In the area of successful landing and guidance of the aircraft on the route, flight safety is perceived as the highest rate of observation of all operational-control functions of the aircraft. The given functions of the aircraft are observable and identifiable by the systems and cognitive perceptions of the pilot. Situational control of the aircraft on the route with the identification of the danger, into which the pilot can get is perceived as an exact element of failure. If the pilot enters such a situation, apriori solutions are offered to him/her by the aircraft information system. The character and emergency solution in the highest criticism of the failure of aircraft systems is the controlled landing in the local safety corridor when guiding the aircraft on the selected route. The aim of the article is the theory of the solution for the introduction of an assistance element in small aircraft with a description of the solution of autonomous choice of geolocation in a defined local environment. By a heuristic experiment in the article, let's prove the methods of selection of geographical areas for landing an aircraft with the possibility of introduction into the aircraft information system. The article presents the methodology of creation autonomous assistance system, based on the measurement of detection areas for landing with the collection of data from the GIS system. This system can assist in pilot training and real flights for small aircraft without difficulty. The effectiveness of such system and the parameterization of its data were shown and proved. The developed models may be further used for creation an autonomous selection system in the event of accidental aircraft failures

Keywords: emergency situation, suitable geolocation, assistance system, flight area, efficiency criteria

DEVELOPMENT OF SYSTEM FOR SELECTING SUITABLE LANDING LOCATION INSIDE THE LOCAL HAZARD AREA

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1. Introduction

The relevance of en-route flight requires the file analytical transmission of all navigation data governing the flight. Such flight control requires the precise and consistent fulfillment of the duties of the pilot and the participants in the flight control, where the result is a state of saturation in the area of the rigorous function of flight safety assurance [1, 2]. It is necessary to know the local danger areas for landing aircraft [3]. Agility and the advantage of an emergency landing in difficult hazardous terrain require a high level of pilot readiness. Its correct evaluation of pilot-technical data, the pilot is able to evaluate and choose the right area for performing an emergency landing.

The decision-making in the aircraft emergency management process is the evaluation of the current situation in the aircraft and the pilot's training. There can be several reasons for landing in difficult terrain. The flight brings an increased risk of a number of extreme situations. Incorrect assessment of a pilot's difficult situation due to neglected mandatory ac-

tions or incorrect habits is catastrophic [4]. Improper coordination of flight control according to individual ATM control functions also creates danger. The local danger area is a defined dimensional area in which a situation arises with the possibility of achieving material or even human damage, an accident, into which the pilot enters with the risk of suffering the consequences. However, this decision is conditioned by a high degree of own risk [5].

Successful use of autonomous assistance system for small aircraft will create a new way to achieve the quality and skill of the pilot, which will be highly relevant in future. His/her position will be placed in the area of managing operator skills and supervising the automatic and safe control of the aircraft. Such solutions and the creation of individual pilots (passengers) can only be in case, when aircraft will be safe and able to carry a passenger a pilot with a different character and ability to control it. Thus, researches in field of development and implementation of system for selecting landing location inside the local dangerous area for aircraft autonomous assistance system seem to be relevant.

2. Literature review and problem statement

According to study [6] today in the EU and other countries there is the growth of small aircraft use for individuals over the large-scale transport. Such situation is determined by number of drivers, such as economic growth, rising needs in personal (individual) mobility, rapidly developing logistics of number of companies. Big share among these reasons according to [7] belongs to development of international tourism. As [8] mentions, these factors stipulate the necessity in developing the net of pilot training centers as well as their training methodology. However, authors rather consider the question of training pilots for general aviation, no attention is paid to training of private pilots – individualists, need for improving methodology for assessing their skills for the possibility of obtaining PPL or ATPL pilot certificates. As scientist, [6] in particular, mention, due to economic growth and consequently affordability of small aircraft, they become achievable for number of interested parties. In the work [9] authors present review on how human factor influences pilot's and passengers' safety and substantiate the need for stronger involvement of pilot's assistance systems during operating the aircraft. But no practical solutions are proposed in this work, rather analytical review. Similar ideas are expressed in [10]. Scientists showed the possibility of distribution decision-making and control procedures between a pilot and adaptive autopilot, where human plays a supervisory role and the autopilot is responsible for low-level regulation and command tracking tasks. The work by [11] considers assistance systems (autopilots) during regimes of basic movement of the aircraft: take-off – flight – landing. But, taking into account ideas in [9] there is a need to develop assistance systems, which will be effective in case of abnormal or emergency situations or in case of human factor influence. Study by [12] successfully solves the issue of autopilot development and operation in hazardous and abnormal flight conditions by means of mathematical model. Similarly, the work by [13] solves the question of developing system for maneuvering of an autonomous small aircraft for mass market technologies. Unfortunately, both studies are related to unmanned aerial vehicles (UAVs) and autonomous assistance systems installed there can't take into account influence of human factor on operating aircraft. This stipulates the need to develop autonomous assistance system for small aircrafts, operated by pilots, especially during emergency of non-standard situations.

3. The aim and objectives of the study

The aim of the study is to address the possibilities of increasing the flight safety of small aircraft during its use as individual transport by means of introducing autonomous assistance system.

To achieve this aim, the following objectives are accomplished:

– determine the efficiency criteria of pilot in emergency landing situation;

– fulfill parameterization of input values for the geographic information system used in aircraft assistance system;

– assess the model of assistance system in conditions of pilot's transition from standard to non-standard flight mode.

4. Materials and methods of research

Method of solving input model situations when entering data into the geographic information system.

Let's call a geo-area that is an area used for the initial analysis of the possibility of emergency landing aircraft. The determination of the variables and the necessary parameters of the aircraft for determining the moment of detection of the geo-area or recognition of the geo-area by the aircraft assistance system is defined as follows:

Known parameters:

– position of the geo-area object in GPS coordinates, with indication of altitude H;

– position of the aircraft "V" in GPS coordinates;

– the flight altitude of the aircraft above the terrain at the time of detection of the geo-area h_l;

– geo-area altitude h_{geo}.

Uknown parameters:

– recognition distance (slant distance) of the aircraft from the geo-area at the time of detection d_l;

– time (moment) of geolocation detection t_d;

– time (moment) of recognition of a suitable geolocation t_{rgeo},

Calculation of the detection and recognition distance (slant distance) of the aircraft from the geo-area. To make the calculation easier to carry out, the resulting illustration is presented in Fig. 1.
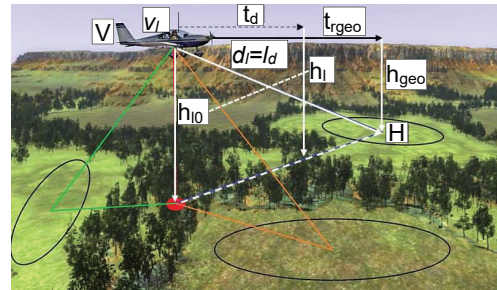

Fig. 1. Procedure for recognizing and measuring the appropriate selection of a geo-area with an indeterminate geographic information system landing assistance system

Let the detection distance l_d (slant distance) of the aircraft from the geo-area at the time of detection t_d be equal to the variable X_D, then (1) applies,

$$X_D = l_d. \tag{1}$$

Let the distance of the aircraft from the geogrid in the horizontal direction l_d at the time of detection of the geogrid t_d be equal to the variable Z_D, then the (2) applies,

$$Z_D = l_d. \tag{2}$$

Let the flight altitude of the aircraft above the terrain h_l at the time of geo-area detection t_d be equal to the variable Y_D, then equation (3) applies,

$$Y_D = h_l. \tag{3}$$

Since it is necessary to calculate the value of the variable X, in a right triangle, let's simply derive (4) using the Pythagorean theorem

$$X_D = \sqrt{Z_D{}^2 + Y_D{}^2} = \sqrt{l_d{}^2 + h_l{}^2}. \qquad (4)$$

Then (5) applies,

$$X_D = \sqrt{l_d{}^2 + \left(h_l - h_{geo}\right)^2}. \qquad (5)$$

The value h_l of the flight altitude of the aircraft at the time of detection of the geo-area t_d, as well as the value v_l of the flight speed of the aircraft at the time of detection of the geo-area, are obtained from an independent TAWS – GPS device located on board the aircraft, which supports the aerial maps or routes and is programmatically compatible with a digital map browser. The TAWS – GPS device is located on board the aircraft and must be able to archive and display the necessary flight data on the route [15].

The values of h_l, v_l can also be obtained from archived records from the on-board instruments of the aircraft, or by means of radar records, but the data obtained in this way cannot be incorporated into digital map browsers [16].

It is possible to calculate the recognition distance d_l (oblique distance) of the aircraft from the geo-area at the time of its recognition t_{rgeo}, (6) applies, but the symbol of the variable X_P changes to X_R, then the equation applies:

$$X_R = \sqrt{l_d{}^2 + \left(h_{geo} - h_l\right)^2}. \qquad (6)$$

In this way, (the instantaneous value of the detection distance l_d and the recognition distance l_{rgeo} of the aircraft from the geo-area at the time of its detection t_d and at the time of detection t_{rgeo}) it is possible to deliver the relevant result to the decision-making members and on-board computers of the aircraft.

5. Results of the study on development of autonomous assistance system for emergency landing

5. 1. Determination of pilot's efficiency criteria in emergency landing situation

Interpretation of the pilot's decision-making processes when evaluating the choice of the need to land with the above stated problems, it is necessary to define the pilot's efficiency criteria. The difference between Q_i entered overall efficiency in pilot control of the aircraft and the selection of a suitable geo-area W_Z and the immediate landing efficiency W_i (which is conditioned by the time course of the flight and the increase in the risk of failures) is defined by the equation:

$$Q_i = W_z - W_i. \qquad (7)$$

(7) represents the optimization of the pilot's decision making and the efforts made by the pilot together with information technologies (Technogenic environment) to achieve the desired result of the emergency landing on the selected area. Let's include this in the pilot's efforts and the technogenic environment of the aircraft, as well as the flight time. Therefore, a general relationship, which it is called the general criterion of landing geo-area optimization, is more appropriate for calculating the effort to find a suitable area:

$$W = \frac{Q}{E}, \qquad (8)$$

where W – is the general criterion of landing efficiency, Q – output technogenic state of the aircraft, E – pilot effort.

(8) makes it possible to perform a quantitative assessment of decision-making only if it is possible to determine the dependencies that link the instantaneous value of landing efficiency with time and the assessment of problems on board the aircraft. As mentioned, the ultimate goal is an efficient landing. The analysis of the growth (decrease E) between the well-known idea of geo-areas and the ascertained fact confirms the need to create their statistically realistic assumptions. The decline in awareness indicates an internal discrepancy in the pilot's decision-making, which will necessitate the resumption of his/her S-growth – the probability of which may be in the form of an additional decision-assist.

The illustration of the given problem is proved by the following model. This type of estimation is performed by monitoring the convergence of the technogenic environment of the aircraft and the pilot. The efficiency E is determined by the increase of the difference Q, (8).

– S-probability related to E as additional decision-assist;
– landing Efficiency 'W' (calculated) position of the geo-area without inertia to the landing point;
– entered 'W_Z' selected geo-area by the pilot or decision element.

For evaluating the best geo-area from selected alternatives, let's choose a mathematical model of the probability distribution: Rayleigh distribution, which has two parameters "a" and "b". These parameters describe the probability of solving problems on board the aircraft "a", where the degree of resolution in crisis situations depends on the pilot and "b" probability density, distribution function, the average value of total flight safety while reducing it by indeterminate aircraft failures. The Rayleigh distribution used is a continuous probability distribution for a positive value of a random variable, which is determined by a fault in aircraft (Fig. 2).

For generating numbers with Rayleigh distribution, the inverse method is the most suitable, which uses the relationship:

$$x = a + b \cdot \sqrt{(-\ln y)}, \qquad (9)$$

where x has a Rayleigh distribution and y has a uniform normalized distribution of the above parameters a and b.

Symbols, concepts, commands algorithms: Variable of the mathematical model of Rayleigh distribution. Values represent Pst., the order of geo-areas, where the probability density $W(x)$, the distribution function, the mean and the variance $D(x)$ are:

$$W(x) = a + b\frac{\sqrt{\pi}}{2}, \quad D(x) = b^2\left(1 - \frac{\pi}{4}\right), \qquad (10)$$

$\pi = 0.1 \div 0.98$; $x_i = 0.57 : -0.62 : 0.9$; specified limits reached from [4], number of increase of technogenic problems in relation to pilot decision-making processes. The functions were written by command syntax and function syntax of MATLAB:

```
pi=0.1;
xi=0.57:-0.062:0.1; % Value changes acording to
π=0.1÷0.98;
Wzi= raylcdf(xi,pi);[xi;Wzi]; % mathematical model of
Rayleigh distribution.
figure(1),s=stairs(xi,Wzi),grid on,set(s,'linewidth',3),
title('Rayleigh distribution function '),
xlabel('Entered values of aircraft flight in the cycle of
geolocation selection only by pilot' ),
ylabel('Value of Rayleigh distribution function'),
```

cdf=1-Wzi; % Condition: when Wzi=1,then cdf=0,(cumulative distribution function).

figure(2),plot(xi,cdf),grid on,

title(' Density of Rayleigh distribution, in reaching area of succesful landing'),

Wi=(xi.*pi);% expertly estimated values of Rayleigh distribution elements.

Q=(xi.^2.*Wzi)-Wi.^2;% Difference, ak Q=0, end of piloting control - landing (ked'u=0).

WiS=sum(xi.*Wzi);% Summary mean,

figure(3),plot(xi,Q),grid on,

title(' Estimation of local efficiency difference Wz'),

Fig. 2 shows the entered flight values of the aircraft in the period when selecting the geolocation by the pilot. This allowed only a detailed statistical evaluation of his/her piloting skill development (control lever movements) until reaching the area of a successful landing with a failure (tested contact values with an area of 60 sec. From a height of 1000 ft.). At other values, the landing success rate decreases. An example is 20 sec.→85 % probabilities of touch. From this, further research is carried out, already in the process of adding this data to the decision – making member, which could be a supplement to the assistance system in finding a suitable area from the database of GIS - TAWS systems.

Outputs of modeling is the growth of the difference in landing efficiency on the selected geo-area with the possibility of using relation (1) as a technogenic efficiency criterion. The proof of efficiency is given by (Matlab), an illustration where it is visible in Fig. 3.

leigh distribution measure (blue line). In connection with reaching the area of successful contact with the surface, the efficiency W (red line) increases in expressing the pilot's efforts to make a successful landing as responsibly as possible.

Fig. 3. The density of the Rayleigh distribution when reaching the area of successful landing on the selected geo-area

The Matlab program enables a detailed statistical evaluation of the effective landing point until a mathematical model is determined. The moments between aircraft failures (randomly) and the pilot's decision on the correct choice of the geo-area were excluded during modelling.

5. 2. Parameterization of input values for geographic information system of aircraft assistance system

Each aviation assistance system in the conditions of selection for autonomous decision-making is based on the collection of parameters (10). These are variable and therefore it is important that their values reach a level that will suit the effective controlled selection of a suitable geo-area.

$$W(i) = W(i) \, [d, a, m, o, \varphi, l, e]. \qquad (11)$$

Distance d – the large length of space between two subjects adversely affects and reduces the overall choice between several alternatives.

The altitude above sea level a – elevation of the proposed alternative as well as the distance are limited to the maximum glide of the aircraft. In the case of a landing with a functional power unit, the total altitude is crucial for the performance of the aircraft.

Meteorological situation m – in adverse conditions where there is reduced visibility or worsened weather situation. The intensity of these phenomena is directly proportional to the increased requirements for the pilot both during the flight on the route and during the final approach and landing.

Obstacles o – an obstruction in an area intended to land, whether inside or outside the aerodrome, presents a high level of danger.

Slope φ – the positive slope of the geolocation contributes favorably to the required landing length.
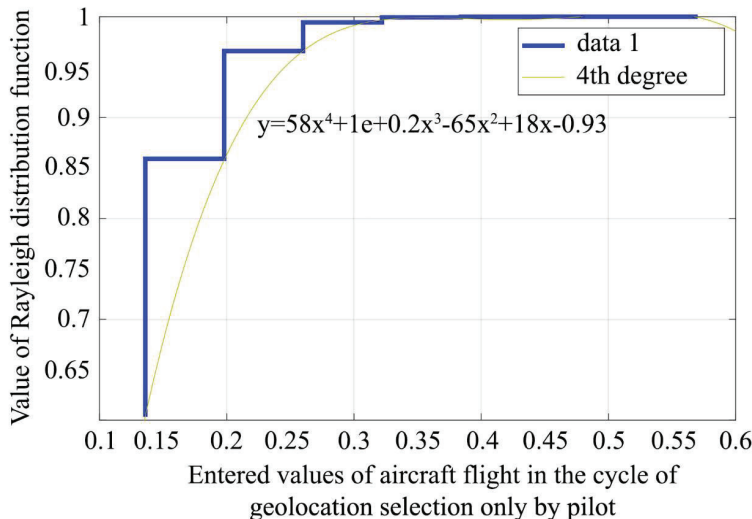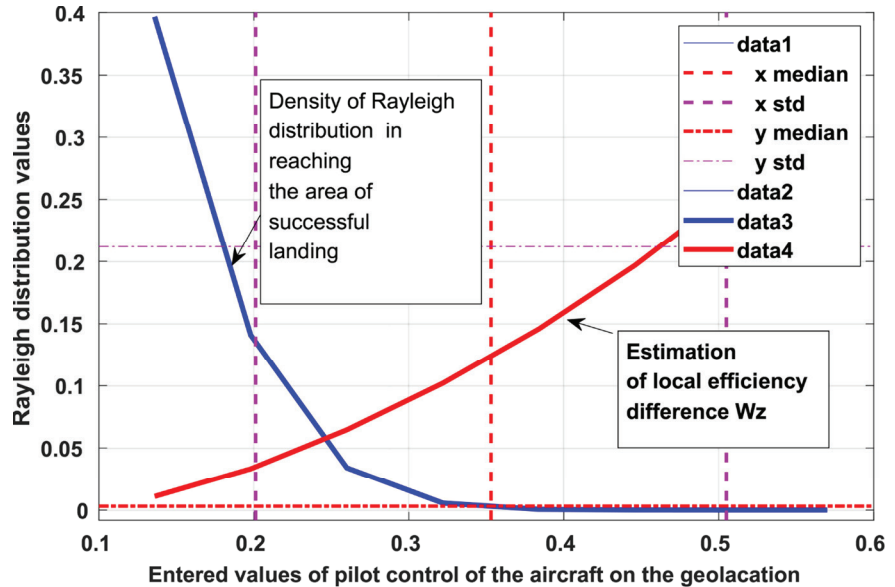

Fig. 2. Rayleigh distribution function

Fig. 3 shows a concentrated multiple test of the landing of the aircraft by the pilot in the period of descent from 15 to 60 sec. according to the values of movement of the handlebars of the small aircraft up to the point of contact with the surface. Based on this, the output is the density of the Rey-

Length l – the horizontal dimension in the longitudinal direction of the path is directly influenced by the path slope parameter.

Terrain type e – individual terrain types of the earth's surface express the current state of the area whose properties may differ in different climatic conditions. Each type has its own physical properties that help increase or decrease landing performance.

Let's name $W_i(t)$ – the efficiency of successful identification of i-geo-areas, then the mathematical model of the efficiency of identification of geo-areas can be described by a product that has the form of notation:

$$W(i) = \prod_{i=1}^{7} W_i(i). \tag{12}$$

If the efficiency of accurate identification of any member $W_i(t)$ falls below a specified level (success is zero=failure), then the resulting efficiency of selection and successful landing is zero. From the following rule is justified in the further procedure of research into the effectiveness of geo-area selection:

– if a failure occurs on the aircraft in the process of selecting the geo-area, then the effectiveness of the assistance autonomous system will be indicated by the indicator "0";

– if the selection process was successful and the pilot decided to interrupt other activities to identify the fault, then such an "output" is characterized by the indicator "1".

The aircraft fault compensation algorithm is usually part of the pilot's curriculum. The pilot gets his/her flight behaviour under control by learning about possible predictions of aircraft failures. The difficult task is to select a new area for the landing of the aircraft during the non-standard performance of the flight task. Therefore, before to select the area where to land or give a solution, let's focus in the article and in the research attention on the creation of a model for estimating the quality of non-standard control and its simulation of the Matlab environment. Let's open the principle of model design by considering the change in the success of landing an aircraft. The reasoning accepts the validity of the difference equation, which can be described:

$$y_i = a \cdot y_{i-1} - (1-a) \cdot q(i), \tag{13}$$

where a – represents the pilot's ability to perceive the properties of the control object in space-time. The perception of the pilot's information ability is supported by avionic systems, which are decisive for determining the aircraft control period – T.

Equation (13) represents a recurrent equation of the landing process in solving the task of tracking the position of the geolocation q_{igeo}.

Let's state that when:

– q_{igeo}=1, the vector function of controlling the aircraft to the landing point is $F \subset Q_{geo}$;

– q_{igeo}=0, the vector function of controlling the aircraft to the landing point is $F \not\subset Q_{geo}$.

Assume that the informative character of the parameter "a" is in the area:
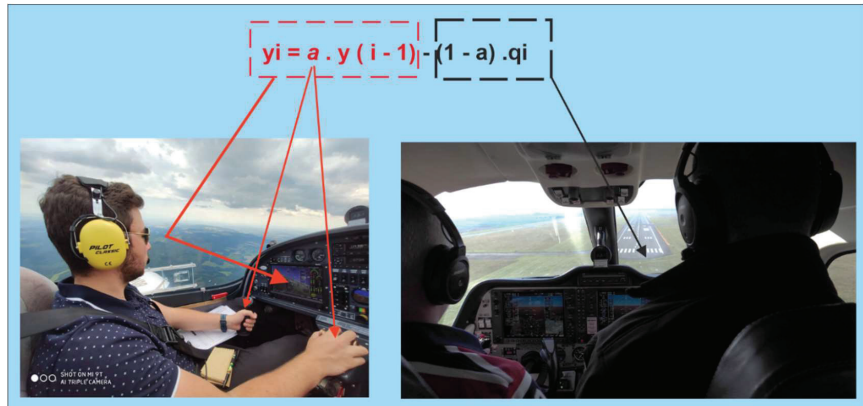
$$0 \leq a \leq 1. \tag{14}$$

Fig. 4. Image expression of a recurrent equation with an expression of the importance of the parameter — a

Limit placement of an aircraft in a geo-area Q_{geo} it is possible to determine according to the character (2) by probability:

$$P_{(q_{igeo}=1)} = p_i, \tag{15}$$

$$P_{(q_{igeo}=0)} = 1 - p_i.$$

A is evaluated by the differential equation for estimating the quality of aircraft control:

$$\dot{y} + T_0 y = \dot{q}, \tag{16}$$

where the point above q represents the derivation (change) of the perception of the position of the geolocation in the current time and where the time constant of the pilot T_0:

$$T_0 = \frac{\Delta t}{1-a}. \tag{17}$$

The parameter "a" in (17) represents the entropic abstraction of the pilot's relationship to the control of the aircraft, where it can be interpreted as the pilot's ignorance of the state of the aircraft (for example, it cannot solve the failure – the pilot have to land). According to the empirical law, the new area of successful fault resolution changes:

$$a = 1 - \frac{4 \cdot \tau_{q=0}}{T}, \tag{18}$$

where q=0 – is the minimum permitted retention time of the aircraft at the boundary of the newly selected geolocation. This time is determined by the characteristics and standards of the aircraft while maintaining the position of the aircraft on the selected flight path.

T – the standard flight control cycle period that is selected or entered. Solution (16) for q=1 this leads to a convolutional integral, which winds the parameters into the final solution a, T_0, T, Δt.

$$y(T) = \frac{1}{T_0} \int_0^T \exp\left\{-\frac{T-x}{T_0}\right\} q(t) d(t), \tag{19}$$

where "q" is a function which, in the above interpretation, indicates the procedural abilities of the pilot. Let's interpret equation (7) as a weight function, the solution of which expresses the quality of the pilot in the local space of control of the current situation.

5. 3. Assessment of assistance system during transition from standard to non-standard flight mode

Dependence of parameters, on the value of ignorance "*a*", the pilot on the selection of a suitable geo-areas by which let's interpret the entropy of ignorance. Specifically, it follows that in the known step t_d, at the maximum value of ignorance and the achievement of assistance $a=0$, the period of finding the geo-area$=\infty$. This means that the pilot's time constant is infinite and the pilot's reactions to the current situation will approach zero. It follows from the above that if the pilot is to reach a decision with a specific degree of professionalism, it is necessary to choose the choice so that "*a*" is as large as possible max=1, i. e. full geo-area search assistance.

This means that the pilot's time constant is infinite and the pilot's reactions will approach zero. It follows from the above that if the pilot is to grow from ignorance to a specific degree of professionalism to land in a selected geolocation, it is necessary to choose the pilot learning so that and is as small as possible.

Then:

$$0 \leq a \leq 1. \tag{20}$$

The investigated aircraft with a co-author pilot [Pastir. D] descends on average from a height of 1000 ft/1.32 NM which is approximately 60 sec. In order for the pilot to be aware of this timing in the event of certain failures and to take this into account when dealing with possible in-flight failures, the decision-maker must monitor his/her ignorance of this timing.

This means that the pilot's time constant is infinite and the pilot's reactions will approach zero. It follows from the above that if the pilot is to grow from ignorance to a specific degree of professionalism to land in a selected place, it is necessary to choose the learning so that and is as small as possible.

Next, let's notice how it changes (19) by the transition of the flight mode to the non-standard mode, when the phase trajectory changes in a short time $\tau_q=0$. Non-standard mode is a flight outside the geolocation. In this case, function (18) indicates a non-standard flight $q=0$, so that – failed to land. In the pilot's view, this fact manifests itself as a situational change to compensate for an aircraft failure, which requires the need for a set time:

$$T=Tn+t, \tag{20}$$

where Tn – represents a non-standard flight time to landing; Δt – time consumption is added (spent flight time deciding to land on the selected area).

The transition from standard to non-standard flight mode to landing requires a fault resolution time, which shifts the total landing time, the period of time by the required fault compensation time. However, when it is known the threshold level, the success level and the threshold y_{trh}, it is possible to construct the landing success boundary function $y(t)$. The shape of the function is:

$$y(t)=1-\exp\left\{-(1-a)\frac{t}{\Delta t}\right\}, \tag{21}$$

where for non-standard flight with failure:

$$y_n(t)=y_n\exp\left\{-(1-a)\frac{t_d}{\Delta t}\right\}. \tag{22}$$

The equation for estimating the limit value of the non-standard flight mode function of an aircraft for landing with a selected geo-area can be determined by the equation:

$$y_n(t)=1-\exp\left\{-(1-a)\cdot\left(t_{rgeo}-t_d\right)\frac{1}{\Delta t}\right\}. \tag{23}$$

The significance of the recurrent equation depending on these values can be accurately estimated from equation (19).

Let the connection between the pilot and the controlled aircraft be determined by the relationship between the time constant of the operator T_0 and the time constant T – controlled aircraft. Then their connection is defined:

$$T_0=\frac{\Delta t}{1-a}\cdot T. \tag{24}$$

An illustration of the local estimate used in the reliability analysis of aircraft systems is performed in the following syntax with Fig. 14, where the basic inputs of the solution of equations (21), (22) are used.

An illustration of the local estimation of landing by a faults on geolocation using a decision system will be performed in the following experiment where the basic inputs with measured values are used.

Average pilot ignorance: $a=0.8$ write values with substitution to (23) in MATLAB Fig. 4. The functions were written by command syntax and function syntax of MATLAB:
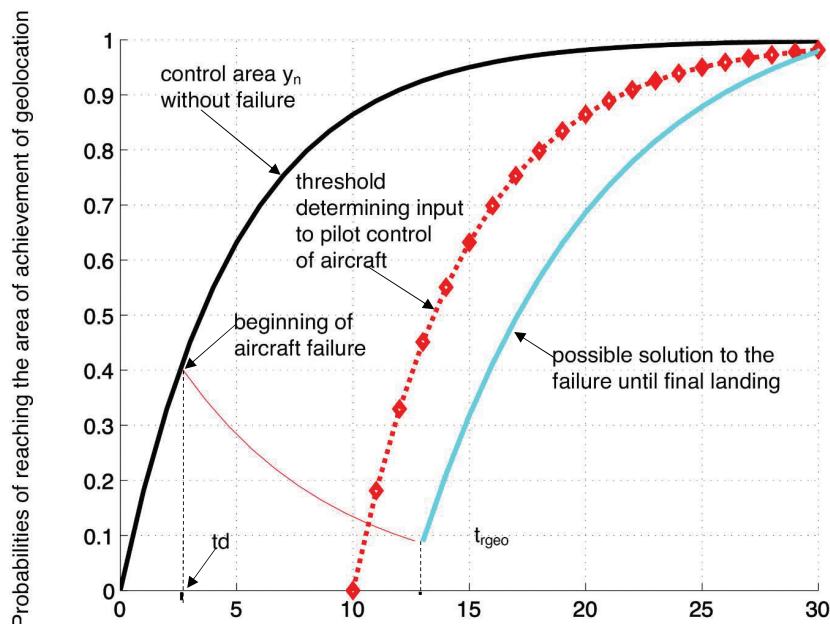
```
t=0:1:60;a=0.8;
dt=1;ys=1-2.718.^(-(1-a).*t);
hold on;
plot(t,ys,'k'),hold on,
yn=0.6;ti=2.668:1:13;a=0.85;
dt=1;
ynt=yn.*2.718.^(-(1-a).*ti);
hold on;
plot(ti,ynt,'r'),
yn=0.8;ti=10:1:60;dt=1;th=10;a=0.8;th=10;
ynht=1-2.718.^(-(1-a).*(ti-th));
plot(ti,ynht,'rd:'),
t1=13:1:60;a=0.87;dt=1;
ys=1-2.718.^(-(1-a).*(t1-13))+0.089;
plot(t1,ys,'c'),
xlabel('Real time and its components in the pilots deci-
sion-making when controlling the aircraft','fontsize',14),
ylabel('Probabilities of reaching the area of geolocation
achievement','fontsize',14),
```

Fig. 5 shows the way the pilot reacts if at time t_d a fault occurs on the aircraft with a time difference of approx. 12 sec. until the decision to change the doctrine of piloting the aircraft. According to the skills of the pilots, it is possible to find a time point from the picture (from this model situation it is 30 sec.) when the pilot identifies with the failure and solves only a successful landing on the selected geo-area. This time point can be shortened by supplementing the direct decision of the assistance system for the correct selection of the geo-area. This will be the result of the creation according to statistical collections on the effectiveness of selected geolocation with GIS – TAWS databases.

With changing ignorance, which is implemented in the personality constant of the pilot, the distance of the aircraft's position relative to the geo-areas changes. This means

that the parameter "a" determines the pilot's time constant by its variance. The skill of the pilot depends on the personality constant. It follows that the "*a*" will be higher and will approach one time constant approaches infinity. In this case, it is clear that the pilot does not control the aircraft and the skill is close to zero. The research results show that the skill is measurable, mathematically modellable, it is an objective method suitable for assessing the professional qualities of a pilot to operate an aircraft.

Fig. 5. Outputs from the pilot doctrine of transition from standard to non-standard flight mode in the event of a failure

From the given results of experimental flights performed by simulator landings and real flights, a partial conclusion can be made: the estimated landing efficiency W of the aircraft depending on the selected geographical area and with the possible failure of the aircraft, the time point (Fig. 5) may be shortened by adding a suitable assistance element.

6. Discussion of the results of the study on development of autonomous assistance system for emergency landing of small aircrafts

Within the study it was found that increase in optimization and decision-making on the choice of geo-areas depends not only on the specifically investigated problem, but also on the specific method used and other internal manifestations. Creating the possibility of examining changes in the regularity of the characteristics of the technogenic part of the aircraft as well as making development forecasts in conjunction with measures to increase efficiency W was expressed by mathematical relationships, (7), (8).

For monitoring the effectiveness of local estimation (selected landing point) let's accept the principle of automation of geolocation selection by GIS based on predictions. This multi-criteria decision-making contains methods, which allowed to evaluate the best geo-area from selected alternatives where it is necessary to know the factors on which the choice depends.

Pilot activity variable value was taken as a variable value during the search for the result of flight stability which changes during flight time. The timing of the emergency landing was expressed in each step activity of the pilot. A percentage of the time is obtained during which the pilot must decide to land on an already selected area in the monitored interval if the last probability of performing this flight action occurs. Thus the actual velocity distribution was approximated by a statistical Rayleigh distribution characterized by the mean wind speed.

For evaluation the landing efficiency on the selected geo-area let's use the relationship (2) that excludes moments between random aircraft failures and the pilot's decision on the correct choice of the geo-area. The efficiency was proved by Matlab program. However, it may be applied until a mathematical model is determined.

The limitation of the study is that the subject of identification are only geolocations which do not contain other problems associated with the successful landing of the aircraft. The rules justifying the procedure of selection of effectiveness of geo-area are in line with the pilot's general emergency procedures. The advantage of these rules is that they eliminate the need to carry out research on each parameter $W_i(t)$, while opening up new research possibilities and methods for estimating a suitable area with the TAWS system (GIS).

By the example flight it was shown that changing the parameters at the value of a successful solution for the selection of the geospatial and descent to it. The achieved numbers are important for estimating their influence on the numerical expression of the probability of reaching the geo-area. The given number with respect to the definition is the personal professional evaluation of the pilot.

Based on the psycho-physiological properties of the development of the pilot's ability, it is possible to infer knowledge, the pilot's readiness to learn to develop his/her professionalism. This one parameter, together with measurable parameters for the detection of the geo-area and the parameters of the aircraft, can make input assumptions for mapping and the exact decision of the selection of a suitable geo-area.

7. Conclusions

1. Criteria of pilot's efficiency, when operating aircraft during hazard or emergency landing situation was estimated. These two criteria are considered and proved to be the most important and valuable in decision making during the flight. The database of the most statistically assumed terrain areas, which are the least likely to have been changed, stopped or other activities have taken place in the last 5–10 years that would prevent the already decisive stage of the pilot's landing was created. And the degree and level of pilot's training to measure his/her skills or ability to perform actions on board the aircraft for an emergency landing was

also estimated. Thus, these criteria were introduced in the assistance system.

2. Parameters of the geographical information system installed in small aircraft assistance system were proposed and set with certain values. For this purpose the data for the last 5 years, where significant failures have caused emergency landings was collected from Slovak aircraft manufacturers. Let's evaluate skills of a pilot in the position of piloting an aircraft on the track and landing without the use of automations and according to cycles of the control lever movement. All the proposed parameters were evaluated as well as its influence on selecting a suitable landing area in emergency situation.

3. The developed model of assistance system was experimentally tested by pilot in conditions of transition from standard to non-standard (emergency) flight mode. Experimental tests proved the effectiveness of the proposed model and efficiency of its use in small aircraft. The model was implemented in an experimental simulator, which is under development. The given simulation conclusions have proved that in certain time series it would be appropriate for the pilot of small aircraft to receive relevant information or the area in front of him/her is safe with the main priority of safe landing. Outputs of modelling show the growth of the difference in the effectiveness of asymptotic learning of the pilot. The program allows to create 5 graphical records of different methodological values, which can be used in the analysis of pilot skills during the landing stages.

This system can assist in pilot training and solo flights for small aircraft without difficulty. It was necessary to show the solution of the effectiveness of such a system and the parameterization of some data, which give an idea of the complexity that needs to be overcome. In this article, it is possible to about indeterminate models, which can be the basis for solving a separate autonomous selection system in the accumulation of ignorance of the pilot and his/her orientation in the event of accidental aircraft failures.

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