Wireless Sensing Technology for Aerospace Applications – the Way Forward

A technology which was originally developed for industrial and commercial applications, there are many aerospace applications that will undoubtedly benefit from reliable and robust wireless sensing technology.

SEA involvement in research and development of wireless sensing technology for high-integrity applications in space positions it to provide wireless system development support to the aerospace industry.

Introduction

Over the past few years there has been a rapid growth in the replacement of physical cabling by RF wireless connections. The wireless field is diverse in respect of application, protocols and technologies, and informed choices need to be made when determining the best approach to meet a range of needs in a high-integrity environment such as aerospace; such choices should be based on a thorough understanding of the technology and direct practical experience.

SEA is currently part of a team, with AgustaWestland, University of Bristol and TRW Conekt, that is undertaking experimental work in the deployment of an IEEE802.15.4 wireless sensor network on helicopters to enable structural monitoring during flight, a project part funded by the Technology Strategy Board. SEA is also engaged in leading a significant project for the European Space Agency (ESA), involving selection of an RF wireless system for use in space flight and space test applications. Previous work has been undertaken for BNSC and ESA on the use of wireless systems for space missions. SEA personnel were inaugural members of ESA's wireless working group and currently advise ESA on the migration of wireless technology into a space standard via the international Consultative Committee for Space Data Standards (CCSDS).

SEA is also actively developing wireless sensor technology and applications for the military under the MoD's and DoD's joint International Technology Alliance programme.

SEA's experience of leading technology integration programmes gives us a good understanding of the challenges and issues involved in introducing new technologies to the aerospace domain. A key issue for any new technology introduction programme is the management and exploitation of the pre-existing intellectual property (IP); this is especially important when there are also potential constraints and issues of ITAR that may complicate procurements and present a barrier to the adoption of new technologies by the end users.

The Need for Wireless Sensing

There are many applications in the aerospace domain which require monitoring of a system parameter and collection of real time data, but where location of the sensors, or access to them, is prohibited by the remoteness of the system's location or the harshness of the environment in which it is operated. Examples of this type of application are engine testing, landing gear in-flight or test status monitoring and space craft or unmanned vehicle data collection.

With ever more sophisticated electronic systems being designed into the modern passenger-carrying airliner, the wiring loom is a significant contributor to the weight overhead of the aircraft. The ongoing efforts to reduce the weight of an aircraft in order to meet aggressive improvements in cost and environmental impact makes a reduction of the amount of wiring on an aircraft a prime target for the airframers. The use of wireless sensing technology would facilitate a significant step in this direction.

Candidate Solutions

The introduction of wireless communications to the development and operation of aircraft in a number of application areas offers significant benefits in flexibility, interoperability, mass reduction and improved robustness. However, there are a number of issues that are raised in the development and deployment of such systems in future aircraft projects. These can be discussed as follows:

EMC is a fundamental concern of any aircraft developer when considering the integration of an RF network. This is addressed through a detailed EMC analysis for the applications where a wireless sensing network is proposed. It is predicted that such concerns should be alleviated by the use of wireless standards where spread spectrum modulation is employed, providing low power spectral density in the bandwidth and hence minimising such interference. These systems also provide central frequency selection, giving the opportunity to avoid potential victims. The advantages of a reduction in the wiring content of an aircraft and the implications on

EMC are especially important in newer aircraft designs using high percentages of carbon fibre in the fuselage construction.

Power is a key trade-off criterion in wireless applications. A prime objective for a sensor wireless network must be that it is completely wireless and therefore local power is required either in a battery, by power scavenging, or a combination of both. This is typically addressed in the trade-off of available parts and COTS wireless networking approaches. In this respect IEEE802.15.4 is a prime candidate, but other approaches should be considered which offer even lower power requirements. In addition to such selections the overall network management and topologies can also be used to manage power requirements by balancing aspects such as data throughput and latency.

RF protocol choice: a wide range of standards have been developed for RF wireless links and networks. These are split between so-called "Wireless Local Area Networks" (802.11b/g/a/n) with ranges in the upper tens of metres, and "Wireless Personal Area Networks" (802.15.1/3/4), with ranges of order 10m or so. The former (generally described as "Wi-Fi") connect to high-speed Ethernets. The Personal networks often have restricted numbers of nodes, and may have master / slave topologies. 802.15.1 (Bluetooth) is most widely used to connect mobile telephones to headsets, earpieces and laptops. 802.15.3 is a higher-speed protocol with similar envisaged applications. Another interesting candidate for connections between aircraft and GSE is a CAN-Bluetooth bridge; CAN is a low-cost robust network and Bluetooth access points are readily available as COTS.

802.15.4 is a somewhat different concept; together with protocol stacks such as those defined under the ZigBee working groups it is becoming increasingly used in home automation systems. It has been seen as a potential protocol for sensor nets and the development of modules for such sensor nets has been a central part of SEA studies.

The list of issues described above is the most obvious but is not exhaustive. Other issues such as reliability, bandwidth, system integration and design for safety critical applications are also fundamental considerations in the decision process.

Robustness and User Acceptance are complementary aspects that must be addressed for the introduction of any new technology into a high-integrity application. The move to wireless in such systems is as big a step as replacement of mechanical systems with electrical systems. As such a system-level approach to ensuring robustness through technology selection, network design with built-in fault tolerance and system demonstration programmes are key to gaining user confidence and acceptance.

Summary

The choice of RF wireless system parameters and technical solution is extremely application sensitive. SEA has a highly experienced and capable team who are able to apply their knowledge in this field to any aerospace application that could benefit from a wireless sensing system, including candidate protocols Wi-Fi, Bluetooth, 802.15.4.

SEA is well aware of new developments such as Wibree and proprietary architectures such as the Toumaz Sensium chip, and is experienced in many 'use case' domains.

Having successfully fulfilled the role of lead contractor in such technology research programmes, SEA has direct experience of the issues associated with incorporating high-integrity technology into challenging environments. SEA's development of the electronics for the MEMS Rate Sensor for Selex is a prime example. Consequently, SEA is well positioned to address intellectual property and ITAR issues that may arise during successful industrialisation of a technology solution.

SEA firmly believes that, as a key member of teams engaged in developing wireless technologies for high-integrity aerospace applications, it can significantly contribute to the development, and influence the direction, of wireless technology in many aspects of the aerospace industry.

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