UDC 656.7.086 (45)

T.F. Shmelova, Doctor of Engineering, Professor,
N.O. Bezpalko, T.O. Alifirenko
(National Aviation University, Ukraine, Kyiv)

Method of diagnosing the current emotional state of the pilot. the manned aircraft to unmanned control in extraordinary situations transferring

Approaches to identifying the current emotional state of the pilot using the methods of dispersion analysis and dynamic modeling were considered; a methodology for determining the stability of the "Dispatcher-Pilot-Aircraft" system with deformations of the pilot's emotional state in non-staff situations was developed. A new approach of acting in case of the inability of the pilot to control the aircraft, which consists in monitoring the pilot`s condition, controlling deformation, and transferring to unmanned automation was considered.

An important place in the unified transport system of Ukraine belongs to air transport, the importance of which is constantly growing in the world. Recently, unmanned aviation is rapidly developing, actively integrated into the aviation system. Currently, an urgent problem in the air navigation system is the full integration of unmanned aerial systems (UAS) and unmanned aerial vehicles (UAVs) into the air traffic management system [1-3].

Every year, airplanes are becoming more perfect and more reliable, but human functions are becoming more complicated. According to statistics, 70% of the causes of aviation events in the world are due to the fault of the human factor [4]. According to the documents regulating flight operation, the final decision in the event of emergency situations is made by the aircraft commander (aircraft). But the responsibility for timely information rests with the air traffic controller, especially in non-staff situations. It is important for the dispatcher to have operational information about the development of the emergency situation; the current emotional state of the pilot controlling the aircraft in order to quantify the forecast of the development of the emergency situation, taking into account the state of the pilot operating in extreme conditions, this is also assumed by the development of air navigation systems (ANS) towards the integration of ground and airborne means with the help of modern satellite technologies [5].

The purpose of the research is to develop a control system for a piloted aircraft as a UAV in the event of an uncontrollable state of the aircraft on the part of the pilot (critical condition of the pilot, loss of the pilot's working capacity, emergence of an off-duty situation, etc.)

Research in world practice on determining changes in the emotional state of L-O is carried out, mainly, due to direct measurements of such physiological characteristics as pulse, blood pressure, hand tremors, sweat, changes in the iris of the eye, etc., using the appropriate medical equipment, sensors [6]. Such studies of the operator's physical condition are of practical importance, but there are difficulties in obtaining actual measurements of the L-O's emotional state in the process of performing professional duties, especially in the event of out-of-hours situations. It is necessary to develop research to obtain real characteristics of the pilot's emotional state without interfering with the ergonomic conditions of his operator activity. Piloting parameters and negotiations in the cockpit are such means of assessing the pilot's work status. More accessible are piloting parameters (deflection of ailerons, rudder, etc.), which are recorded by modern means [7].

In case of deformation of the emotional state of the pilot (critical changes in behavior, loss of pilot's ability to work, etc.), and bias in his decision-making in conditions of risk, the concept of human mental activity was applied, which is based on the property of human consciousness to delay or accelerate the flow of subjective time relative to real time. Deformation of the pilot's emotional state is determined using a priori models of human operator activity, built on the basis of a posteriori studies of the actual material of the investigation of aviation events [1; 8].

Spontaneous (optimal) piloting is characterized by the correctness and timeliness of the pilot's actions in a special situation. As emotional stress increases, the pilot may switch to potentially dangerous types of mental activity: emotional - with actions ahead of real time and rational - with actions delayed relative to real time. Spontaneous piloting is ensured, for the most part, by automatic mental processes and is characterized by the infallibility of the pilot's actions within the limits of previous experience [6]. The actions of the pilot in the spontaneous, emotional and prudent modes of activity are determined by the phase trajectories of the deflection of the ailerons and the rudder [1; 9].

The graphs (Figure 1.a-b) reproduce the types of deformations of the emotional experience of the pilot controlling the PC, depending on the deflections of the ailerons when emotional stress appears. The ability to use these graphic models in real time will allow timely recognition of the pilot's emotional state.

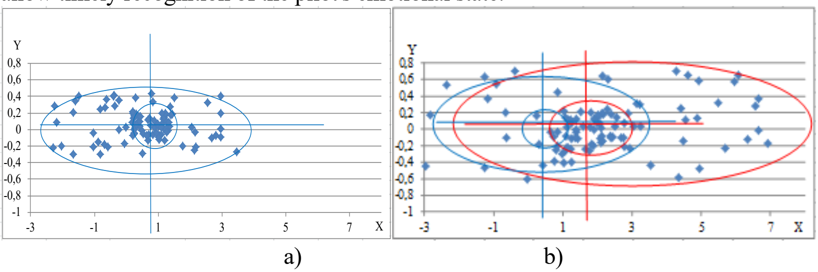

Figure 1. Graphical presentation of the variance of deformation from the spontaneous type into a reasonable type pilot activity: (a) Spontaneous type of activity; (b) Reasonable type of activity

A methodology for identifying the pilot's current emotional state has been developed using the methods of dispersion analysis, with the help of which dispersions are determined for spontaneous, emotional, and rational types of mental activity. In order to diagnose the emotional state of the pilot, the critical state of the aircraft, and to determine the stability of the "Dispatcher - Pilot - Aircraft" energetic system when the emotional experience is deformed in the event of an emergency situation in flight, a methodology for determining the stability of the "Dispatcher - Pilot - Aircraft" energetic system has been developed [8; 9]. Monitoring the current emotional state of the pilot and diagnosing deformations of emotional experience in the form of transitions to dangerous types of pilot activity (reasonable or emotional) in extreme situations and determining the functional stability of operators will allow timely prevention of the development of the flight situation towards deterioration.

The proposed technique will make it possible to timely diagnose and predict the possible actions of a human operator in emergency situations. Developments may be of significant interest to airlines that seek to achieve high quality monitoring under the LOSA ("Line operations Safety Audit") program and are offered for use within the LOSA flight safety audit program in order to create a database of crew actions in real flights [8; 9]. As a result of the previous research, the condition of the pilot was defined and the deformation of the emotional state of the pilot in-flight was diagnosed. If it is unsatisfied (in the case of hypoxia or high level of stress) needs to transfer the airplane to unmanned control. The way to make the airplane an unmanned aerial vehicle means piloting by remote control or onboard computers considered.

There was a such an experience in the USA, where a transformed jet airplane into a UAV [12]. In September 2013, the unmanned version of the famous F-16 jet called QF-16 UAV made its first flight. From that moment, it became clear that the modification of traditional aircraft into UAVs is more than a mere experiment. Using a hand-held transmitter, the operator communicates with an electronic receiver inside the aircraft, which then sends signals to move mechanisms that change the position of the plane. Considering that the QF-16 was developed in 2013 as a full-scale aerial target (FSAT) [13] for the US Air Force (USAF) by Boeing, nowadays it has become a well-tested system that has full potential to be implemented in civil aviation.

Transformation may highlight the main stages to convert the airplane into UAVs:

1. Creation of the preliminary mathematical model using artificial Intelligence methods [8; 9].
2. Adaptation of control algorithm and organization of necessary research works on the piloted airplane.
3. Test flights of the piloted version with available control systems on the Customer’s base.
4. Conduct the flight program (with the pilot) and monitor and fixing of parameters in the auto-pilot mode/clarification of antenna positions on the aircraft.
5. Clarification of the mathematical model.
6. Compilation of design documentation and transfer of a prototype.
7. Technology transfer for independent production and control of the UAVs.
8. As a result, need properly define the condition of the pilot and if it is unsatisfied (in the case of hypoxia or high level of stress) we need to transfer the airplane to unmanned control.

Conclusions

The diagnosis of the emotional state of L-O ANS was carried out using the methods of dispersion analysis. Models of dangerous deformation of the emotional state of L-O ANS in the event of OVP occurrence were obtained.

The stability of the ANS in case of deviation of the emotional state of the L-O's mental activity from the optimal one, in the case of deformations of the L-O's emotional state was determined.

The next part of the work included consideration of possible ways to transfer the aircraft to unmanned control. As a result, it is possible. For this, it is necessary to take the system of unmanned aerial vehicles from the military sphere and introduce it into the civil one. And we hope that it will be implemented soon.

References

1. Kharchenko V.P. Avionics of unmanned aerial vehicles / V.P. Kharchenko, V. I. Chepizhenko, A. A. Tunik, S. V. Pavlova. - K.: "Abris-print" LLC, 2012. - 464p.
2. Guide to Remotely Piloted Aviation Systems (DPAS) / Doc. 10019/AN 507. 1st ed. - Canada, Montreal: ICAO, 2015.-190 p.
3. Unmanned aviation systems (UAS) / Circ. ISAO 328-AN/190. - Canada, Montreal: ISAO, 2011. - 66 p.
4. Leichenko S.D. The human factor in aviation: a monograph in 2 books / S.D. Leichenko, A.V. Malyshevskii, N.F. Mykhailik - Kn. 1. – Kirovohrad: IMEX, 2006. – 512 p.
5. Kharchenko V.P. Decision-making by the air navigation system operator: monograph / V.P. Kharchenko, T.F. Shmelova, Yu.V. Sikirda – Kirovohrad: KLA NAU, 2012. – 292 p.
6. Global air navigation plan in relation to CNS/ATM systems. / Doc. 9750. - Canada, Montreal: ICAO, 2007. - 139 p.
7. Bazlev D.A. The concept of building an on-board information-expert system to support pilot actions in special flight situations / D.A. Bazlev, V.N. Evdokymenkov, N.V. Kim, M.N. Krasilshchikov // Bulletin of computer and information technologies. – 2007. – No. 1. – P.15–20.
8. Socio-Technical Decision Support in Air Navigation Systems: Emerging Research and Opportunities: manuscript / Tetiana Shmelova, Yuliya Sikirda, Nina Rizun, Abdel-Badeeh M. Salem, Yury N. Kovalyov. - International Publisher of Progressive Information Science and Technology Research, USA, Pennsylvania. 2017. - P. 305
9. Shmelova T., Arnold Sterenharz, Yu.Sikirda. Automated System for Monitoring and Diagnostics Pilot's Emotional State in Flight. Proceeding International Journal of Information Technologies and Systems Approach (IJITSA) / Editor-in-Chief: Manuel Mora (Universidad Autónoma de Aguascalientes, Mexico) IJITSA, 2021
10. Lefebvre V.A. Functions of fast reflection in bipolar selection / V.A. Lefebvre, J. Adams-Weber // Reflective processes and management. - 2001. - No. 1. - July-December. - Vol. 1. - P. 34–46.
11. Kharchenko V.P. Graph-analytical models of decision-making by a human operator of an air navigation system / V.P. Kharchenko, T.F. Shmelova, Yu.V. Sikirda // Bulletin of the National Aviation University. – 2011. – No. 1. – P. 5–17.
12. www.naumenko.info / Pavel Naumenko / Library and Information Science Resources 2014
13. https://www.airforce-technology.com/ QF-16 Full Scale Aerial Target 08 December 2016