accurate and more efficient ways of determining elements for fire, selection firing unit especially the weapon sets and activities of units in the firing position. AFSCS will allow to the firing line of scattered firing position, using any number of weapon sets, which appropriate to ensure the firing task without undue increase in their number. At the same time reduce the time needed for decision-making of artillery authority in fire control system and reduce the risk of human error factor.

7.4 Time and space validity of meteorological report

<table>
<tr><th>Kind of meteorological report</th><th>Space circuit of validity [km]</th><th>Time validity
[hours]</th><th>Note</th></tr>
<tr><td>METCM</td><td>50</td><td>4 [1)]</td><td rowspan="3">[1)] Is valid only with settled weather.</td></tr>
<tr><td rowspan="2">METEO-MIDDLE</td><td>10</td><td>3 [1)]</td></tr>
<tr><td>35</td><td>2 [1)]</td></tr>
<tr><td>METEOMIDDLE-APPROXIMATE</td><td>Is valid only for battalion (troops), whose meteorological team compiled a report.</td><td>1</td><td>For entry heights to 800 m of meteorological report for full preparation, to 1600 m for shortened preparation of firing data for effective fire without registration fire (if is valid a. 172 and 174 in Rules of fire).</td></tr>
<tr><td>Report of meteorological guard
of rocket launcher company</td><td>Is valid only for rocket launcher company, whose meteorological guard carried out airy probing.</td><td>Only for one fire task.</td><td>Airy probing has to be ended not later than 15 minutes before fire.</td></tr>
</table>

References and further reading:

1) MO ČR. *Bojové použití dělostřelectva Armády České republiky*. Děl-1-1. Praha: 2002. 92 s.

2) MO ČR. *Dělostřelecký průzkum, topograficko-geodetická a meteorologická příprava dělostřelectva všeobecné palebné podpory*. Děl-6-4. Praha: 1996. 144 s.

3) MO ČR. *Palebná služba pozemního dělostřelectva*. Děl-3-1. Praha: 1995. 185 s.

4) MO ČR. *Doktrína Armády České republiky*. Praha: 2004. 148 s.

5) MO ČR. *Bezpečnostní strategie České republiky*. Praha: 2003. 22 s.

6) AAP-6 *(STANAG 3680), NATO glossary of terms and definitions, Přehled termínů a definic používaných v NATO.* Brusel: NSA, april 2007.

7) AArtyP-1(A) (STANAG 2934) *Artillery Procedures, Dělostřelecké postupy*. Brusel: NSA, březen 2004.

8) AArtyP-5 (STANAG 2484) *Field artillery tactical doctrine, Taktická doktrína polního dělostřelectva NATO*. Brusel: NSA, leden 2002.

9) AAP-38 (STANAG 2484) *NATO Artillery Glossary, Terminologický slovník dělostřelectva NATO*. Draft document. Brusel: NSA, únor 2001.

10) STANAG 2014 F*ormats for orders and designation of timings, locations and boundaries, Struktura rozkazů, uvádění časových údajů, názvů, míst a rozhraní.* Brusel: NSA, říjen 2000.

11) ČOS 10001 *Dělostřelecké zbraně názvy a definice.* Praha: Úřad pro obrannou standardizaci, katalogizaci a statní ověřování jakosti, 2006. 20 s.

12) SOBARŇA, M., POTUŽÁK, L., VONDRÁK, J., aj. *Základní pojmový aparát pozemního dělostřelectva AČR*. Brno: Univerzita obrany, 2011. 186 s.

13) Pravidla střelby a řízení palby pozemního dělostřelectva (dělo, četa, baterie, oddíl). Pub-74-14-01. Vyškov: Správa doktrín Ředitelství výcviku a doktrín, 2007. 256 s.