UDC 629.7.051.062.2-52(043.2)

D.A. Prosvirin, postgraduate student (NAU, Ukraine, Kyiv)

ENCHANTMENT OF AUTOMATIC FLIGHT CONTROL SYSTEM QUALITY AT APPROACH PHASE

Analysis of emergency situations depend on phases of flight is done. Application of modern model based technologies for automatic flight control systems development is considered. The program for aircraft-automatic flight control system control loop simulation and visualisation is developed. Improvement of the automatic flight control system characteristics

Introduction

Analysis of emergency situations abroad shows that, more than 50 % of general accidents happen at take-off and landing phases of flight. And duration of these phases is only 2% from the average flight duration. Specified data were taken from general report of Boeing Company (see Figure 1 below).

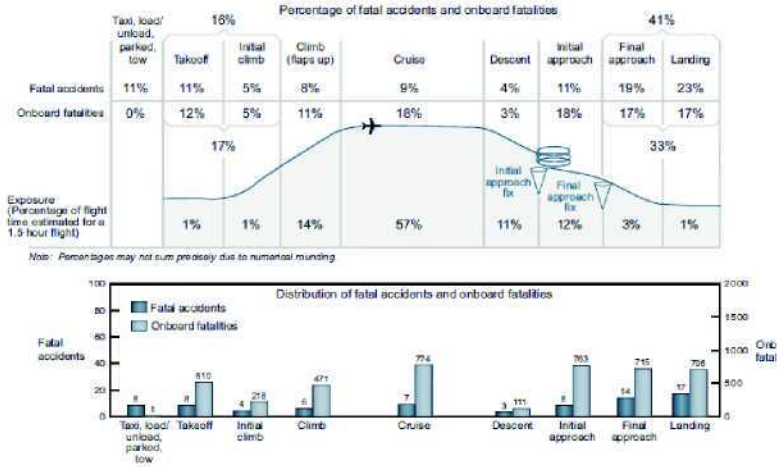

Figure1. Fatal accidents and onboard fatalities by phase of flight (Worldwide commercial jet fleet – 2003 through 2012)

Many academic papers and researches are dedicated to aircraft control quality improvement at the critical flight phases [3-7]. All they are based on knowledge of the nominal aerodynamic characteristics or using normalized diagrams for the correction of the main maneuvers on the take-off and landing according to the a priori known factors: temperature, airport height, runway slope, wind velocity vector, etc. As noted in several studies [3, 4, 8], the existing technique of decision at the take-off and landing based only on the time of reaching the aircraft so-called the decision speed V1, can not prevent accidents are caused by too low acceleration characteristics of the aircraft, the loss of traction, the excess of the permissible mass,

brakes failure or deviation of weather conditions from the expected. So, search for new solutions and methods of improvement automatic flight control characteristics is relevant task and thereby increasing of aircraft flight. In some cases it is not possible to assess the performance of the aircraft flight control systems quality by the direct method - flight tests - because of the limitations of the existing objective conditions for its implementation. This, and the relative duration, spending resource of real assets and substantial economic costs of flight tests enforce to search for a more rational methods of work organization that to assess flight control systems performance [1]. In addition, the U.S. Federal Aviation Administration (FAA), European Aviation Safety Agency (EASA) and other international authorities of aviation security insist on the use of functional safety standards, that to ensure the proper functioning of a complicated electronic equipment of aviation systems in any foreseeable conditions, to exclude defects and the possibility of the aircraft crashes.

Development of automatic control lows

Automatic control of the lateral movement is implementing through the channel of the rudder and ailerons. Rudder channel provides damping of oscillations around the normal axis, and the eliminating of slip angle. Roll and heading purposive control is provided by ailerons in coordinated turn mode. Testing of the specified roll angle and heading is provided by the simultaneous operation of the rudder and ailerons [4]. Research of the automatic control laws of lateral movement is based on a decomposition principle (division) of rudder and ailerons channels. For this purpose, the original object of the control lateral movement is divides into two sub-objects which are implementing flat turn and coordinated turn modes. Approbation of flight parameters prediction method at the landing phase was implemented on computer bench. Operator's panel allows to set the inertial-mass, geometric characteristics of aircraft and creates landing scenarios in accordance with Flight manual (see Figure 1 below).

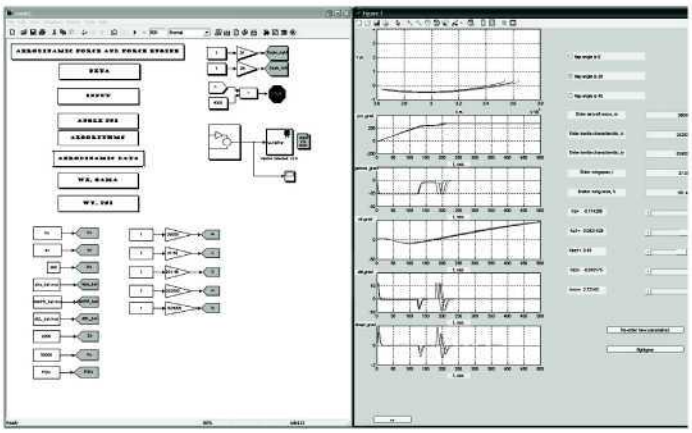

Figure 2. The main operator's panel setting window

Analysis of the control law in the «Approach» mode

In the issue of analysis below, is recommended to reduce the gear ratio for the lateral coordinate to value $K_z = 0.06$ ($K_{z\ calc} = 0.1$). Inclusion to the control law of the mentioned correction improves the control quality in the wind disturbance, i.e, the presence of this correction is required. Analysis of the $K_{\tilde{r}}$ impact on the control quality at the worst set of disturbances indicates expediency to increase the value $K_{\tilde{\Gamma}}$ to 0.2 (previous value was 0,043). In addition, limitation function is added to the integral component of the control law. The results of the of the control law in the «Approach» mode research (Figure. 3) are the new (improved) control laws in the rudder and aileron channels. The above approach will: carry out the synthesis of automatic control law in the rudder channel; execute the development of aircraft autopilot lateral movement control schemes, implement the following modes of AFCS: roll stabilization mode, heading stabilization mode and to develop the functional circuits that implement automatic control of the heading and roll angles.

Fragment of developed control lows analysis at "Approach mode" with specified conditions showed below.

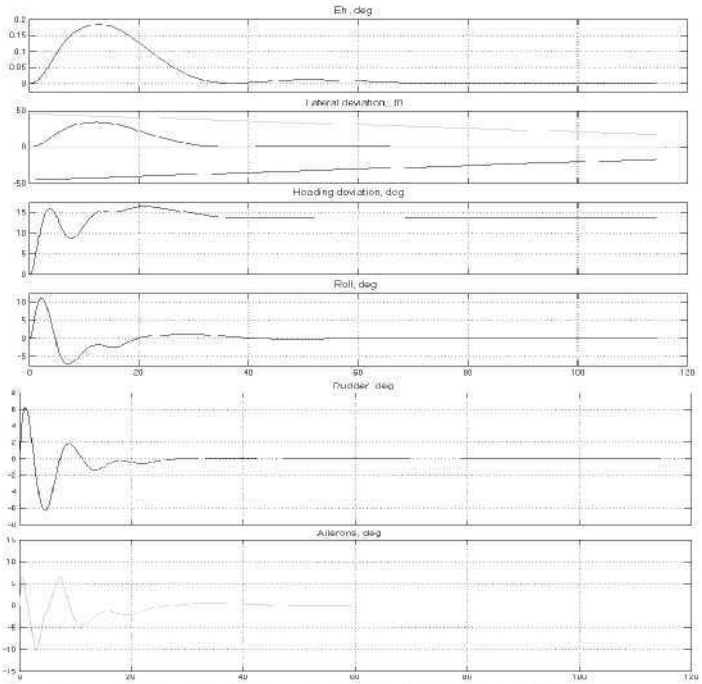

Figure. 3. Wz=-15m/s, Fmx=-1,5(=3 deg), Fmy=1 (=-3 deg), Z=-20m.

Conclusion

This article addresses approach of automatic flight control system quality enchantment that allows engineers to facilitate development and maintenance process. Determination of the automatic flight control system architecture and verification are passing at the level of model. It saves the time, which usually takes to significant verification efforts (models can be verified as soon as they are available even in parts). As it can be seen from above results the mathematical modeling was conducted within the permissible range and did not exceed the requirements of the specified type aircraft. Therefore, the use of the above algorithm is reasonable. In conclusion, we note that the presented approach to the enchantment of automatic flight control system quality allows to perform a preliminary analysis of the different modes of automatic flight control system at the stage of co-design the aircraft and automatic flight control system; to carry out maintenance of automatic flight control system semi-natural test; to perform statistical analysis of approach mode with significant savings in material costs during the flight test ; make recommendations of automatic control loops setting at the flight test of automatic flight control system, which will reduce the time and cost of field research and certification of automatic flight control system; meet the requirements of safety functional standards, simplify the development process and reduces costs.

References

1. Software considerations in airborne systems and equipment certification (RTCA/DO-178B): DO-178B- [December 1. 1992]. - Washington. D.C. 20036 USA, 1992.-112.
2. Efficient Development of Safe Avionics Display Software with DO-178B Objectives Using SCADE Suite™: [Methodology Handbook]. - France: Esterel Technologies, 2012. - 110.
3. Shligerski A., Model-based development of safe application software for safety-critical railways systems using scade tool environment/ Shligerski A., Umanski V.-M.: Functional safety – theory and practice, 2009.-pp.13-21.
4. Myers J. Software Reliability – Principles and practices/ Myers J.-N.Y.: IBM Systems Research Institute Lecture in Computer Science, Polytechnic Institute, 1976.-360.
5. Statistical Summary of Commercial Jet Airplane Accidents. Worldwide Operations. 1959 20, Boeing. July 2012.
6. Глубокая М.Г. Бортовая система поддержки принятия решений на этапе взлета пассажирского самолета. // Техника воздушного флота, т. LXXXII, 1 (690), 2008 — С. 21—30.
7. Никифоров С.П. Бортовая система контроля разбега — эффективное средство повышения безопасности взлетов транспортных самолетов // Техника воздушного флота. — 2002. 3—4, С.47-54.
8. Pinder S.D. Aircraft Takeoff Performance Monitoring in Far-Northern Regions: An Application of the Global Positioning System. // Ph.D. thesis. — University of Saskatchewan. — 2002.