Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

Abstract #XXX *(to be filled by the organizers)*
Preferred Topics: SUSTSP / SYSINT / REUSSA *(3 maximum from the list of topics)*
Corresponding author: ZAJDEL Albert
e-mail of corresponding author: albert.zajdel@ilot.lukasiewicz.gov.pl
Type: Oral / ~~Poster~~ *(select)*
Status of corresponding author: Regular / ~~Student~~ *(select)*
For student corresponding author: student member of one of the following:
3AF / AAAR / AIAE / AIDAA / CzAeS / DGLR / FTF / NVvL / PSAA / RAeS / SVFW / EUROAVIA

Title

Flight test verification of Hardware in the Loop simulations of the PZL-130 Orlik aircraft stabilization system that uses trim tabs in the lateral channel

Authors

Albert ZAJDEL [1], Michał Welcer [1], Cezary Szczepański1[1], Mariusz Krawczyk[1]*

** Corresponding author*
[1] Łukasiewicz Research Network – Institute of Aviation, 02-256 Warszawa, Poland,
albert.zajdel@ilot.lukasiewicz.gov.pl

Abstract

Over the years, many aircraft manufacturers have introduced more electric architecture to their aircraft. These upgrades often concern replacing or modifying hydraulic system, actuators, and mechanical controls with electric solutions. As a result of reduced aircraft mass, fuel consumption, emissions, system complexity and its maintenance it is very beneficial for the suppliers and users [1, 2].

One of the areas where an electric system can be applied is the aircraft trimming system. Such system retrofit creates an opportunity for the aircraft that need automatic stabilization and has a trim tab on every primary control surface: aileron, elevator and rudder. Although not common in smaller aircraft, control system that uses trim tabs are used in large aircraft due to the high moments required to deflect primary control surfaces.

The project, which results are presented in this paper, concerns design, development, simulation and hardware in the loop testing, and finally, ground and flight testing of a stabilization system that uses trim tabs for the Polish military trainer aircraft PZL-130 Orlik. The first question was if the trimming system would generate enough moment to deflect primary control surfaces and if the primary control deflection response caused by its trim tab deflection would be fast enough to keep the aircraft in stabilized flight in the cruise speed range. To assess that a flight test campaign was conducted during which the pilot controlled the aircraft only by using trim tabs. The main results from these tests are presented. The outcome was that it is possible to perform all the planned manoeuvres, even aerobatic ones like a barrel roll. It was also possible to identify trim tab-primary control surface deflection dynamics, used in the model-based design process of stabilization system design, development and testing.

At first, the nonlinear aircraft model was built in Simulink, including aerodynamics with slipstream effect [3], trim tab and actuators dynamics. Then the stabilization system was modelled, including its control laws, state machine and interfaces. After the model in the loop simulation tests, stabilization system software was automatically generated and transferred into the designed and manufactured onboard computer. Together with our actuators [4], the whole system underwent hardware-in-the-loop simulation testing before installation on aircraft and ground and flight testing.

The paper compares results obtained during simulation and flight test in the lateral control channel. The lateral control channel covers heading stabilization using an aileron trimmer and counter slipstream mode with a rudder trimmer. This channel was tested in flight at first because it is easier to tune than a longitudinal channel due to lack of nose up or down

movement, which can lead to stall or dive. There are differences between control system transient responses to the same inputs are discussed, but in general, in both cases, the aircraft response was stable.

References

[1] Okhapkin, A.; Steblinkin, A. An Approach to Fuel Savings and Environmental Benefits Assessment of Electrified Primary Flight Control Actuation System for Short/Medium-Range Passenger Aircraft. *More Electric Aircraft 2017 Proceedings*, **2017**.

[2] Garriga, A.G.; Govindaraju, P.; Ponnusamy, SS.; Cimmino, N.; Mainini, L. A modelling framework to support power architecture trade-off studies for More-Electric Aircraft. *Transportation Research Procedia*, **2018,** *vol. 29*, pp. 146-156, https://doi.org/10.1016/j.trpro.2018.02.013

[3] Krawczyk, M.; Graffstein, J. A Proposition of Control Augmentation System for Dumping the Harmful Impact of Slipstream in Turboprop Airplanes. *Scientific Papers of Rzeszów University of Technology-Mechanics*, Rzeszów **2013**, *Vol. 288*, pp. 287-295, http://doi.prz.edu.pl/pl/publ/mechanika/38

[4] Zajdel, A.; Krawczyk, M.; Szczepański, C. Pre-Flight Test Verification of Automatic Stabilization System Using Aircraft Trimming Surfaces. Aerospace 2022, 9, 111. https://doi.org/10.3390/aerospace9020111