UDC 656.71.057

Yu.M. Kvach PhD
(National Aviation University, Ukraine)

Simulation of observation of glissade LEDs

The aerodrome system of glide fires facilitates piloting during approach aircraft. According to the observed color and signal intensity, the pilot must immediately determine the altitude above the runway. The development of LED technology allows to design the LED equipment for aerodrome light signaling systems - PAPI glide path. Design features with an LED module, the angles of installation of the glide path, the difficulty of observing the airfield LED fires - these factors influence eye contact decision. If the glide path system fails, the crew will not be able to determine the location in space. To solve the complex problem of controlling the perception of LED signals during approach aircraft, a tool using the MatLab interface is offered. The tool simulates the perception of light created on the retina of the pilot eye from the glide path system at the aerodrome in the MatLab interface. The possibility to simulate lighting will help significantly reduce the risk of air crashes.

Problem statement

Taking into account that visibility of a glide fire must be provided from a certain area of space, it is clear that the photometric figure (frame) must be normalized in accordance with ICAO recommendations [1] Spatial radiation parameters (Fig. 1) provide the necessary guidance during approach. In addition to the above lighting requirements, it is necessary to take into account that the isocandel curves are constructed for the minimum values of the red color intensity.

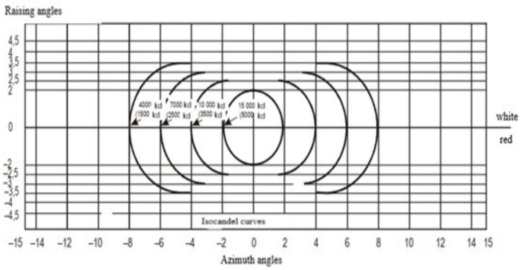

Fig. 1. Distribution of light intensity of PAPI and APAPI

Also, the light intensity in the white sector of the beam should be not less than two times and not more than 6.5 times the intensity of light in the red sector. According to the perception of light color by the pilot, it is necessary that the colors of glide path fires correspond the requirements of the International Commission on Illumination (ICI) (Fig. 2) [2]. But it is impossible to set color characteristics so as to completely eliminate the possibility of their misperception.

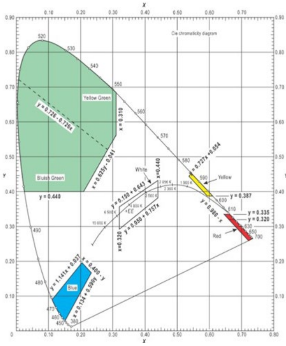

Fig. 2. Color of LED aerodrome fires of the glide path

For reliable recognition, it is important that the illumination in the eye significantly exceeds the perception threshold and the color does not change significantly due to selective atmospheric attenuation (absorption) and the color vision of the pilot was normal. There is also a risk of distortion of color perception in very strong illumination of the eye, which is caused by a source of high light intensity at close distance. It is known from experience that satisfactory recognition is possible if sufficient attention is paid to these parameters. The color characteristics are based on the study of visual perception and correspond to the coordinate system adopted by lighting commission ICI. The color parameters of the glide path are compared with the parameters determined on the outer curve of the isocandel (fig.1), to ensure that there is no color change to prevent incorrect reading of the light signal by the pilot.

Materials and methods

The development of LED technologies has allowed to develop a project of LED aerodrome glide path NL 03V-PAPI-WR (Fig. 3). The most important quality in the use of LED modules in the design of PAPI system is the possibility to create directional light.

Fig 3. Glide path fire NL 03V-PAPI-WR

The NL 03V-PAPI-WR LED glide path fire consists of six white and six red Cree LEDs (Fig. 4).

In the research of light radiation of LED glide path fire light has the following parameters (Fig. 5):

- by color: x = 0.6903 y = 0.3094 / u/ = 0.5179 v/ = 0.5222
- 100 percent color purity at 619.5 nm wavelengths
- luminous flux 211.9 lm
- the radiation color of the LED module corresponds to the color factor RGB: R = 95.7% G = 4.3% B = 0.0%

Fig. 4. Glide fire consists of six white and six red LEDs

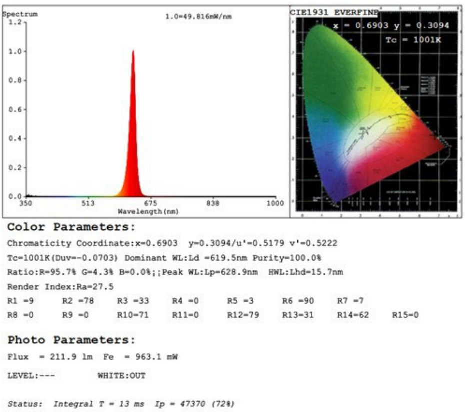

Fig. 5. The result of the research of the color characteristics of PAPI glide path fire

Experiments

To solve the problem of observing light signals from LED glide path fires, a toolbox using the MATLAB interface is proposed [3-5]. The proposed toolkit allows to simulate fragments of a light signal picture in the time shortage conditions at the stage of visual piloting. With the help of tools in the environment MatLab the illumination which is created on the retina of the pilot eye from the glide path LED fires system depending on the input of respective data is simulated:

- light distribution of glide path in the format of ies-files [4]

- the coordinates of the pilot relative to the system of glide path to determine the trajectory between the light emitter and the receiver;

- location of the glide path on the runway;

- parameters that characterize the complexity of meteorological conditions due to background brightness (L_{back}), atmospheric transparency and meteorological visibility (MVR).

Toolkit allows to get:

- lighting created by the glide path system on the retina of the pilot's eye (E_0);

- Allard illumination created by the light of glide path fire on the retina of the pilot's eye (E_A):

$$E_A = (I / R^2)\, \tau^R, \qquad (1)$$

where E_A is lighting created by the glide path system on the retina of the pilot's eye at a distance R;

τ is the specific transmittance coefficient of the atmosphere (transmittance of atmospheric layer thickness of unit length);

- general illumination created by the light of the glide path system on the retina of the pilot's eye (E);

- threshold of illumination that allows to estimate visibility of glide path fires depending on difficult meteorological conditions;

Threshold illumination E_{thr} depends on the brightness of the background and is a continuous function approximated by the expression:

$$\log E_{thr} = 0.05(\log L_{bgr})2 + 0.57\log L_{bgr} - 6.66, \qquad (2)$$

where E_{thr} is threshold illumination, lx;

L_{bgr} is the brightness of the background, cd/m^2;

- graphic representation of illumination from the glide path system;

- graphic representation of illumination created by each aerodrome fire from the glide path system (Fig. 6);

- graphical representation of the light signal radiation direction of the glide path LED fires.

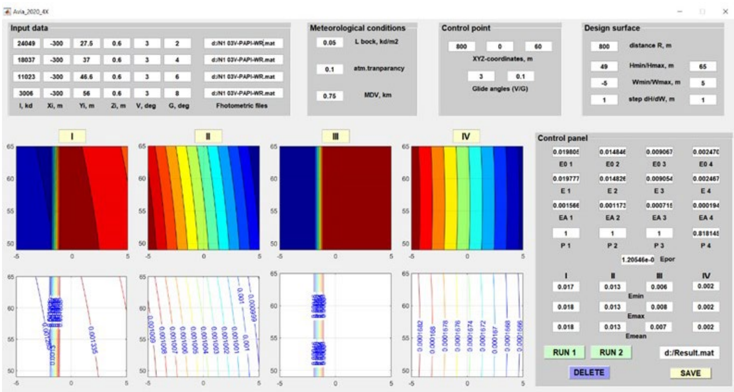

Fig. 6. Graphic representation of light radiation of glide path LED lights

Simulating the direction from one LED fire of the glide path system and from the glide path system with the respective light intensity on the retina of the pilot's eye allows to get conclusions about their contribution to the overall picture of the visual indication perceived by the pilot.

References

1. International Civil Aviation Organization. (2017) Electrical Systems, Aerodrome Design Manual. Second Edition (Doc 9157, Part 5) International Civil Aviation Organization. Montreal, Canada.
2. International Commission on Illumination. Colorimetry/ (2019) Color Space 1976 L * a * b * (ISO / CIE 11664-4: 2019 (E)) (Part 4).
3. Kvach Yu. Participation in the development of the research plan and modeling. https://doi.org/10.1016/j.bbr.2018.04.021
4. Kvach Yu. (2019). Modeling illumination on the retina of the pilot’s eye during in complicated meteorological conditions in MATLAB environment. Svitlotekhnika and elektroenergetika. Volume 55. https://doi: 10.33042/2079-424X-2019-2-55-59-62.
5. Kvach Yu. (2021). Observations of LED Side Lights at the Stage of Visual Piloting. Safety in Aviation and Space Technologies. Pages 1-13. https://doi.org/10.1007/978-3-030-85057-9_1

https://link.springer.com/chapter/10.1007%2F978-3-030-85057-9_1.