UDC [735.072.8.08:004]:629.7.014 – 519(045)

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RECOMMENDATIONS FOR OPERATOR TRAININGS OF UNMANNED AERIAL VEHICLE

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The substantiating number of recommendations for creation a simulator for unmanned aerial vehicle remote pilots training is considered. The article presents the formulas for calculating a number of characteristics that are specific to simulator for unmanned aerial vehicle remote pilots training.

Keywords: unmanned system; remote pilots; computer simulator.

Introduction. For development and production in Ukraine unmanned system (UnS) it is necessary the training and certification of the operators and the external pilots (EP) for unmanned aerial vehicle (UAV). At the same time UAV is component of the UnS.

In Ukraine there are three the best known companies that develop and manufacture flight simulators:

– Company “Маркет-МАТС”, Lviv;
– Company “Линкстар”, Kyiv;
– Company “Литер-Навигация”, Kyiv.

The scope of activity the ANTONOV’s Aeronautical Scientific/Technical Complex also includes the tasks for training and retraining of pilots and technical personnel on simulators, which are developed at the enterprise [2].

However, at present, at the Ukrainian market are not presented the simulators for EP developed by these firms.

At the process training of EP and pilots of aircrafts there are both common and different stages. Significant differences also have simulators for EP and pilots of aircrafts [1].

The main difference of simulator for the EP is that not necessary to model its mobility. This significantly reduces the cost of development, production and operation. The complexity and duration of the EP training creates necessitate the development of simulators for the EP parallel with the creation of unmanned aircraft. In this case, Flight manual for given type of UAV is not ready but it is required for remote pilots. The training of operators, who working with the target load, which is set on unmanned aerial vehicles, in this paper is not considered.

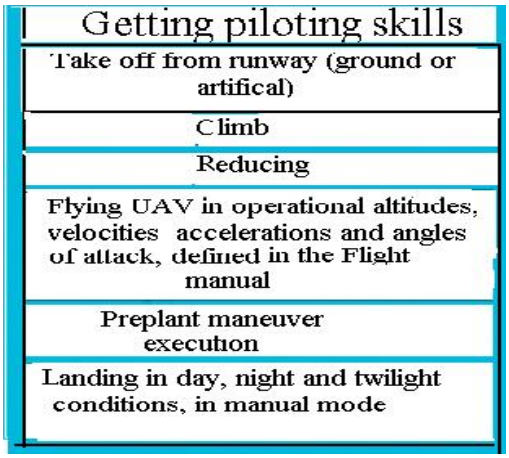

Fig. 1. Tasks, which can solve the EP with help of CS

The process of EP training is a multistage. First, the theoretical discipline, learning to work with the equipment of UAV, fulfills piloting (taxi, takeoff and landing, routes, visits to various runways airfields etc.). Purpose of computer simulator (CS) (fig. 1) is to solve only of the part tasks of the whole simulator at the EP training [3].

Part of tasks on CS must be solved by operator, which works with target load (fig. 2).

Generalized block diagram of the simulator for the EP training is shown in fig. 3 [3].

Generalized block diagram of the simulator for the operator training is shown in fig. 4.

Important condition for successful flight is the coordinated and smoothly running work of the EP and the operator.

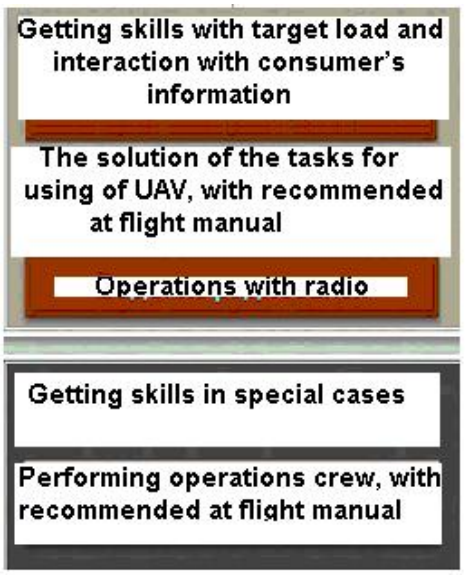

Fig. 2. Tasks, which can solve the operator of target load with help of CS

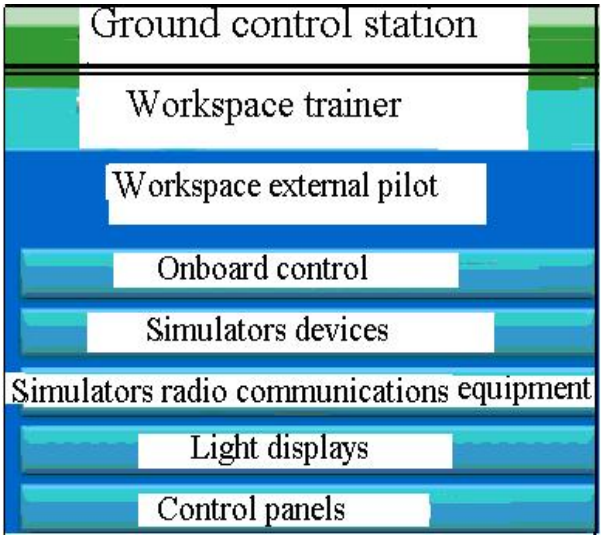

Fig. 3. Generalized block diagram of the simulator for the EP training

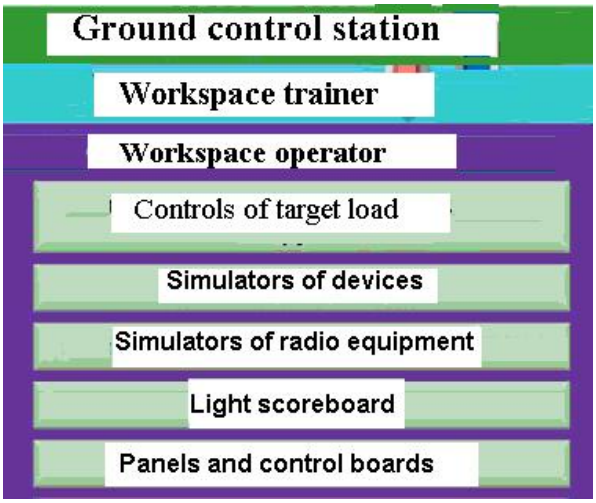

Fig. 4. Generalized block diagram of the simulator for the operator training

Over the last few years the rendering process using computer software has received considerable attention [4; 5].

For example, programs Autodesk 3ds MAX 2012 and AutoCAD 2011 allows the creation of controlled systems (simulators) with virtual reality.

Exercises of the remote pilots on simulators can not replace full flight training and it is a subsidiary class [8]. Their main value lies in the fact that the EP can work out the following exercises:

– Basic operations with major systems of UAV;
– Interaction with the pilots of other UAV;
– The work with standard controls;
– The support of a variety flight's modes.

One of the main advantages of the simulator is the ability to repeatedly replay a situation, with changing conditions and environment, with opportunity of watching and examining video of flight.

It is possible to change the whole flight or some of its elements, seeing ourselves and analyzing errors. In the virtual world, on each task we can spend as much time as needed for person for its full perception and testing of correct responses.

Simulator allows dealing with many tasks more quickly and efficiently. It is best way to remember the studied material, to move from simple to complex.

Statement task. In document 9625 ICAO [1] there are two recommended numerical characteristics of the simulator, and is reasonable to apply them at design of CT for the EP.

First – is the size of the field of visualization in the following ranges:

– vertical 0–300;

– horizontal 0–750.

Second – is the fact that the line-of-sight tracking remote objects, which projected on the screen, requires positional deflections eyes of pilots from the center of visualization system on the screen.

The value of this error – "parallax" (parallax (from Greek means "change, alternation") is a change of apparent position of the object relative to the remote background, depending on the position of the observer) and can be estimated by the formula

$$\alpha = \text{arctg}(D / L), \tag{1}$$

where D – distance from the pilot's head to the centre settings of visualization system; L – distance from the centre settings of visualization system (usually center of screen) to observed object on the screen.

Parallax of remote pilot is equal to 18 degrees, in case of simultaneous training of the EP and the operator on the simulator and configuring of visualization system on pilot's of left, if distances D = 1,0 m and L = 1,05 m, how it is shown in fig. 5.

Document 9625 ICAO requires the value of the parallax which is not more than 10 degrees for each pilot. It is possible while setting of the rendering on equidistant point of the screen between the EP and the operator. Parallax is 9 degrees for both pilots depending on the middle point of the screen (see fig. 5) for L = 1,25.

The substantiating number of recommendations for creation a simulator for UAV remote pilots training is a task of this paper.

For solution of this task the stages of EP training should be analyzed and experience of construction training system of pilots for UAV in other countries should be taken into account.

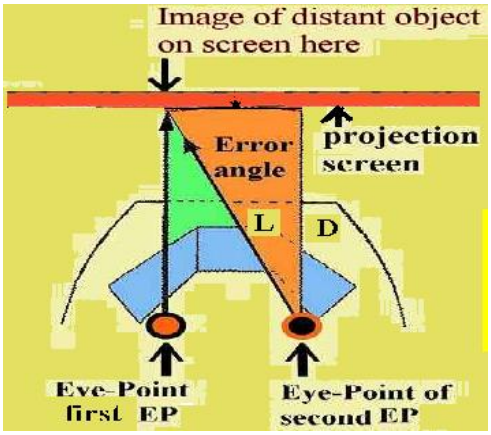

Fig. 5. An example of the layout of the operator and the EP relative to screen CS

Ways of task solving. The piloting of UAV can be divided in two categories:

1) In limits of UAV sight;

2) At absence of UAV sight.

For piloting of UAV in limits of sight it is necessary well-defined the observation of UAV with help of naked eye and visual tracking its main flight's characteristics.

The control is made with indicators of flight information and video from on-board camera for piloting of UAV at absent of its sight.

By analysis of computer games, which simulate a flight of aircraft, we can make next conclusions:

1) At tracking the flight area by help of camera, direction of view and optical axis of camera are usually coincide and focused on observed object. This makes uncomfortable simultaneous tracking of basic motion of parameters UAV: velocity of motion, angle of attack, pitch angle, the course and altitude;

2) Large screen of computer allows with high precision to observe the flight's area. At the same time computer screen is less saturated with various objects. But if the EP has large screen, then he must be placed at reasonable distance from the screen;

3) To unload (to release) the visual channel of perception of the EP it is advisable to inform the pilot of the UAV during the approach to the critical modes of flight through auditory and tactile channels of perception [6].

As known [7], maximal rate of eye movements at tracing ω_{pe} is approximately 40 deg /sec.

The interval of time, which must spend pilot at deviation of view direction from considered object on center of screen, is $t_1 \approx \alpha / \overline{\omega}_{pe} = 0,5\text{sec}.$ at maximal admissible value of parallax and mean rate of eye movements at tracing $\overline{\omega}_{pe}$ = 20 deg/sec.

The interval of time can increase in that case, when considered object is located in one corner of screen and digital parameters of UAV motion in other (fig. 6).

For calculation of interval of time, in this case, we can write next formula:

$$t_2 \approx \frac{2\text{arctg}\left(d_{pc} / (2D)\right)}{\overline{\omega}_{pe}}, \qquad (2)$$

where d_{pc} – diagonal of CS screen.

Fig. 6. An example of the layout of the devices and UAV on screen CS

Dependence of the time t_2 from the value d_{pc} for given values D is shown in fig. 7. As it follows from calculations, the interval of time t_2 is very great. Certainly, shifting his gaze from center of screen to its corner, the interval of time is reduced twice.

Moreover the EP, when performing this operation, must additionally use a head turning. With it can decrease this interval of time. However, in this case pilot must to execute more physical operations and his activity decreases.

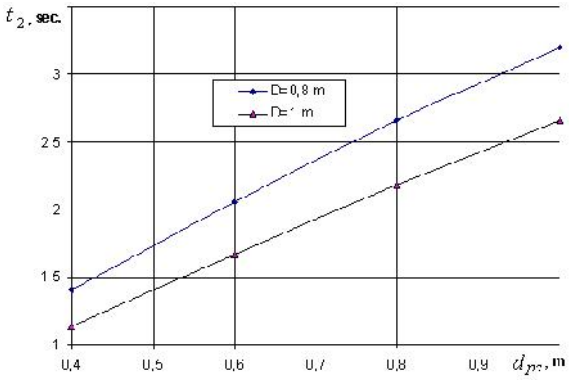

Fig. 7. The dependence of the time, which is required for moving the eyes diagonally CS screen

Image of flight area for EP with a typical size of the PC screen distorts the real information from camera since the typical size PC screen is usually given by the ratio *Hs*/*Ls* = 0,75…0,8 (sometimes 0,56), where *Hs*, *Ls* – altitude and width of PC screen, and ratio field imaging is 0,4 (30 deg/75 deg). Application of not typical size of the PC screen allows to receive more correct the image of flight area.

Conclusion. In the article peculiarities of functioning the computer simulator for UAV remote pilots training are considered.

Some characteristics of the CS screen were calculated by formulas (1), (2).

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Рекомендації для навчання операторів безпілотних літальних апаратів

Проведено обґрунтування низки рекомендацій під час розробки тренажера для навчання операторів безпілотних літальних апаратів. Представлений перелік завдань, що виконуються зовнішнім пілотом і оператором цільової навантаження безпілотних літальних апаратів. Наведено розрахунки помилок фотографічного паралакса і часу переміщення погляду оператора по монітору комп'ютера.

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Рекомендации для обучения операторов беспилотных летательных аппаратов

Проведено обоснование ряда рекомендаций при разработке тренажера для обучения операторов беспилотных летательных аппаратов. Представлен перечень задач, выполняемых внешним пилотом и оператором целевой нагрузки беспилотных летательных аппаратов. Приведены расчеты ошибок фотографического параллакса и времени перемещения взгляда оператора по монитору компьютера.