Structural Integration of Antennas into an Aircraft

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***Abstract*—This paper gives an overview about the key note speech within the scientific workshop of ACASIAS project related to structural integration of antennas into aircrafts.**

***Index Terms*—antennas, communication, navigation, electronic warfare, comoposite, glass fibre, carbon fibre.**

I. Introduction (*Heading 1*)

Today military aircrafts requires up to 60 different antennas for communication, navigation and identification subsystems. Additional antennas are required for the sensor and mission system like electronic warfare and reconnaissance systems. Especially the needs to be applicable for network centric operations will increase the number of systems and therefore the number of required antennas.

All these systems require complex antenna subsystems using a numerous type of radiating elements, covering frequency ranges from HF up to EHF frequency bands in active and passive operational modes.

Due to the fact that the place of interest for additional antennas is limited and operational restrictions will reduce the possibility of installing complex antenna systems.

This speech gives an overview of integration technology for conformal antennas with load-bearing capabilities for different applications, test methods, qualification processes and shows many practical examples which has been realized for the demonstration of its technical maturity.

II. Applications and Frequency Bands

Structural integrated antennas are applicable for all RF system application for civil and military applications in a ground, air or naval operational environment and has to fulfill the fundamental applications of conventional antenna systems.

They cover applications for communication and data link providing voice and data transmission service under line of light and beyond line of sight, e.g. satellite communication, ground or space based navigation systems, identification and electronic warfare applications.

The relevant frequencies are covering a wide range in the RF spectrum from several MHz, in some cases much lower, up to several GHz. Depending on the frequency of interest applicable radiating elements have to be developed.

III. Motivation

The numbers of antenna systems are significantly increasing on all types of mobile platforms due to its increase of functionalities e.g. networked operation, connectivity, safety systems, etc. However the integration locations, regarding placement or ensuring optimum radiation characteristics are limited, even when integration constraints, e.g. shadowing by the vehicle structure or mechanical limitations, are resulting in many challenges of integrating the antennas.

For this reason an innovative approach was identified to integrate antenna into the aircraft structure with the benefit to get access to new and never applied integration areas on aircrafts.

With this approach, another challenge occurs. Two engineering disciplines, namely RF and structural engineering, have to be combined into one product at the end.

Aligned with this technology were the expectations to reduce aero dynamic drag, weight, noise, integration effort and RADAR signature reduction.

IV. Examples

A. *Laboratory Test Samples*

Within the technology development activities a dedicated roadmap was developed to mature this technology. At the beginning the main focus was laid on familiarization with the different materials, e.g. RF substrates and fibre composites, and the concept development for different antenna solutions applicable for planar, one dimensionally and two dimensionally curved surfaces. The initial applications were driven by fighter RADAR applications. For this reason the laboratory test samples were designed for X-band applications on super sonic highly agile platforms.

B. *Flight Test Demonstrations*

During the technology elaboration a certain maturation level was achieved for the decision entering into the next era. This was done with the development of two antenna demonstrators for testing during flight.

The first demonstrator was realized as an active electronically steered antenna array as part of a data link system for the transmission of real time video sensor data during air operation. For this purpose an antenna array with 64 radiating elements, fed by miniaturized transmit receive modules was developed, manufactured and integrated.

The second demonstrator becomes necessary, when an additional data link for command and control applications has to be integrated onto the demonstration vehicle. For this purpose an annular slot antenna operating in the S-band was developed, tested and integrated in the upper nose section in front of the air intake of the demonstrator UAV. Especially this demonstrator was a very good example, about the beneficial use of SIA getting access to former not approved integration locations.

In both cases our in house UAV technology demonstrator was used for this purpose.

V. Application Extension

After successful realization of these demonstrators further applications were identified to enhance the SIA technology to other system needs. In these activities the main focus was laid on enhancing the operating frequency to lower and extremely higher bands. Antenna test samples for the use in the VHF, UHF and L-band for communication and navigation and in the K-/Ka-band for wideband high data rate satellite communication were developed, manufactured and successfully ground tested.

VI. Testing and Qualification

In parallel to the development activities complex test and verification concepts to ensure structural integrity of each antenna sample were developed. These tests cover the structural behavior, mechanical impact, electromagnetic properties and RADAR cross section characteristics.

Intensive testing was performed during life cycle tests.

VII. Future Expectation

Despite of designing and manufacturing a lot of antenna samples for many applications many challenges are still to be covered. In this speech this technology was only applied to fiber composite materials. However other materials for aircraft applications, like GLARE, might be appear in the future. Also the use of additive manufacturing technologies offers some new benefits for this application. Combined with the use of meta materials and fractal structures hopefully better performance characteristics will be expected.

Another challenge is the development of new antenna radiating elements providing more efficiency, higher bandwidth by significantly reduced size.

Therefore a lot of activities in the area of research and technology for structural integrated antennas remain.

VIII. Summary

With this speech a comprehensive overview of structural integrated antennas was given with a further view on future challenges and opportunities.