NEWSLETTER N°4

January 2020

Welcome to the ACASIAS project newsletter

ACASIAS' goal is to reduce the environmental impact of aircraft by improving aerodynamics and reduction of the weight of the aircraft. ACASIAS will embed sensors and antennas into typical aircraft structures (for instance fuselage panels, winglets and tails). The aerodynamic performance is improved by the conformal and structural integration of antennas. The noise reduction of CROR engines inside the cabin is facilitated by installation of an Active Structural Acoustic Control (ASAC) system in the lining.

Word from the Coordinator

For the ACASIAS project the year 2019 was an exciting year with great progress. The detailed designs of the four innovative structures are ready, and we are about to realize the designs in hardware. The knowledge and expertise of the ACASIAS team are the driving force behind these pioneering innovative structures.

The results of our ACASIAS research and developments were presented to a greater public at the European Conference on Multifunctional Structures in Barcelona, which was successfully organized by CIMNE and supported by members of the ACASIAS project and the ECO-COMPASS project. I am very proud of the ACASIAS team and I would like to thank the team for their contributions to the ACASIAS project so far.

The coming months will be decisive for the ultimate success of the ACASIAS project. I am looking forward to the results of all tests still to be carried out. I hope that we will continue the ACASIAS Research with the same team spirit as before. I wish the team all the best in their research during the last period of our project.

In this fourth issue of our newsletter, you will find the latest results achieved by our project partners about the development of the smart fuselage panel with embedded Ku-band Satcom antenna array and for the smart winglet with integrated VHF communication antenna. The interview with Cees van Hengel shows that it is necessary to look beyond the boundaries of one's own field in order to make a successful contribution to the ACASIAS project.

I wish you all a good reading

Harmen Schippers

NEWS & EVENTS

New publication about Noise reduction in aircraft with smart lining panel

>> Read more

ACASIAS presentation leaflet is downloadable :

>> Download the pdf

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Smart SATCOM fuselage panel: WP2 results

In ACASIAS WP2 (Smart SATCOM fuselage panel) a fuselage panel with an integrated conformal Ku-band distributed antenna array is developed. This development will address several performance aspects such as structural performance, thermal performance and RF performance. Structural performance will be assessed by manufacturing a representative fuselage panel, which will be tested in full size in the NLR fuselage panel test rig. Solutions for cooling of the RF electronics will be investigated by definition, manufacturing and test of breadboards. The RF aspects will be evaluated by performing measurements on breadboards and on active antenna tiles mounted in the full size panel.

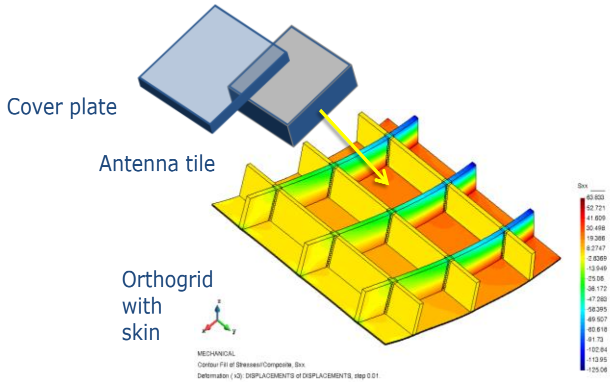

Figure 1: Integration of antenna tiles in an orthogrid fuselage panel.

In Newsletter 2 of the ACASIAS project, we reported about the preliminary design of the integrated Ku-band antenna. In the meantime we have passed the Preliminary Design Review and the Detailed Design Review and the manufacturing of the orthogrid and antenna tiles are ongoing.

Coupon, element and detail tests have been carried out at VZLU as part of the structural analysis. These tests were supported by CIMNE who performed an extensive numerical analysis on the structural elements and details, and also on the complete fuselage panel. These structural tests were completed successfully. Both the numerical analysis and the structural tests have been used to complete the Detailed Design. Currently the orthogrid panel is being manufactured. Once manufactured, the fuselage panel will be tested in NLR's fuselage panel test rig.

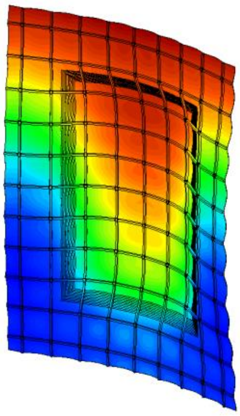

Figure 2: Numerical analysis of orthogrid fuselage panel.

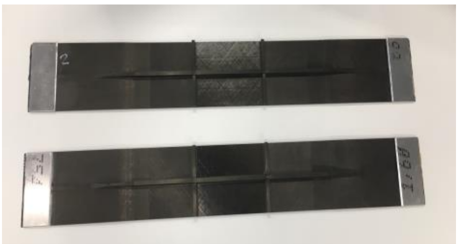

Figure 3: Rib run-out on test (part of the structural element testing).

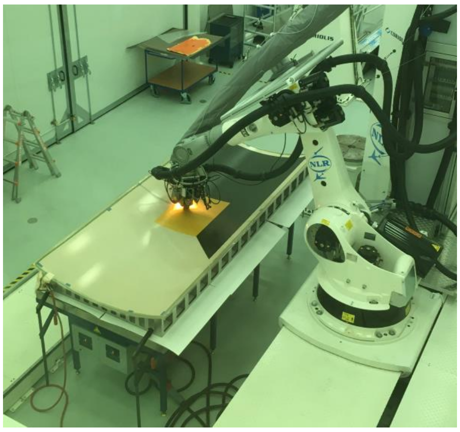

Figure 4: Manufacturing of orthogrid panel with NLR's fiber placement machine.

The antenna itself consists of a number of tiles, each of them made out of of three separate PCBs (Printed Circuit Boards): the antenna PCB (developed by NLR), the RF distribution PCB and the amplifier PCB (both developed by IMST). Several test structures have been manufactured of these PCBs to assess the RF performances and tolerances of the PCB manufacturing. The results have been used to finalize the Detailed Design of the antenna tiles.

Also the thermal management of the antenna tiles was 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 of in the amplifier PCB). The active cooling shows a very fast response and ample capacity to keep the temperature of the amplifier PCB at an appropriate level.

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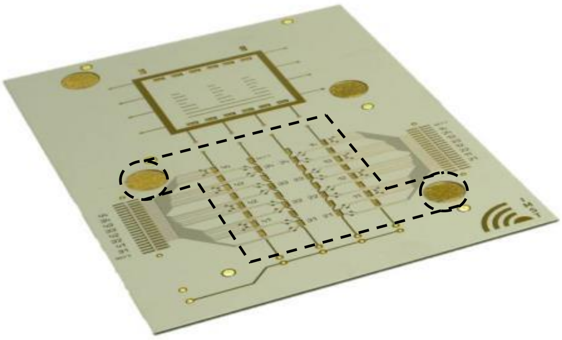

Figure 5: PCB with integrated liquid cooling.

The influence of the CFRP orthogrid and GFRP skin (radome) on the antenna performance was analysed by IMST and NLR. Simulations were carried out to determine the radiation pattern of the integrated antenna. Also the potential influence of lightning diverters on the antenna performance was evaluated. Currently the antenna PCBs are being manufactured. Subsequently the antenna tiles will be assembled at IMST, who will then perform RF tests and thermal tests on the antenna tiles. Finally the antenna tiles will be integrated in the orthogrid fuselage to determine their RF and thermal performance.

Winglet with integrated VHF radio antenna: WP4 results

ACASIAS innovative structure in the 4th work package, the winglet with integrated VHF radio antenna, is now in the transition phase from design data to hardware! The latest progress has been presented on 12th November in Braunschweig in our review meeting.

The optimization loops regarding antenna and structural performance at IMST and INVENT are concluded. As a result, the antenna window is smaller as previous solutions. The main structural material of the winglet will be CFRP. In order to transmit the radiation of the antenna within the winglet to the outside, a glass fibre "window" is included to the ply books of the skins. The smaller window increases the lightning strike protection as well as the strength in this area. The antenna will be produced by TRACKWISE.

Figure 6: simulated antennas radiation

We faced challenges in the last months, but not only project related challenges. INVENT (which is mainly responsible for the production of the winglet) moved its production location. Even though the new production site is only a few hundred meters away, the original forms for the winglet are not yet completely finished.

Figure 7: INVENT's new production facility

Besides the task to simulate and integrate an antenna into a winglet, there is also the task from the manufacturing point of view in WP4. For this purpose, an out of autoclave manufacturing process will be investigated. The CFRP moulds comprise electrical heater mats integrated to the layup. Since we use two fibre-reinforced resin moulds for the production of the winglet, two different heating concepts are being investigated. One shell is equipped with a heatable CFRP layer, which is operated by means of a current and a specific temperature control system. A second mould uses metallic heating wires sewn onto a glass fibre, which is embedded in the mould.

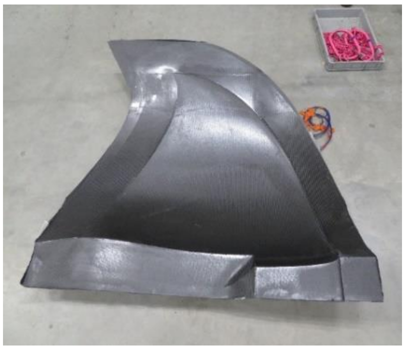

Figure 8: CFRP mould with integrated heating for the lower skin of the winglet

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The whole control is based on a raspberry pi minicomputer. With a GUI (graphical user interface) heating curves can be specified. The information on the temperature of the mould is determined with 4 thermocouples. Via connection to a LAN (local area network) the system can be controlled and modified by any computer within this LAN.

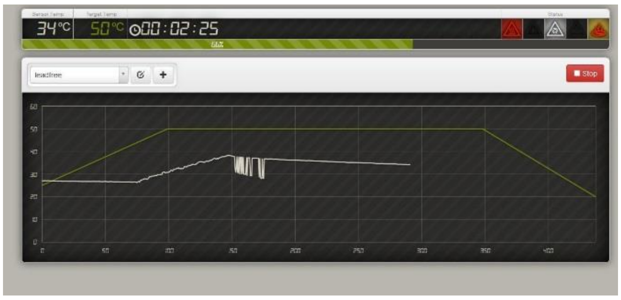

Figure 9: GUI of the control device for heatable moulds during test phase

Two different test winglets will be built. The first winglet produced will be used for the RF tests. It will be a slightly modified version with an additional opening for modifications to be carried out on the antenna. This opening is necessary to find the optimal feed position in the real environment for the antenna. This winglet is also equipped with the parts and materials which can influent the shielding and radiation properties: lightning protection & position light dummies.

The second winglet is produced to evaluate the mechanical performance. VZLU then tests this winglet for strength and stiffness. The calculated deformations from previous simulations have to be checked.

To verify the design approach and structural analysis of the GFRP "window", specific samples are produced. The focus is on the transition zone between GFRP and CFRP in the skin of the winglet.

2019 ACASIAS Achievements

The year 2019 has been a very rich year, full of events and promising results.

The ACASIAS partners have notably participated to many workshop and conferences, such as the 10th European Networking Event in Düsseldorf, the EuCNC 2019 in Valencia, The International Paris Air Show in Paris; the ESA Antenna Workshop in Noordwijk and the EASN conference in Athens.

One of the most notable event of these has been the EMuS2019 conference organised by the ACASIAS partners, at CIMNE premises in Barcelona in June 2019.

Figure 10: EMuS2019 Conference in Barcelona. Top left, Harmen Schipper the ACASIAS coordinator; Bottom right, Cees Van Hengel, Fokker Aerostructure; Bottom, Constantinos Soutis; Plenary speaker from Manchester university.

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This event has been the occasion to share the ACASIAS results from the scientific and industrial community of Multifunctionnal Structures, but also to discover the results from other collaborative projects, such as the ECOCOMPASS project. As special plenary speakers were invited Robert Sekora, froms Airbus Defense and Space, Eve J. Barbero, from West Virginia University, Constantinos Soutis from Manchester university and Simon Waite from EASA.

Many advances have been made in the field of multifunctional structures, and not only in the aeronautic field. Thanks to the variety of the speakers and attendees, coming from all over the world and from many fields of expertise, the EMUS conference made a presentation of these advancement. The presentations concerned active acoustic panels, aircraft with conformal antennas, composite panels with integrated antenna tiles, eco-composite structures, fibre-metal laminate panels with integrated antennas, multifunctional materials, technology with integrated antenna tiles, winglet with integrated VHF antennas.

The EMuS2019 showed the complexity to achieve advanced multifunctional structures and the multidisciplinary nature of the work necessary to achieve performant and competitive designs to be integrated in automobiles, ships and yachts, aerostructures, etc.

After the success of this first edition, this event may become a bi-annual rendezvous among the scientific and the industrial community in order to present the recent advances made on mechanical structures with multiple functions.

GET-TOGETHER

EUCAP2020, COPENHAGUE, 15TH 20TH MARCH 2020

EuCAP is Europe’s largest and most significant antennas and propagation conference attracting academic and industrial participants at all career stages from all over the world. It is a great forum for exchange of new technical-scientific achievements, for demonstrating state-of-the-art technology, and for establishing and strengthening professional networks.

The ACASIAS partners have been invited to organise scientific workshop session during that event. Six presentations will be done with a keynote from the IAB member Robert Sekora, from Airbus Defense and Space, the presentation of the ACASIAS project by the coordinator, Harmen Schippers, and the presentation of:

- VHF communication antenna for integration into an aircraft winglet;
- VHF/GNSS antennas integrated into a classical Fibre Metal Laminate fuselage panel;
- Ku-band SatCom antenna for integration into a novel Fuselage Panel;
- Innovative cooling system for of active components in structurally integrated phased arrays antennas.

Source: https://www.eucap2020.org/

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INTERVIEW

ACASIAS newsletters offer you the possibility of getting to know some of the project partners a little better… Thus, the Interviews section will let you discover the day-to-day life of the people involved in achieving the ACASIAS goals.

In this edition of the ACASIAS Newsletter n°4, we propose you the interview of Cees Van Hengel, working as Team Lead Fuselages, Product Group Moveables and Fuselages within Fokker Aerostructures. Mr van Hengel, holds an MSc in Aerospace Engineering from Delft University of Technology, and has over 30 years of experience in Aerospace Engineering. He has worked in several positions in the areas of aircraft structural design and structures, as well as FML-related Research and Technology Development.

The tags leading the interview are: **Fiber Metal Laminate – VHF Slot Antenna –GNSS Patch Antenna – Integrated Flex PCB**.

CEES VAN HENGEL
FOKKER AEROSTRUCTURES -THE NETHERLANDS

Q1: You are involved in the ACASIAS WP5 Smart FML fuselage panel, which aims to integrate GPS and VHF antennas directly in the fuselage structure. Could you explain the principle and challenges of these developments?

In WP5 we are talking about two antennas: the GNSS antenna which is small (about 10 cm circular), and the VHF which is big: about 75 x 10 cm. In both cases, the "base material" is Fiber Metal Laminate (FML) which consists of conductive aluminium layers and isolating glass-fibre epoxy layers. In a highly simplified way, the principles for both antennas are the same: we use the electrical properties of the FML to create the desired electro magnetical behavior in the antenna area of the laminate, while at the same time make sure that the laminate can still perform its original structural function, which is to carry mechanical loads. Of course the presence of the antenna area causes a disturbance in the laminate, so local reinforcements are needed (additional metal and glass-epoxy plies). As you can imagine from the dimensions, the disturbance caused by the GNSS antenna is much smaller than that of the VHF antenna, so the VHF is the one that is the most difficult to realize.

This explanation is only about the structural aspect, which is already a significant challenge by itself (which, by the way, includes finding a concept that has potential to be accepted by the airworthiness authorities as certifiably safe). Another challenge is designing the resonator part of the VHF antenna, but fortunately that is in the hands of the NLR team so I don't have to worry about that. Similarly, the electrical connection is dealt with by colleagues from Fokker ELMO. Also the structural analysis (by CIMNE) and the testing (by VZLU) are not trivial, and then there is the matter of integrating flexible PCBs for Trackwise. So plenty of challenges that we are addressing in the WP5 team. The final challenge will be to see if there is a business case for the concept, but this will have to wait until we know what the concept will actually look like.

So far the technical challenges. Another one, that we hadn't been aware of before, is the challenge of working together with people from different technical backgrounds, i.e. structures people and antenna people. In the beginning of the project this lead to quite hilarious misunderstandings (the abbreviaton "RF" means something entirely different in these two worlds: it is «Radio Frequency» for one, and the all important «Reserve Factor»for the other), but now the antenna people start to understand structure, and vice versa. Personally I find this growth of understanding one of the most rewarding aspects of the project- like learning a new language.

Q2: What is innovative about these research activities?

The concept of integrating an antenna in an FML has been around for probably 5 years at least, when an early GPS-sized prototype has been tested in a

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collaboration between NLR and FMLC. Also, the concept of an integral “radio wave transparent window” in an FML (or carbon fibre composite for that matter) has been around over 10 years at least. What is really new now is that we are developing concepts that have the potential to be certified as aircraft primary structure. Secondly, for the VHF antenna it looks like the “glass-filled hole” in the FML skin will be more than just a window, and thereby increasing its weight efficiency, but this still needs to be confirmed by testing.

Q3: What are the strengths of Fokker Aerostructure in the ACASIAS consortium?

Fokker Aerostructures (GKN Fokker Aerostructures, officially) is used to dealing with high profile OEMs for large aircraft but also for business jets, so we know what is important to this kind of customer.

Also from the previous Fokker Aircraft company we still have the experience of what is required to make a part acceptable for airworthiness certification, so this helps us look beyond the current research phase.

Thirdly, our manufacturing facilities allow us to make aerospace quality parts, while at the same time checking for future manufacturability aspects.

Finally, Fokker Aerostructures is closely connected to the colleagues from Fokker Elmo, who understand electronics, and also to Fokker Techniek, who have service experience. And all this under the umbrella of GKN, who have a broad range of manufacturing and engineering activities that can also be called in for help or advise.

In short, I believe the presence of Fokker in the ACASIAS WP5 team helps to create integral antenna concepts that have the highest possible potential for future success.

Q4: The WP5 uses directly the structure of the FML panel to create an antenna when the other Work Packages focus on integrating electronics on the structure: are there some benefits that WP5 can gain from the work performed in the other WPs?

I am not an expert on electronics, so I cannot say if it is a benefit or not to integrate them onto the structure. When thinking about operational damages (like lightning strike), I imagine that easy replacability is also a design requirement, so it may in fact be more desirable to have the antenna and the electronics as separate parts. Also you must remember that FML panels can be quite large- say 10 x 3 meter as for A380. In that case, it’s more convenient to do the manufacturing of the structure/antenna panel as one step, and just hook it up with a cable to the electronics at a later stage.

Early integration can also be a cost matter: structural panels are delivered very early in the aircraft assembly process (sometimes up to a year before delivery of the actual aircraft), so you don’t want expensive electronics to be tied up all that time. Also there’s the structural assembly process itself which involves attaching of substructure (stringers and frames) by often riveting, and this can lead to damages of the electronics (or at least requires measures to avoid damages). All in all good reasons *not* to integrate the electronics.

Q5: Your research topic is very disruptive: how does the work performed in WP5 correlate to general trends in industry?

Integration of functionalities is always a complex balance: sometimes it works, but sometimes the separate parts are better. In cars, antenna’s apparently are getting integrated into the bumper areas, so there the trend is to integrate (or at least combine). Also, on advanced military aircraft, so-called conformal sensors have already been used for decades, but there the cost-performance figures are different, so this not a trend in commercial aviation.

For fast and far flying business jets, range and esthetics are important, so there an OEM may be willing to pay for a more expensive and probably heavier integral antenna than for a conventional “bolt on” installation. If this is so for a passenger aircraft like an A320, we’ll have to see. Also, integrating functions means you can’t have them separately as an option anymore. Aircraft customers tend to have many small configuration differences between one operator and another, so standard integration can be an issue for non-standard equipment.

Altogether “structure” is usually the “simple” part of an aircraft (as opposed to the engines and systems), so to make the structure “smart” is not common. But who knows, « smart structure » could become the trend on next generation aircraft!

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