

# Operator – Pilot Learning Success With Aviation Ergatic System Control

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**Abstract** The unique mission of operator – pilot during the performed flight lies in the responsibility for selected aircraft position doctrine along determine flight trajectory determined by programme. The mutuality of the relationship of the operator - pilot (OP) and the aircraft completes the image of an ergatic system [7] in which the OP is bound to the object (aircraft), makes decisions in complex flight situations, optimises the transfer of the aircraft into a regular flight. OP also decides about the change to manual aircraft control, which is the main feature of a selective method of flight ergatic system along determined flight trajectory control. The paper shows a method of determination and evaluation of operator – pilot with the aim to obtain quality in successful fulfilment of aviation ergatic system.

**Keywords** operator – pilot (OP), AES aviation ergatic system, asymptotic estimation

**JEL** L93

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## 1. Introduction

The process of the operator – pilot learning has been standardised by European conventions and the flight schools are obliged to comply with them. The aim of aviation faculties is not only to comply with the learning processes but also to perform research in the areas which lead to increased quality of education by the application of new knowledge and technologies a finally to the increase of aviation safety according to the rule that the higher education quality means the higher quality of the student (operator – pilot). Also educational institutions in Slovak republic follow this way, University of Žilina and Technical University of Košice. The researches performed in the conditions of those universities are devoted mainly to the development of new technological processes which are implemented in the educational process which reflects in the upbringing of young specialists in the area of air transport who will later be able to utilise new approaches to the development of the air transport. This is how the importance of air transport will grow on both national and international levels. Technological approaches to increase the effectiveness of flights and air operation safety which have been found by research have been used by the form of knowledge transfer and the development into practical conditions of air transport. The developed technological processes enable their use in the cooperation with the practice to develop and support specialist education of young research workers on higher level

of quality within practical specialist education, mainly on the third (PhD.) level of university study. The research described in the paper can also build foundation for the estimation of the feasibility of future professionals' listing into the process of asymptotic learning how to control an aircraft.

Asymptotic learning is a process of gradual stabilisation of operator – pilot aviation ergatic system according to pre-determined conditions, which determine the estimation of AES quality together with the influence of defined final progression of stimuli necessary for learning in the process of aircraft control and keeping it within flight envelope [4]. The operator – pilot performs the functions of ergatic complex, presents the generator of stimuli together with aircraft control. The difference in the metasystem values and immediate state of ergatic complex is the stimulus sASSce. The difference estimation evokes the control subject (operator – pilot and aircraft assistance system), which performs gradual steps and converges the metasystem of aircraft in a limit way with the ergatic system space-time. The running process of required concord is connected with the adaptive asymptotic learning (i.e. gradually along the exponent line). Repetition of control abilities and obtained experience, which is the result of AES state observation output confrontation and leads towards permanent refinement of operator - pilot. Realised skill in aircraft control in connection with knowledge of character, intellectual features of the object are the AES quality demonstration AES. [2]

In intellectual control of complex aircraft complexes, the skill, when it is possible to perform the activity in the control process in the most suitable way and the least possible effort on the base of acquired knowledge and previous practical activity, is important. [1]

## 2. Level of Skill of OP Estimation during asymptotic Learning

From the viewpoint of asymptotic learning it is possible to interpret skill as an open recurrent progression, which enables to follow the dynamics of the variable  $y_i$ , when  $i = 1, 2, 3, \dots$  within the range of  $j$  – time cycle ( $j = 1 \dots N$ ) of the ergatic process. In given case it is suitable to visualise the asymptotic learning by a recurrent relationship in the shape, which is described in [1] as:

$$y_{(i)} = ay_{(i-1)} + (1-a)q_{(i)}, \quad 0 < a < 1 \quad (1)$$

Where:

$y_i$  – is the estimation of asymptotic learning success

$q(i)$  – is the success of obtaining of the determined meta-system (solution aim), which is below marked by the symbol ASS (area of successful solution)

Where:  $q(i) = 1$ , then obtaining ASS is a success

$q(i) = 0$ , then obtaining ASS is a failure

$a$  – constant, which determines the mutuality of the features of operator – pilot and further on, the range ( $0.5 \leq a < 1$ ) is considered

From the above mentioned it follows that the estimation can be characterised as follows:

$y(i) = ay(i-1) + (1-a)$ , if  $q(i) = 1$

$y(i) = ay(i-1)$ , if  $q(i) = 0$

$y(i) = ay(i-1)$ , if  $q(i) = y(i-1)$

AES control characteristics are the input into the solution of differential equation (1). For the need of AES features comparison (i.e. OP and the object - aircraft), ASS characteristic types (i.e. type functions), which express mutuality features, have been selected. [6], [3]

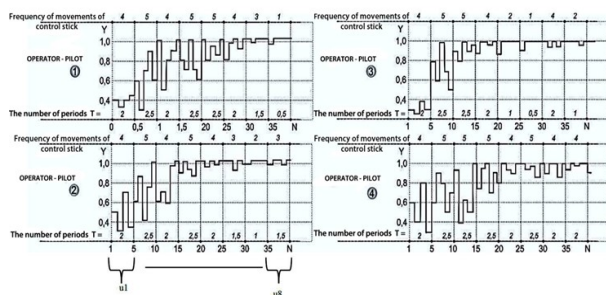


Figure 1. Representation of skills of different operator – pilots in AES control mode [7]

As it follows from Figure 1, the skill, [5] which has been illustrated for concrete cases by the calculation of mean values of AES control lever variation, is decisive for control. It is obvious that the form of the above mentioned characteristic is exponential. Movement of aircraft flight control stick gradually decreases in the mentioned characteristics, which shows the quality of operator - control skills to control

the aircraft. Characteristic features (i.e. two types) of two learning OP's have been illustrated. AES mathematical models, which contain considered characteristics and object, have been made for this purpose.

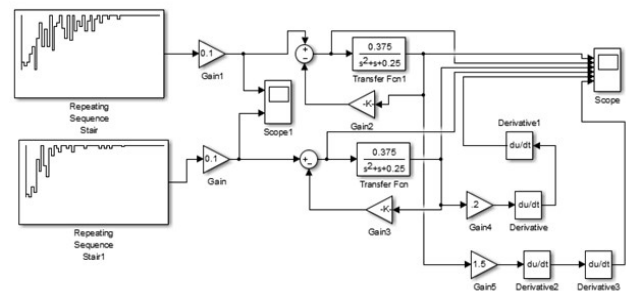


Figure 2. Scheme of AES features simulation with type characteristics of two operators - pilots

Legend:

- 1 – simulation model of OP1, OP3 characteristics (Fig.1),
- 2 – simulation model of object features
- 3 – oscilloscope – AES dynamics observation

Simulated outputs:

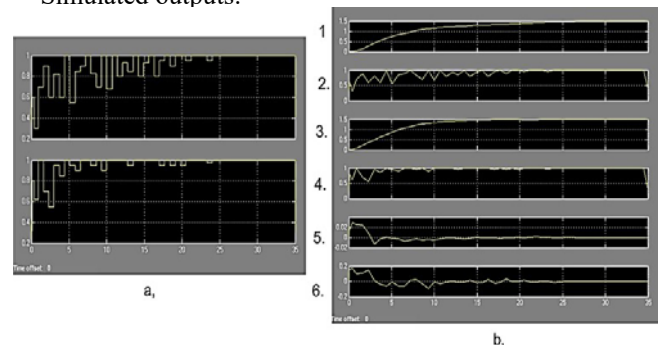


Figure 3. Outputs of AES simulation for OP manual control

*a, inputs OP1, OP3. b, 1 – dynamics of the change angle-off attack evoked by movement the control stick OP1, 2 – control and feedback difference parameter, 3 - dynamics of the change angle-off attack evoked by movement the control stick OP3, 4 - dynamics of the change angle-off attack evoked by movement the control stick OP1, 5 – dynamics of AES acceleration evoked by OP3, 6 – dynamics of AES acceleration evoked by OP1*

If the AES acceleration characteristics quality criterion is determined, then aircraft control learning process for OP3 can be evaluated by the value  $a = 1$ . OP1 can be integrated into the class with value = 0.5 (this evaluation means the expression of OP instructor experience, who is characterised by “i”, high degree of knowledge in control and obtained skill, which presents the connection of theory with practice).[7]

Next, it is possible to highlight the eligibility of such claims and the sensibility in OP integration into classes.

In researching OP skills it is suitable to select a type method of internal structure evaluation of control stick movement in the observed asymptotic learning cycle [1],[2]. The method of research accepts the programme environment Matlab, which enable the availability of task solving by the determination of mean values of movement control stick, Fig. 1. The progression of the programme of mean values calculation follows:

#### OP mean values

```
OP1 = [0.4 0.35 0.4 0.5 0.6 0.3 0.7 0.9 0.6 0.82 0.6 1.0
0.55 0.85 0.9 1.0 0.83 0.7 1.0 0.68 1.0 0.8 0.93 0.85 1.0 0.8
0.93 1.0 0.8 0.95 1.0 0.9 1.0 1.0 0.95];
```

```
t=([1:4:36]); %time of AES cycle control
```

```
y1=[0.4 0.5 0.9 1.0 1.0 0.68 0.93 0.85 1.0]; %random
selection of control stick movement by OP1, according to
object control cycle
```

```
[t';y1']; %control lever movement check and table
construction
```

```
figure(1), plot (t',y1'), hold on, %representation of
control stick movement in AES control for OP1
```

```
OP3=[0.3 0.25 0.34 0.32 0.8 0.62 1.0 0.7 0.55 0.95
0.85 1.0 0.95 0.9 1.0 1.0 0.95 1.0 0.9 1.0 1.0 1.0 0.95 1.0
1.0 1.0 1.0 0.95 1.0 0.95 1.0 0.95 1.0 1.0 1.0 1.0 0.98 1.0
1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0];
```

```
%selection according to OP1 criteria concord:
```

```
y3=[0.3 0.32 0.7 1.0 1.0 1.0 0.95 1.0 0.95];
```

```
[t';y3'];
```

```
plot(t',y3'),
```

```
plot(t',y3',r'),
```

```
ans =      1.0000      5.0000      9.0000     13.0000
17.0000     21.0000     25.0000     29.0000     33.0000
```

```
      0.4000      0.5000      0.9000      1.0000      1.0000
0.6800      0.9300      0.8500      1.0000
```

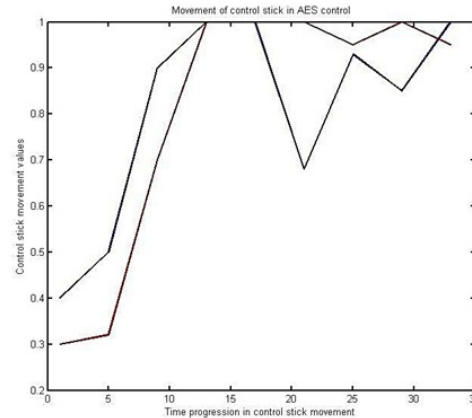
```
ans =      1.0000      5.0000      9.0000     13.0000
17.0000     21.0000     25.0000     29.0000     33.0000
```

```
      0.3000      0.3200      0.7000      1.0000      1.0000
1.0000      0.9500      1.0000      0.9500
```

```
title ('Movement of control stick in AES control'),
```

```
xlabel('Time progression in control stick movement'),
```

```
ylabel('Control stick movement values')
```



**Figure 4.** Control lever movement measurement during AES control Outputs of AES simulation for OP manual control

## 2.1. Partial conclusion

According to Fig. 2 and the simulation results, according to Fig. 3, (control stick movement - Fig. 4) it is possible to estimate the skill for each OP in an expert way. It is possible to guess that the skill  $OP3 > OP1$ . The correctness of intuition decision is possible to be confirmed by the calculation of mean values of skill measurement, which can be performed in the environment MATALAB in the following way.

## 3. OP Skill Quality Measurement

The simulation of operators - pilots (OP1, OP3) has been performed according to a programme algorithm respecting the following orders:

```
%Numeric integration of differential equation (1) of es-
timation variable is listed in MATLAB environment (see
Numerical %Estimation of Pi Using Message Passing) and
required adjustment to the following form
```

```
%yF=@(tau)1/T0/(2.718^(T/T0))*(2.718.^(tau/T0)*q(tau)
)=1/T0(atan(b)-atan(a))=1.% integral differential equation
% a,b:[a,b]- upper, bottom limit (gradually) of integral
yF.
```

```
%For the estimation of operators quality (skills) it is suf-
ficient to determine variable standard which accepts the
principle of its asymptotic growth. The selected standard is:
%T0=n*T, where: N=(observed section(u)/number of
control inputs(r)).Then: T0=u/r*T.
```

```
%T-number of period control inputs
%After substituting parameters into integral equation the
following form is obtained
```

```
%yF=@(tau)(r/u*T)/(2.718^(r/u))*(2.718.^(tau*(r/u*T))
*q(tau).
```

*%Skill estimation by equation yF requires the application of the following orders*

*%[a, b];integral limits  
%P>> myIntegral = quadl(yF, a, b). P-sequence number of sections of OP inputs.*

*%The above mentioned method is applied on the control skill (quality) estimation of both OPI and OP3 operators – pilots whose control inputs are illustrated in Fig (1).*

*% Graph description:  
%Graph Y(N) of each OP presents the function of approximation process into ASS along an exponent line.*

*% N-number of observed sections „u“ in which control inputs with the number or „r“ are recorded.*

*%Final aim of control is the state Y(N)=1.Therefore q(tau)=1 – success.*

*%First control input in section recording: first vertical recording. End of recording is on vertical line of the following section.*

*%First operator skill estimation is marked:*

*% OPI. P11.  
% First section ul(fig.1)*

*r=4;u=5;T=2;  
yF=@(tau)(r/(u\*T))/(2.718^(r/u))\*(2.718.^(tau\*(r/u\*T)))  
a=0.36;b=0.44;[a,b];*

*myIntegral=quadl(yF,a,b),  
% P12.*

*r=5;u=5;T=2.5;  
yF=@(tau)(r/(u\*T))/(2.718^(r/u))\*(2.718.^(tau\*(r/u\*T)))  
a=0.36;b=1;[a,b];*

*myIntegral=quadl(yF,a,b),  
% P13.*

*r=4;u=5;T=2;  
yF=@(tau)(r/(u\*T))/(2.718^(r/u))\*(2.718.^(tau\*(r/u\*T)))  
a=0.5;b=1;[a,b];*

*myIntegral=quadl(yF,a,b),  
% P14.*

*r=5;u=5;T=2.5;  
yF=@(tau)(r/(u\*T))/(2.718^(r/u))\*(2.718.^(tau\*(r/u\*T)));  
a=0.6;b=1;[a,b];*

*myIntegral=quadl(yF,a,b),  
% P15.*

*r=5;u=5;T=2.5;  
yF=@(tau)(r/(u\*T))/(2.718^(r/u))\*(2.718.^(tau\*(r/u\*T)));  
a=0.8;b=1;[a,b];*

*myIntegral=quadl(yF,a,b),  
% P16.*

*r=4;u=5;T=2;  
yF=@(tau)(r/(u\*T))/(2.718^(r/u))\*(2.718.^(tau\*(r/u\*T)));  
a=0.8;b=1;[a,b];*

*myIntegral=quadl(yF,a,b),  
% P17.*

*r=3;u=5;T=1.5;  
yF=@(tau)(r/(u\*T))/(2.718^(r/u))\*(2.718.^(tau\*(r/u\*T)));  
a=0.97;b=1;[a,b];*

*myIntegral=quadl(yF,a,b)  
% P18.*

*r=1;u=5;T=0.5;  
yF=@(tau)(r/(u\*T))/(2.718^(r/u))\*(2.718.^(tau\*(r/u\*T)))*

*a=0.95;b=1;[a,b]  
myIntegral=quadl(yF,a,b),  
% Independent values of sections:*

*N=[1 5:5:35],  
%Function:*

*YN1=[0.0273 0.5722 0.3064 0.4532 0.2851 0.1524  
0.0160 0.018];*

*%Obtained skill estimation is:  
OZ1=1-YN1,*

*%Graf OZ1:  
plot(N,OZ1,'bo-'),hold on,*

*title(' OPERATOR-PILOT SKILL ESTIMATION'),  
xlabel('Observation sections '),ylabel('Skill estimation values'),*

*%Equally the following have been calculated:  
% OP3.*

*N=[1 5:5:35];  
YN3=[0.2225 0.4338 0.4598 0.0823 0.0392 0.0360  
0.0345 0.0119];*

*OZ3=1-YN3;  
plot(N,OZ3,'k'),hold on,*

*t=[1 5:5:35]';  
y=[0.0273 0.5722 0.3064 0.4532 0.2851 0.1524 0.0160  
0.018];*

*plot(t,y,'bo-'), hold on, h = plot(t,y,'b'), hold off,  
title('Input data'); ylim([0 0.45])*

*%y = C(1)\*exp(-lambda(1)\*t) + C(2)\*exp(-lambda(2)\*t),  
type fitfun*

*start = [0;.0261];  
outputFcn = @(x,optimvalues,state) fitout-*

*putfun(x,optimvalues,state,t,y,h),  
options = optimset('OutputFcn',outputFcn,'ToIX',0.1),*

*estimated\_lambda =  
fminsearch(@(x)fitfun(x,t,y),start,options)*

*hold on,  
t=[1 5:5:35]';y=[0.2225 0.4338 0.4598 0.0823 0.0392  
0.0360 0.0345 0.0119];*

*plot(t,y,'go'), hold on, h = plot(t,y,'g'), hold off,  
title('Input data'); ylim([0 0.45]),*

*xlabel(' observation sections '),ylabel(' skill estimation mean '),*

*type fitfun  
start = [0;.018];*

*outputFcn = @(x,optimvalues,state) fitout-*

*putfun(x,optimvalues,state,t,y,h),  
options = optimset('OutputFcn',outputFcn,'ToIX',0.1);*

*estimated\_lambda =  
fminsearch(@(x)fitfun(x,t,y),start,options)*

*hold on*

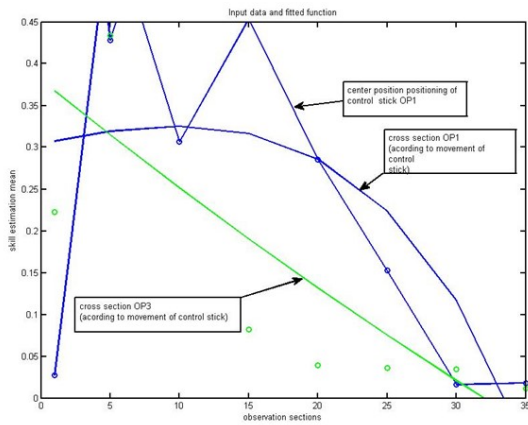


Figure 5. Output reliability characteristics of OP and object mutuality.

## 4. Conclusions

The defined conditions of mutuality research expressed by the character of operator – pilot and the object can be quantified only on the base of experiences which are inserted into the solution by a subjective judgement of an expert. Mutuality quantification in the paper is presented by the parameter „a“, which indirectly enables the realisation of algorithms which have been confronted with the possibilities offered by MATLAB. The simulation of object mathematical models and later OP simulation through the term „skill“ uncovers manifested dependence, which can be used to estimate the reliability of object control by the operator - pilot. The method presented in the paper demonstrates its flexibility to the variants of the control of object control by OP. Appertaining influence of the skill, which is evaluated by movement the aircraft control stick against its mean position in the paper, creates a good prerequisite for the creation of supplementary classification classes which show OP quality and its use for concrete flight tasks solutions. The four used OP characteristics serve as type functions which can create a base for the qualification of the suitability of professionals selection into the process of asymptotic learning to control aircraft in relevant educational environment.

## ACKNOWLEDGEMENTS

This paper has been created following the project in the process of solution which has been co-financed by the EU sources entitled Implementation of scientific research knowledge to the Air Transport -ITMS 26220220010.



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