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SLOVAK REPUBLIC

INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2014
Brasov, 22-24 May 2014

ELECTRONIC WAR AND MODERNIZATION OF AIR DEFENCE MEANS

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Abstract: *This article deals with current problems of evalution of the effectivity of radars protection against electroning jamming. The first part examines experience with electronic warfare in local conflicts and electronic countermeasures. The paper presents basic notions and division of electronic jamming.*

The second part describes a new method of evaluating effectivity of influence of electronic jamming on radars activity. Using Saaty method of multifunctional evaluation in computer environment gives distinctioned values to differcut sorts of jamming. The example of Air Defence missiles system SA – 6 Gainfull shows the possibility of using this methodic.

Keywords: *electronic warfare, jamming, countermeasures, radar protection, AD missile system*

Introduction

A plane has gone missing. Not a small one, but a large Boening, Malaysia Aerlines with more than two hundred people on board and nobody can find it. It is just China that admit they have more than 20 satellites in that region monitoring the area. Nobody knows how many satellites do the USA, Russia, Great Britain and France have, but we can assume that it might be far more. And in spite of that, a plane goes missing. Could this be caused by Martians? Or are we witnessing another electronic war, the results of which will be known in 20 or 30 years? We should remember what the electronic war is and when it arose. As a consequence, smaller countries like us should modernize radar and missile machinery, different approaches, evaluations and policy of solving problems.

1. Electronic war

Electronic war – a term not many people know today. They do not know it first occured in 1967 in relation to the Third Arab-Israeli War also called Six-Day War due to its short duration and rapid progress. The author of the term is major Edgar Ballance, the later Chief of Intelligence service of the British Air Force. He relates the usage of this term with appointing gen. Bar-Lev the Chief of Staff of Israeli army on 3rd December 1967. The general, who later became famous for creating the so-called Bar-Lev Line along the Suez Canal on the occupied Siani Peninsula, has probably for the first time realised what electronics meanins especially within combat aviation and air defence. At the beginning of the year 1968 Israel took action that is part of the electronic fight even today(1):

- equipping all planes (Phantom) with radiation warning receivers NRL and launched missiles warning system,
- equipping planes with jammers– especially with active narrowband ones,
- equipping diverse groups deployed to the Egyptian coast of Suez Canal with simple radiolocation jammers – active and passive, while until this time they had been focused on direct elimination o fair defence units (in the first part of the war up to 70% of air defence units were eliminated by diverse groups),
- determining special groups for seizing radiolocation means or their parts (this was the way the special comando on 27th of December 1969 seized antenna set and parts of radiolocation devices of a P-12 telemeter, the predecessor of P-18),
- elektronic monitoring of the representatives of Arab forces and their elimination (9th March 1969 the Chief of Staff of the Egyptian Armed Forces gen. Riad was killed, 9th September 1969 chief military advisor of USSR in Egypt killed).

Egypt reacted to these measures adequately:

- enhancing and equipping all aviation resources and air defence with unified identification device (at the beginning of the war the ratio of shootdowns was 1:1),
- deploying air and underwater diverse groups to the other bank of Suez Canal,
- equipping with the modernized PLRK SA-2M and SA-3M,
- arrival of soviet pilots and new MiG-21 Js in Egypt and their deployment in direct air defence of Nile road from Aswan to the Mediterranean sea,
- creating a system of early warning,
- creating systems of anti-aircraft missile defence around objects of state importance.

After the adoption of Rogers peace plan in 1970 it was time for analyzing and evaluating the mentioned measurements with a definite result – electronic warfare is becoming an integral part of any operation. The concept of **electronic war** was born.

At present, there is probably nobody who would doubt the importance of electronic measures related to the success of an operation or combat. Essential elements are (2):

- obtaining information superiority in the desired region,
- obtaining electromagnetic superiority in the field of electronic reconnaissance and electronic warfare.

Elektronic war, as a military activity in which the electromagnetic spectrum is used to obtain information about the enemy, performs organizational and technical measures for preventing, disrupting or impeding the enemy and protect one´s own electronic resources.

With the development of electronics the means of electronic warfare develop rapidly. Various forms and types of lighting weapons, laser weapons and high-frequency weapons are becoming a bigger and bigger threat for air defence, radiolocators and anti-aircraft launchers. For the most types of radiolocators, especially the older ones, the biggest threat is active, passive, broad-band or narrow-band, modulation or non-modulation jamming and all types reduce reconnaissance and firing options of launchers.
The second part of this article deals with fighting the enemy.

The division and effect of individual types of radiolocator, evaluation of radiolocators resistance and the effect of jamming on firing options of units, formations o fair defence were and continue to be current questions.

2. Air defence measures within the electronic war

Basic division of radiolocation jamming can be found in many sources (3). To evaluate the effect of individual types of jamming on the activities of radiolocators we can use the method of multicriteria evaluation. A group of evaluation experts has been chosen from teachers with rich experience from practice and lots of theoretical knowledge. Six types of jamming with a significant effect on activities of radiolocators were compared:

- active noise nawwor-band jamming,
- active noise broad-band jamming,
- nonsynchronous pulse jamming,
- synchronous pulse jamming, response,
- synchronous pulse jamming, non-response,
- passive jamming.

According to the Chart No 1, of comparing the significance of individual types of solutions we get a reciprocal matrix of pairwise comparison - Chart 2.

Chart 1

A1	9	8	7	6	5	4	3	2	x1	1	2	3	4	5	6	7	8	9	A2
A1	X																		A3
A1														X					A4
A1					X														A5
A1	X																		A6
A2	X																		A3
A2							X												A4
A2									X										A5
A2	X																		A6
A3																		X	A4
A3													X						A5
A3												X							A6
A4					X														A5
A4							X												A6
A5								X											A6

Chart 2

	E1	E2	E3	E4	E5	Σ E_i
A1	24	21	11	26	33	115
A2	23	18	24	19	27	111
A3	0	13	5	3	3	24
A4	22	13	20	13	5	73
A5	7	5	0	7	0	19
A6	3	0	5	0	6	14

After determining the maximum eigenvalue of matrix and determinant of the matrix,
$6 \leq \lambda_{max} \leq 23$ det = 0,000381
eigenvector of matrix will be the solution of homogenous set of linear equations, that will after modification be as follows:

$$w_1 - 0{,}1985\, w_2 - 0{,}3971\, w_3 - 0{,}9927\, w_4 - 1{,}1919\, w_5 - 1{,}5883\, w_6 = 0$$
$$w_2 - 0{,}4955\, w_3 - 1{,}2386\, w_4 - 1{,}4864\, w_5 - 1{,}9819\, w_6 = 0$$
$$w_3 - 0{,}9334\, w_4 - 1{,}2081\, w_5 - 1{,}5375\, w_6 = 0$$
$$w_4 - 0{,}4010\, w_5 - 0{,}8071\, w_6 = 0$$
$$w_5 - 1{,}1310\, w_6 = 0$$

Values of eigenvector after solving the equation:

$w_6 = 1$, $w_5 = 1{,}1310$, $w_4 = 1{,}2607$
$w_3 = 4{,}0806$, $w_2 = 7{,}2464$, $w_1 = 7{,}2464$
$\Sigma E_i = 21{,}9651$

and after the modification of normalized eigenvector representing the value of individual types of jamming are as follows:

$w_1 = w_2 = 0{,}3299$, $w_3 = 0{,}0574$, $w_4 = 0{,}1857$, $w_5 = 0{,}0515$, $w_6 = 0{,}0455$

The mentioned values can be used when evaluating the quality of radiolocator devices. For better understanding there is an example in Chart 3.

Chart 3

type of jamming	weight	protection device in RNRL 1S91
1.noise active narrow-band jamming	0,33	RRL 1S11M1 uses: - manual regulation of amplification of receivers; - realignment of transmitter frequency; - turning off the channel of the receiver, in which jamminghas been detected; NRL 1S31M1 uses: - manual regulation of amplification of receivers; - realignment of frequency; - switching on the „jamming 1S31M1“ regime; - semiautomatic monitoring c in D; - using inertial tracking
2.noise active broad-band jamming	0,33	RRL 1S11M1 uses: - manual regulation of amplification of receivers; - realignment of transmitter frequency; - turning off the channel of the receiver, in which jamminghas been detected; NRL 1S31M1 uses: - manual regulation of amplification of receivers; - realignment of carrier frequency; - switching on the „jamming 1S31M1“ regime; - semiautomatic monitoring c in D; - using inertial tracking
3.non-synchronous pulse jamming	0,057	- VNIS circuit - SMT circuit (selection of moving targets) - reducing amplification of jammed channel using the „RRU“ knob.

4. synchronous response pulse jamming	0,186	- VNIS circuit - SMT circuit (selection of moving targets) - reducing amplification of jammed channel using the „RRU" knob.
5. synchronous pulse non-response jamming	0,051	- realignment of carrier frequency;
6.passive jamming	0,045	both RRL 1S11M1 and NRL 1S31M1 - next periodic compensation -2x or 4x subtraction; - wind compensation circuit (internal phasing); - SPC - with internal phasing; - with external phasing.

For individual types of jamming the mentioned circuits are used for RNRL 1S91, PLRK 2K-12 KUB. To determine the quality of radiolocator we can use the following formula:

$$K_{KV} = \frac{\sum_{i=1}^{n} w_I}{\sum_{j=1}^{n} w_J}$$

where: i – is the number of protection devices in radiolocator,

j – is the number of types of jamming affecting the radiolocator,

w – is the weight of individual types of jamming.

With proof we can confirm the effectivity of protection listed under numbers 1, 3 and 6,

then value $K_{KV} = \frac{0,427}{1} = 0,427$

The bigger the K_{KV} value, the better the quality of radiolocator regarding jamming protection. The coefficient value in last generation radar technology will be close to one.

Similarly we can apporach when counting the coefficient of jamming that affects the reduction of firing options, especially for determining the probability of eliminating the target and mathematical hope of the number of eliminated targets. Professional literature offers the relation to calculate the probability of eliminating target regarding the coefficient of jamming resistance – P_{CR} (3).

$$P_{CR} = [\,1 - \prod_{i=1}^{n} (1 - P_i)\,]\, K_{KV}$$

or eventually $P_1 = P_2 = P_i$

$$P_{CR} = K_{KV} \,.\, [\,1 - (1 - P_1)^n\,]$$

The calculation itself or the way of defining k_{ru} has has never been stated and in practice various values k_{ru} have been used depending on individual literature. However, if we have defined norstandardized weigh coefficients characterizing the relation between individual types of jamming and the coefficient characterizing the quality (resistance) of radiolocator, we can also determine the coefficient of jamming, which determines the value $P_{CR.}$

To calculaze K_{RU} we can use the following formula:

$$K_{RU} = \frac{1}{1 + \sum_{i=1}^{m} w_i}$$

where:

m – number of protection device agens radiolocator jamming,

w_j – weigh of individual type sof jamming.

For the example of calculating the quality of radiolocator the value P_{CR} provided P_1 = 0,7, when launching two rockets will be determined by following values.

$$P_{CR} = 0{,}7\left[1-(1-0{,}7)^2\right] = 0{,}63$$

The credibility of the calculations will be higher the higher the quality of experts participating in input data of the multicriteria decision-making for the calculation of weights of individual types of jammings.

Conclusion

The above stated calculation of radiolocator coefficient and jamming coefficient is not a definite solution of the given issue. The methodology represents just one of the possible ways of solutions. It can be a stimulus for a discussion, as well as serve other researchers as one of the criteria for the evaluation of radiolocators and anti-aircraft launchers, for the selection of machinery necessary for the AF of SR. It can also allow to evaluate our own firing options in air combat more wisely in the phase of planning or operation.

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