Ku-band SatCom antenna for integration into a novel fuselage panel

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***Abstract*—In the H2020 project ACASIAS (Advanced Concepts for Aero-Structures with Integrated Antennas and Sensors) a phased array antenna for Ku-band satellite communication will be integrated in a fuselage panel of a future aircraft. The integration covers the structural aspects, the electromagnetic aspects, the thermal aspects and the lightning protection. This paper addresses only the electromagnetic aspects and the lightning protection.**

***Index Terms*— Smart fuselage panel, orthogrid, hybrid composite skin, Ku-band, SATCOM antenna, structural integration, lightning protection, active cooling.**

I. INTRODUCTION

The main objective of the ACASIAS project is to contribute to the reduction of energy consumption of future aircraft by improving the aerodynamic performance through conformal and structural integration of antennas that are normally protruding. This paper deals with the conformal integration of an electronically steerable Ku-band antenna for satellite communication, which does not require anymore a protruding radome. An artist impression of the conformal integrated antenna is shown in Fig. 1.

Fig. 1. Conformal and structural integration of Ku-band electronically steerable phased array antenna

The development of the integrated antenna array is based on an earlier development of Ku-band antenna tiles in the FP7 project SANDRA [1]. SANDRA resulted in the availability of Ku-band antenna tiles of size 10cm x10cm, with an approximate height of 4cm. Integration aspects like structural performance, lightning protection and thermal management were not addressed. In ACASIAS, these aspects are taken into account while still considering the functional performance of the antenna. The antenna tiles will be integrated in an orthogrid of Carbon Fibre Reinforced Plastic (CFRP) (Fig. 2). Since CFRP is conductive this orthogrid may have an influence on the antenna performance. In addition a Glass Fibre Reinforced Plastic (GFRP) skin is used as an electromagnetic transparent window for the antenna. This radome will also influence the performance of the antenna. The structural design of the orthogrid is discussed in [2].

II. DEVELOPMENT OF THE ANTENNA TILES

The complete antenna array consists of 25 antenna tiles. Each antenna tile consists of three multilayer Printed Circuit Boards (PCBs): an antenna PCB (with the passive radiators), a distribution network PCB (to combine or split the power of the antenna elements) and the amplifier PCB (with the High Power Amplifiers for the transmit antennas or a Low Noise Amplifier for the receive antennas) (Fig. 2). Since the active components have a low efficiency, cooling of the antenna tile is necessary. The three parts of the antenna tile are connected through slot coupling.

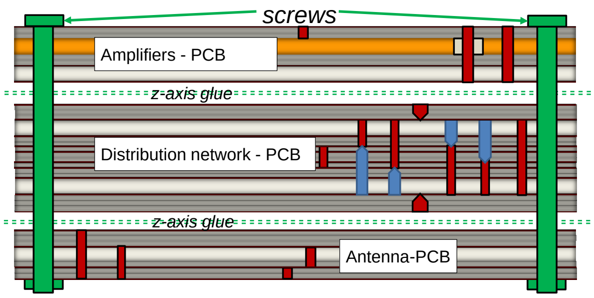

Fig. 2. Antenna tile (Stack-up of multi-layer PCBs).

Each tile includes 8 x 8 antenna elements. In the case of the receive tiles, the antenna elements are stacked patches, achive sufficient bandwidth (2 GHz).

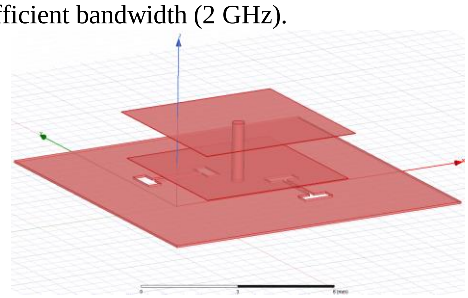

Fig. 3. Antenna element with stacked patches.

III. INTEGRATION OF THE ANTENNA ARRAY

Only four functional antenna tiles will be manufactured with the aim to check the antenna performance, in order to reduce prototyping costs. The rest will be dummy tiles, without RF functionality, in which the active components will be used as heating elements, to check to the thermal management of the antenna array. The development of cooling solutions for the antenna tiles is addressed in a separate contribution of this workshop [3].

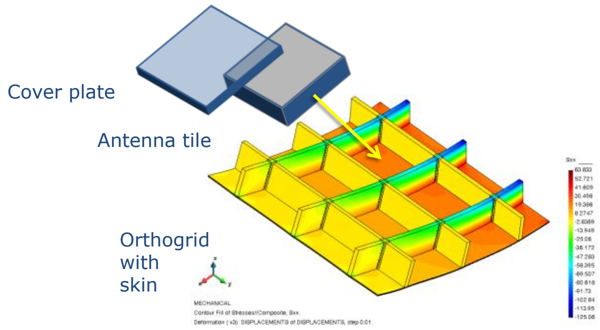

Fig. 4. CFRP orthogrid with GFRP skin. The antenna tiles will be embedded in the cells of the orthogrid.

The antenna tiles are integrated in the orthogrid structure in an array of 5 x 5 tiles. The tiles will be separated by the ribs of the orthogrid. The distance between the antenna elements in a tile is half a wavelength. However, the distance between the antenna tiles is larger than half a wavelength due to the thickness of the ribs. This separation will have an influence on the radiation pattern of the antenna array, especially for large scan angles. For large distances between the antenna tiles grating lobes may occur in the radiation pattern. In addition the conductive ribs may have an influence on the performance of the antenna elements at the edge of the tiles. Electromagnetic simulations have been carried out with an FDTD simulator (EMPIRE XPU™) to determine the radiation pattern of the embedded Ku-band antenna (Fig. 2). These simulations have also taken into account the influence of the GFRP skin.

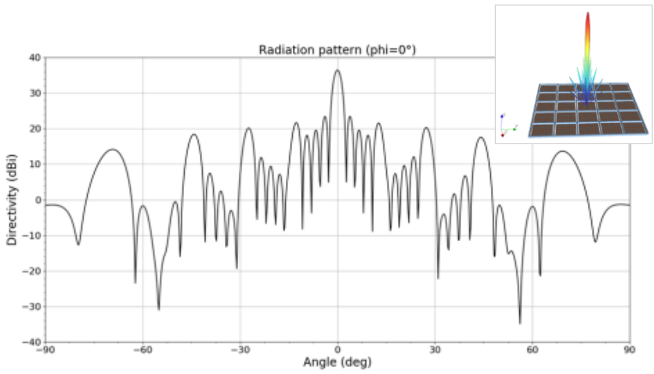

Fig. 5. Radiation pattern of the full 40*40 elements array (gap between 8*8 tiles: 7 mm) calculated by using EMPIRE XPU™. The simulation takes into account the interaction between the antenna tiles and the effect of the dielectric skin and the CFRP ribs.

IV. LIGHTNING PROTECTION

The integrated antenna needs to be protected from the direct and indirect effects of lightning. The primary protection of the antenna will be implemented by using lightning diverters in the non-conductive GFRP skin. In addition the antenna elements will have a protection against ESD and high voltage by using a grounding via in the centre of the patches. Electromagnetic simulations will be performed to determine the influence of the lightning diverters on the antenna performance.

V. CONCLUSION

The orthogrid and the antenna tiles are currently being manufactured. Once manufacturing and integration is completed, measurements will be carried out to check the electromagnetic and thermal performance of the integrated antenna.

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