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PARAMETERS NUMERICAL VALUES OF ERRORS DISTRIBUTION LAW IN COORDINATE MEASURING PROCESS AT THE DIFFERENCE-DISTANCEMEASURING PASSIVE LOCATION METHOD

In this article a method for measuring clarifying error distribution laws of spatial coordinates of the aircraft is developed, the numerical values of distribution parameters is assessed. It was determined that commonly measuring errors in the difference ranging method of passive radar obey Charlier law.

Keywords: *passive radiolocation, difference distance measuring method, the distribution law of errors.*

Introduction

Problem statement. One of the most important theoretical and technical solutions to ensure the required accuracy of determining the coordinates of attack aviation aircraft operating in the widespread use of forces and means of radio electronic warfare, is the use of passive radiolocation information subsystems.

Literature analysis. Analysis of passive systems functioning accuracy is well known and discussed in detail in [1–6]. In these research, accuracy issues are discussed mainly as applied to the problem of determining the distance to the radio-emitting targets in polar and rectangular coordinate systems at difference ranging method of passive radar. In addition, usually it is considered a reception center symmetrical arrangement place of acceptance, and the distribution law of coordinate measurement error is normal. It is obvious that at reception center arbitrary location places to the direction airplane motion the law of distribution of measurement errors will be different from the normal, that is a consequence of the system of difference solutions of nonlinear equations.

The purpose of the article. Development of the method for determining the distribution laws of the measurement error of the spatial coordinates the aircraft at the difference distance measuring method, passive location and clarification of the numerical parameter values of the distributions laws.

Main material

For design values measurement errors rectangular aircraft coordinate method of statistical test was used. A calculating program is implemented MAPLE package due to were obtained histogram distributions of errors in determining aircraft coordinate system with the coordinates of the proposed statistical sample size, which provides the necessary validity of the results [7].

synchronization system error of unified time is 0.01 ms [8]. In this case, the mean square error (MSE) of the difference distance value will be 4.2 meters and will be the same for all places of acceptance, places of acceptance coordinates unchanged. Positioning measurement error means of instrument provides navigation aids and amounts to 15 m. In the calculations it was considered that aircraft flying level is 1000 m, and its other coordinates correspond to:

– far bound of detection zone (18 km);

– far bound of target designation (13 km);

– far bound of missile weapons defeat zone (8 km);

– far bound artillery weapons defeat zone (4 km).

In determining error distribution laws of coordinates measuring based on the resulting calculation of histograms, following continuous theoretical distributions have been selected with the possible values on the whole numerical axis [9; 10]:

1. the normal distribution law;
2. double-sized exponential distribution (Laplace distribution);
3. Cauchy distribution;
4. minimum value distribution;
5. maximum value distribution;
6. dual exponential distribution;
7. logistic distribution;
8. Champernaun distribution;
9. Charlier distribution.

To determine the numerical values of parameters distributions the method of least squares approximation to within 10^{-6} was used. As a fit test criterion was selected with specification the distribution of the type χ^2 Person with a 5% significance level.

As an example method of determining the type theoretical distribution of the histogram by data approximation is obtained by the statistical tests method,

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aircraft coordinates x = 18000 m, y = 9000 m, z = 1000 to z-th component.

Fig. 1 shows the initial histogram describing the distribution of measurement error of z coordinate.

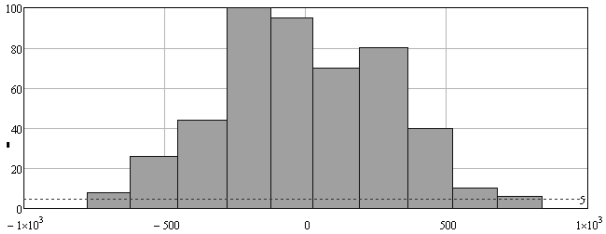

Fig. 1. Initial histogram

Then it is shown its using the method of minimal squares with error 10^{-6} for each of the above 9 theoretical distributions are determined by their parameters.

After determining numerical values parameters of the probability density for each of the laws (fig. 2), the theoretical probability density (fig. 3) for each of the error values of original histogram may be determined.

Calculations result is determined that the aircraft coordinate measurement errors for the selected direction obey the law Charlier with the distribution density [9]:

$$f(x)=\frac{1}{\sigma}\phi\left(\frac{x-\mu}{\sigma}\right)\left\{1+\frac{\gamma_1}{6}\left[\left(\frac{x-\mu}{\sigma}\right)^3-3\left(\frac{x-\mu}{\sigma}\right)\right]+\right.$$
$$\left.+\frac{\gamma_2}{24}\left[\left(\frac{x-\mu}{\sigma}\right)^4-6\left(\frac{x-\mu}{\sigma}\right)^2+3\right]\right\},$$

where μ is the mathematical expectation;

σ is standard deviation;

γ_1 is the asymmetry;

γ_2 is the excess;

$\phi(x)$ is the probability density of the standard normal distribution.

The distribution function is:

$$F(x)=\frac{1}{2}+\Phi_0\left(\frac{x-\mu}{\sigma}\right)\times\left\{\frac{\gamma_1}{6}\left[\left(\frac{x-\mu}{\sigma}\right)^2-1\right]+\right.$$
$$\left.+\frac{\gamma_2}{24}\left[\left(\frac{x-\mu}{\sigma}\right)^3-3\frac{x-\mu}{\sigma}\right]\right\}.$$

Then the hypothesis that error is distributed by Charlier law with the specified parameters, which can be verified using the criterion Pirson consent with a 5% significance level. Similar check is subject to error, and the distribution of the hypothesis under other laws.

Given the data in fig. 3 can be calculated the probability that the error falls into defined range of the calculated and theoretical normal distribution:

$$P(\alpha \le X \le \beta)=F(\beta)-F(\alpha).$$

The calculated of the distribution function for this case and normal distribution are shown in fig. 4 (1 is derived law; 2 is normal distribution).

From the data analysis shown in fig. 4 it follows that the probability that the error in the measurement coordinate z, distributed by Charlier law and equal to 440 m, is 0.9. In a normal distribution this probability can be achieved when measuring error is 520 m.

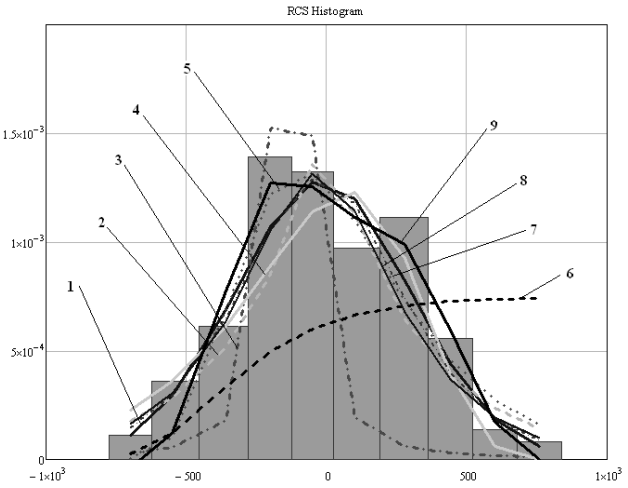

Fig. 2. The calculated value of the probability density for various distribution laws (numbers corresponds to the distribution form)

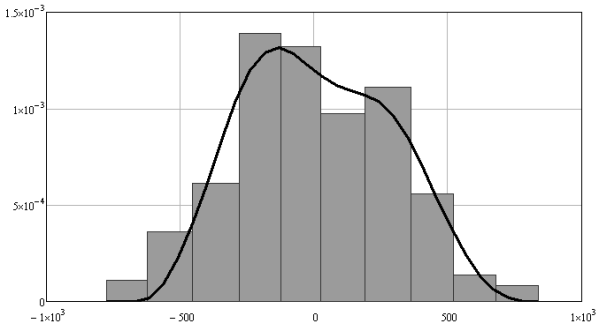

Fig. 3. Calculated probability density of errors measurement

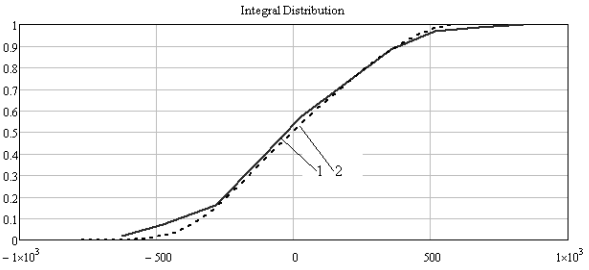

Fig. 4. A theoretical distribution function (1) and the distribution function of the normal distribution (2)

Assuming the probability P=0.9, which corresponds to the probability of aircraft capture at autofollow mode of automatic issuance of targeting in the absence of interference, we get that precise definition of

the error distribution law of coordinate measurement allows to speak about targeting errors reduction. This reduces the size of the search area and the reaction time of the complex in conditions of electronic suppression.

Findings

The calculation results show that the measurement error of rectangular coordinates of the aircraft at the difference distance measuring method, passive location, usually are subject to Charlier law. In most practically important cases, clarifying the error distribution law can improve the probability of tracking aircraft by issuing more precise targeting, allowing to reduce search area size and complex reaction time, which is important during the shooting.

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ЧИСЛОВІ ЗНАЧЕННЯ ПАРАМЕТРІВ ЗАКОНІВ РОЗПОДІЛІВ ПОМИЛОК В ПРОЦЕСІ ВИМІРУ КООРДИНАТ ПОВІТРЯНОЇ ЦІЛІ ПРИ РІЗНИЦЕВО-ДАЛЕКОМІРНОМУ МЕТОДІ ПАСИВНОЇ ЛОКАЦІЇ

В.В. Куценко, С.П. Коваленко, Д.Д. Добровольський

У роботі розроблений метод уточнення законів розподілу помилок виміру просторових координат літака, проведена оцінка числових значень параметрів законів розподілів. Визначено, що найчастіше помилки виміру при різницево-далекомірному методі пасивної радіолокації підкоряються закону Шарлье.

Ключові слова: *пасивна радіолокація, різницево-далекомірний метод, закон розподілу помилки.*

ЧИСЛОВЫЕ ЗНАЧЕНИЯ ПАРАМЕТРОВ ЗАКОНОВ РАСПРЕДЕЛЕНИЙ ОШИБОК В ПРОЦЕССЕ ИЗМЕРЕНИЯ КООРДИНАТ ВОЗДУШНОЙ ЦЕЛИ ПРИ РАЗНОСТНО-ДАЛЬНОМЕРНОМ МЕТОДЕ ПАССИВНОЙ ЛОКАЦИИ

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В работе разработан метод уточнения законов распределения ошибок измерения пространственных координат самолета, проведена оценка числовых значений параметров законов распределений. Определено, что наиболее часто ошибки измерения при разностно-дальномерном методе пассивной радиолокации подчиняются закону Шарлье.

Ключевые слова: *пассивная радиолокация, разностно-дальномерный метод, закон распределения ошибки.*