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BSI Standards Publication

# Information technology — Sensor networks — Guidelines for design in the aeronautics industry: active air-flow control

# National foreword

This Published Document is the UK implementation of ISO/IEC TR 22560:2017.

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A list of organizations represented on this committee can be obtained on request to its secretary.

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# TECHNICAL REPORT

colour inside

## Information technology – Sensor network – Guidelines for design in the aeronautics industry: active air-flow control

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# INFORMATION TECHNOLOGY – SENSOR NETWORK – GUIDELINES FOR DESIGN IN THE AERONAUTICS INDUSTRY: ACTIVE AIR-FLOW CONTROL

## FOREWORD

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ISO/IEC TR 22560, which is a Technical Report, has been prepared by subcommittee 41: Internet of Things and related technologies, of ISO/IEC joint technical committee 1: Information technology.

This Technical Report has been approved by vote of the member bodies, and the voting results may be obtained from the address given on the second title page.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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# INTRODUCTION

The number of wireless connections is growing exponentially around the world. Wireless communications are expanding to areas previously reluctant to use this type of technology. In the field of aeronautics, wireless intra-avionics applications are just recently gaining acceptance both in industrial and academic arenas. This late adoption is mainly because wireless transmissions have been conventionally associated with reliability and interference issues. Aeronautics applications on board aircraft are highly critical and therefore the inherent randomness of wireless technologies created lots of skepticism, particularly for sensing, monitoring and control of critical aeronautical subsystems. In addition, uncontrolled wireless transmissions can potentially create interference to other aeronautical subsystems, thus leading to malfunctions and unsafe operation. However, recent interference and reliability studies with state-of-the-art wireless standards suggest safe operation and thus the feasibility of a relatively new research area called wireless avionics intra-communications (WAICs). In the last few years, wireless technology has started to be used on board for systems that conventionally used only wire-line infrastructure (i.e., as replacement of cables). It is also being used for applications which are now only possible thanks to the wireless component (e.g., indoor localization, tracking and wireless power transfer). Examples of potential applications of wireless avionics intra-communications are the following: structure health monitoring, avionics bus communications, smoke sensors, interference monitoring, logistics, identification, replacing of cables, fuel tank sensors, automatic route control based on optimized fuel consumption and weather monitoring, automatic turbulence reduction or active air-flow control, EMI (electromagnetic interference) monitoring, and flexible wiring redundancy design.

The avionics industry will experience a wireless revolution in the years to come. The concept of “fly-by-wireless” opens several issues in design, configuration, security, spectrum management, and interference control. There are several advantages in the use of wireless technologies for the aeronautics industry. They permit reduction of cables in aircraft design, thus reducing weight. Reduction of weight also leads to increased payload capacity, longer ranges, faster speeds, and mainly savings in fuel consumption. The reduction of cables can also improve the flexibility of aircraft design (less manpower for designing complex cabling infrastructure). Additionally, wireless technologies can reach places of aircraft that are difficult to reach by cables, while being relatively immune to electrical cable malfunctions. Wireless technology also provides improved configuration and troubleshooting with over-the-air functionalities of modern radio standards.

This document presents the application of wireless sensor and actuator networks for the dynamic tracking and compensation of turbulent flows across the surface of aircraft. Turbulent flow formation and the associated skin drag effect are responsible for the inefficiency of airplane design and thus act as major factors in increased fuel consumption. The area of active air-flow control represents the convergence of several scientific fields such as: fluid mechanics, sensor networks, control theory, computational fluid dynamics, and actuator design. Due to the high speeds experienced by modern commercial aircraft, dense networks of sensors and actuators are necessary to accurately track the formation of turbulent flows and for counteracting their effects by convenient actuation policies. The use of wireless technologies in this field aims to facilitate the management of the information generated by the large number of sensors, and reduce the need for cables to interconnect all the nodes or groups of nodes (patches) in the network. Additionally, the use of the wireless components opens new issues in joint propagation and turbulence flow modelling. This document presents the design principles of active air-flow control systems using dense wireless/wired sensor networks compliant with the ISO sensor network reference architecture (SNRA). Standardized interfaces will help developers create smart cloud avionics applications that will improve fleet management, optimized route traffic, and computation of actuation profiles for different moments of an aircraft mission. This also lies within the context of future technological concepts such as Internet of things, Big Data, and cloud computing.

# INFORMATION TECHNOLOGY – SENSOR NETWORK – GUIDELINES FOR DESIGN IN THE AERONAUTICS INDUSTRY: ACTIVE AIR-FLOW CONTROL

## 1 Scope

This document describes the concepts, issues, objectives, and requirements for the design of an active air-flow control (AFC) system for commercial aircraft based on a dense deployment of wired/wireless sensor and actuator networks. The objective of this AFC system is to track gradients of pressure across the surface of the fuselage of aircraft. This collected information will be used to activate a set of actuators that will attempt to reduce the skin drag effect produced by the separation between laminar and turbulent flows. This will be translated into increased lift-off forces, higher vehicle speeds, longer ranges, and reduced fuel consumption. The document focuses on the architecture design, module definition, statement of objectives, scalability analysis, system-level simulation, as well as networking and implementation issues using standardized interfaces and service-oriented middleware architectures. This document aims to serve as guideline on how to design wireless sensor and actuator networks compliant with ISO/IEC 29182.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 29182-2:2013, *Information technology – Sensor networks: Sensor Network Reference Architecture (SNRA) – Part 2: Vocabulary and terminology*

ISO/IEC 29182-3:2014, *Information technology – Sensor networks: Sensor Network Reference Architecture (SNRA) – Part 3: Reference architecture views*

ISO/IEC 29182-4:2013, *Information technology – Sensor networks: Sensor Network Reference Architecture (SNRA) – Part 4: Entity models*

ISO/IEC 29182-5:2013, *Information technology – Sensor networks: Sensor Network Reference Architecture (SNRA) – Part 5: Interface definitions*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 29182-2:2013 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org.obp