EASA
European Union Aviation Safety Agency

MODEL-SI – Digital twin concept for the design verification of VTOL aircraft and drones

Contractor

Zürcher Hochschule für Angewandte Wissenschaft (ZHAW)

Consortium Members

None

Contract period

12/12/2022 - 11/08/2024

Budget

700 000€

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to visit the webpage of this project

MODEL-SI
MODELING AND SIMULATION

Main objectives:

Digital technologies are already being deployed throughout the air transport system. Not only these technologies may improve the safety, productivity, accessibility and sustainability but they also raise new security and privacy risks, while involving significant changes to business models, working processes standards and regulations.

The aim of this research project is to explore a combination of methodologies that may be able to deliver practical and reliable flight load envelopes and load distributions, for eVTOL designs propelled by several rotors, operated by fly-by-wire at different stage of the development lifecycle and in support to airworthiness certification activities.

The main challenge, compared to conventional aircraft, is to consider a large number of combinations of possible configurations, control laws, flight regimes, individual rotor speeds / accelerations, and possible failures/degraded conditions. It is impractical to explore all these combinations by flight testing. Modelling and simulation should significantly contribute to this activity. The simulation model will also adequately represent the complex aerodynamics of rotor interaction, including unsteady effects.

Impacts & benefits

The research project will:

- Assess the possible changes to existing aviation standards, to flight data collection and SMS, in order to support the deployment of the digital solutions, while improving the safety management processes used by aviation authorities, operators and industry;
- Prepare the roadmap(s) for the changes to airworthiness, flight operations, maintenance, training standards aiming at effectively supporting the planning of regulatory activities and the preparation of deployment activities;
- Provide a comprehensive knowledge base on the series of solutions and options, their impact on operations, working processes, aviation standards, the associated regulatory changes identified and the main indicators for their economic impact.

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

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Further reading

Advances in computational capabilities and the power of modern computer systems enable the use of complex accurate mathematical and numerical models. However, there is a limit to how many high-fidelity Computational Fluid Dynamics (CFD) simulations can be reasonably run and stored during a certification project, or for continued airworthiness (CAW) assessments.

In this context, the research will look into the development of a parametric aerodynamic model, simpler than a CFD, that would support certification, as it could be run many times in a short time frame.

With the support of Artificial Intelligence techniques, this parametric model can be adjusted to approximate the input/output measurements from the available data, considered as ground truth: a high fidelity CFD, wind tunnel and/or flight test data. In this sense, the parametric model is a digital twin of a certain configuration and usage of the aircraft. The model parameters are updated considering design evolutions (e.g. of the control laws), and training with the flight test/wind tunnel/ CFD measurement data. In addition the use of the model while aircraft is in service may support the early detection of structural health related issues.

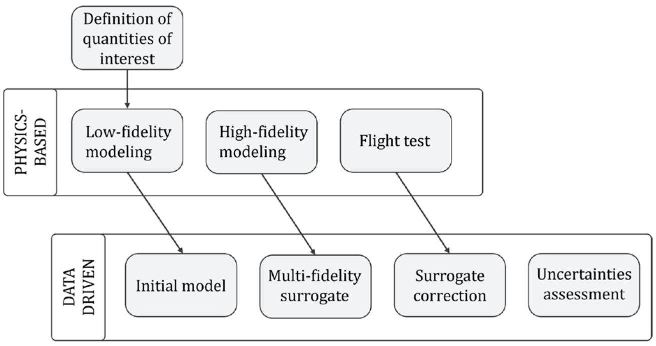
The project team will look into the possibilities of Machine Learning to create a model purely driven by data. This needs a sufficiently large amount of training and validating data.

Another possibility is to combine data with a physics-based method. For example, an Artificial Intelligence method that combines prior knowledge (such as model physics or previous data and information) and new data (similarly to a Kalman filter). The simplified model should be integrated with the flight control loop. The resulting loads resultants and load distributions should be subsequently validated, according to recognized Validation & Verification principles.

In particular for validation, from new inputs, outputs and their uncertainty intervals would be inferred. If the CFD or test values fell within these intervals, the model would be considered as validated.

The project will start with a thorough **review of the existing literature**, industry standards and regulations and identify the solutions relevant for the research. A detailed **workplan for the development of the case study** will also be developed.

In a second stage, the project team will develop the practical use cases for the **assessment of the impact of the identified solutions**, analysing the main changes compared to existing operations, the key benefits and constraints (or limitations) for the different users, as well as the maturity level reached and remaining uncertainties. In this scope, several stakeholder workshops are foreseen – to present the use cases developed, review the results obtained and collect feedback.



Lastly, the research will identify the **main changes and gaps with regards to regulatory materials and aviation standards** which are required for the gradual deployment of the digital solutions proposed.

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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