SECTION IX. MILITARY SCIENCES, NATIONAL SECURITY AND SECURITY OF THE STATE BORDER

DOI 10.36074/logos-18.08.2023.23

JUSTIFICATION OF THE TYPE AND VOLUME OF RESERVE OF ELEMENTS RECONNAISSANCE-FIRE SYSTEM

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The results of the analysis military conflicts of the last decades [1–4] indicate an increase in the share of tasks involving the destruction of targets by reconnaissance-fire systems (RFS). However, as the weight of these systems increases, the volume of measures to counteract them increases [3–5]. According to [6], the more effective a weapon sample is, the more efforts are made to neutralize it. That is, the greater the role RFS in the confrontation, the more effort is devoted to fighting them, therefore, the less stable its functioning will be, which in turn will lead to a decrease in the effectiveness of their use.

To increase the ability of complex military systems to function in conditions of various failures, a reserve of forces and means is planned. In general, two main types of reserve are considered - loaded and unloaded [7]. At the same time, taking into account the conditions of operation of reconnaissance and fire systems, it is impossible to unambiguously determine the volume and type of reserve of elements to achieve the required level of stability of the operation of the system as a whole.

To assess the stability of RFS functioning during a military (combat) activity, we applied methods from a reliability theory [8–10]. In particular, to calculate the operational stability of non-renewable RFS with the active redundancy of structural and functional elements, a method for calculating the probability of trouble-free operation of a non-renewable system with an active redundancy [8–10] was employed. The initial data for this method are the total number of individual structural and functional elements (n), the failure intensity rate (λ), the duration of a military (combat) activity (RFS operation time) (t), the number of redundant elements (ne). A general view of the structural scheme of RFS reliability with the active redundancy of structural and functional elements is based on data from [8]; it is shown in Fig. 1.

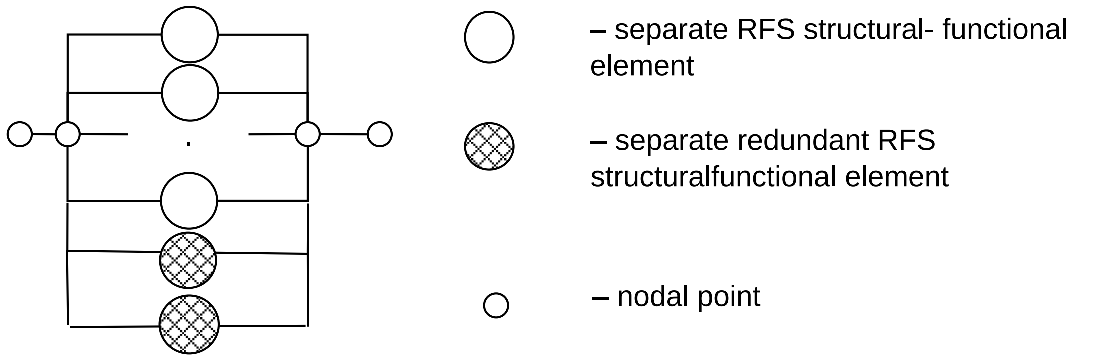

Fig. 1. **Structural diagram of the reliability of RFS with active redundancy of structural and functional elements**

Accordingly, the probability of trouble-free operation of RFS with the active redundancy of structural and functional elements is calculated from the following formula given in [8-10]:

$$P(t)_{r,ar} = 1 - (1 - e^{-\lambda t})^{n_e + 1}, \tag{1}$$

To calculate the functional stability of RFS with passive redundancy of structural-functional elements, we used a method for estimating the probability of the failure-free operation of a non-renewable system with passive redundancy [8, 9]. The initial data for this method are the same as for the method of calculating the probability of trouble-free operation of RFS with active redundancy. A general view of the structural scheme of the reliability of RFS with passive redundancy of structural-functional elements is based on data reported in [8]; it is shown in Fig. 2.

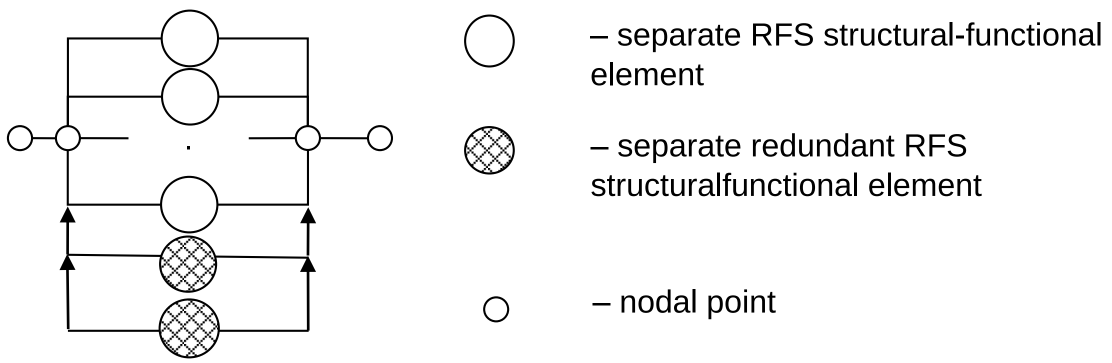

Fig. 2. **Structural scheme of the reliability of RFS with passive redundancy of structural-functional elements**

Accordingly, the calculation of the probability of the failure-free operation of RFS with passive redundancy of structural-functional elements is based on the following formula given in [8-10]:

$$P(t)_{r,pr} = e^{-\lambda t} \sum_{i=0}^{n_e} \frac{(\lambda t)^i}{i!}, \tag{2}$$

To assess survivability as a component of the stability of RFS functioning with various structural and functional schemes, a brute force method [9] is used. The essence of the method is to compare the performance coefficients of several structural and functional schemes by sequentially checking the system for survivability in case of the consistent failure of system elements. The application of this method could be visually represented in the form of a table of performance coefficients for two schemes (Table 1)

Table 1

Performance coefficients of RFS (for two schemes)

State No.	System element			Loss		Performance coefficient Kj	
	1	. . .	*n*	Scheme 1	Scheme 2	Scheme 1	Scheme 2
1	0		1	$l_{1.1}$	$l_{2.1}$	$K_{1.1}$	$K_{2.1}$
.	.	. . .	.	.	.	.	.
n_j	1	. . .	0	$l_{1.j}$	$l_{2.j}$	$K_{1.j}$	$K_{2.j}$

An indicator of RFS survivability under this method is the mathematical expectation of the number of working elements [9]:

$$M_s = \sum_{j=1}^{n} K_j P_j, \tag{3}$$

where, M_s – is the mathematical expectation of the number of working elements of the system;
K_j – is the performance coefficient of the system in the j-th state, it is determined from formula $K_j = \frac{n_{w,j}}{n}$ [9];
$n_{w,j}$– is the number of working elements of the system;
n– is the total number of the system's elements;
n_j– is the number of the j-states of the system;
P_j–is the probability of the j-th state of the system determined from the following formula given in [10]:

$$P_j = 1 - C_n^l q^l (1-q)^{n-l}, \tag{4}$$

where, l– is the number of simultaneous failures by the elements of the system;
q– is the probability of failure of the system element.

The application of the proposed approach will allow to substantiate the type and volume of the reserve of structural and functional elements for any type of reconnaissance-fire systems, which has three subsystems (reconnaissance, control, fire influence) taking into account the peculiarities of its operation.

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