PILOT PERFORMANCE AND CHANGES IN THE FLIGHT DATA PRESENTATION

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The contribution is a presentation of a project focused on research of pilot traning methods using flight simulators while bringing us closer to the methodology of measuring pilot performance applied during the research. The article is centered on the fundamental hypotheses and the research activities in the field of investigating how changes in the prezentation of flight an navigation information affect pilot performance. Also detailed are the analysed procedures of pilot performance measurements and methods of studying workload.

K e y w o r d s: flight simulator, pilot, performance, workload, training methods.

1 INTRODUCTION

Time pressure, woking in shifts, workload exceeding standard limits represent make up the professional workload for the aircrew, the presence of which they cannot be obviated. Maintaining a certain aircrew performance level is one of the preconditions of achieving high level of flight safety in air transportation. Aircrew performance is affected by several factors, either objective or subjective ones.

They mostly include factors that influence physical, psychological health (fitness, health, sleep, working shifts, workload, time pressure, alcoholc, medicine, addictive drugs), physical factors of the conditions of work (temperature, humidity, noise, vibrations, lighting, ionizating radiation, dust, vapurs), factors related to the socio-psychological aspects of work (responsibility, adjustment to the environment, cultural problems, teamwork, motivation, de-motivation, management, surpervision, leadership).

All the groups of the aforementioned factors can be come sources of psychological stress for the aircrew, substantially affecting their performance. Within the framework of the project named as „Research of the methods of pilot training using flight simualtros“, ITMS code of the project: 26220220161, co-financed from EU founds, research is conducted by the Education training & consulting company a.s. (j.s.c.) in cooperation with the Faculty of Aeronanutics TUKE with focus on the issue of performance and psyhcological stress of pilots generated by changing flight data presentation.

When dealing with the topic, we came across with notions such as psychological stress, workload, emotional stress, stressor, stress etc. Understanding the difference between stress and workload is important for handling them. One can speak of workload when the acting physical, social and psychological stimuli do not cross the limits of one´s personal stability and he or she is capable of coping with them within a short period of time. The individual is experiencing stress when the forces of these stimuly are exceeding the borders of tolerance.

The notion of stress is to help describe how human organizms reacts to the demands and requirements of the environment, not taking into consideration whether these demands are pleasant or unpleasant as human organizm is always trying to maintain a physiological balance (homeostasis) despite the continuously changing external conditions. High level of stress is accompanied by unpleasant physiological and psychological reactions such as the accelerated and deeper breathing, perspiration, more intensive cardial rate, muscular tension, dryness in the mouth, hyprtension, activation of metabolic reserves, strong emotionality, lower level of attention, fear, disability to decide, avoiding responsiblitiy, higher rate or errors etc. The level of resistivity of human beings to stress is a highly individual feature.

In being in search of potentials for higher performance of the staff under higher workload while reducing the negative impacts of stress to their activities, our attention is focused their causes. As it has been stated earlier, high potential for failure is the common denominator of all kinds of workloads. It is the reason why the research project is centered on the possibilities of reducing workload and thereby indirectly decreasing the level of stress burdening the aircrew, thus improving their performance and preventing potential failures from happening. The strategic aim of the project research conducted by ET&Cc, a.s. in cooperation with the FA, TUKE, is to focus research on improving air traffic safety and the follow-up transfer of the new findings into economic practice.

The project is run within the framework of two activities under the following names:

1. Analyzing simulator training procedures for pilots - professional supervision of this activity is ensured by an analytic team made up of the expert staff of the FA, TUKE.
2. Research and optimization of simulator techniques and their validation in practice – professionial supervision of the activity is provided by the resarch team of aviation experts from the ET&Cc, a.s (j.s.c.).

2 ANALYZING SIMULATION TRAINING PROCEDURES FOR PILOTS

The initial phase of the project realization was about mapping the status quo in the field of applied procedures as part of aviation staff preparation and training with emphasis laid on the efficiency of the flight simulators and their contribution to raising the level of air transportation safety. The analysis was aimed to identify those processes, which can be marked as insufficient in terms of pilot training and having

negative impact on air transport safety. The analysis itself was conducted both for domestic and foreign environments and was channelled into the following segments of the avaition environment – airliners, aviation schools, units of military aviation, manufacturers and operators of flight simulators.

The contribution will further be aimed at one of the identified processes in terms of their application or non-application within the process of pilot training with focused on changing presentation of basic flight and navigation data on the instrument panel in the cockpit. Current progress in the field of presenting the basic flight, navigation and power plant data on the dashborard is about replacing the classical analogous indicators (speedometer, artificial horizon, vertical speed indicator, turn and bank indicator) for glass-cockpit presentation using a primary flight display in combination with a navigation (e.g. GARMIN 1000), which are in some cases introducing fundamental changes in the way of presenting information necessary for flying at and navigating an aircraft. The changes also affect pilots´performances in terms of their performing techniques of piloting, a fact that becomes apparent in variances of actual aircraft positions and trajectory compared to those required parameters. The current status, wich is also a reflection of legislative requirements stated for pilot preparation, is unsuitable in terms of the significant changes of data presentation.

Airworthiness of the pilot is bound to a type, regardless of cockpit ergonomics for the presentation of the selected data. The new situation enables for the pilot already experienced in flying, by analogoue form of presentation on a concrete type of aircraft, to perform a flight using glass-cockpit presentation on the same type of aircraft and vice-versa, without any need for conversion training nor extra theoretical preparation. Such situation is frequent mostly in general aviation, assuming that the issue of changing presentation varies with the different categories of pilots, e.g. in terms of flight proficiency, number of hours flown, length of aviation career, etc.

Based on the outputs of the analysis, for the purposes of research activities, two hypotheses have been set up, which will help obtain new findings in the area of our concern:

1. Based on the findings of the analysis we suggest that the effect of the changing presentation from analgoue to glass-cockpit will have a negative effect on those pilots, who have been flying only by analogue data presentation, flying only a small number of hours (cca up to 100 flight hours), or are at their very initial stage of flight training with minimum experience in instrument flying. This category of pilots will form the 1st test sample of pilots, the so-called beginners. Assuming that the transition in data displaying is preceeded by a training method using flight simulators, changes in the presentation will reduce psychological workload and improve pilot performance, precision of piloting and ultimately air trasportation safety as it.
2. Based on the findings of the analysis it is assumed that the effect of changing from analogous to glass-cockpit presentation or vice-versa will be more present in the proficiency of those pilot, who have been flying with one form of presentation, or having flown a larger number of hours using another form of presentation before the change occured. In view of the fact that aircrafts are operated with both forms of presentation, pilots are confronted with alternating forms of presentation, some made within a short period (e.g. even within a day) and some over longer periods of time. These category of exprienced pilots will form the 2nd test group. It is assumed that the change in presentation is preceeded by a new training method, then the change will result in reducing psychological workload and improving pilot performance, lessening psychological stress and increasing precision of piloting and thereby air traffic safety.

The next part of contribution is providing more details about the research specifications for the issue resulting from Hypothesis 1.

3 RESEARCH SPECIFICATION

Research related to Hypothesis 1 was oriented on defining the effect of changing the analogue presentation into glass-cockpit one in terms of beginner-pilots´performance. All phases of research-related flights (piloting in the assigned zone) were carried out on aircrafts and flight simulators as instruments-flights while making partial use of the natural horizon (in a ratio of cca 80 % flying on instruments to the one of 20 % flying by the natural horizon).

As the testing sample also comprised pilots in the very initial phase of training, in the beginning a basic theoretical preparation taking 1 hour as familiarization with basic piloting techniques. The theoretical preparation was followed by basic techniques of piloting on an analogue-presentation simulator taking l hour. After having flown the exercise, the Pilot Performance Measurement 1 was made (see Point 4 of the contribution). Then came the training of basic techniques of piloting an analogue presentation simulator taking 8 flight hours with focus on maintaning the required flight parameters during:

- straight-and-level flight,
- horizontal turn completed at a given heading ,
- climb turn at a pre-determined rate of climb and completed in a given heading,
- descent turn at a predetermined rate of descent completed in a given heading.

After completing the whole introductory programe for the simulator with analogue presentation, the Pilot Performance Measurement 2 was made on and

analogue simulator taking 1 hour. It was followed by a basic theoretical preparation for an aircraft in real operation that took l flight hour and then Pilot Permformance Measurement 3 was made on an aircraft with analogue presentation, again taking 1 hour. This stage of research in flying on analogue presentation aircraft ended with Pilot Performance Measurement 4, with focused on pilot flying an aircraft with analogue-presentation, lasting for 1 hour.

In the next phase of research, the pilots were divided into two groups:

Group A

Pilots assigned to *Group A* completed transition to an aircraft with glass- cockpit presentation while making use of currently training procedures applicable for changing from analogue presentation to galss-cockpit one.

Within the framework of this transition, the pilots received a brief familiriazation with glass-cockpit presentation in terms of the procedures currently valid for such changes in presentation, whereas the numbers of hours flown indicated thereafter were mostly exceeding real numbers of hours applied in practice and in most cases use of flight simulator is absent. It means that the testing objects within *Group A* have gone through a short theoretical preparation taking l hour and then it came to the Pilot Performance Measurement 5, made on a simulator with glass-cokpit presentation, taking l hour. It was followed by Pilot Performance Measurement 6 on an aircraft with glass-cockpit presentation lasting for 1 flight hour.

The procedure helped identify the impact of changing the presentation (from analogue to glass-cockpit one) on pilot performance in terms of the pricision of piloting and at the level of workload while making use of the current procedures applicable to such changes for pilots when changing for glass-cockpit presentation on a single type of aircraft, or when changing the aircraft type.

Group B

Pilots assigned to *Group B* have completed transition for an aircraft with glass-cockpit presentation by the new training procedures designed for changing from analogue to glass-cockpit presentation.

They were informed in details about glass-cockpit presentation in terms of the new training procedures applicable to such change in the form of data presentation. It means that the monitored subjects have received a detailed theoretical preparation lasting for 3 hours, basic training of piloting on a flight simulator with glass-cockpit presentation taking 4 flight hours. Then followed the Pilot Performance Measurement 5 made on a glass-cockpit simulator lasting 1 flight hour. Pilot Performance Measurement 6 was made on an aircraft with glass-cockpit presentation, lasting for l flight hour.

Applying the procedure as above, it was possible to identify the effects of changing data presentation (from analogue to glass-cockpit) on pilot performance in terms of the precision of piloting, levels of workload when making use of the new training applicable to such changes in cockpit data presentation. At the same time, one could compare of the impact of the transition from analogue presentation to glass-cockpit one precision made on pilot performance when applying the currently and new procedures applicable to such change in presentation.

4 PILOT PERFORMANCE MEASUREMENT

As part of the research activities realized within the project, Pilot Performance Measurements were made in the following two ways:

1. By identifying the variance of the actual true flight parameters from those required in the specified phases of flight. The variations were verified with a time delay of 1 second for a period of cca l minute in the given modes of flying. For each given mode of flight, 3 measurements were made, while two subsequent flight being identical.

For the purpose of recording the actual flight parameters, the project adhered to the following procedures:

- Recording flight parameter on a TRD 40 flight simulator using the Instructor station SW in Performance function,
- Recording flight parameters when flying on real aircraft using the Flight data recorder supplied by TRADIP, s.r.o.,
- Recording flight parameters (maximal variances) by the pilot-instructor into an evaluation form.

Variances of actual flight parameter from the required ones are verified during:

- straight-and-level flight (altitude, heading),
- horizontal turn (altitude, bank, completed in a heading),
- climb turn (rate of climb, bank, completed in a heading),
- descent turn (rate of descent, bank, completed in a heading).

2. In via recording the psycho-physiological parameters of the pilots for the purpose of quantifying the level ov workload, measurements performed during the entire flight were focused on:
   - heartbeat frequency,
   - breathing frequency,
   - body temeprature,
   - physical activity (3D actigram),
   - intenzity of muscular activities.

The level of workload for the purpose of the research is defined as variations of the selected psycho-physiological parameters of the pilot from those of the selected initial level of these parameters of the same pilot expressed in both digital and graphical forms. Within the project framework, we work with the hypothesis in

which we assume that assuming that to a certain level of pilot workload, in line with the stated definitions, the load is negatively affecting pilot performance, e.g. also in terms of the precision in piloting techniques. It means that, by way of measuring the levels of pilot workload, it is possible to quantify pilot performance. For the measuring purposes, the project makes use of the measuring device developed by the Faculty of Bio-medical engineering of the ČVUT Prague.

The basic parameters and the set-up of the measurement device:

- Telemetric scanning unit
  - in on-line mode, wireless communication via a wireless XBee interface,
  - in off-line mode, possibility of recording data onto an SD card.
- Sensor module for scanning heartbeet frequency.
- Sensor module for scanning body temperature.
- Sensor module for scanning physical activity (3D actigram).
- Sensor module for scanning breathing frequency.
- Sensor module for scanning the intensity of muscular activity.

5 CONCLUSION

Research of testing samples and data collection have already been completed. What is going on now is further processing of the collected data and getting them ready for evaluation. Such a research conducted in the field of air traffic safety should bring about improvement by way of obtaining new information about training methods of pilots is aimed reducing their psychological workload that negatively affect their activities. Employing flight simulators enables verification of the new methods applicable to pilot training and thus ensures fulfillment of the project´s strategic aim – contribution to the improvement of air transportation safety.

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