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METHOD OF ASSESSMENT OF INFORMATION AVAILABILITY OF RADIO INFLAMMATION SOURCES BY DEVICES OF RADIOELECTRONIC RECOGNITION

Providing information superiority over the enemy is becoming a prerequisite for conducting military operations. The main type of information support is military intelligence, and its basis is radio-electronic intelligence. During the analysis of the known scientific achievements in the direction chosen by the authors of the research it was established that at present there is no general methodology for assessing the capabilities of the forces and devices of radio-electronic intelligence for the information (reconnaissance) availability of electronic intelligence sources that is suitable for the use in automation devices of various control units, which connects separate indicators of information accessibility in generalized on the basis of the use of modern intelligence-information models. The authors of this research conducted a methodology for assessing the availability of radio-emission sources by the devices of radio-electronic intelligence. In the course of the research, the authors used the basic provisions of the theory of radioelectronic intelligence, the theory of communication, the theory of electronic warfare, the theory of signals, and general scientific methods of analysis and synthesis. The technique developed by the authors makes it possible to evaluate sources of electronic intelligence from the point of view of the expediency of including in the outline the distribution of forces and devices for different conditions of the situation (stages of combat or operations), effectively manage the forces and devices of extraction and processing in the interests of solving radio-electronic intelligence tasks, and evaluate the degree of this efficiency. This technique, which is an integral part of the general methodology for the distribution of forces and intelligence, can be applied at the command posts (grouping of troops, military units) of electronic intelligence and will increase the efficiency of conducting searches of sources and objects of electronic intelligence, as well as the distribution of forces and resources for tasks, objects and sources. In addition, it can be used to assess the effectiveness of existing and promising devices and complexes of electronic intelligence and electronic warfare. Taking into account the above, the direction of further research should be considered the development of scientific and methodical apparatus for improving the efficiency of conducting radio-electronic intelligence.

Keywords: radio communication systems; radio resources, noise immunity; radio electron suppression; radio-electronic intelligence; secrecy.

Introduction

In the traditional theory of radio electronic intelligence (REI), the information (intelligence) accessibility (IA) of a control and communication system is understood as a set of inherent intelligence management and communication features that allow to disclosure this system with a given probability for a given time [1–3].

Information accessibility in one or another degree is evaluated for solving the following tasks:

conducting a search of sources and objects REI;

calculation of objects and sources of REI during the analysis of the radio electronic environment (REE);

distribution of forces and resources according to tasks, objects and sources;

evaluation of the effectiveness of the developed facilities and complexes.

In practice, the evaluation of the IA is not fully implemented.

For solving search problems in peacetime conditions for the usual environment (due to the uncriticality of the problem-solving cycle), a predominantly "bunching method of detecting and defending the noise" sources of REI is widely used. In this case, in the course of the noise defense, as a rule, only qualitative (whether or not), semantic, hardware and sign availability are determined, which is determined on condition of obtaining a full indication of the implementation of all types of actions: interception, routing, technical analysis and processing.

For other conditions REE, there are regimes of gaining an association with an increase in the total resource and normatively distributed resource for possible sources without a detailed calculation of their IAs, taking into account the time costs and the authenticity of the detection. The purposefulness of the search for these conditions from the point of view of the REE detection cycle is low primarily due to the lack of reliable predictive estimates of sources of IAs and the general methodology for evaluating the capabilities of the RAI system by source IAs [3, 6].

In order to calculate objects and sources, the IA is evaluated basically qualitatively (whether or not) in the form of electromagnetic availability (EMA) for regulatory distances for typical frequency ranges, excluding the radiated power of radio emission sources, the nature of the terrain and the type of waves.

The evaluation of the effectiveness of facilities and complexes that are developed for solving the problems of detecting a control system (CS) and radio technical provision (RTR) of an eventual opponent is carried out on separate indicators of the IA – EMA and partially hardware.

The question of formalization, and even more so, the automation of the basic processes of IA evaluations

for various conditions of the REE and individual stages of the conduct of hostilities are not resolved. The causes of the main shortcomings in the practice of assessing the IA are the disadvantages of the theory. The urgency of the research topic is stipulated [5, 7]:

the lack of a common methodology for assessing the capabilities of REI forces and devices for informing (intelligence) availability of REI sources suitable for the use in the automation tools of various management units, linking individual IA indicators to a generalization based on the use of modern intelligence-information models (IIM);

the account of optimal topologies (combat orders) of the elements of the REI system, its operational and technical characteristics for the analysis of the interrelationships between components of the IA in the interests of quantitative generalized evaluation of both for the sources of radio inquiries (PI) and radio engineering intelligence (REI);

low criticality to the solvable problem of the used private indicators of the IA in the form of qualitative assessments, the lack of a quantitative description of the most of them, the mistaken orientation of qualitative assessments on the organization of management and communication of traditional systems 80-90-th, which prevents reliable estimates of the IA and on their basis to form an optimal (suboptimal) plan for resource allocation;

low indicators of adequacy apply models, especially in perspective communication systems, for groups of "modular forces", their control systems based on complex automated systems and low-structural availability public communication systems using networks with self-organization and satellite communication systems (WIN-T program). The modern communication system is in line with the concept of the NNEC (NATO Network Enabled Capability), which is based on the American concept of NCW (Network-Centric Warfare) [3, 4].

Without solving these problems, the quality of the task of assessing the capabilities of the REI forces and devices of information (intelligence) availability of REI sources in the interests of the first division of forces and resources in the REI planning and, therefore, the execution of tasks for the purpose, will steadily decrease.

The purpose of this article is to develop a methodology for assessing the availability of radio emission sources by devices of radio-electronic intelligence.

Presentation of the main material

The method of estimating the capabilities of REI forces and devices of information (intelligence) availability of REI sources is an element of the general methodology for the distribution of forces and devices of reconnaissance and presents a set of elements (methods, operations) of the traditional and proposed scientific and methodical apparatus, based on which is a combination of statistical and logical methods calculation, applied in a certain logical sequence for the formation of adequate components: the potential, technical and real sources of REI sources.

The method makes it possible to evaluate REI sources from the point of view of the expediency of including in the initial plan distribution of forces and devices for different conditions of the situation (stages of battle or operation), effectively manage the forces and devices of extraction and processing in the interests of solving the problems of REI and assess the degree of efficiency.

The basis of the developed methodology is the structural-spatial models of the location of objects and sources on the ground for each group activity, the model of the combat forces and REI devices [7, 9]. They describe the classes of classes of activity, their interrelation with objects and sources, the characteristics of the latter from information groups, the distribution of depth and manifestation in the objects of the REI, as well as the optimal military units of the REI unit (military unit or connection) for different conditions of the situation. The structure of the proposed method is presented in Fig. 1.

The most important elements of it are three partial methods: formation and maintenance of the database of the characteristics of communication systems (CS) and radiocommunication grouping [8, 11]; formation of

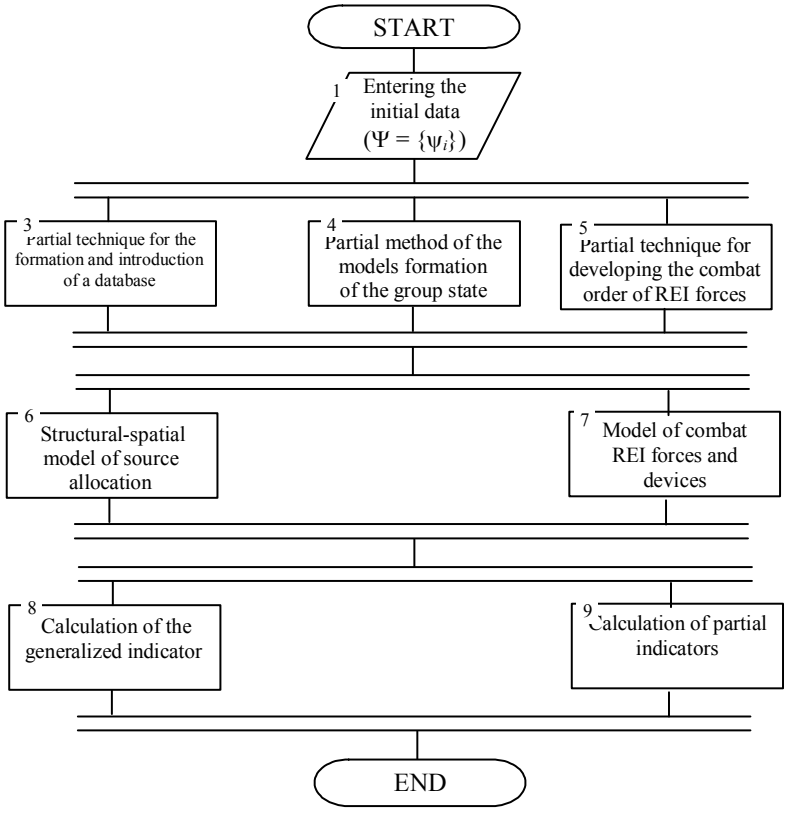

Fig. 1. Algorithm for implementing the proposed methodology

models of manifestation of the states of the grouping through the sources (objects) of the REI and their reconnaissance features (RF) of varying degrees of similarity [7]; the development of combat forces and REI forces [7].

The source for data evaluation are: intelligence-information models of groups of states (hypothetical, reference and working) [7, 10]; combat and numerical composition of the faction of an eventual enemy; reference data on the military use of the Armed Forces, the CS and the RTS (statutes, concepts and av.); the composition of the REI forces and devices and their operational characteristics.

In this methodology, while solving the problems of assessing the capabilities of the forces and devices of the REI, the following restrictions and assumptions are imposed on the sources of the REI's data:

the apparent availability of REI sources is determined from the point of view of solving problems of recognition of operational-tactical appointment (OTA) sources, the disclosure of objects through them;

the assessment of the IA capabilities is carried out primarily in the interests of the distribution of forces and devices, while this assessment is an essential component in calculating the importance (informative) of the source of intelligence, which is determined by the probability of information availability of the P_{av} source, the importance of the objects that are part of the source, the amount objects in the network;

the resource is distributed for all types of posts: existing complexes and prospective complex [2], management and processing posts are taken into account while calculating the intelligence (sign) availability [6];

the search and observation organization model is consistent, the search is conducted in terms of frequency, space and sources.

As a method for solving the problem of estimation, as shown by the analysis of its dimension and an analysis of the calculating individual indicators methods, the integration of statistical and logical calculation methods [6] can be used, which allows for the introduction to restrict on the computing space.

Models are formed for three levels of their similarity: hypothetical (absolute similarity), reference and work (full similarity).

To evaluate the availability of REI sources, we introduce generalized and partial indicators based on the following considerations:

The generalized indicator should evaluate the possibility of the IA as a whole, and partial (individual elements): the potential accessibility [10], technical, authenticity of detection time. Based on the requirements of the system approach, the theory of similarity of the model and the real system, as well as using the basic requirements for intelligence as characteristics: completeness, timeliness and reliability, we will conduct the synthesis of indicators.

A generalized indicator of the IA will be determined to take into account the following components of the evaluation as real intelligence availability based on the statistical model [6]:

the probability of potential accessibility (P_{pav}) consisting of partial indexes of IAs: semantic probability (P_{sav}), sign (P_{sign}) and structural (P_{str}) accessibility. It implements basically its own characteristics of the security of intelligence control systems (levels of information processes of the interaction of open systems model) [8, 10];

the probability of technical availability (P_{tav}), consisting of partial indicators of the IA: the probabilities of electromagnetic (P_{pre}), spatial (P_{spat}), hardware (P_{har}) availability. It characterizes basically its own capabilities of the REI system to detect communication processes at different levels of the model of open systems interaction (physical, data transmission and network levels).

Then the generalized indicator of the capabilities of the forces and devices of radio intelligence on the *i*-th IA source will look

$$P_{iavi} = P_{tavi} P_{pavi},$$

where i is the serial number of the REI source; P_{tavi} is the probability of technical availability of the first REI source; P_{pavi} is the probability of potential informational accessibility of the first REI source.

The probability of potential availability (P_{pav}) of the sources of radio inquiries will be determined by the implementation of at least one event the possibility of its constituent elements and is calculated by the formula

$$P_{pav} = 1 - \left(1 - P_{savi}\right)\left(1 - P_{signi}\right)\left(1 - P_{stri}\right).$$

The probability of technical availability (P_{tech}) of the sources of radio inquiries will be calculated as the intersection of the events of the implementation of its constituent elements:

$$P_{techi} = P_{prei} P_{spati} P_{hari.}.$$

In order to make a decision to include the REI source in the outline of the distribution of forces according to the indicator of information accessibility (without taking into account the comprehensiveness of object coverage), it is expedient to select the following criteria: when $P_{iav} < 0,2$ (low), it is inappropriate to plan the source for inclusion in the outline of the distribution of forces and devices for REI conducting; when $P_{iav} = 0,2 - 0,5$ (average), it is possible to plan a source for REI conducting; when $P_{iav} > 0,5$ (high) - the source is appropriate to plan for conducting intelligence.

Consider separate indicators of information accessibility, synthesizing them in a probabilistic form.

The semantic availability of the control system is determined by the degree of the use in it of the individual and group linear encryption equipment, the use of structural encryption, the stability of the methods used by radio control methods of the secret control of troops (card coding, formalization of messages, improvement of protocols and services model of interaction of open networks), language barrier, manifestation of semantic radio transmitter to recognize objects and states.

To calculate the capabilities of forces and devices of radio intelligence on the semantic availability of the source it seems logical to calculate the proportion of open, encoded, encrypted and formalized messages in his work and taking into account the availability of each type of message to determine their total probability as a measure of generalized availability.

In this case, the probability of the semantic availability of the *i*-th source will be calculated according to the formula

$$P_{savi} = K_{oi}P_{stri} + K_{ki}P_{stri} + K_{ei}P_{savi} + K_{fi}P_{savfi},$$

where $K_{o(c,e,f)}$ is the coefficient, taking into account the share of open (coded, encrypted, formalized) messages in the work of sources, calculated as the ratio of the number of open (coded, encrypted, formalized) messages to the total, respectively;

$P_{sav(c,e,f)}$ is the probability of semantic accessibility of open (coded, encrypted, formalized) messages, which is expressed as the ratio of accessible and inaccessible messages of this type from the point of view of the manifestation devices of semantic intelligence for the recognition of objects and states.

The significance of accessibility is determined by the stability of the manifestation of the intelligence of the system of communication and radio engineering, as well as the cost of the forces and devices to detect or confirm them [11, 12].

As a result of the analysis, it was found that the most expedient to assess the sign availability on the stability of manifestation (informative) of structural-statistical (logical) reconnaissance signs of recognition: operative-tactical assignment of the REI sources; operational-tactical affiliation (OTA) of objects through the REI sources; states of activity through the REI sources.

It is obvious that the capabilities of REI forces and devices for the apparent availability of sources will be expressed in terms of the probability of the apparent availability of the sources (P_{sign}), which in this case will be calculated according to the formula

$$P_{signi} = 1 - \left(1 - P_{avri}P_{spati}\right)\left(1 - P_{avsi}\right),$$

where $P_{avri(spat,avs)}$ is the probability of recognition of the *i*-th source (objects, states of activity), the calculation of which is carried out in accordance with the statistical recognition theory (the Bayes scheme for sources, recognition through the main and subordinate sources of sources for the objects, on the basis of the logical method by analyzing and deciding on the manifestation of intelligence attributes through sources for the object states of activity (0 or 1) [5, 12].

The structural availability of the communication system is determined by the degree of correspondence of the structure of the communication system and radio technical support to the structure of the control system of troops and weapons.

The capabilities of the REI forces and devices of structural accessibility are logically expressed due to the probability of structural accessibility, the size of which will be affected by the degree of compliance of the structure (spatial and managerial) of the communication system structure control system, the accuracy of the location of sources of radio emission, as well as to detect a change in the location of sources (objects) while changing the state of the group.

Given the high cost of time and the complexity of calculating the accuracy of the location for each correspondent network, determining the quantitative assessment of the correspondence degree of the communication system management system, it is advisable to analyze the probability of structural accessibility on the basis of average estimates by the types of communication systems and graduation distance from line of forces collision: $P_{str} = 0,5 - 0,75$ for team communication; $P_{str} = 0,1 - 0,3$ for general communications systems.

The electromagnetic availability of intelligence sources is quantified by the maximum distance between the points (areas) of the REI facilities and sources of radio-emission location, in which sources of detection are ensured. The magnitude of electromagnetic availability is influenced by various factors, the main of which are:

parameters of the radio-emitting radiation sources (frequency range, power, type of radiation, antenna gain, taking into account losses in the antenna feeder path);

parameters of the REI devices (sensitivity of receiving devices and the gain of the antenna-feeder path);

conditions for the radio waves propagation for frequency ranges.

The content of the traditional indicator is described in detail in [12].

While assessing the capabilities of REI forces and devices of electromagnetic availability of REI sources, consisting of several sources of radio emission, there are different options for calculations: the main station network, network area, the most distant correspondent network (in theory, this is not defined).

The indicator of the location of objects (sources of radio emission) in the estimation of the P_{pre} sources can be synthesized in the following form: while placing objects (sources of radio emission) belonging to the *i*-th source, for the full depth of operative construction in all zones, we accept $P_{pre} = 0,7$; when placed in several zones - $P_{pre} = 0,8$, when located only in one zone (in the 1-st echelon, in the 2-nd or in the reserve) - $P_{pre} = 1$.

Spatial accessibility is determined by the assessment of the capabilities of the REI system to ensure the availability of electromagnetic access from the Earth, flight-lifting, space and floating devices for all sources of radio emission.

It is logical to conduct a calculation for maximum electromagnetic availability, and the probability of spatial availability to be determined as the ratio of the time spent in the radio emission source in the area of a maximum electromagnetic availability for the appropriate location of the installation of REI facilities to the cycle of intelligence:

$$P_{spati} = t_f / T_c ,$$

t_f is the total time of finding the source in the zone of maximal electromagnetic availability; T_c is the total time of the intelligence cycle.

Hardware availability is determined by the degree of the forces and devices expenditure of the REI to detect, beam and intercept signals from emitters entering the communication system (radio equipment).

It is logical to count on the availability of hardware on the most important of its characteristics, expressed in a probabilistic form: by frequency (P_{avf}); in the form of a signal (P_{avs}); in the form of used gears (P_{avg}).

Thus, the probability of hardware availability, based on the analysis, will be calculated as the intersection of all three characteristics (events):

$$P_{har} = P_{avf} + P_{avs} + P_{avg} .$$

At the same time, the probability of availability of hardware by frequency, taking into account a rather long cycle of intelligence, will be determined:

$$P_{avf} = \Delta F_{pi} / \Delta F_i ,$$

where ΔF_{pi} is the frequency bug of the source in which signal reception by the intelligence devices is possible;

ΔF_i is the frequency range in which the operation of the indicated source is possible.

The probability of hardware availability by the type of signal obviously needs to be considered as the ratio of the number of types of signals that can use the source and available to the REI devices - K_{di} (by the demodulation, registration, etc.) to the total number of signal types on which the K_{si} source can function

$$P_{hari} = K_{di} / K_{si}.$$

The probability of hardware availability according to the type of used transmissions can be calculated as the ratio of the gear types number on which the source operates and the forces and devices of intelligence capable of intercepting them are K_{ii} to the total number of transmissions types in which the K_{souri} source operates:

$$P_{hari} = K_{ii} / K_{souri}.$$

Consequently, in the general form, the probability of the hardware availability of the *i*-th source will be calculated as

$$P_{hari} = P_{prei}\left(\Delta F_{pi} / \Delta F_i\right)\left(K_{di} / K_{si}\right)\left(K_{ii} / K_{souri}\right).$$

Thus, the probability of information availability of the REI source will be calculated according to the following expanded formula:

$$P_{hari} = \left(\Delta F_{pi} / \Delta F_i\right)\left(K_{di} / K_{si}\right)\left(K_{ii} / K_{souri}\right)\times$$
$$\times\left\{\begin{array}{l}\left[1-\left[1-\left(K_{oi}P_{stri}+K_{ki}P_{stri}+K_{ni}P_{ni}+K_{fi}P_{fi}\right)\right]\times\right.\\ \left.\left[1-\left(1-\left(1-P_{ii}P_{spati}\right)\left(1-P_{spati}\right)\right)\right]\left[1-P_{stri}\right]\right.\end{array}\right\}.$$

The conclusion from the article

The method developed in the article allows to estimate the sources of the REI in terms of the expediency of including in the outline distribution of forces and devices for different conditions of the situation (the stages of the battle or operation), effectively managing the forces and devices of extraction and processing in the interests of solving the REI problems and assessing the degree of this efficiency.

This method, which is an integral part of the general methodology for the distribution of forces and devices of reconnaissance, can be applied at command posts (grouping, military unit and subunit), and will increase the efficiency of conducting the search for the REI sources and objects, as well as the forces and devices distribution for tasks, objects and sources. In addition, it can be used to assess the effectiveness of existing and promising tools and REI and RES complexes.

Taking into account the above, the direction of further research should be considered the development of scientific and methodical apparatus for improving the efficiency of conducting radio-electronic intelligence.

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Методика оцінки інформаційної доступності джерел радіовипромінювання засобами радіоелектронної розвідки

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Забезпечення інформаційної переваги над противником на сьогодні стає основною умовою для ведення воєнних операцій. Основним видом інформаційного забезпечення є воєнна розвідка, а її основою – радіоелектронна розвідка. В ході проведення аналізу відомих наукових досягнень в обраному авторами дослідження напрямку встановлено, що на даний час відсутня загальна методика оцінки можливостей сил і засобів радіоелектронної розвідки по інформаційній (розвідувальній) доступності джерел радіоелектронної розвідки, що є придатною для використання в засобах автоматизації різних ланок управління, що зв'язує окремі показники інформаційної доступності в узагальнений на основі використання сучасних розвідувально-інформаційних моделей. Авторами зазначеного дослідження було проведено розробку методики оцінки інформаційної доступності джерел радіовипромінювання засобами радіоелектронної розвідки. В ході дослідження авторами були використані основні положення теорії радіоелектронної розвідки, теорії зв'язку, теорії радіоелектронної боротьби, теорії сигналів та загальнонаукові методи аналізу та синтезу. Розроблена авторами методика дозволяє оцінювати джерела радіоелектронної розвідки з точки зору доцільності включення в вихідний план розподілу сил та засобів для різних умов обстановки (етапів бою або операції), ефективно управляти силами і засобами добування і обробки в інтересах вирішення задач радіоелектронної розвідки та оцінювати ступінь цієї ефективності. Дана методика, що є складовою частиною загальної методики розподілу сил і засобів розвідки, може бути застосована на командних пунктах (угруповання військ, військової частини і підрозділу) радіоелектронної розвідки і підвищить ефективність ведення пошуку джерел і об'єктів радіоелектронної розвідки, а також розподілу сил і засобів за завданнями, об'єктами і джерелами. Крім того, вона може бути використана для оцінки ефективності існуючих та перспективних засобів і комплексів радіоелектронної розвідки і радіоелектронної боротьби. Враховуючи зазначене, напрямком подальших досліджень слід вважати розробку науково-методичного апарату підвищення ефективності ведення радіоелектронної розвідки.

Ключові слова: система радіозв'язку; радіоресурс; завадозахищеність; радіелектронне подавлення; радіоелектронна розвідка; скритність.

Методика оценки информационной доступности источников радиоизлучения средствами радиоэлектронной разведки

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Обеспечение информационного превосходства над противником на сегодня становится основным условием для ведения военных операций. Основным видом информационного обеспечения является военная разведка, а ее основой – радиоэлектронная разведка. В ходе проведённого анализа известных научных достижений в выбранном авторами исследования направлении установлено, что в настоящее время отсутствует общая методика оценки возможностей сил и средств радиоэлектронной разведки по информационной (разведывательной) доступности источников радиоэлектронной разведки, пригодной для использования в средствах автоматизации различных звеньев управления, связывающей отдельные показатели информационной доступности в обобщенный на основе использования современных разведывательно-информационных моделей. Авторами указанного исследования была проведена разработка методики оценки информационной доступности источников радиоизлучения средствами радиоэлектронной разведки. В ходе исследования авторами были использованы основные положения теории радиоэлектронной разведки, теории связи, теории радиоэлектронной борьбы, теории сигналов и общенаучные методы анализа и синтеза. Разработанная авторами методика позволяет оценивать источники радиоэлектронной разведки с точки зрения целесообразности включения в исходный план распределения сил и средств для различных условий обстановки (этапов боя или операции), эффективно управлять силами и средствами добычи и обработки в интересах решения задач радиоэлектронной разведки и оценивать степень этой эффективности. Данная методика, которая является составной частью общей методики распределения сил и средств разведки, может быть применена на командных пунктах (группировка войск, воинской части и подразделения) радиоэлектронной разведки и повысит эффективность ведения поиска источников и объектов радиоэлектронной разведки, а также распределения сил и средств по задачам, объектам и источникам. Кроме того, она может быть использована для оценки эффективности существующих и перспективных средств и комплексов радиоэлектронной разведки и радиоэлектронной борьбы. Учитывая указанное, направлением дальнейших исследований следует считать разработку научно-методического аппарата повышения эффективности ведения радиоэлектронной разведки.

Ключевые слова: система радиосвязи; радиоресурс; помехозащищенность; радиоэлектронное подавление; радиоэлектронная разведка; скрытность.