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INDEX OF SNIPERS' SHOOTING CAPABILITY

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A b s t r a c t :

The article presents a new principle of capability evaluation of armed forces snipers' shooting. The proposed method of shooting capability evaluation is original and the shooting process variability of individual snipers has been taken into account.

1. Introduction

The current growth in the number of terrorist attacks and serious criminal acts requires the improvement of snipers' training, the methods of this training, as well as the evaluation methods of snipers' capability and readiness to reliably hit the specified target anytime.

The military sniper often operates for a long time and in difficult terrain and under hard climatic conditions. His/her task is mostly to get to the place of deployment unobserved (the place is often in the opponent's rear), to wait in concealment and to hit the assigned target. After that, he/she usually changes the post and performs the next task. While carrying out the task, he/she exposes himself/herself, as well as his/her weapon (see Figure 1) and other equipment and kit to various effects of the environment.

Figure 1 Military sniper rifle 12,7 mm FALCON [www.zvi.cz]

The weapon used – the military sniper rifle must be not only resistant to different environment influences, but it also has to be mobile and appropriate for long transports and aircraft or helicopter jumps. The military sniper often performs tasks that include shootings at live and lifeless targets at long distances (up to 1.000 m).

Unlike the military sniper, the police sniper usually does not operate for a long time and in difficult terrain and under hard climatic conditions. He/she is mostly transported to the spot where he/she takes up an optimal firing position assigned by the commander of the action, as close to the target as possible. The police sniper often openly demonstrates force and determination of the police to act. After the action he/she does not have to leave the post unobserved. The time of the police sniper's deployment is limited to several minutes or hours; it takes more than 24 hours only exceptionally. In comparison with the military sniper weapon, the police sniper weapon (see Figure 2) is more fragile; it does not have to meet any special requirements in terms of high resistance against mechanical damage or weather conditions. The weapon can be even transported to the spot by another person and in a transportation cover, which can serve as a weapon pad during firing.

Figure 2 Sniper Rifle CZ700-SniperM1 [www.czub.cz]

Foreign statistics data analyzing real actions of police snipers have shown that the average distance at which the shooting was carried out was only about 65 – 70 m. The longest distances were about 400 m and most of the actions took place at a distance shorter than 100 m [3].

The sniper has to hit a live target by the first shot. The hit must be directed to a part of the body specified in advance. The firing is basically conducted in two ways:

- firing intended to only wound the person and to restrict his/her movement or other activities,
- firing intended to reach the lethal effect.

The intention of the latter way is to stop all body functions in a time limit as short as possible, so-called one-hit end. The fastest way to reach this aim is to hit the central nervous system (further CNS). The hitting of CNS is more effective than the hitting blood circulation or the breathing system (lungs). The hitting other part of the human body does not necessarily have to be lethal.

To enable the only shot to immediately stop the conscious activity of a live target, the sniper must hit, if possible, the centre of muscular tension, movement co-ordination and balance keeping which is cerebellum – the part of the brain between rear/back lobes of brain hemispheres, middle brain and spinal cord. When this part of CNS is hit, motoric skills break down and the person cannot consciously move a muscle. The size of this part of CNS can be marked by a circle of a diameter of 80 mm - see Figure 3.

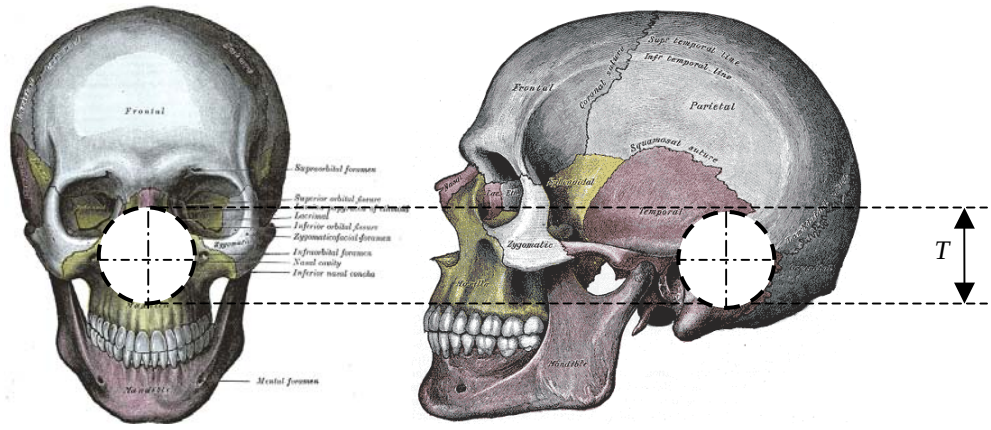

Figure 3 Basic etalon for evaluation of preciseness of snipers' shooting process (adapted according to [3] and http://cs.wikipedia.org)

The value of ϕ 80 mm represents the basic etalon for precision evaluation of sniper's shooting process ($T = \phi$ 80 mm).

Bearing in mind the above-mentioned considerations about the size of the sniper's target, the training and performance should be organized and evaluated. This article presents the proposal of a new evaluation method of sniper's capability that expresses this evaluation by the only number.

2. Shooting capability

During sniper's shooting, a large number of factors influence the trajectory of projectile that becomes evident by the fact that the point of the hit does not fully correspond to the aiming point.

Each shooting process shows variability the source of which is, apart from the sniper, the weapon itself (sniper rifle), the cartridge used, as well as the importance of the situation and the environment in which the shooting takes place (temperature, air humidity, atmosphere optical qualities, wind speed and direction etc.) – see Figure 4.

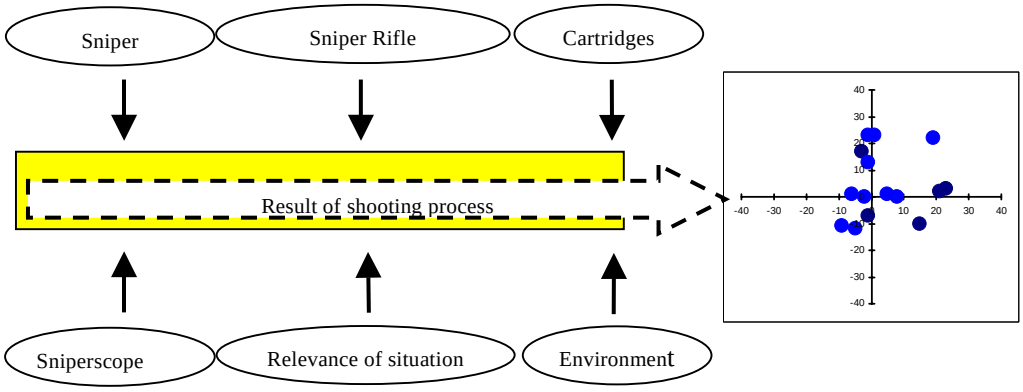

Figure 4 Sources of shooting process variability

If we mark the coordinates of sniper's hits from the distance d by symbols ${}^{d}x$ and ${}^{d}y$, we can determine the value of hit radius ${}^{d}r$ (see Figure 5) that represents the distance of the hit from the aiming point (centre of gravity of prescribed target area).

$$ {}^{d}r = \sqrt{{}^{d}x^{2} + {}^{d}y^{2}} \qquad (1) $$

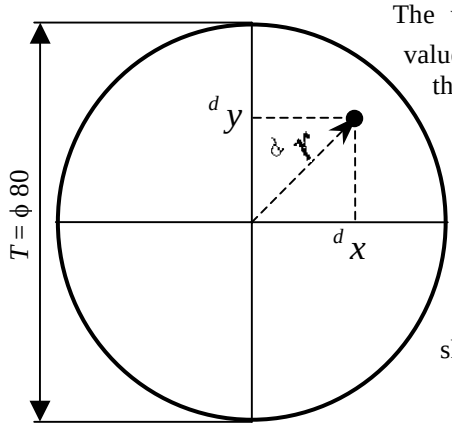

Figure 5 Radius of shot ^{d}r

The value of hit radius reaches only positive values ($^{d}r \geq 0$). To enable the sniper to meet the requirement of hitting the target by the first shot, the radius hit value ^{d}r must not exceed the value 0,5 T , which means 40 mm.

The term sniper's shooting capability can be defined as his/her capability to always hit the prescribed area of the target – diameter T from the distance d by the first shot.

3. Index of sniper's shooting capability

Sniper's shooting capability will be numerically evaluated by shooting capability index $^{d}c_s$ that is generally defined as:

$$^{d}c_s = \frac{requirement\ \ for\ sniper's\ shooting}{variability\ of\ \ snipers\ shooting\ \ process\ at\ the\ distance\ \boldsymbol{d}} . \qquad (2)$$

The requirement for sniper's shooting is derived from appropriate characteristics of the target (e.g. dimensional). If the target is a live target, the prescribed target area is a circle area of the diameter $T = \phi 80$ mm. If the characteristic of the prescribed target area is expressed by means of hit radius ^{d}r (see Figure 5), the requirement for sniper's shooting will be equal to 0,5 T = 40 mm.

Variability of sniper's shooting process at the distance d is being determined by an interval in which, with assigned probability, all values of sniper's hits occur. If the shooting process variability occurs in normal distribution, we can determine the interval in which, with assigned probability, all values of sniper's hits occur by multiples of standard deviation $^{d}s_r$.

For the evaluation of sniper's shooting process it is essential to determine the standard deviation $^{d}s_r$ in such a way that each hit will be evaluated as a result of sniper's first shot. In practice, we first of all determine the difference between radii of two first hits following one after another. We determine a so-called moving range for hit radii $^{d}R_{k_l}$:

$$ {}^{d}R_{k_l} = \left| r_l - r_{l+1} \right|, \tag{3} $$

where r_l is the radius of *l-th* hit,

r_{l+1} is the radius of *(l + 1th)* hit.

It means that firstly, after the second hit we will subtract the second hit radius from the first hit radius, then the third from the second etc. Using the average moving range we will estimate the standard deviation of certain sniper's hit set from evaluated *n* hits:

$$ {}^{d}s_r = \frac{\overline{{}^{d}R_k}}{d_2} = \frac{\overline{{}^{d}R_k}}{1.128}, \tag{4} $$

where d_2 is a so-called Hartley's conversion constant whose magnitude for the moving range of two values is 1.128 [1],

$\overline{{}^{d}R_k}$ is an average moving range calculated from the relation:

$$ \overline{{}^{d}R_k} = \frac{\sum_{l=1}^{n-1} {}^{d}R_{k_l}}{n-1}, \tag{5} $$

where n is a hit number.

Sniper's shooting capability index at the distance „*d*" $ {}^{d}c_s$, as the only number for the evaluation of shooting process capability is defined by the following relation:

$$ {}^{d}c_s = \frac{0.5T - \overline{{}^{d}r}}{3({}^{d}s_r)} = \frac{40 - \overline{{}^{d}r}}{3({}^{d}s_r)}, \tag{6} $$

where $\overline{{}^{d}r}$ is the average hit radius for determined distance *d* calculated from the relation:

$$ \overline{{}^{d}r} = \frac{\sum_{i=1}^{n} {}^{d}r_i}{n}. \tag{7} $$

In the denominator of the relation (6) that calculates capability index $ {}^{d}c_s$, there is the value of three standard deviations $3({}^{d}s_r)$ which represents interval estimation of sniper's shooting process variability with the probability of 99.73 % (assuming normal distribution) – see Figure 6.

Table 1 shows basic criteria for sniper's evaluation according to his/her shooting capability index.

Table 1

Criteria for the evaluation of the sniper's shooting capability index value

Capability index	Evaluation of a sniper	Verbal evaluation
${}^{d}c_s < 1.00$	**Incapable**	Sniper has either high shooting process variability or the average value of hit radius is too high
${}^{d}c_s \geq 1.00$	**Capable**	Sniper has low shooting process variability, as well as low average value of hit radius both of which ensure carrying out the task by the first shot

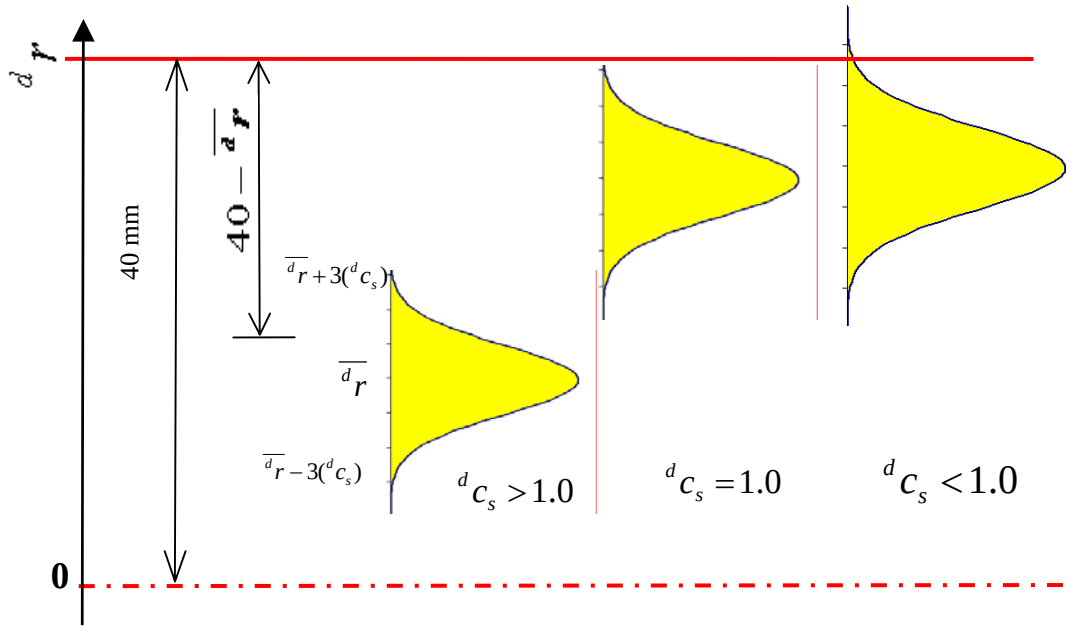

Figure 6 Shooting process variability with different positions ${}^{d}\overline{r}$, hence with different values ${}^{d}c_s$

Table 2 shows the results of test shooting of snipers A, B, and C at the distance of 100 m. To make the table easy to understand, the values of individual hits are mentioned only up to the fifth evaluated hit.

Table 2

Evaluation of three snipers at the distance of 100 m

Sniper	Variable	Hit number shooting time						Average value	Standard deviation	Capability index
		1 *8 a.m.*	*2* *9 a.m.*	*3* *11 a.m.*	*4* *13 p.m.*	*5* *14 p.m.*	..		$^{100}s_r$	$^{100}c_s$
A	^{100}x [mm]	-3	-1	15	21	23	..		5.83 [mm]	1.30
	^{100}y [mm]	17	-7	-10	2	3	..			
	^{100}r [mm]	17.26	7.07	18.03	21.10	23.19	..	$\overline{^{100}r}$ =17.33		
	$^{100}R_k$ [mm]	-	10.19	10.96	3.07	2.10	..	$\overline{^{100}R_k}$ =6.58		
B	^{100}x [mm]	-9	12	13	8	19	..		8.87 [mm]	0.86
	^{100}y [mm]	-11	11	19	0	15	..			
	^{100}r [mm]	14.21	16.28	23.02	8.00	24.21	..	$\overline{^{100}r}$ =17.14		
	$^{100}R_k$ [mm]	-	2.07	6.74	15.02	16.21	..	$\overline{^{100}R_k}$ =10.01		
C	^{100}x [mm]	-5	-1	-6	-2	5	..		3.14 [mm]	3.41
	^{100}y [mm]	-12	13	1	0	1	..			
	^{100}r [mm]	13.00	13.04	6.08	2.00	5.10	..	$\overline{^{100}r}$ =7.84		
	$^{100}R_k$ [mm]	-	0.04	6.96	4.08	3.10	..	$\overline{^{100}R_k}$ =3.54		

Based on the data in Table 2, we can evaluate the snipers as follows:

Sniper's A capability index for the distance of 100 m is $^{100}c_s(A) = 1.30$ and the sniper is evaluated as capable ($^{100}c_s > 1$).

Sniper's B capability index for the distance of 100 m is $^{100}c_s(B) = 0.86$. The sniper is incapable for this distance ($^{100}c_s < 1$).

Sniper's C capability index for the distance of 100 m is ${}^{100}c_s(C) = 3.41$. The sniper is capable and, moreover, he is the most reliable one of all the snipers, since his capability index is of the highest value.

The most suitable sniper for the shooting at the distance of 100 m is the sniper C. In case of emergency, it is also possible to use the sniper A to fulfil the task at this distance.

The sniper B is not suitable for carrying out a task at the distance of 100 m. His incapability is caused by a high value of shooting process variability (${}^{100}s_r = 8.87$ mm) which is the highest of all the evaluated snipers. On the other hand, the average value of hit (impact) radius was even better than that of the sniper A. But the sniper A has the shooting process variability significantly lower and his results are more stable.

The lowest shooting variability and the best shooting capability shows the sniper C.

4. Conclusion

The suggested method of the evaluation of armed forces snipers' shooting capability by means of capability index broadens the range of evaluation methods of snipers' performance. Because the capability index is expressed by one single number, it can be used by a commanding officer as an useful aid for quick decisions during an action.

The following table presents an example of a capability card of an intervention snipers unit consisting of seven snipers A – G.

Table 3

Capability card of unit members

Sniper	d = 100 m	d = 200 m	d = 300 m	d = 400 m
A	1.30	1.39	1.11	0.93
B	0.86	0.72	0.66	0.69
C	3.41	3.12	2.85	1.80
D	2.75	2.33	2.05	1.35
E	3.20	3.11	2.61	1.60
F	4.11	3.75	2.57	1.51
G	2.75	2.13	1.43	0.91

According to the Table 3, a quick decision can be made about the best sniper for a

certain task. We can also decide which of the snipers is best for given distances:

- the most suitable sniper for the distance up to 200 m is the sniper F,
- the most suitable sniper for the distance between 300 and 400 m is the sniper C,
- snipers A and G are suitable for the distance up to 300 m,
- snipers D and E are suitable for all distances (up to 400 m),
- the sniper B is not suitable for any shooting task.

R e f e r e n c e s :

[1] Juran, J. M. and Godfrey, A. B., Juran´s Quality Handbook – Fifth Edition. McGraw-Hill, 1999.

[2] Majtaník, J., Quality of armament (script). Military Academy, Brno, 2004.

[3] Jankových, R., Majtaník, J., Evaluation of Snipers´ Shooting Capability. I International Scientific Conference on Special technology, Bratislava, Slovakia, 2006.

Introduction of Authors:

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