Analysis of the Performance Criteria of Optoelectronic Systems

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Abstract
Analysing the results of the case study, I believe that the optimal choice optoelectronic systems is very important to determine and rank the performance criteria according to their contribution to fulfilling the mission and it is essential that these systems belong to the same category in terms of their performance. By synthesizing and presenting the fundamental concepts and processes that characterize the theme, we created an affordable material that facilitates the assimilation of the subject by students and others interested in this field. In a military environment constantly alert changing, it is desirable to be always one-step ahead of the enemy, is normal concern of specialists in all categories of weapons for knowledge, development and improvement of optoelectronic devices, so you can better use in battle.

Keywords
performances, optoelectronic systems, engineering value method, weights

1. Introduction

The main task of this paper consists of making the optimal choice of optoelectronic systems depends on their performance criteria.

The purpose of evaluation of these systems is to characterize their ability to deliver images that allow visual recognition and identification of targets depending on the use. Analyzing device performances, based on thermographic equipment is the assessment parameters presented as following [1, 2, 3, 4]:

- minimum detectable temperature difference (MDTD) - this parameter is subjective, serving to describe the thermal imager system's ability to detect small targets;
- minimum resolvable temperature difference (MRTD) - is a characteristic that describes the ability sighting system based thermal imager to detect details with a reduced thermal contrast target – fund;
- the signal-to-noise (S/N) ratio is the amount of photocurrent emitted from the photocathode to illuminate it is given and photocurrent emitted by the photocathode when not illuminated. This parameter indicates how noise is appreciated influence on image quality. The human visual system perceive different levels of noise jumps, skips produce image brightness variations of image areas overlap;
- the effective distance of observation - is one of the most important characteristics of optoelectronic devices because the distances of detection, recognition and identification of a target is the primary criteria for evaluating the thermal imager systems used in the military. Determination by direct measurement of these distances for a target of interest when evaluating a particular sighting system based on thermal imagers, is based on the observation (atmospheric conditions and background);
- response function - is a function that adjusts the signal (the lighting of the screen) depending on the size of the target;
- increasing the angle (γ) defines the tangent of the angle that is seen through the eyepiece, the image of an object formed by the camera lens and the tangent of the angle at which the object is seen with the naked eye. This value is defined by a digit followed by the multiplication sign "x".

Multisensor optoelectronic equipment designed to increase skills in terms of meeting the remit and objectives of the system in different lighting conditions or poor visibility or to align precisely with the target pipe and on determining the distances to the target [6].

After studying them theoretically, there are certain optical parameters outlining scales running optimally on the system's ability to perform the tasks for which it was designed

2. The Engineering Value Method. Systems Election Based on Technical Characteristics. Case Study

For a detailed analysis of the performance criteria, of optoelectronic equipment systems, the question is the effective election of existing choice. Choosing provides also the fulfillment of all the mission in the most appropriate manner (choice based on specific technical characteristics).

Regardless of the type of optoelectronic equipment the purpose remains the same: making a detection as exactly as possible to allow the destruction of the enemy force with an efficiency as increased, so with consumption as low as possible of ammunition in order to ensure fulfillment of fight missions and to avoid the personnel or material losses caused by the discovery of the offensive position by the missing of the targets [9].

The ability to fulfil the mission of view systems both night-time and daytime of each optoelectronic device is conditioned by the technical characteristics of them. In accordance with the current threats the most important requirements of the optoelectronic equipment, which must be met, are [10]:

- merger of multispectral images;
- depending on the viewing mode of the image of the target which interests us, the optoelectronic system concerned must ensure a sensitivity and a signal noise/radio as greater;
- acquired images to be determined at a resolution as high;
- for appliances of view on the night time, the performance improves as the pupil of entry into the lens and, implicitly, the distance to the focal length are higher, but the important thing is to maintain a balance between the dimensions and the size of appliance;
- FTO to be adapted to the destination of the appliance;
- eliminating the effect of "hypnosis" that occurs when the observer's eyes are immobilized in eyepieces of the appliances on the night time;
- the reliability will be imposed by the degree of use planned;
- reducing the power consumed;
- great convenience of observation for a very long time;
- interface possibility with other points of information both from inside the vehicle (commander, mechanical conductor, shooter - if they have the possibility of the video display) and from the band of control or from a decision center and joint control [12];
- high compatibility of communication protocols and data links between different types of weapon systems (unit shooting) and the structure of command and control immediately above (to be compatible electromagnetic other means radio, military and civilian, under endowment of purchasing systems) [11];
- the possibility of sight both on the time of day and night time;
- possibility of increasing the field of view by putting device on a mobile platform (rotating platform);
- optimum distance detection, recognition and identification of a target [11].

The problem which arises at the choice of the systems on the basis of the criteria according to the technical characteristics of their and implicitly of logistic equipment is that the same group of systems, the above parameters are different. So for some systems a part of parameters are superior to the others and the other parameters are lower and reverse. Also the measure of the superiority or inferiority is also different.

Because of present systems must be chosen one, the question of choosing one which has technical level most appropriate for application. It is obvious that is relative and is limited to those listed.

We have established criteria and minimum requirements (features) C_i, with the name and minimum value for each parameter conformable with Table 1 [5, 7, 8].

For relatively technical differences (relative adequacy) regarding the destination optoelectronic systems analysis will be limited to using a tool as objective. It is intended that they be ordered by a coefficient of technical level (adequacy) to be calculated and which differentiate them quantitatively.

On the basis of the significance of the parameter C_i for each system we gave a share p_i sub unitary for each criterion so as to fulfill the condition:

$$\sum_{i=1}^{m} p_i = 1 \quad (1)$$

Using the method of calculation of the weights we have established certain direct relationships of importance between parameters of the systems. Through this calculation we tried to obtain the reducing of errors due to lack of experience in the design of the systems.

Table 1. Criteria and weights of analyzed systems

Parameter	Parameters name	P_I	Selex Aspis (S_1)	Euroflir 350 (S_2)	Jimuc (S_3)	MP3 Sights (S_4)
C_1	Frequency band [μm]	0.11	[8-12] <12	[3-5] <5	[8-14] <14	[3-5]
C_2	Increasing angular [pixels]	0.03	2.5	8	4	8
C_3	Power dividers (resolution)	0.03	800 × 600	1920 ×1080	640 × 480	640 × 512
C_4	Human distance detection [m]	0.33	700	14000	3200	15000
C_5	Distance detection (panzer) [m]	0.33	1500	18000	5000	20000
C_6	Visual field	0.17	17.9 × 13.5	1.3 × 2.4	8.6 × 6.45	12 × 2.5

The calculation involves quantification of the relative importance of the parameters having levels for description, like:

$a_{ir} = 1$ – C_i feature is as important as C_r feature;
$a_{ir} = 2$ – C_i feature is more important as C_r feature;
$a_{ir} = 3$ – C_i feature is much more important as C_r feature;
$a_{ir} = 0$ – other situations than those above.

In this association: $i = 1, 2, \ldots, m$ and $r = 1, 2, \ldots, m$.

The weights shall be calculated using the relationship (2):

$$p_i = \frac{\sum_{r=1}^{m} a_{ir}}{\sum_{i=1}^{m}\sum_{r=1}^{m} a_{ir}}, \quad i = 1,2,\ldots,m. \quad (2)$$

In order to facilitate the data tracking, they can be written in the matrix form, for our case (m = 6) as well as is represented the table 2.

The weights calculated in descending order are as follows:

$p_4 = p_5 = 0.33$
$p_6 = 0.17$
$p_1 = 0.11$
$p_2 = p_3 = 0.03$

In order to be able to be interpreted as well the resulted weights for each of the parameters, is represented in figure 1.

We have chosen as a reference EUROFLIR system as a basis of comparison considering that it has the technical level (adequacy) 100.

We have set the subsets S_1, respectively I_1, and S_2, respectively I_2 so:

-S_1, the subset of parameters which as they have higher values, the system is the most appropriate and I_1 the subset of appropriate indicators;

-S_2, the subset of parameters which as they have the values lower, the system is more appropriate to be used I_2 the subset of appropriate indicators.

Table 2. The matrix of the calculation of the weights

	a_1	a_2	a_3	a_4	a_5	a_6	$\sum_{r=1}^{6} a_{ir}$
a_1	0	2	2	0	0	0	4
a_2	0	0	1	0	0	0	1
a_3	0	1	0	0	0	0	1
a_4	3	3	3	0	1	2	12
a_5	3	3	3	1	0	2	12
a_6	2	2	2	0	0	0	6
							$\sum_{i=1}^{6}\sum_{r=1}^{6} a_{ir} = 36$

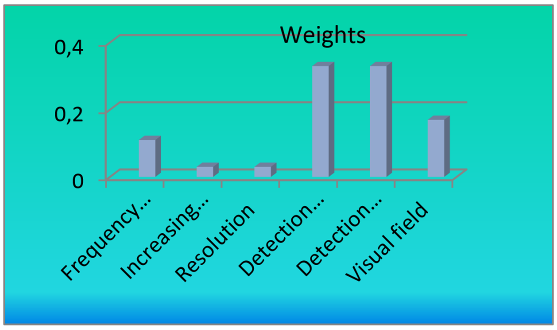

Fig. 1. The weights depending on specific parameters

For our case (m = 6), the subsets are:

$S_1 = \{C_3, C_4, C_5\}$ and $I_1 = \{3, 4, 5\}$

$S_2 = \{C_1, C_2, C_6\}$ and $I_2 = \{1, 2, 6\}$

We have calculated the technical coefficient according to the level of system integration (relative to the reference system S_2) in accordance with the relationship (3):

$$C_{NT_j} = \prod_{i \in I_1} \left(\frac{C_{ij}}{C_{ik}} \right)^{p_i} \cdot \prod_{i \in I_2} \left(\frac{C_{ik}}{C_{ij}} \right)^{p_i} \cdot 100, \quad (3)$$

where:

- C_{ij} represents the value of C_i parameter of j system;
- C_{ik} represents the value of C_i parameter of UT_k reference system.

For this case study I established m=6 and n=4. I considered the reference system S_2 as I previously specified, consequently C_{NT_2}, represents the coefficient of adequacy of the chosen reference system S_2 EUROFLIR, which is equal to 100.

The next step consists in calculation of the adequacy coefficient for system S_1 represented by C_{NT_1}

$$C_{NT_1} = \left(\frac{4800}{20736} \right)^{0.03} \cdot \left(\frac{7}{140} \right)^{0.33} \cdot \left(\frac{15}{180} \right)^{0.33} \cdot \left(\frac{5}{12} \right)^{0.11} \cdot \left(\frac{18}{2.5} \right)^{0.03} \cdot \left(\frac{31.2}{241.65} \right)^{0.17} =$$

$$= 0.96 \cdot 0.37 \cdot 0.44 \cdot 0.91 \cdot 1.06 \cdot 0.71 = 0.107$$

$$C_{NT_1} = 11 \text{ (approximated value)}$$

The adequacy coefficient for system S_3 is represented by C_{NT_3} :

$$C_{NT_3} = \left(\frac{3072}{20736}\right)^{0.03} \cdot \left(\frac{32}{140}\right)^{0.33} \cdot \left(\frac{5}{18}\right)^{0.33} \cdot \left(\frac{5}{14}\right)^{0.11} \cdot \left(\frac{18}{4}\right)^{0.03} \cdot \left(\frac{31.2}{55.47}\right)^{0.17} =$$

$$= 0.94 \cdot 0.61 \cdot 0.65 \cdot 0.89 \cdot 1.05 \cdot 0.91 = 0.3169$$

$$C_{NT_3} = 32 \text{ (approximated value)}$$

For the system S_4 the adequacy coefficient C_{NT_4} is calculated as follows:

$$C_{NT_4} = \left(\frac{32768}{207360}\right)^{0.03} \cdot \left(\frac{15}{14}\right)^{0.33} \cdot \left(\frac{20}{18}\right)^{0.33} \cdot (1)^{0.11} \cdot \left(\frac{18}{8}\right)^{0.03} \cdot \left(\frac{31.2}{30}\right)^{0.17} =$$

$$= 0.95 \cdot 1.02 \cdot 1.03 \cdot 1 \cdot 1.02 \cdot 1.01 = 1.0282$$

$$C_{NT_4} = 103 \text{ (approximated value)}$$

In conclusion, following the application of this method it was showed that system S_4 (MP3 Sights) has the highest coefficient of adequacy.

In terms of established performance criteria, current and future threats, and the most important requirements that must be have optoelectronic devices, MP3 Sights system is most suitable to be used. In addition, it could be a benchmark for design, construction, and use of other optoelectronic systems.

For optimal choice of these systems, we believe it is very important to determine and rank the performance criteria represented by their optical parameters.

It is also essential that these systems belong to the same category in terms of their performance.

3. Conclusions

After study and by accumulating information, which we have transposed in this work, I believe that optoelectronics applications plays a major role in the military environment optoelectronic devices used in contemporary conflicts ensure a decisive advantage on the side who use them as regards for obtaining the victory. Much more, in conditions of modern optoelectronic war we cannot talk about the destruction of the enemy troops without that they must first be discovered or if the aims may not perform under any conditions.

The work has had in view the construction of a complete image and suggestive connected with the problematic in the field, respectively a better understanding of the role and of the contributions, which the optoelectronics device bring in the field of modern fight.

From the category of optoelectronic devices used in modern military environment, aiming multisensor systems constitute a very capable midst of combat they managed to fulfill a variety of requirements depending on the type of combat missions and increase efficiency in battle by enhancing human skills. In support of this statement, in chapter two of this work we have highlighted the fact that the differentiation from the point of view of system performance multisensor optoelectronic which is made with the aid of technical parameters which are set, which in their turn are assessed by means of certain features.

The comparative analysis of systems of multisensor had the finality connected with establishing of the variance of the construction of the optimum optoelectronic equipment used in military equipment of the modern armies. To achieve this objective, we presented the main advantages and disadvantages of multisensor systems, we analyzed which is the most efficient type of power supply, and at the same time we have highlighted types of functional modules of this systems.

I think that the devices on the night time offers a technically superior unquestioned, because we must consider the fact that the actions of fighting takes place in a fast pace in space and time, without differences between day and night. The means of fighting used by the enemy forces can be very precise and with a great power of destruction and non-disclosure at the time of the coming enemy, because of the reduced visibility, can be a high price in the final result of the fight.

The application of the engineering method value in order to achieve the proposed objective, in the calculation of the coefficients of technical level and of the shares of each criterion, as well as in the illustration and the interpretation of the results of the study in graphical form.

By analyzing the results of the case study, I think that for an optimal choice of optoelectronic systems it is very important to establish and prioritize the performance criteria on the basis of their contribution to the fulfillment of mission and it is essential that the systems to be part of the same category from the point of view of these performance.

In conclusion, in a military environment found in continuous change an environment alert in which it is desirable to be all the time with one step ahead of the enemy, is normal the concerning of the specialists in all categories of weapons for the knowledge, development and improvement of the optoelectronics devices in order to be able to use them as well in the fight.

References

1. Pearsică, M., Răcuciu, C., Radu, A. (2004): *Dispozitive optoelectronice și aplicații.* Editura Academiei Forțelor Aeriene „Henri Coandă", Brașov, Romania (in Romanian)
2. Voiculescu, E., Marița, T. (2001): *Optoelectronică.* Editura Albastră, ISBN 973-9443-96-6, Cluj-Napoca, Romania (in Romanian)
3. Necșoiu, T. (1990): *Echipamente de termoviziune.* Editura Tehnică, București, Romania (in Romanian)
4. Cojoc, D., Drăgulinescu, A. (2009): *Optică tehnică*. Editura Matrix Rom, ISBN 978-973-755-531-1, București, Romania (in Romanian)
5. http://sofradir-ec.com/hownightvisionworks/
6. Lefebvre, E. (2007): *Advances and Challenges in Multisensor Data and Information Processing*. IOS Press, ISBN 9781586037277
7. * * *: http://www.finmeccanica.com/en/-/aspis-1
8. * * *: ATN ThOR 3 Thermal Weapon Sight
9. Crețu, E., Nicoară, I., Spulber, C. (2001): *Calculul și construcția aparaturii optoelectronice*. Editura Academiei Tehnice Militare, București, Romania (in Romanian)
10. Spulber, C., Mârzu, M., Crețu, E. (1999): *Sisteme optoelectronice de vedere pe timp de noapte*. Editura Academiei Tehnice Militare, București, Romania (in Romanian)

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