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JUSTIFICATION OF THE APPROACH FOR CALCULATING THE PARAMETERS OF AVIATION EMERGENCY AND RESCUE OPERATIONS WHEN USING VISUAL SEARCH

The proposed approach for substantiation of the parameters of visual search-and-rescue aircraft that associates features of a search object, altitude of the observer and bandwidth monitoring.

Keywords: visual search, search-rateline aircraft, search options.

Problem statement. One of the components of rescue operations is finding people who have experienced disasters, or so-called search objects (OS). With the uncertainty of the city accident/disaster or the whereabouts of the victims area of search can reach a considerable value (the search of the wreckage of aircraft or vessels, damaged pipelines, rescue boats with shipwrecked the like) and therefore the search operation is advantageously carried out with search-and-rescue aircraft (SRA). Search in some cases is carried out using electronic methods, but often by direct visual inspection by the crew SRA zone observations or analysis of the images transmitted from unmanned aerial vehicles.

The procedure for conducting the visual search with the help of SRA is regulated by normative documents [1-3], which proposed several schemes: sector search; the square that is expanded; with the survey track line; parallel inspection (comb); a wavy line (parallel galsan); contour search around the mountains.

A visual search of the aircraft, it is recommended to exercise at an altitude of 500-600 m, the helicopter is at an altitude of 200-300 m above the surface.

These documents contain certain recommendations regarding the parameters of the search, namely, requirement, 25% overlap of swath, although the band width is determined quite arbitrarily, since it is clear that its value depends on many factors.

Thus, the normative documents do not contain the values of the parameters of visual search by using search-and-rescue aircraft, their reliance on search terms and search parameters of objects and their scientific justification remains open.

Analysis of recent researches and publications. A search of the scientific literature on the organization of visual search using the SRA demonstrated the lack of sources on this subject.

Application of mathematical calculations in the organization and conduct of search operations, namely, to assess the likelihood of success when conducting a search in one or another way used in the models [4-6]. These models are General and do not allow to consider the change of search parameters, and especially to justify the parameters of aviation emergency and rescue operations in the application of visual search.

Statement of the problem and its solution. The aim of this work is justification of approach for calculation of aviation emergency and rescue operations in the application of visual search.

The probability P of finding a real estate search on flat terrain (surface water) depends on a sufficiently large number of objective and subjective factors:

- the area Ω of the zone of survey;

- visible size θ (magnitude of the solid angle under which the visible OS), which in turn depends on the size S of the search object (provided that the longitudinal and transverse dimensions of OS not significantly different) and the height h of flight of SRA;

- the depth of the search (the width L of the span in case of single span SRA, which is associated with a range of monitoring r, which, in turn, is connected with an optical resolution λ of auxiliary optical devices or visual acuity of the observer, the light conditions ϑ (related to weather condition, time of day and season of the year, as well as the use of lighting devices) and "visibility" of the OS, which is limited by the contrast ω of the search object against the background color of the environment, tall size OS compared to the roughness μ of the environment (height of vegetation, waves));

- speed v of movement of SRA (which affects the time of fixing the OS in the field of view of the observer);

- the time t of observation, which affects the fatigue of the observer;

- experience η of the observer (the weighting factor).

Thus

$$P = f(\Omega, \theta(S, h), L(r(\lambda, \vartheta), \omega, \mu), v, t, \eta). \quad (1)$$

The clarification of the dependence of (1) would find and, therefore, in the future to maximize the probability of finding OS.

Assuming that the probability P of finding OS is directly proportional to the visual size

$$P \sim \theta(S, h) \cdot f(\Omega, L(r(\lambda, \vartheta), \omega, \mu), v, t, \eta)$$

it is necessary to investigate how the value θ from the search parameters.

Search-and-rescue aircraft performs flight at an altitude h above the earth's surface (water). A small element of OS denoted as ds. In this case, the entire OS will be seen by the crew of SRA under a solid angle

$$\theta = \int_S \frac{\cos\alpha}{r^2} ds, \qquad (2)$$

where α – the angle of view on OS, measured from the normal to the surface (Nadir) and r – distance from SRA to the OS, S – the square of OS (Fig. 1).

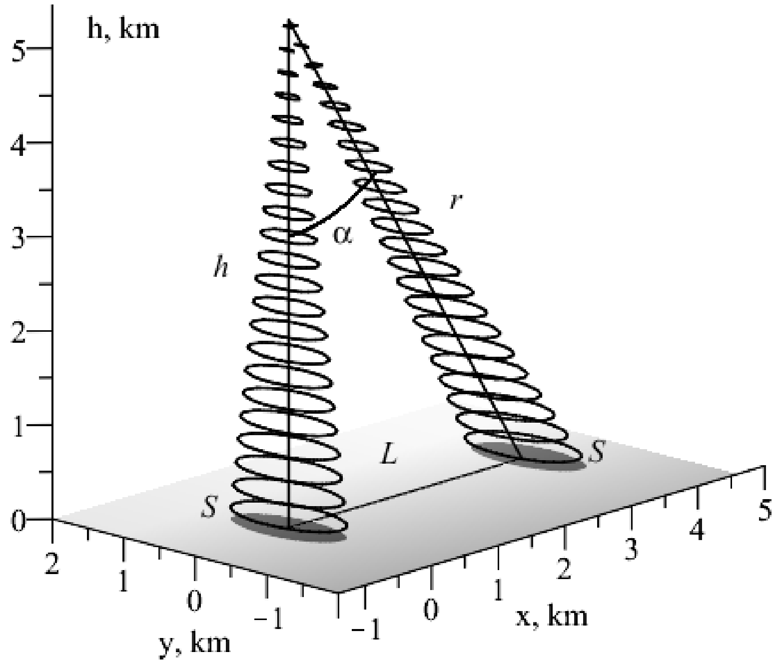

Fig. 1. Finding the solid angle under which the visible search object

In the case when the largest dimension OS will be much less than the height h

$$r = \frac{h}{\cos\alpha}$$

and the expression (2) can be written as

$$\theta = \frac{\cos^3\alpha \cdot S}{h^2}. \qquad (3)$$

In Fig. 2 shows the graph of (2) square $S = 10$ м^2 (area rescue boat).

The figure shows that the magnitude of the solid angle decreases rapidly with increase in the altitude of SRA, and with increasing angle of view.

Since the likelihood of being OS in a single span of a search of the vessel depends on the magnitude of the solid angle under which the visible ow from the aircraft, the value of this angle cannot be arbitrarily small. Setting restrictions on its value (requires additional research, since it depends on other factors), it is possible to find the relation between aircraft altitude and angle. Latest and limits the bandwidth of the observation with a single span of SRA.

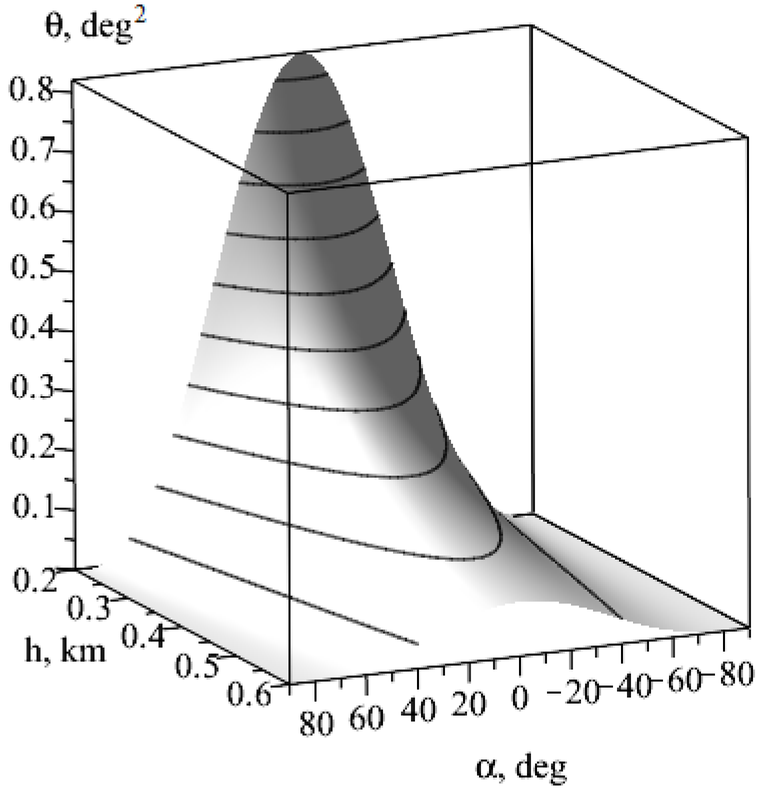

Fig. 2. The graph of the solid angle $\theta(h,\alpha)$ under which OS is seen, the height of SRA and the angle of view

In Fig. 3 shows the histogram obtained on the basis of the graph dependencies $\theta(h,\alpha)$.

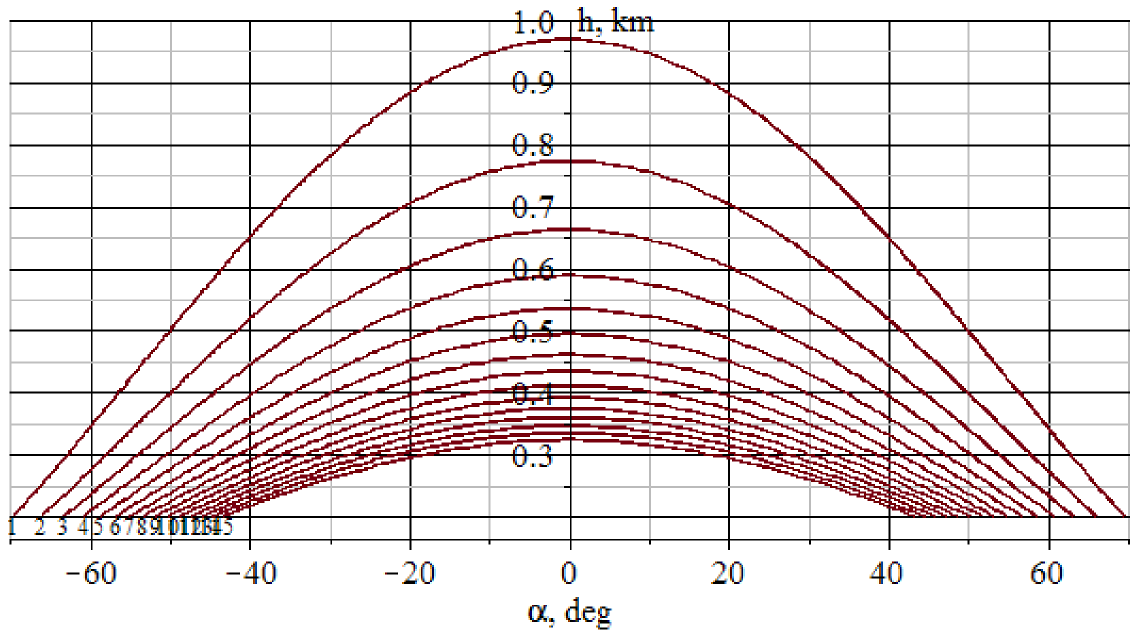

Fig. 3. Histogram to determine the ratio of the height of SRA, and the limiting value of the angle depending on the apparent size OS ($\theta = 0.015 + 0.02 \cdot i$ deg^2, $i = 1...15$)

For example, if the characteristics of the object, the environment and separate optical power of the optical devices allow to identify OS with visible size not less than the height $0.095\ \deg^2$ of a search may not exceed 600 m, and the angle of view 60^0.

Maximum height h and observation bandwidth L for the different apparent sizes are illustrated in Fig. 4.

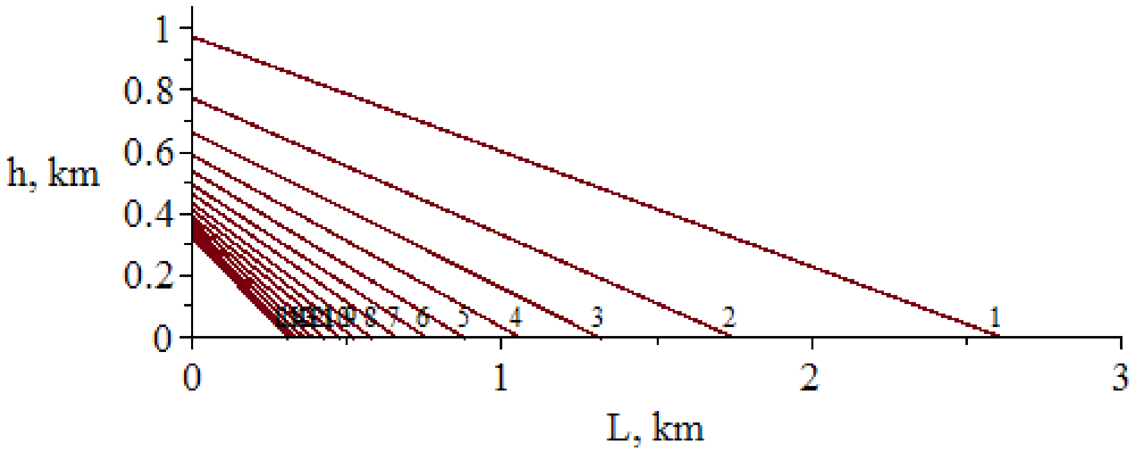

Fig. 4. The graph of the maximum height h and observation bandwidth L for the different apparent sizes

Thus the bandwidth of the observation (in each direction) also may not exceed 1040 m.

Conclusions. First, the proposed approach for calculating the parameters of aviation emergency and rescue operations in the application of visual search persons in distress, or objects of search.

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Обґрунтування підходу для розрахунку параметрів авіаційних аварійно-рятувальних операцій при застосуванні візуального пошуку

Запропоновано підхід для обґрунтування параметрів проведення візуального пошуку з пошуково-рятувальних повітряних суден, що пов'язує між собою характеристики об'єкту пошуку, висоту польоту спостерігача та ширину смуги спостереження.

Ключові слова: візуальний пошук, пошуково-рятвальне повітряне судно, параметри пошуку.

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Обоснование подхода для расчета параметров авиационных аварийно-спасательных операций при применении визуального поиска

Предложен подход для обоснования параметров проведения визуального поиска с поисково-спасательных воздушных судов, который связывает между собой характеристики объекта поиска, высоту полета наблюдателя и ширину полосы наблюдения.

Ключевые слова: визуальный поиск, поисково-спасательное воздушное судно, параметры поиска.