Overview and main achievements of the ACASIAS project

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***Abstract*— Conformal and structural integration of antennas into aircraft components will contribute to the sustainability of future aircraft because they cause less additional aerodynamic drag than protruding antennas. This paper presents an overview of aero-structures with integrated antennas and the main achievements as obtained in the ACASIAS (Advanced Concepts for Aero-Structures with Integrated Antennas and Sensors) project.**

***Index Terms*—antennas, radomes, satellite communication, VHF communication, winglet, fuselage panel.**

I. Introduction

The goal of ACASIAS is to reduce the fuel consumption of future aircraft by improving aerodynamic performance and by facilitating integration of new and efficient propulsion systems. ACASIAS will help to reduce CO_2 and NO_x emissions by aircraft and thus help to make aviation more sustainable. The aerodynamic performance is improved by the conformal integration of antennas which reduces the aerodynamic drag of protruding structures, such as blade antennas or large radomes for satellite communication. Furthermore, through structurally integrated antennas, the risk of damage of protruding antennas will be reduced, and therefore the ACASIAS project will also contribute to reduction of maintenance costs and will minimize operational delays.

CROR propulsion systems are a promising concept to reach a resource efficient transport, able to realize up to 25% fuel and CO_2 savings but the CROR engines have a main disadvantage: the radiation of annoying multi-harmonic noise leading to high sound pressure levels in the cabin. In the ACASIAS project a lining panel with an integrated Active Structural Acoustic Control (ASAC) system is being developed to reduce the noise levels in the cabin. The availability of this lining panel will facilitate the installation of CROR engines.

The ACASIAS project receives funding from the EU H2020 program under grant agreement No 723167. The project brings together 11 partners from 6 countries covering the three main disciplines required: composite structures, advanced antennas and miniaturized sensors in a multidisciplinary project (see also Ref. [1]). In this EuCAP scientific workshop *Antennas for Integration into aircraft structures* the main achievements about antenna research and developments of the ACASIAS project are presented.

II. Overview

The ACASIAS project focuses on challenges posed by the development of four aero-structures with multifunctional capabilities. The following concepts are considered:

- A composite stiffened ortho-grid fuselage panel for integrating Ku-band SATCOM antenna tiles
- A sandwich lining panel with integrated sensors and wiring for reduction of CROR cabin noise
- A smart winglet with integrated VHF notch antenna
- A Fibre Metal Laminate GLARE panel with integrated VHF communication slot antenna and integrated GNSS (Global Navigation Satellite System) antenna.

A. *Conformal integration of Ku-band Satcom antenna*

For the conformal and structural integration of an electronically steerable Ku-band antenna a novel composite fuselage panel with orthogrid stiffening is being developed in ACASIAS. The fuselage panel has been design in such a way that the cells of the orthogrid can be used to embed Ku-band antenna tiles which were developed by NLR, IMST and other partners in the EC FP7 SANDRA (Seamless Aeronautical Networking through integration of Data links, Radios and Antennas) project (see [2]). The development of the novel fuselage panel addresses several performance aspects such as aerodynamic improvement, structural performance, thermal performance and RF performance. The aerodynamic benefits of the conformal and structural integration have been discussed in [3]. Structural performance is assessed by manufacturing a representative fuselage panel that will be tested in full size in the NLR fuselage panel test rig. The manufacturing of the fuselage panel has been discussed in [4]. The development of the Ku-band antenna and its structural integration into the panel are discussed in [5].

Also the thermal management of the antenna tiles is addressed. Cooling of active RF electronic components inside the antenna tile is necessary because these components produce a lot of heat due to their low efficiency. Two types of cooling systems were investigated: a passive cooling system (copper plate in the amplifier PCB) and an active cooling system (liquid cooling embedded in the amplifier PCB). Part of this research is presented in [6].

B. *Sandwich lining panel for reduction of engine cabin noise*

An Active Structural Acoustic Control (ASAC) system for reduction of CROR noise inside the aircraft cabin is developed with minimal impact on weight. The main components of the system are sensors, actuators and wiring. Sensors measure the vibrations of the lining to estimate its sound emission into the cabin. Based on these signals a controller calculates force signals for actuators on the lining. The actuator forces change the vibration behaviour of the lining in order to reduce its sound emission. All these components are structurally integrated in a composite honeycomb lining panel. For the wiring that connects sensors, actuators and controller flexible PCBs are used. The development of the sandwich lining panel with an integrated ASAC system has been presented in [7].

C. *VHF communication antenna in winglet*

The challenge is to build a VHF communication antenna with a rather large wavelength into a winglet of a small transport aircraft of the type Evektor EV55. The design of the winglet with integrated VHF antenna requires multiple fields of expertise. The aerodynamic shape of the winglet has been optimized for reducing the vortex drag at the tip of the wing. The design also fulfills the structural need for inducing aerodynamic forces and moments to the wing, remains stable in the event of bird strikes. Furthermore, it will resist lightning strikes.

The VHF antenna is obtained by a notch structure in the winglet. The antenna has a slit in a ground plane, tapered at its open end, giving the shape of a trumpet, to increase the bandwidth. The winglet shell is made out of Carbon Fibre Reinforced Plastic (CFRP) covered with a copper mesh for lightning protection. A Glass Fibre Reinforced Plastic (GFRP) “window” is included to allow the antenna to radiate. The development of the antenna is presented in [8].

D. *VHF communication antenna in fuselage GLARE panel*

The challenge is to fully integrate a VHF communication antenna into a classical fuselage panel, i.e. to get the antenna function as an integral part of a structural component that fulfils a load-bearing function. The design has taken into account the limited space between the stringers and frames which support the skin. The skin is made of GLARE material, which consists of metal layers bound together by glass fiber layers and resin to form a cohesive laminate. The VHF antenna is made in the panel by creating a slot with appropriate length in the skin and by adding a so-called parallel resonator box in the limited interior space. The slot in the skin is filled up with glass material as available in GLARE. The development of the antenna has been discussed in [9] and [10] .

E. *GNSS antenna in fuselage GLARE panel*

The GNSS antenna is realized as a double patch antenna. Such a stacked patch antenna shares many similarities with the FML layers of the GLARE panel in terms of buildup and the electric properties of the used material layers. The antenna can therefore be made directly in the GLARE panel with slight modifications to the buildup of the FML layers.

III. Main Acheivements

The main achievements of the ACASIAS project are::

- Novel technologies for the efficient manufacturing of fuselage panels and winglet with structurally integrated antennas.
- Four smart aircraft structures with conformal antennas.
- Novel technology for active cooling of active electronic components inside integrated PCB antennas.

Acknowledgment

This work has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 723167, ACASIAS project. Partners in the project are: Netherlands Aerospace Centre (NL), Fokker Aerostructures (NL), German Research Center DLR, CIMNE (Spain), INVENT (Germany), VZLU (Czech Rep), EVEKTOR (Czech Rep), Trackwise (UK), IMST GmbH (Germany), L-Up (France) and Fokker Elmo (NL).

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