Development of a multipurpose test rig and validation of an innovative rotorcraft vertical tail

TAILTEST

Clean Sky Project No. 865123

https://www.horizon-tailtest.eu/

1st Newsletter

TAILTEST project adresses topic JTI-CS2-2018-CFP09-AIR-02-74 of the 9th Call for Proposals of Clean Sky II "Development of a multipurpose test rig and validation of an innovative rotorcraft vertical tail".

The main objectives of the TAILTEST are:

• To perform structural tests and FE models validation to support the certification process of an innovative rotorcraft vertical tail.

• To develop, apply and validate advanced numerical models for the simulation of debonding propagation in adhesively bonded or welded structural joints.

In order to achieve the above-mentioned main objectives, a number of intermediate steps have been identified:

• To design and manufacture an innovative multipurpose test rig to be used for testing a full-scale rotorcraft fin, as well as parts of the fin structure like the spar-to-skin joints. The developed test rig will include a load application mechanism able to apply loads representative for rotorcraft tail structures. Moreover, the test rig will be designed in a way that a variable stiffness of the fuselage to fin joint can be achieved.

• To perform structural tests on a rotorcraft vertical tail, up to ultimate load for at least the representative load cases, applying an adequate number of conventional measuring sensors like strain gages (SGs) and Linear Variable Differential Transformers (LVDTs)or more sophisticated contactless strain measurement systems (Digital Image Correlation - DIC).

• To perform structural analysis of the fin utilizing the Finite Element Method (FEM) and validate developed numerical models by correlating displacement and strain measurements acquired during the structural tests with the respective numerical results.

• To develop advanced numerical models for the simulation of debonding propagation in composite structural joints.

• To perform mechanical tests in order to obtain the material properties required for the application of the above mentioned advanced numerical models for the debonding prediction.

• To design and perform a sub-scale structural test (spar-to-skin joints, panel), using the multipurpose test rig. This test will be used for the validation of the debonding numerical models at sub-component level.

TAILTEST ninth call of programme Clean Sky 2 project is aimed to development of multipurpose test rig for validation of an innovative rotorcraft vertical tail has started in 2019 year and is conducted in Czech Aerospace Research centre (VZLU) as coordinator cooperating with Greek Athena Research centre (Athena RC) and Fokker Aerostructures as participant. This project is a part of project chain and contributes into conceptual aircraft type of Next Generation Civil Tiltrotor with the reduction of fuel consumption and CO2 emissions by lowering the structural weight of a rotorcraft tail through application of thermoplastics. The project is resolved in 6 Work packages.

WP1 – Management. It concerns the project management and coordination activities including the prompt periodical reporting as well as creation the certification strategy for damage tolerant bonding joints.

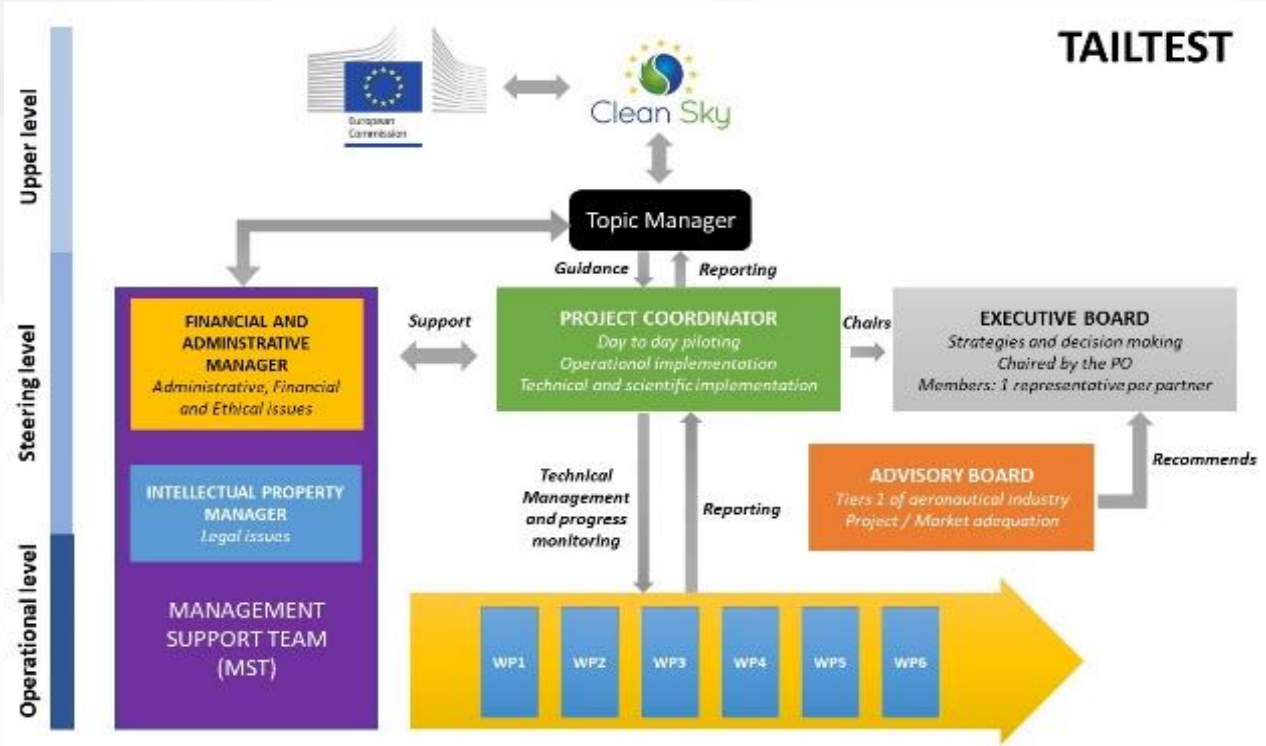
WP2 - Design and manufacture of the multipurpose test rig where the main objective is the design and manufacturing of a multipurpose test rig including the test plan development to be used for certification structural tests of a thermoplastic vertical tail fin as well as for testing of representative structural joints, see Figure 1. Based on definition of fin loading and joint stiffness requirements the preliminary design of test rig focusing on variable joint stiffness and innovative load application capabilities will be optimized through detailed FE analyses of the complete testing facility. Consequently, the test rig will be equipped by test article and completely instrumented.

WP3 – Test execution. The V-tail will be tested together with rear part of the fuselage. Only the one deck of the V-tail will be part of the tested structure. The second deck will be compensated by dummy when the real stiffness of the second deck will be simulated and experimentally verified. The test article will be instrumented including usage contactless optical systems, see example in Figure 2. The static tests will be completed up to ultimate load. The test will be monitored by cameras and measured data will be remotely monitored and evaluated. The final test report will contain the test setup, test rig and the test articles descriptions, test process, strain gauges and deflection measurements.

WP4 - Numerical validation & correlation is devoted to numerical simulation of fin structural behaviour and validation of the respective FE model. Consisting of two tasks it deals with the fin FE analyses under the loading conditions during testing and with the correlation of calculated and measured data and the validation of the FE model.

WP5 - Interface debonding propagation simulation test and analysis of a spar-to-skin joint. The aim is development and validation a numerical model for debonding simulation in hybrid joints and material damage for static and dynamic loads. Validated model will be based on spar-to-skin joint and used for virtual testing of the vertical tail and the design optimization of the fuselage/fin joining

Graphical representation of structure of the TAITEST project



Project coordinator

VZLU - Czech Aerospace Research Centre, Prague, Czech Republic
Website: www.vzlu.cz, Telephone: +420 225 115 153

VZLU is a scientific and technical organization located in Prague in the Czech Republic. It was established in 1922 as a military research organization. Now, VZLU is a joint-stock company where the state is the majority shareholder. The major multidisciplinary fields of VZLU include aerodynamics, structure strength and durability, material and corrosion engineering, turbomachinery and composite materials and technologies. Through its three subsidiaries the VZLU group can offer accredited environmental and mechanical testing, prototype and batch production of composite parts and satellite equipment development. R&D capacities of VZLU contribute notably to the progress of aerospace industry, surface transport, defence & security sector, power industry and civil engineering. VZLU develops international R&D cooperation especially on the platform of EU Framework Programs.

Regarding the scope of the TAILTEST project, **VZLU** will take the role of project coordinator and partner responsible for multipurpose test rig design and manufacturing, full-scale experimental validation of rotorcraft vertical tail, numerical models development and verification.
Therefore, VZLU will be responsible for the tasks considering full-scale verification, mechanical testing with evaluation of structuracl elements using contactless optical measurement systems (DIC) and modelling of defects and numerical prediction.

Activities of VZLU involved in the project:

I. Management, Coordination

II. Structural analyses (numerical simulations)

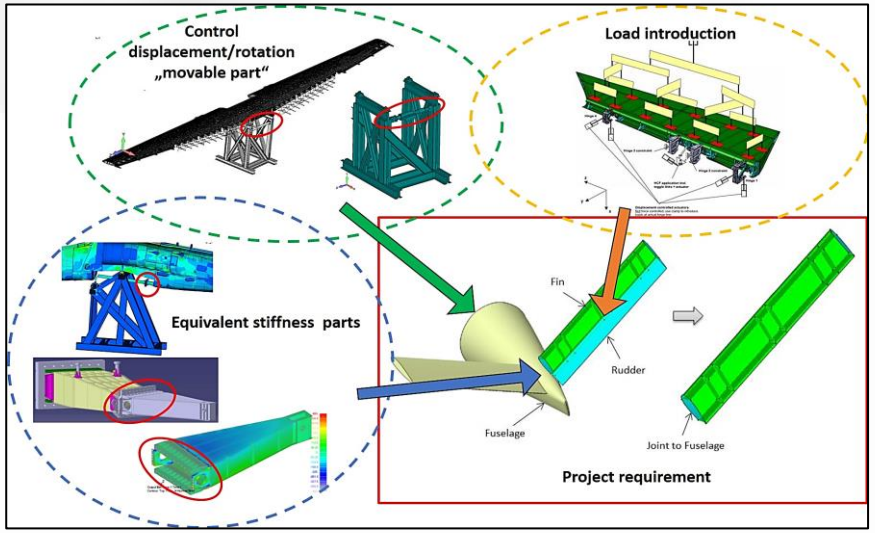
- FE simulations
- FE models development and verification

III. Mechanical testing

- Mechanical testing of structure elements
- Strain measurements
- Design of test concepts, clamping devices, etc.
- Multichanel full-scale testing

IV. Test rig design and manufacturing

Overall view of full scale fatigue test



Schematic representations for the design of the variable stiffness test rig based on VZLU previous applications

KEY PERSONS AND CONTACTS

Dr. Roman Růžek
Project coordinator and tests
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Qualification: Mechanical engineer (Czech technical University - CTU, Prague, Czech Republic). Dr. - Physical engineering and Materials Science (CTU, Faculty of Nuclear Science and Physical Engineering). Member of Material CapTech EDA, EASN and CSM (Czech Society for Mechanics). He has over than 30 years experience in aerospace field.
Function: Senior Scientist, Head of Material and Technology Department, Aviation Division VZLU, Material testing specialist, Coordination of national and European Union Projects (H2020 CleanSky).

Dr. Radek Doubrava,
Numerical analyses and tests
Head of Structural Analysis Department, Divison Aviation
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Qualification: Mechanical engineer – aircraft design (Czech technical University - CTU, Prague, Czech Republic). Ph.D. - Physical engineering and Materials Science – fatigue crack growth (CTU, Faculty of Nuclear Science and Physical Engineering). Since 01/1997 Researcher in VZLU (Czech Aerospace Research centre). Since 2009 Head of the Computational analyses group in VZLU.
Function: Key Researcher, responsible for numerical simulation and verification, Representation of the Centre at conferences and to stakeholders.

Matin Oberthor,
Design and experimental testing
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Qualification: Mechanical engineer (Czech technical University - CTU, Prague, Czech Republic). Since 08/1998 Researcher in VZLU (Czech Aerospace Research centre).
Function: Key Researcher, responsible for experimental testing.

Beneficiary 1

Athena Research Centre (ATHENA-RC) (GREECE)

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The ATHENA-RC is a public research institute founded in Patras, Western Greece on 1998. It is currently hosted in Patras Science Park premises. Since 2003, ATHENA-RC is part of the Research and Innovation Centre in Information, Communication, and Knowledge Technologies “Athena” (RC Athena), operating under the auspices of the General Secretariat of Research and Technology (G.S.R.T) of the Greek Ministry of Education and Religious Affairs. The main aims of ATHENA-RC are the active participation and substantial contribution at high-technology sectors, which relate to integrated industrial systems, with the objective of increasing the competitiveness of the Greek industry, through application of state-of-the-art technologies. ATHENA-RC has established strong collaborations with the industry in Greece, Europe, and USA. It closely collaborates with the Department of Electrical and Computer Engineering and the Department of Mechanical Engineering and Aeronautics of the University of Patras. ATHENA-RC has been involved in large-scale R&D projects funded by the European Commission and the G.S.R.T. as well as by direct bilateral agreements with the Greek industrial partners. It has a proven record in the area of aerostructures (analysis and testing) proven by the participation of its collaborating researchers in several EC funded projects in the Aeronautics sector.

The main roles of ATHENA-RC in the various tasks of the project are:

Task 2.3: Test rig design optimization

Task 4.1: FE simulation of tail fin

Task 4.2: FE model validation

Task 5.1: Advanced debonding prediction models

Task 5.2: Characterization tests to provide input to the debonding prediction models

Task 5.3: Virtual testing of spar to skin joint

WP6: Exploitation, dissemination and communication

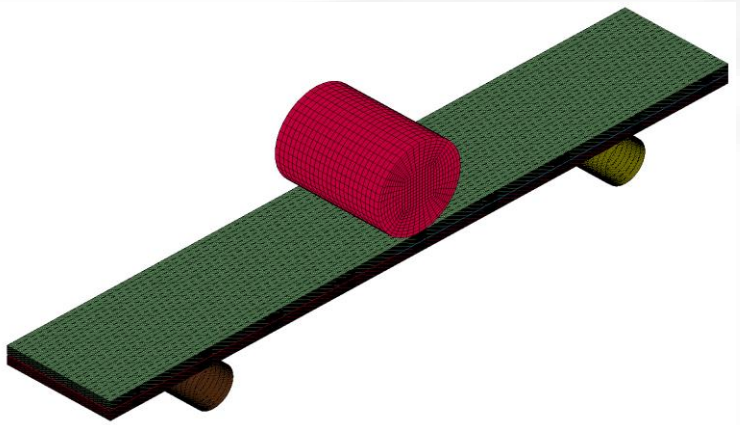

Figure 4: Fatigue DCB test, Fatigue ENF test, Mixed-mode fatigue test and simulations of the tests

KEY PERSONS AND CONTACTS

Dr. George Lampeas

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Project technical and administrative manager -ATHENA-RC

has 30 years of experience in the technology of composite structures, as well as in advanced computational modelling for aerospace structures with emphasis in simulation of composite joining technologies. He is co-author of 6 international books and of more than 100 scientific publications in international journals. In TAILTEST project he will be the project manager for ATHENA-RC and main point of contact.

Dr. Konstantinos Tserpes

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Technical expert for ATHENA-RC

is a Mechanical Engineer with a PhD in strength of composite materials. His research interests are in strength of advanced composite materials and structural parts, mechanical behaviour of nanomaterials and nanocomposites and multiscale modelling and simulation. He has published more than 60 papers in scientific journals, more than 80 papers in conference proceedings and 4 chapters in international books. He has co-edited 2 international books and co-organized an International Conference.

Dr. Konstantinos Fotopoulos

Numerical analyses and experimental testing

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Qualification: Diploma by the Mechanical Engineering and Aeronautics Department (MEAD, University of Patras, UPAT, Greece). Ph.D. – Efficient analysis of laminated anisotropic structures (UPAT, MEAD, Laboratory of Technology and strength of Materials (LTSM)). Researcher in LTSM since 10/2012. Collaborating researcher in ATHENA-RC/ISI since 01/2021.
Function: Key Researcher, responsible for numerical simulation and experimental testing.
Topics: Composite structures, Experimental testing, Numerical analysis of damage, FE simulation in LS-Dyna and Ansys Mechanical APDL FE codes.

Harry Psihoyos

Numerical analyses and experimental testing

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Qualification: Mechanical & Aeronautical Engineer (University of Patras, UoP). M.Sc. – Advanced Materials (University of Ioannina). Ph.D. candidate in Mechanical Engineering & Aeronautics (UoP).
Function: Key Researcher ***Topics:*** Modelling and Experimental testing.

Topic Manager

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Fokker Aerostructures BV is part of Fokker Technologies, an enterprise with a turn-over of 760 M€ in 2014, owned since end of 2015 by GKN Aerospace. Fokker Technologies delivers aircraft components for 75 platforms, such as Airbus A320, A350 and A380, Boeing 747-8, Lockheed Martin F35 Lightning II (JSF), Boeing Apache, Boeing Chinook, Gulfstream 550 and 650, Dassault F6X, F7X and F8X, Bombardier C series, NH90 helicopter and Agusta Westland AW169. Fokker Aerostructures is a Design and Build specialist in the design and development of primary structure components for both civil and military air vehicles. It is perceived by it's customers as a technology supplier which enables it's customers to improve their product performance by employing advanced material technology to lower structural weight and reduce product life cycle cost at an affordable cost level.

In the scope of the TAILTEST project, FAE acts as the Topic Manager. As the Topic Manager, FAE is responsible for providing technical input and guidance to ensure a perfect fit between project LIFTT and CFP project TAILTEST.

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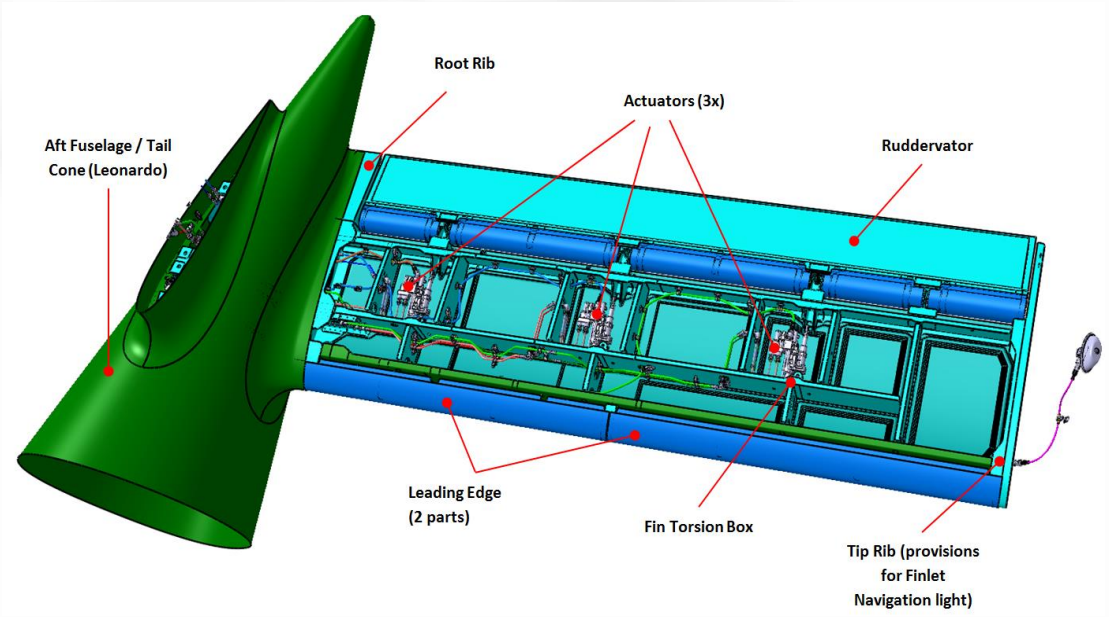
Link between LIFTT and TAILTEST:

LIFTT project is a core partner project under AIRFRAME ITD and aims to develop an innovative flying V-tail for the NGCTR-TD rotorcraft. The flying V-tail contains advanced thermoplastic parts, manufactured with the latest developed production technologies, such as out-of-autoclave and press forming.

A CFP-project was defined to validate the new technology through test & simulation and to start fundamental research on innovative features in the field of thermoplastic joints. The Clean Sky Joint Undertaking, awarded the CFP project to the TAILTEST consortium. The main results of the CFP-project will contribute to obtaining the Permit-to-Fly for the innovative flying V-tail and to accelerate the development of innovative features for future structures.



KEY PERSONS AND CONTACTS

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Qualification: Aerospace engineer Bsc (Aerospace Engineering, INHOLLAND Delft). Msc. – Innovation Management (Technical University of Eindhoven)

Function: Project Manager of several (funded) technology development projects

Topics: Innovation management, technology development, project management