EASA
European Union Aviation Safety Agency

Enhanced fault detection and diagnosis solutions for air data systems

Contractor

Airbus

Consortium Members

TU Delft

Contract period

15/11/2022 - 14/11/2024

Budget

760 000€

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Main objectives:

Looking back at aviation history, multiple factors such as e.g. improved training or Safety Management System implementation have brought continuous significant safety improvements. Innovative and advanced control also played a major role in enhancing the safety, especially thanks to technology like the digital Fly-By-Wire (FBW) systems first introduced in 1988 with the Airbus A320 Program. FBW technology provides more sophisticated control of the aircraft and flight envelope protection functions. However, some systems failures may lead i.a. to unexpected behaviour of these useful features which could lead, under some extremely unlikely combination of factors and / or circumstances, to more complex situations to manage from the control point of view. A particular failure class of interest is related to aircraft sensors prone to harsh environmental (e.g. probe contamination), operating (e.g. severe fuselage damage) or damage conditions (e.g. during maintenance) which could lead to simultaneous and potentially consistent multiple erroneous measurements. The current certified system monitoring state of practice is mainly based on consistency tests, cross checks, or built-in-test of various sophistication, and inspection. In this R&I project, the introduction of additional safety nets that are meant to catch complex failures upon occurrence is expected to enable the next step in aviation safety.

Recent safety incidents have underscored the potential impact of common causes on two or more air data parameters, eluding detection through existing checks. This can lead to the incorporation of erroneous air data parameters (e.g., airspeed, angle of attack) into flight control laws. The project's primary goal is to devise and advance methods for detecting and/or withstanding multiple, consistent, and potentially simultaneous air data sensor malfunctions. These advancements aim to enhance EASA certification standards and aid in evaluating new designs proposed by aircraft manufacturers.The goal is decomposed into two main objectives:

1) to identify and characterise realistic air data sensor malfunction signatures and scenarios, including consistent and simultaneous erroneous behaviours from multiple sources;

2) to propose innovative methods for detecting and robustly handling complex scenarios of multiple consistent simultaneous air data probe failures. Methods such as flight parameter estimation (FPE), fault detection and diagnosis (FDD), will be investigated, utilizing model-based (e.g. estimators/virtual sensors), data-based (i.e., model-free methods, signal processing treatment), or hybrid approaches. Special attention will be given to ensuring solution performance and robustness, preventing any degradation in the current availability of the flight control law level.

Impacts & benefits

The project involves defining a benchmark and evaluating solutions for performance and robustness in diverse scenarios. The gained knowledge in the failure mechanisms and the feasibility of additional system safety nets is expected to support potential evolutions of EASA certification standards together with potential evolutions of aircraft manufacturer designs.

This project has been funded from the European Union's Horizon Europe research and innovation programme.

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Further reading

Fly-By-Wire (FBW) has become the predominant standard for large civil aircraft, delivering substantial benefits in safety and performance. Its adoption has significantly propelled the aviation sector forward in recent decades. Large civil FBW aircraft depend on hardware redundancy and fail-safe strategies to navigate abnormal or off-nominal situations inherent in the complex engineering of modern civil aircraft. This includes addressing a multitude of potential failure cases. Central to the management of abnormal/off-nominal situations are onboard fault mitigation technologies. These play a pivotal role in enhancing the reliability and resilience of large civil aircraft, ensuring their safe operation even in challenging circumstances.

The project encompasses the following tasks:

- **Task 1: Establishment of an aircraft model :** Establish a representative simulation model for large transport aircraft to evaluate proposed monitors with realistic flight dynamics, controls, sensors, and faults.
- **Task 2: Identification of failure scenarios and robustness cases:** Establish a database of realistic air data sensor malfunctions and scenarios, using data from FMEAs, incidents, and operator-provided real-flight data. Proposed solutions must be robust and not trigger additional faults. Evaluate safety impacts.
- **Task 3: Identification of possible solutions:** Propose robust solutions for identified failure scenarios, covering model-free, model-based, or combined methods. Categorize with advantages and disadvantages. Organize a Stakeholders workshop for feedback.
- **Task 4: Evaluation via simulation of the most promising solutions:** Implement and evaluate the top solutions on the simulator, defining algorithms, tuning, and conducting simulation tests for effectiveness and robustness. Document results and deliver comprehensive materials.
- **Task 5: Selection of the suitable solutions (e.g. monitors, estimators) and conclusion:** Evaluate simulation test results, highlighting pros/cons, scenario coverage, limitations, abandoned solutions, and selected solutions. Synthesize findings in a final report, including recommendations for further research activities and industrialization.

This project is part of the portfolio of EASA managed research projects funded under the European Research Programmes. Projects under this portfolio address research needs of civil aviation authorities and are geared to generate mid-term benefits after the successful completion of the project to enhance safety, security and sustainability.

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