Perspective Method for Determination of Fire for Effect in Tactical and Technical Control of Artillery Units

Martin Blaha, Karel Šilinger, Ladislav Potužák and Bohuslav Přikryl
Department of Fire Support, University of Defence, Faculty of Military Leaderschip Kounicova 65, Brno, Czech Republic

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Abstract: This paper is focused on perspective method for determination fire for effect in tactical and technical control of artillery units in the perspective of automated artillery fire support control system and deals with a proposed method of adjust fire. This method is designed for artillery of these armies that are using the field artillery. Artillery units of the Army of the Czech Republic, reflecting the current global security neighbourhood, can be used outside the Czech Republic. The paper presents problems in the process of adjust fire method, from results arising from creating a fictional auxiliary target; by using an adjustment gun; Abridged preparation and Simplified preparation. The paper compares these methods in terms of time, accuracy (probable error in target distance and target fire direction) and frequency of use in peace and war.

1 INTRODUCTION

The basic task of artillery weapon systems is an indirect firing, thus engaging targets kilometres away and beyond the line of sight.

Calculation of the fire elements is a lengthy process based on the mathematical apparatus of several disciplines such as Ballistics, Meteorology, Geography and Theory of probability. Automation of this calculation process speed up availability of fires and reduces the likelihood of errors (Blaha and Sobarňa, 2009).

At the same time, the user removes the necessary knowledge of basic principles and procedures for calculating the fire elements of fire and creates the illusion of correctness of himself.

Because of the destructive power of artillery fire, the feelings of perfection cannot be relied upon. The basic operating rule of tactical using of artillery fire is to supervise calculated fire elements before any target engagement.

Artillery of the Czech Army identified deficiencies in the ability to conduct timely, simultaneous in the best, control outputs its primary automated fire control system, and calls for the introduction of substitute and control software – PVNPG-14M to calculate and control fire elements for the firing. To fulfil its supervisory functions, the software must fully respect all valid artillery procedures for manual (classical) calculation of fire elements.

From the perspective of the application, software must be open for easy deployment of internal adjustments and additional functions, use common programming language and allow installing and running on modern touch platforms with the Windows operating system, which is implemented in the Czech Army.

Effective artillery fire without adjustment is in most cases based on the complete preparation. Complete preparation is method which prepare basic elements. However not always are necessary condition, which can be found in publication Pub 74-14-01 (Fire rules and command & control of field artillery), fulfilled (Blaha and Brabcová, 2012).

If it is not possible to calculate elements for effective fire with complete preparation nor by creation of fictional auxiliary target, fire adjustment is absolutely necessary.

Basic fire adjustments methods are divided into two subcategories; either with or without artillery reconnaissance assets (devices).

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Fire adjustment with artillery reconnaissance assets is divided as: fire adjustment with laser range finder, fire adjustment with PzPK Sněžka radar, fire adjustment with designated observer posts and fire adjustment with ARTHUR radar.

Fire adjustment without artillery reconnaissance assets are divided as: bracketing, fire adjustment with O-T bracketing, fire adjustment using lane of fire layout, fire adjustmnet with consective control according to world sides, scale fire adjustment, adjustment with use of stopwatch, fire adjustment based on presumption.

Each of these fire adjustment methods require special technical equipment and specific condition, which are need to be fulfilled. Most common fire adjustment methods are fire adjustment with laser range finder, fire adjustment with PzPK Sněžka radar, fire adjustment with ARTHUR radar and bracketing.

2 COMPARISON OF METHODS FOR DETERMINATION OF FFE

There are several ways to set firing data for Fire for Effect (FFE) of artillery units. They differ in accuracy and terms, which permit us to apply FFE. For FFE it is important to decide the most accurate way of setting the firing data in every situation.

This decision making action was provided by artillery commanders during training activities, where they generally had only instruments and information, which usually resulted in one and the only way of setting firing data for effective fire (Pub-74-14-1, 2007).

While using Artillery Fire Support Control System it is necessary to define specific terms for setting firing data for effective fire by different means.

Firing data for FFE can be set by these methods:

- Complete preparation – Accurate Predicted Fire (APF);
- By using an adjustment gun;
- By results from creating fictional auxiliary target;
- Abridged preparation;
- Simplified preparation;
- Fire adjustment.

Each of this methods will be examined in terms of time, accuracy (probable error in target distance and target fire direction) and frequency of use in peace and war.

2.1 Analysis in Terms of Time

The results are summarized on figure 1 below.

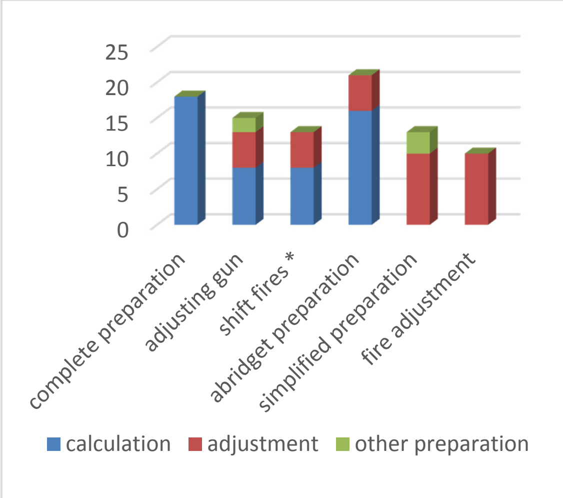

Figure 1: Graph of time – consuming.

The fastest method is Fire adjustment.

2.2 Analysis in Terms of Accuracy

This parameter is examined in terms of probable error in target distance and target fire direction. In chapters below interesting data are shown in tables and graphs. The source of these data is (Blaha and Sobarňa, 2010), however for this article it is not important the original data, but the comparison of methods and identification of the best way (which is discussed in detail in the following text).

2.2.1 Probable Error in Target Distance

The results are summarized on figure 2 below. The most accurate method (in distance parameter) is Fire adjustment according the figure 2.

Figure 2: Graph of probable error in target distance.

2.2.2 Probable Error in Target Fire Direction

The results are summarized on figure 3 below.

Figure 3: Graph of probable error in target fire direction.

The most accurate method (in direction parameter) is Shift fires according the figure 3.

2.3 Analysis in Terms of Frequency of Use

This parameter is examined in terms of frequency of use in peace condition and war condition. The source of these data is (Blaha and Sobarňa, 2010), however for this article it is not important the original data, but the comparison of methods and identification of the best way (which is discussed in detail in the following text).

2.3.1 Frequency of Use in Peace

The results are summarized on figure 4 below.

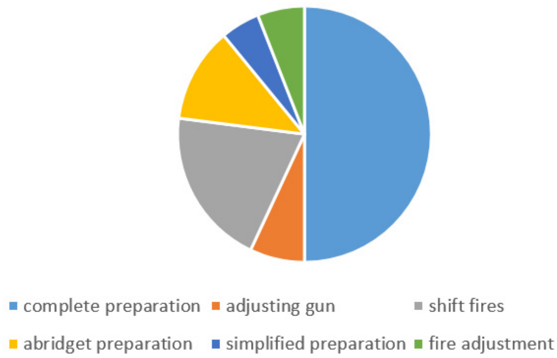

Figure 4: Graph of frequency of use in peace.

2.3.2 Frequency of Use in War

The results are summarized on figure 5 below.

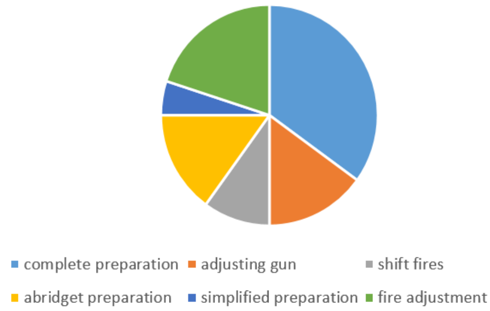

Figure 5: Graph of frequency of use in war.

The final ranking is shown in the table below. According the table of final ranking is the best method for determination Fire for Effect the Fire adjustment.

		Propable Error		Frequency of use			Ranking of each element
	Time	Target Distance	Fire Direction	Peace	War	Conclusion	preparations
complete preparation	0,3	1,0	0,9	1,0	1,0	0,7	3.
adjusting gun	0,5	0,9	1,0	0,0	0,3	0,7	4.
shift fires	0,7	1,0	1,0	0,3	0,2	0,8	2.
abridget preparation	0,0	0,6	0,7	0,2	0,3	0,3	5.
simplified preparation	0,7	0,0	0,0	0,0	0,0	0,3	6.
fire adjustment	1,0	1,0	1,0	0,0	0,5	0,9	1.
scales of each criterion	0,4	0,3	0,2	0,1	0,1	1,0	

Figure 6: Table of final ranking with scales.

3 FIRE ADJUSTMENT PROCESS WITH LASER RANGE FINDER

Laser range finder is assign to identify range to objects and blasts from observation post. Generally, laser range finder can be used to measure horizontal angles and also bearings under condition of orientation laser range finder into kilometre north.

Fire adjustment with laser range finder is one of the fastest and most accurate methods of adjustment. Initial conditions and requirements for fire adjustment are as following:

a) Forward observer must be able to find out distance with precision of 10 meters.

b) Laser range finder must be able to measure horizontal angles or on observation post must be different angle measuring device; this device must be oriented into kilometer north.

c) Into automatic command and control fire support system of artillery (ASRPP – DEL) must be input observer post grid coordinates, fire post and target coordinates; that also means that this grids must be available in Division fire support coordination center (FSCC) and in Brigade fire control centre (FCC).

d) Target must be observable (target which can be seen from a ground observation post).

Process fire adjustment with laser range finder is represented in scheme 30 Fire Adjustment with laser range finder. The master weapon set fire one shot with calculated elements. Forward observer (FO) measures distance and bearing from observation post up to blast and measured values insert into ASRPP – DEL (AAP-6, 2009).

Than system automatically calculates distance and angle of elevation correction values for fire position and handover these values to the weapon sets. ASRPP – DEL via measured values on blast computing blast deviations from target for observation post and compare these deviations with limiting values tabulated in publication Pub 74-14-01 (Fire rules and command & control of field artillery). If are deviations meet these limitation, fire for effect with corrected values can began.

When deviations are higher than tabulated values, another shot is fired with corrected values and then fire for effect is to start.

4 FIRE ADJUSTMENT WITH PZPK RADAR PROCESS

PzPK Sněžka radar is equipment used to recognize and determine location of moving targets and blasts.

Fire adjustment with PzPK Sněžka radar is fast and accurate method of adjustment. His biggest advantage is that coordinates of blast (point of impact) determine radar autonomously and that excludes instance of human failure. Initial conditions and requirements for fire adjustment are same as in the case of fire adjustment with laser range finder. However, there are additional requirements applicable with PzPK Sněžka radar:

a) Fire adjustment is performed with impact fuse.

b) Charge is selected to fulfil 20° angle of impact.

c) Fire adjustment has to be made with constrained sheaf (Blaha and Brabcová, 2010).

Process fire adjustment with PzPK Sněžka radar is represented in scheme Fire Adjustment with PzPK Sněžka radar. Master weapon set fires one shot with calculated elements. Radar measures distance and bearing from observation post to blast and measured values inserts into ASRPP – DEL. Then, system automatically calculates distance and angle of elevation correction values for firing position and pass on to the weapon sets. All weapon sets than fire one shot volley. Radar measures distance and bearing from observation post to volley center and operator insert these measurements into system (ASRPP – DEL), which calculated distance and direction correction for fire position, that also includes correction for sheaf modified on target width and these values are than handover to weapon sets, which can now fire for effect.

5 FIRE ADJUSTMENT WITH ARTHUR RADAR PROCESS

ARTHUR radar is equipment used to recognize and determine coordinates of shooting artillery and blasts. Fire adjustment with ARTHUR is fast and accurate method of adjustment. His advantage is similar to fire adjustment with PzPK Sněžka radar (Blaha, 2010).

In addition, radar have power to calculate and distribute before projectile hit the ground. Initial conditions and requirements for fire adjustment with ARTHUR are following:

a) Fire adjustment has to be made with constrained sheaf.

b) Grid coordinates of ARTHUR radar, fire position and target must be insert into ASRPP – DEL that also means that this grids must be available at Division fire support coordination center (FSCC) and Brigade fire control centre (FCC) (Blaha and Potužák, 2011).

Fire adjustment with ARTHUR radar process is defined in Publication Pub 74-14-01. But we can apply fire adjustment process for PzPK Sněžka. So this process will be as following: Master weapon set fire one shot with calculated elements. Radar calculates grid coordinates of blast and insert these into ASRPP – DEL.

The system than automatically calculates distance and direction correction values for fire position and handover these values to the weapon sets. All weapon sets shot one volley round with corrected elements and constrained sheaf. Radar calculates grid coordination volley center, these values than insert into ASRPP – DEL, which calculated distance and direction correction for fire position, that also includes correction for sheaf modified on target width and these values are than handover to weapon sets, which can now fire for effect.

Both types of radar can carry out fire adjustment which are detected by different means of reconnaissance. Grid coordination accuracy of radars must corresponded to the complete preparation conditions.

6 FIRE ADJUSTMENT WITH BRACKETING PROCESS

Bracketing is relatively fast and accurate so therefore is this type of fire adjustment the most common method of fire adjustment without artillery reconnaissance assets. Initial conditions and requirements for bracketing are following:

a) Forward observer (FO) must have equipment which is able to measure horizontal angles in artillery quantity.

b) FO estimate observer-target distance with accuracy 0,5 kilometer, value which we get is called O-T factor (OTf).

c) Observer post grid coordinates must be inserted into ASRPP - DEL; that also means that this grids must be available at Division fire support coordination center (FSCC) and Brigade fire control centre (FCC).

Master weapon set fire one shot with calculated elements. Forward observer measure angle deviation in artillery quantity, which is multiple by O-T factor, then we change a mark and we get direction correction in metres. Forward observer estimate distance deviation, which can reach values 200, 400, 800, 1600 m. Blast behind the target have correction mark "+", blast before the target have correction mark "-".

Size of distance leap is chosen to have second round with different correction mark than first. Forward observer change mark, which gave him distance and direction correction. This values are inserted into ASRPP – DEL.

System calculates distance and direction correction values for fire position and handover these values to weapon sets. Master weapon set than fire with corrected fire elements by second shot. FO repeat this process, where distance correction is half compared to prior shot (Mazal and Stodola, 2015).

Fire for effect is initiated after setting correction according to publication Pub 74-14-01.

Other fire adjustments are rarely used and therefore are not mention any further.

7 CONCLUSION

In case that ASRPP – DEL will be broken, will be proceeded with fire adjustment strictly according to publication Fire rules and command & control of field artillery.

Artillery reconnaissance may insert polar or grid coordinates of targets or blasts into ASRPP – DEL. (Blaha and Šilinger, 2015).

However, it is absolutely necessary to mark which kind of coordinates FO insert.

The most effective way to prepare elements for Fire for Effect of artillery units is fire adjustment. The specific condition and procedure are described above.

List of Abbreviations:

ARTHUR	Artillery Hunting Radar
ASRPP-DEL	automatic command and control fire support system of artillery
FO	Forward observer
OTf	O–T faktor, Observer – Target Factor

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