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RESULTS OF INVESTIGATION THE INFORMATION CRITERIAS TO EMPOWER CREW ENVIRONMENT PERCEPTION POSSIBILTIES BY PSYCHOLOGIC INFLUENCE

Theoretical aspects of optimization and calculation main informational criterions to empower the environment picture perception from cabin are an actual problem. Solving problems of mental state influence on crew and establishing of main informational criterions which have to been calculate to empower possibilities of environment visual perception. It demands explaining many theoretical aspects.

Introduction. In order to empower the visual perception of the external information environment of the cockpit crew was developed the modern theory of imaging [1], and monitoring.

The purpose of the research. Construction of image of the environment subject on the operator's retina according to rules of geometrical optics: light beam from point B, directed through the front nodal point *B* of eye N, passes through the second nodal point *N'* parallel to the initial direction. Let the object which height y, is at a distance l from the eye. We assume that the absolute value of $l \geq f$. β_y linear increase, equal to the ratio y' to y takes the

$$\beta_y = \frac{y'}{y} = \frac{\alpha l'}{\alpha l} = \frac{l'}{l} \qquad (1)$$

As l — negative value, increase of β_v — negative. So, image, occurred on the retina, is reverse and reduced.

Analysis of recent researches. Visualizing systems in aerospace industry are subdivided onto two groups [2], which are be applied when angular size γ of observing details of image is too small — lesser than limiting resolution angle. Linear detail's size *h* is very small too. When accommodation value is 4 diopter, pilot can see subject on the image from distance l_0 =250 mm. Let limiting angle is δ =1', or $2{,}9\cdot10^{-4}$ radians. So $h = \delta\ l_0 = 2{,}9\cdot10^{-4}\cdot250 \approx 0{,}07$ mm. If $h \leq 0{,}07$ mm, linear size *h* may be great, but distance to image's object and it's details *l* is very big. But there is no sense to approximate it to distance, less than l_0 (distance of best vision), because further approximation will lead to defocusing the image on retina. If detail's size is so small, that $\alpha = h/l_0 < 3\cdot10^{-4}$, we are unable to see it distinctly. $3\cdot10^{-4}$ – limiting resolution angle (approximately 1'), l_0 usually equal 250 mm with focus distance *f*, we will see detail not at the angle α , but at bigger angle α : $\alpha' = h/f$ with increasing to formula

$$\Gamma = \alpha'/\alpha = l_0/f \qquad (2)$$

But there is no sense to improve the increase above a certain value Γ_p . Light diffraction limiting the minimal detail's size *h* on the image, which still may be seen at larger increasing.

$$h = \lambda / (2n \sin u) \qquad (3)$$

where : λ, n — wavelength and medium refractive index;

u — angle between optical axis and last beam emanating from the object;

It's known [1], that multiplication of $n \sin u$ called numerical aperture and is denoted by A

$$A = n \sin u \qquad (4)$$

If value u is tends to 90°, so $\sin u \approx 1$. At $n \approx 1.5$ $A \approx 1.5$, and $2n \sin u \approx 3$. So, in the best case it's possible to see the detail on the image, which size is $h = \lambda / 3$. By naked eye pilot can see part of visual information size h_0. Considering limiting resolution angle is $\delta = 1' = 3 \cdot 10^{-4}$, we get

$$h_0 = l_0 \cdot 3 \cdot 10^{-4} = 250 \cdot 3 \cdot 10^{-4} = 7.5 \cdot 10^{-2} = 0.075mm \qquad (5)$$

Consider that main characteristics of "eye — visual information" system are: visible magnification Γ_T, angular field 2β and matrix diameter D' which realize definite symbol during image transmission. Visible magnification Γ_T of system is equal to it angular magnification γ_T

$$\Gamma_T = tg\,\beta' / tg\,\beta \; D / D' = -f_1' / f_2' \qquad (6)$$

where : 2β and $2\beta'$ — angular field of optical system in space of objects on image;

D and D' — diameters of input and output values of system "eye — visual information";

f_1', f_2' — focus distances of system "eye — visual information";

Linear $\beta_л$ and longitudinal α increasing of system are calculated by the formula:

$$\beta л = 1 / \Gamma_T, \qquad \alpha = 1 / \Gamma_T \qquad (7)$$

Angular field 2β of system "eye — visual information" is interconnected with angular field $2\beta'$ and visible by pilot on the control panel

$$tg\,\beta = tg\,\beta' / \Gamma \qquad (8)$$

Formulation of the problem. Result of integration the function *f(x, y)*, which is denoted by *R*, depends on the which straight line is used for integration and may be shown in equation

$$\chi \cos \varphi + y \sin \varphi - s = 0 \qquad (9)$$

Assume that the function f (x, y) is integrated over all straight lines. Then various values of R are obtained, which in this case act as a function of two variables R (s, φ). Such integration can also be seen as a transformation [3] of the function f (

x, y) in the plane { x, y }, which is to the function R (s, φ) on the set of lines defined by integrals of f (x, y) along the lines. Function R (s, φ) is often called the transformed function f (x, y). In addition, a function R (s, φ) is considered as f (x, y) or as a function which describes the projection data. Last name try to reflect the geometric meaning, namely that in this transformation all values of the function f (x, y) lying on the line, as it were integrally projected to the corresponding point {s, φ}

A new approach to solve problems outlined in the hypothesis [4] is the following. In the mathematical model solution of the problem is reduced to finding obvious inversion formula that allows for the function R (s, φ) to find f (x, y), or otherwise - to search the inverse transformation.

$$R(s,\varphi) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\delta(x\cos\varphi + y\sin\varphi - s)\,dxdy$$

(10)

where : s — distance from origin to this line;

φ — angle, between axis x and perpendicular from origin to this line.

Scientific result. We add one more rectangular coordinate *{x', y'}*, turned on the angle φ orelatively to *{x, y}*. During transition from one coordinate system to another, coordinates are changing $x = x'\cos\varphi - y'\sin\varphi$, $x' = x\cos\varphi - y\sin\varphi$, $y = x'\sin\varphi - y'\cos\varphi$, $y' = -x\sin\varphi - y\cos\varphi$ (11)

Making values substitution in (11). Than

$$R(s,\varphi) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x'\cos\varphi - y'\sin\varphi, x'\sin\varphi + y'\cos\varphi) *$$

$$* \delta(x'-s)dx'dy' = \int_{-\infty}^{\infty} f(s\cos\varphi - y'\sin\varphi, s\sin\varphi + y'\cos\varphi)dy'. \quad (12)$$

To do so, switch to a coordinate *{x, y}*, wherein the line (9) is given by the equation $x' = s$ and is parallel to axis y'. Therefore, integration by this direct function in the coordinates x', y', it is equivalent to the integration over $x'=s$. It is reflected in last equation (12). For function *f(x, y)*, which is no equal to zero in limits within a limited area, it also converted value is determined by expression (11) So, if *f(x,y)* is different from zero inside the circle of radius a, then instead of one (12) we have

$$R(s,\varphi) = \int_{-\sqrt{a^2-s^2}}^{\sqrt{a^2-s^2}} f(s\cos\varphi - y'\sin\varphi, \quad s\sin\varphi = y'\cos\varphi)dy'. \quad (13)$$

$$R(-s, \varphi + \pi) = R(s, \varphi). \quad (14)$$

The main material of the study. We believe that the beneficial effect of M perception is greater than less parts that can be considered, i.e., a beneficial effect as it increases visual acuity of pilot's vision

$$M = V'/V \quad (15)$$

where : V и V' — acuity naked and armed eyes correspondingly, during visualizating of environment.

Established[4], that benefical effect of M depend on such characteristics of "eye — visual information" system: increasing of perception Γ_T и diameter of the entrance pupil of the eye D. The character of this dependence is not the same in different conditions of cockpit lighting.

$$M = c\Gamma_T^x D^y \quad (16)$$

where : c, x, y – numbers dependent adaptive brightness.

At changing brightness from $3 \cdot 10^{-3}$ to $3 \cdot 10^{-2}$ кд/м^2 beneficial obeys the laws of certain experimentally $M = c\sqrt{\Gamma_T D}$, where $c \approx 0{,}3$. For comparative assessment of the characteristics and twilight efficiency often used numerical value $\sqrt{\Gamma_T D}$, which is called "twilight number". Beneficial effect in daytime lighting conditions in the perception of the conditions for $2 \le D' \le 7.5$ suggested to calculate using a formula

$$M_{on} = 1.06\ \Gamma_T \sqrt{1 - 1.65 / D'} \cdot \quad (17)$$

Formulas (16) and (17) include parameter D'. In daylight perception visual acuity determined by the quality of the image, formed on the retina, which in this case is characterized by indirect parameter values D'. Problem solving hypothesis. Denote in the experiment, that m^n – determines as selection the one of equiprobable variants of image perception by "eye — visual information" system and information volume Htransmitting to eye during visualization is

$$H = n \log_2 m, \quad (18)$$

where: n — number of independently resolvable elements in eye sight, is inversely proportional to the square resolved element, i.e. $n \approx 1/\psi$.

m — the number of gradation of brightness, which can distinguish eye depends on resolvable element size and contrast threshold.

Decreasing of ψ tends to increasing of contrast threshold and, corresponding decreasing of brightness gradation number. Theoretical research of function $H(K)$ showed, that it get maximum at contrast K= 1.

Therefore confine ourselves the evaluation of a of H - information capacity, i.e. the maximum amount of information that can get in the perception of environment by the crew eye

$$H = 2\pi \int_0^{\beta} \frac{\sin \sigma \, d\sigma}{(\psi'(\sigma))^2} \quad (19)$$

where : σ — angle between direction to this point of the field of view and the optical axis of the object visualization, *(rad)*;

2β — angular field of visualized object which pilot percepts, *(rad)*;

$\psi'(\sigma)$ — angular limit of eye resolution of image's objects details during perception at give point of field;

$\psi'(\sigma)$ characterizes resolution possibility of "eye — visual information" system.

Information visualization capacity is denoted as H_0. Every real visualized information is denoted K_H value — quality information criterion [2]

$$K_H = H / H_0 \qquad (20)$$

where: H — information capacity of visualization when viewed from the cockpit.

Personal contribution of the authors is as follows. For qualitative visualization recommended value set between 0.04 to 0.12, and this criterion depends on the characteristics of pilot's vision age changes for optimal information perception

$$P' = P_1 \times P_2 \qquad (22)$$

CONCLUSIONS. Field of view of objects from the cockpit is less than the angular field of visualization environment, i.e., $2\Omega_Г < 2\beta$ и $2\Omega_B < 2\beta$, $P_2 = 1$. However, the probability of detecting an object in the image is determined by monitoring the entire probability P_1. The experiments revealed that the average search time corresponding to the probability of detection of 0.63, will be determined for the images by the configuration of an extended single object and a single point object from the formula

$$\overline{t'} = (2\beta')^2 / \left[c\,(K')^2 (\gamma')^3 (L')^{0.3}\right],$$
$$\overline{t'} = (2\beta')2\,(L')^{2n} / \left(a\,(E')^2\right) \qquad (23)$$

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