



The European Organisation for Civil Aviation Equipment
L'Organisation Européenne pour l'Équipement de l'Aviation Civile

PROCESS SPECIFICATION FOR WIRELESS ON-BOARD AVIONICS NETWORKS

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CHAPTER 1

GENERAL FRAMEWORK

1.1 SCOPE OF WORK

This document is intended to provide guidance on the airworthiness certification process for electronic aircraft equipment installed or integrated on board an aircraft, featuring a wireless communication function to allow for exchange of information with other equipment installed or integrated on board the same aircraft. These wireless communication functions are part of the aircraft configuration and their proper functioning will need to be approved through airworthiness certification authorities. These systems are named Wireless On-board Avionics Network (WOBAN) systems throughout this document (see Table in Appendix A).

Wireless communications between intentionally transmitting portable electronic devices (T-PEDs), which are not part of the approved aircraft configuration, are already covered by existing standards (e.g. ED-130A [7], DO-363 [17]) and are outside the scope of this specification.

Similarly, wireless communication systems such as those used for air-to-ground, air-to-air and air-to-satellite communication and navigation purposes are also outside the scope of this specification.

WOBAN systems may use globally available radio frequency spectrum resources such as the global frequency allocations for Industrial, Scientific and Medical (ISM) applications. These frequency bands are often made available by telecom regulatory authorities on the basis of license exemption or a general authorization for use (see paragraph B.2.2 in Appendix B).

WOBAN systems may also be designed for use in a particular aeronautical spectrum allocation which is dedicated for the purpose described above (for example, the frequency allocation in the frequency band 4 200 – 4 400 MHz). WOBAN systems that operate in this band are also referred to as Wireless Avionics Intra-Communication (WAIC) systems [48].

This process specification is applicable to all on-board wireless systems that fulfill the above definition, i.e. all WOBAN systems.

The proposed requirements as well as the process and means to demonstrate compliance of a particular system implementation to these requirements are described throughout the remainder of this document. This specification hence provides guidance to *WOBAN Component Developers*, *Application Developers*, *WOBAN System Integrators* as well as the *Certification Applicants* that are seeking airworthiness approval for their products. This guidance includes a description of the proposed activities that should be performed and the supporting information that should be generated. It is also intended to assist the airworthiness certification authorities in addressing the certification aspects of WOBAN systems.

Whenever reference to other guidance material, such as EUROCAE ED or RTCA DO documents, is made throughout this Process Specification, unless otherwise stated, always the latest revision of that document shall apply.

1.2 DOCUMENT STRUCTURE

The document contains five main chapters.

Chapter 1 provides the general framework for which this Process Specification (PS) is applicable. It defines its scope, describes the document structure and identifies related guidance material and related activities carried out in other EUROCAE working groups.

Chapter 2 provides the definition of a Wireless On-board Avionics Network (WOBAN) system and describes the WOBAN system elements and the associated terminology. It further provides a description of a number of typical WOBAN system topologies.

Chapter 3 provides a description of typical development scenarios for WOBAN systems including an introduction of individual development tasks and their assignment to stakeholders. Furthermore, it introduces aspects of certification planning, including airworthiness aspects and instructions for continued airworthiness. It addresses as well safety assessment and protection requirements.

Chapter 4 provides Guidance on requirements for the development process for WOBAN systems including those related to radio/telecom regulations, communication performance and protection of the WOBAN system against external effects.

Chapter 5 provided guidance on the verification of the requirements introduced in Chapter 4.

1.3 RELATION TO THE WORK OF-OTHER EUROCAE WORKING GROUPS

1.3.1 EUROCAE WG-72 “Aeronautical Information Systems Security”

This process specification uses as a basis for the WOBAN security related topics the following documents created by WG-72:

- EUROCAE ED-201 – “Aeronautical Information System Security (AISS) Framework Guidance”, December 2015 [8]
- EUROCAE ED-202A/RTCA DO-326A – “Airworthiness Security Process Specification”, June 2014 [9]
- EUROCAE ED-203 – “Airworthiness Security Methods and Considerations”, September 2015 [10]
- EUROCAE ED-204/RTCA DO-355 – “Information Security Guidance for Continuing Airworthiness”, June 2014 [11].

1.3.2 EUROCAE WG-99 “Portable Electronic Devices (PED)”

WG-99 developed a general methodology for verifying whether an aircraft is tolerant with regards to electromagnetic emissions from T-PEDs. WOBAN systems, unlike T-PEDs, are a part of the approved aircraft configuration. While in this aspect WOBAN systems and TPEDs certainly differ, the methodology for demonstration of T-PED tolerance of aircraft systems can equally be applied for verifying tolerance against electromagnetic emissions from WOBAN-NAS (Non-Aeronautical Standard) systems. This is because T-PED radio technology and operational frequency ranges are essentially the same as that used for WOBAN-NAS systems. The special case of WAIC systems operating in the aeronautical frequency band 4 200 – 4 400 MHz involves front-door coupling of WAIC emissions into the receive band of the radio altimeter system as well as radio altimeter emissions into the receive band of the WAIC system. Since this is a question of the ability of both WAIC and radio altimeter systems to coexist in the same frequency band, it needs to be addressed by system design measures rather than by demonstrating electromagnetic compatibility. This case is discussed in further detail in paragraph 4.3.3.2 and Appendix E.

This process specification considers the testing methodology developed by WG-99 to test the tolerance of an aircraft against T-PEDs, as applicable for the testing of the aircraft tolerance against WOBAN. The following documents developed by WG-99 complement the process described in this process specification and should be used for guidance:

- EUROCAE ED-130A/RTCA DO-363, Guidance for the use of portable electronics devices (PEDs) on board aircraft, December 2016 [7]
- EUROCAE ED-239/RTCA DO-307A, “Aircraft Design and certification for portable electronic device (PED) tolerance, December 2016 [12].

CHAPTER 2

WIRELESS ON-BOARD AVIONIC NETWORKS

2.1 INTRODUCTION

This chapter provides a generic description of WOBAN systems and introduces the terminology used throughout the remainder of this document. Examples of typical WOBAN topologies and configurations are discussed at the end of this chapter.

2.2 DEFINITION OF WOBAN AND TERMINOLOGY

The term WOBAN refers to wireless networks that provide communications for aircraft functions. These functions are introduced to an aircraft through either a Type Certification (TC), a Design Change to a TC, or a Supplemental TC (STC).

Appendix A provides categories of possible wireless application use cases.

A WOBAN system provides the following high-level functionality:

- reception of data from an application as part of the aircraft function,
- transfer of data across the network to its intended destination in accordance with a specified quality of service,
- delivery of data in its original format to the intended application,
- management of the network operation and its configuration.

A WOBAN system consists of WOBAN components. These components can be WOBAN nodes, network management functions or any other entity necessary for a proper WOBAN system operation. Generally, a WOBAN system comprises two or more WOBAN nodes and an entity responsible for managing the network. A WOBAN node is connected to one or more applications, where each application is part of one or more aircraft function(s). WOBAN nodes wirelessly transmit and receive application data. The network management entity can either be integrated into the WOBAN nodes or can be hosted within dedicated processing entities.

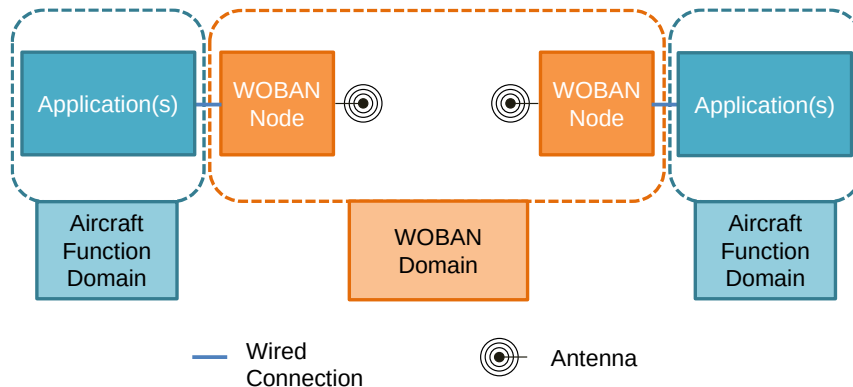


FIGURE 1: WOBAN SYSTEM EXAMPLE

WOBAN nodes are installed at fixed locations or are movable within a designated on-board area. The latter type of node is also referred to as a movable WOBAN node within this PS. In addition to transferring data between applications, WOBAN nodes may also be used for relaying data to extend the communication range of a network. Relay nodes may not necessarily be connected to an application. Fixed and movable WOBAN nodes (including relay nodes) are part of the approved aircraft configuration.

WOBAN systems may include provisions for granting network access on a temporary basis to nodes which are not part of the approved aircraft configuration, e.g. for aircraft servicing or maintenance purposes. These nodes are referred to as guest nodes. Guest node access will be on a temporary basis that is restricted to aircraft ground operation only. It is recommended that the WOBAN system has a special mode of operation that is only applicable for restricted access conditions.

2.3 TYPICAL WOBAN TOPOLOGIES AND CONFIGURATIONS

WOBAN system implementations differ depending on factors such as, aircraft type, configuration and targeted function(s). Consequently, a broad range of WOBAN topologies and configurations are possible. This section provides an overview of some typical WOBAN topologies and their configurations.

2.3.1 Point-to-Point WOBAN system

The simplest WOBAN topology consists of two WOBAN nodes using a single wireless communication link as depicted in [FIGURE 2](#). The two depicted WOBAN nodes provide wireless communications for a single aircraft function.

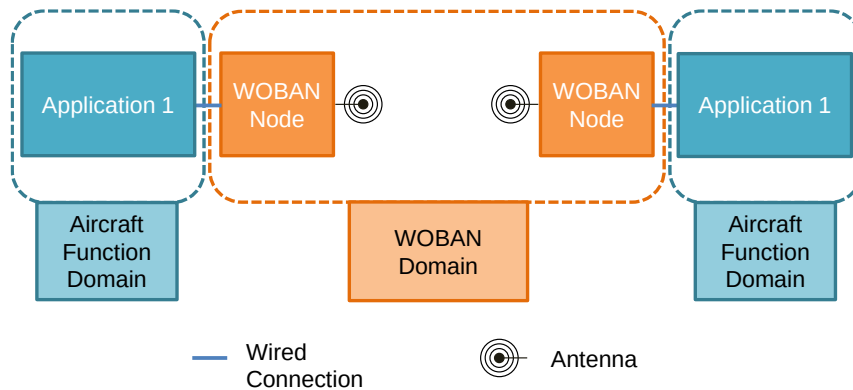


FIGURE 2: POINT-TO-POINT, SINGLE AIRCRAFT FUNCTION WOBAN SYSTEM EXAMPLE

The same topology can be used to provide wireless communications for several aircraft functions. In this case the network must be configured such that a WOBAN node is able to physically interface with multiple applications and to distinguish between them. Such a configuration is depicted in [FIGURE 3](#), where applications 1 to 3 represent (parts of) different aircraft functions.

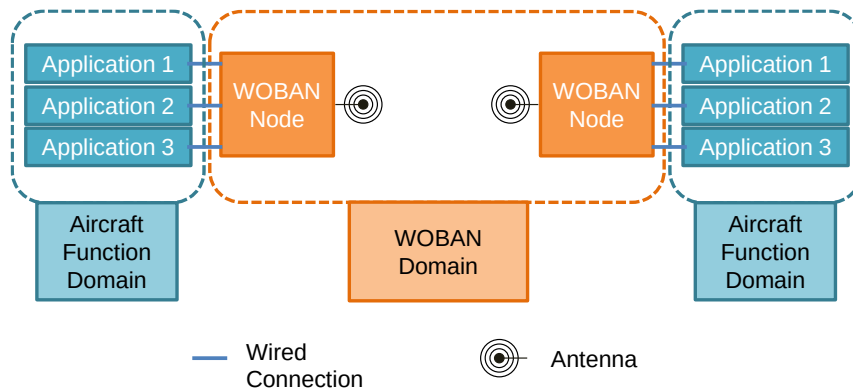


FIGURE 3: POINT-TO-POINT, MULTIPLE APPLICATIONS WOBAN SYSTEM EXAMPLE

2.3.2 Centralized Point-To-Multi-Point WOBAN System

A centralized point-to-multi-point network topology consists of more than two WOBAN nodes. At least one particular node in the network is connected to all the aircraft functions that make use of the WOBAN system via a wired avionics data bus. This node serves as a gateway between the wired avionics data bus and all other WOBAN nodes in the network. Consequentially, it must be in mutual radio range of all other nodes.

The remaining WOBAN nodes connect to a single or several applications which, for example, send or receive data to/from an actuator or a sensor. This network topology and configuration is depicted in [FIGURE 4](#). Centralized point-to-multi-point WOBAN systems may include more than one WOBAN node that serves as a gateway to increase radio coverage and redundancy.

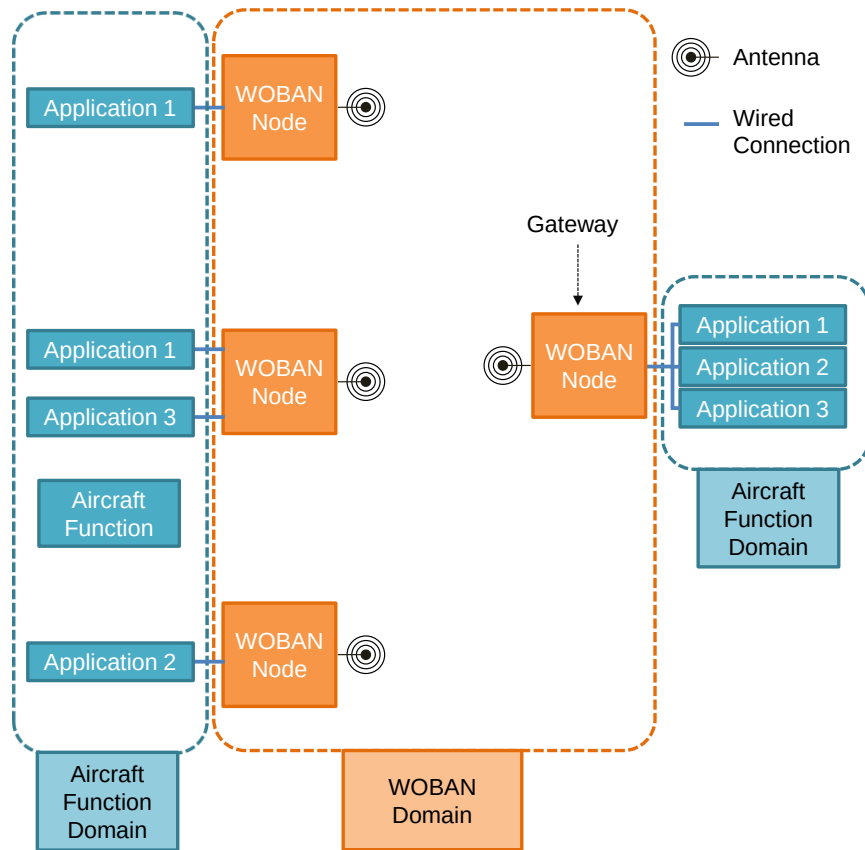


FIGURE 4: CENTRALIZED POINT-TO-MULTI-POINT WOBAN SYSTEM EXAMPLE

2.3.3

Multi-Hop WOBAN system

A Multi-Hop network topology consists of multiple WOBAN nodes which are transmitting or receiving data of the connected applications. These nodes may also relay messages to other nodes. However, Multi-Hop WOBAN systems may also include WOBAN nodes whose sole purpose is to relay data for the purpose of increasing radio coverage. In addition, Multi-Hop WOBAN systems may also include nodes that serve as a gateway as described above.

FIGURE 5 shows an example of a Multi-Hop WOBAN system. In the depicted example, WOBAN nodes 1 and 2 may directly communicate to exchange data of application 1. The same applies for WOBAN nodes 5 and 6 with respect to application 3. However, WOBAN nodes 2 and 5 require one or more relays to exchange data related to application 2. A possible route to connect nodes 2 and 5 could be via node 3. Other routes are possible, for example, via nodes 4 and 6, where the latter also acts as a relay node besides serving application 3.

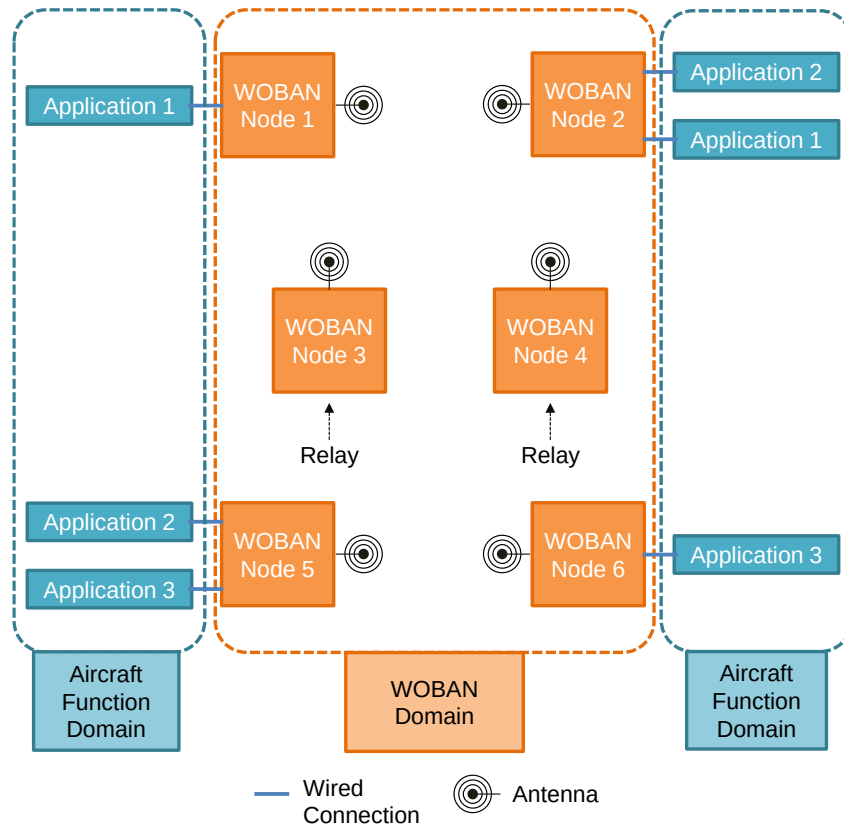


FIGURE 5: MULTI-HOP WOBAN SYSTEM EXAMPLE

CHAPTER 3

CERTIFICATION GUIDANCE

3.1 INTRODUCTION

This chapter identifies the stakeholders involved in the development and certification of a WOBAN system. It defines the necessary certification tasks and provides an overview of a number of typical WOBAN system certification scenarios. The information provided in this chapter is intended to support the applicant in the development and certification process applicable to WOBAN systems.

3.2 DEFINITION OF STAKEHOLDERS AND TASKS

The following stakeholders can be involved in the development, integration and compliance demonstration of a WOBAN system:

- ***WOBAN Component Developer***: Responsible for the development of WOBAN components, e.g. WOBAN nodes or network management function.
- ***Application Developer***: Responsible for the development of applications in respect to the associated overlaying aircraft functions.
- ***WOBAN System Integrator***: Responsible for building a new or modifying an existing WOBAN system. The *WOBAN System Integrator* is responsible for ensuring that all WOBAN applications that use the network meet their performance objectives.
- ***Certification Applicant***: Responsible for aircraft-level integration of a single or multiple WOBAN system(s) and for providing certification documentation in order to obtain certification approval for a WOBAN system installation including their applications. The *Certification Applicant* is typically the aircraft manufacturer or a STC design organization.
- ***Certification Authority***: The *Certification Authority* is the organization(s) granting approval on behalf of the individual State(s) responsible for aircraft airworthiness certification.

NOTE: The stakeholder names defined above appear in 'italic' notation throughout this Process Specification

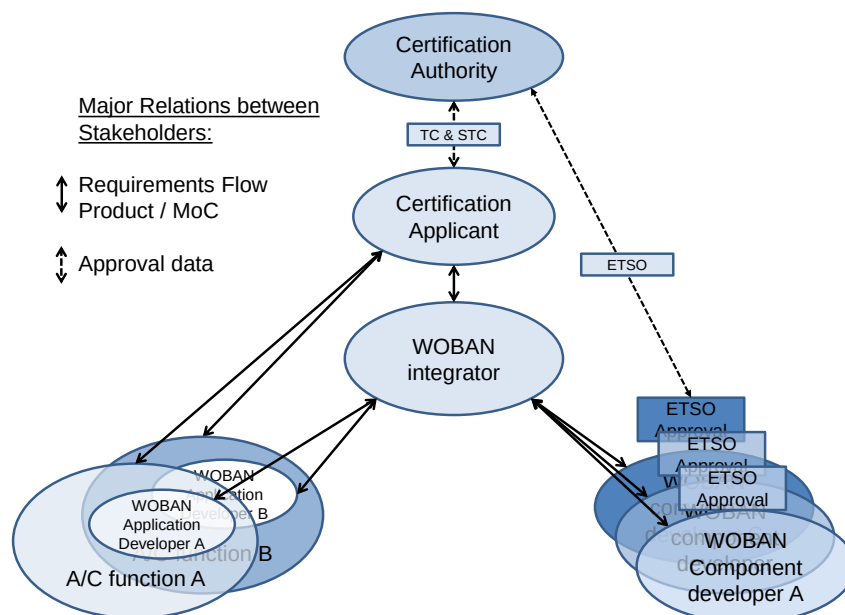


FIGURE 6: STAKEHOLDER – TASK RELATIONSHIP

The development and integration of a WOBAN system as well as the compliance demonstration for that system requires the following tasks:

- **Task 1 – WOBAN component development:** This task comprises the development of WOBAN components and their testing against validated certification requirements. WOBAN components can be approved independently from applications in accordance with established ETSOs and relevant certification requirements proposed in CHAPTER 4 of this PS.

NOTE: *At the time of development of this EUROCAE PS an ETSO for WOBAN does not exist. It is expected that such ETSO will be developed by EASA.*

- **Task 2 – Application development:** This task comprises the development of new applications or the modification of existing applications. Applications should be tested together with the WOBAN system used by these applications against an approved set of certification requirements. Applications could be approved independently from each other and from the WOBAN system, by demonstrating that the application can fulfil its intended function for the characteristics specified by the WOBAN usage domain.
- **Task 3 – WOBAN system integration & configuration:** This task comprises the architectural integration of WOBAN components and applications into a new WOBAN system or the addition of WOBAN components and/or applications to an existing WOBAN system. This task also includes the configuration of all WOBAN system components (i.e. nodes, network management and applications) in a way that the network in its entirety and all associated applications fulfil their intended function. Generally, the development of a WOBAN system should be designed to meet certification requirements provided in CHAPTER 4 of this PS.
- **Task 4 – WOBAN aircraft integration:** This task comprises the integration of a WOBAN system into the target aircraft or the modification of an existing WOBAN system of the target aircraft. Furthermore, this task includes demonstration of compliance with the certification requirements proposed in CHAPTER 4 of this PS.

Generally, parties involved in the certification process can be associated with more than one of the stakeholder roles defined above and consequently also with more than one of the tasks. For example, a party could develop WOBAN nodes and applications together and, therefore, fit into the definition of a WOBAN Component and *Application Developer*.

3.3 TYPICAL DEVELOPMENT SCENARIOS

This section describes typical WOBAN system development scenarios. The scenarios are discussed with respect to involved stakeholders and tasks described in the previous sections. Furthermore, objectives for incremental certification of WOBAN systems and components are introduced.

Appendix D describes an incremental compliance demonstration process in which a set of specific Means of Compliance (MoC) is mapped to each stakeholder per each development scenario.

3.3.1 Scenario 1: WOBAN component development

Description:

In this scenario WOBAN components are developed without consideration of specific target applications or specific aircraft types. The development is performed against applicable requirements (e.g. generic performance and reliability classes). WOBAN components may be approved, if these requirements are based on applicable standards, e.g. an ETSO. The scenario applies for WOBAN components which are based on purpose build and/or commercially available hardware and software.

NOTE: *At the time of development of this EUROCAE PS an ETSO for WOBAN does not exist. It is expected that such ETSO will be developed by EASA.*

Objectives for incremental certification:

- To support incremental certification, WOBAN components should be developed against applicable application-level airworthiness requirements agreed with the *Certification Authority*.
- The product data sheet of an approved WOBAN component should clearly identify technical characteristics (e.g. performance parameters and limitations) relevant for *Application Developers*, *WOBAN System Integrators*, *Certification Applicants* and certification authorities.
- WOBAN components should support the segregation of applications that use the network.

Involved stakeholders and related tasks:

- WOBAN Component Developer: Development and compliance demonstration in accordance with Task 1 as defined in paragraph 3.2.
- Certification Authority: Parts and Appliances approval (e.g. based on ETSO).

3.3.2

Scenario 2: Application development

Description:

In this scenario an application is developed for a specific aircraft function. It is assumed that the application development uses available WOBAN components approved according to Task 1 as defined in paragraph 3.2. The composition of developed application and used WOBAN components is qualified against the specific requirements imposed by the aircraft function (for example maximum achievable data rate, minimum tolerable transmission latency) by Means of Compliance proposed in CHAPTER 5.

Qualification testing should include a set of requirements representing characteristic environmental conditions (e.g. electromagnetic environment, temperature range, pressurized or unpressurised area) representative for the target aircraft type(s).

Objectives for incremental certification:

- Applications should be developed such that the behavior of one application does not affect the performance of other applications using the same WOBAN system.
- Optionally, an application associated with an aircraft function which can be implemented on board different aircraft types may be approved against requirements agreed with the *Certification Authority* when using approved WOBAN components.

Involved stakeholders and related tasks:

- Application Developer: Development of the application as part of a specified aircraft function in accordance with Task 2 as defined in paragraph 3.2.
- Certification Applicant: Specification of the aircraft function, including the certification requirements for that function in accordance with Task 2 as defined in paragraph 3.2.
- Certification Authority: Approval, review and approval statement for the concerned aircraft function.

3.3.3

Scenario 3: New WOBAN system development and aircraft integration

Description:

This scenario covers the development of a new WOBAN system and its integration into the target aircraft. Two cases are considered:

- Replacement or extension of an existing wired network: in this case the characteristics and performance of the affected aircraft functions remain unchanged. Therefore, the WOBAN system must be developed against the requirements that the aircraft functions impose on the wired network to be replaced by the WOBAN system. In this context, applications serve as a simple interface between WOBAN node and aircraft function (see paragraph 2.2).

- Joint development of a WOBAN system and aircraft functions making use of it: In this case the WOBAN system is developed against the requirements of the aircraft functions. In contrast to the previous case these requirements may be defined such that an optimum exploitation of the WOBAN system capabilities and performance is possible, for example by accounting for the characteristics of the utilized wireless communication. Instead of serving as a simple interface, the application may become an integral part of the aircraft function itself.

When integrated into the aircraft, the WOBAN system should be tested under representative operational conditions against requirements agreed with the *Certification Authority* as describe in CHAPTER 5.

Objectives for incremental certification:

The WOBAN system should support the addition, removal and modification of applications and respective WOBAN components while maintaining the existing certification evidence of other applications using the WOBAN system.

Involved stakeholders and related tasks:

- WOBAN System Integrator: Integration and configuration of WOBAN system in accordance with Task 3 as defined in paragraph 3.2. Furthermore, the WOBAN System Developer may also be responsible for WOBAN component and/or application development if the WOBAN system is not based on approved WOBAN components and/or applications.
- Certification Applicant: Integration of the WOBAN system into the target aircraft in accordance with Task 4 as defined in paragraph 3.2.
- Certification Authority: Validation of certification evidence and granting of aircraft approval.

3.3.4

Scenario 4: Modification of aircraft functions

This scenario deals with modifications of aircraft functions making use of a WOBAN system. These modifications result in the addition of changes to or removal of applications and/or associated WOBAN components as well as changes to the WOBAN system configuration.

Objectives for incremental certification:

- The *WOBAN System Integrator* should demonstrate that the performed modifications do not impact the segregation and performance of other applications using the WOBAN system. The demonstration should include analysis and if necessary test to prove that the existing verification evidence for these applications remain valid.
- The *Certification Applicant* should provide evidence that the modifications meet requirements agreed with certification authorities.

Involved stakeholders and related tasks:

- WOBAN Component Developer: In case of changing or adding a new developed WOBAN component the *WOBAN Component Developer* may be involved and will take responsibility for Task 1 as defined in paragraph 3.2 (refer also to Scenario 1: WOBAN component development).
- Application Developer: Modification of affected applications and demonstration of compliance with applicable certification requirements.
- WOBAN System Integrator: Integration of modifications into the existing WOBAN system in accordance with Task 3 as defined in paragraph 3.2.
- Certification Applicant: Integration of modified WOBAN system into the target aircraft in accordance with Task 4 as defined in paragraph 3.2.
- Certification Authority: Validation of certification evidence and granting of aircraft approval.

3.3.5 Scenario 5: Modification of RF propagation environment

Description:

This scenario is concerned with modifications to the aircraft impacting the Radio Frequency (RF) propagation environment in which the WOBAN system is operated (for example changes in the cabin configuration).

There is a need to assess the continuing performance and defined capabilities of the WOBAN system's communication links after such aircraft changes. The extent of the assessment should depend on the extent of the aircraft-level changes and their impact on the RF-propagation environment. However, it is required to follow the instructions and the guidelines of the certification holder, which were established in order to ensure continued airworthiness (refer to paragraph 0).

As a result of this assessment, two cases can be distinguished:

- Changes to the RF-propagation environment do not impact the performance of the WOBAN system: In this case it should be checked that the established verification evidences remains valid (for example by built-in self-testing performed by the WOBAN system). No further actions are required.
- Changes to the RF-propagation environment impact performance of the WOBAN system such that the established certification evidence is invalidated: In this case, the WOBAN system must be re-configured (refer to Scenario 4: Modification of aircraft functions).

Involved stakeholders and related tasks in the latter case:

- System Integrator: Reconfiguration of the existing WOBAN system in accordance with Task 3 as defined in paragraph 3.2, such that applicable certification requirements are met.
- Certification Applicant: Applies the configuration changes to the WOBAN system on board the target aircraft in accordance with Task 4 as defined in paragraph 3.2.
- Certification Authority: Validates certification evidence and grants aircraft approval if case (2) becomes required.

3.4 CERTIFICATION PROCESSES

3.4.1 Certification requirements common for all stakeholders

Stakeholders responsible for one or more of the tasks described in paragraph 3.2 above should also apply industrial standards (e.g. ED-12C [2] / DO-178C [14], ED-14G [3] / DO-160G [13], ED-80 [5] / DO-254 [16]) in fulfilling their duties. Particular guidelines for the development of civil aircraft and systems are defined in ED-79A [4] / SAE ARP 4754A [22]. The following aspects need to be particularly considered by the stakeholder(s):

- Requirements validation management
- Configuration management and control of products and documentations
- Quality assurance and independent checking procedures (if required)
- Certification liaison support
- Development and verification tracking process (problem reporting, etc.)

The standards that are applicable to the development of software and complex hardware should apply to the development of WOBAN components and applications.

Aircraft-level requirements should be validated, i.e. reviewed for completeness and correctness before allocation of functions to the system. This step should follow the principles as provided in ED-79A [4].

3.4.2 Certification planning

For certification of the WOBAN system, the *Certification Applicant* should prepare a certification plan that describes the installation and the proposed Means of Compliance (MoC) with applicable airworthiness requirements in accordance with the certification basis. The *Certification Applicant* should further explain how the safe use of the WOBAN system under prescribed conditions is ensured.

Certification aspects addressed within the following paragraphs should be covered by the certification plan of a WOBAN system. Some of these aspects and requirements may or may not be applicable for a given installation/application. For example, possible vulnerabilities with respect to safety and integrity as well as installation specifics such as installed locations of WOBAN nodes may not be applicable. Their applicability will be dependent on the aircraft function(s) that make use of the wireless communication capabilities offered by the WOBAN system and will need to be determined on a case-by-case basis.

3.4.2.1 General certification requirements for systems

The following list of paragraphs from EASA Certification Specifications for Large Aeroplanes (CS-25) [1] is not exhaustive, but represents typical requirements which could be applicable to a WOBAN system, e.g. dependent on installation location and electrical power source:

- 25.789 (a) Retention of Items in the cabin,
- 25.869 (a) Fire Protection,
- 25.901 (c) Sustained Engine Imbalance
- AMC 25-24
- 25.1301(a)(b) Function and installation,
- AMC 25.1301
- 25.1309(a)(b)(c) Equipment installation and Safety,
- AMC 25.1309
- 25.1310(a)(b) Power,
- 25.1316 Lightning protection,
- 25.1317 High-Intensity Radiated Fields (HIRF) protection
- 25.1322 Warning, Caution and advisory lights,
- 25.1351 (a) General - Electrical Systems,
- 25.1357 Circuit protective devices,
- 25.1360 Precautions against injury,
- 25.1431(a)(b)(c)(d) Qualification,
- 25.1529 Instructions for Continued Airworthiness (including Appendix H of CS 25.1529),
- 25.1581 Airplane flight Manual,
- 25.1707 EWIS.

NOTE: *For installations on aircraft of category other than “Large Aeroplanes” the relevant requirements should be used (e.g. CS-23, CS-27, CS-29, etc.). Associated compliance standards and guidance material (EUROCAE, RTCA, SAE documents) are applicable in most cases. However, the decision of applicability will be based on the kind of operation and the class of aircraft.*

NOTE: *Means of compliance shall be demonstrated to the responsible authority for agreement.*

3.4.2.2 System safety assessment

A system safety assessment should be provided to the *Certification Authority*. It is recommended to follow the existing guidance given in SAE ARP 4761 [23]. The certification plan should provide the objectives and an overview about the system safety assessment.

The system safety assessment will be a vital part of the approval process of a WOBAN system. Therefore, this PS provides further guidance on the safety assessment process particularly relevant for a WOBAN system, which will be described in paragraph 3.4.3.

3.4.2.3 Electromagnetic compliance demonstration

The introduction of WOBAN systems using wireless communication for the interconnection of avionic systems raises new issues related to the EMC qualification process which have to be assessed before. The WOBAN system shall be designed and installed to prevent any radiated or conducted electro-magnetic interference (EMI) to aircraft systems covered by CS-25.1309(a)(1) [1].

The *Certification Applicant* should perform a detailed RF and EMI assessment that defines the characteristics of the total RF environment in the aircraft and the vulnerability of aircraft systems to interference. The assessment of the effects of radiated emissions may be based on the guidance given in ED-130A/DO-363 [7] or specific guidance material developed for WAIC systems.

NOTE: *Guidance for T-PED is referred to in this case, because the principles for testing and assessment used in ED-130A/DO-363 are equally applicable to WOBAN-NAS systems because they use the same wireless technologies.*

Electromagnetic compliance testing or analysis should demonstrate that the installed system, when operating, will not introduce interference effects during all possible system operation and failure modes. The RF field strength used during the test should reflect the incorporation of a safety margin increasing the test levels above the worst-case emissions from the installed WOBAN system or components thereof. Acceptance from airworthiness authorities should be sought in defining such margin. The electromagnetic field generated should ensure adequate coverage throughout all areas of the aircraft relevant for the envisaged application.

WOBAN system's transmitters (when active) will generate increased levels of intentionally radiated emissions in the operating frequency range and unintentionally radiated emissions in the out-of-band and spurious domains. Receivers have a high sensitivity in their operating frequency range and, therefore, an increased susceptibility to RF energy emanating from the electromagnetic environment in that frequency range. If the WOBAN system is supposed to be active during critical flight phases, such as take-off and landing, particular attention should be paid to the non-interference demonstration during these phases of flight. Special attention should be paid to flight guidance systems, electronic flight control systems, electronic display and alerting systems, electronic engine control systems, radiocommunication and radionavigation systems including the Instrument Landing System (ILS) and the GBAS Landing System (GLS). This list is not exhaustive and the *Certification Applicant* should assess all installed systems which may be affected by the introduction of a wireless system.

The general environmental qualification process for airborne equipment described in ED-14G [3] can be used as guidance; however, it will not be sufficient to cover all EMC aspects related to WOBAN systems. This chapter defines a set of requirements to achieve a sufficient level of assurance that WOBAN systems will not adversely affect other aircraft systems and vice versa. The *Certification Applicant* should provide evidence to the certification authorities that the WOBAN system under consideration meets the following requirements.

3.4.2.3.1 **EMC qualification according to ED-14**

Any airborne equipment is required to be qualified to its intended environmental conditions using the test-procedures of ED-14G [3]. For WOBAN systems it is important to notice that the assessment of the radiated emissions according to ED-14G section 21 is limited to non-intentional (spurious) emissions. The assessment of the equipment's susceptibility to RF interference (ED-14G section 20) excludes the communication frequency range(s) of WOBAN system's receivers.

3.4.2.3.2 **Intentionally radiated emissions**

The intentionally radiated emissions of the transmitting components of a WOBAN system (as single transmitting devices and as a combination of multiple, potentially simultaneously transmitting devices in a network) should not adversely affect other aircraft equipment.

3.4.2.3.3 **Susceptibility to non-intentional interference**

The wireless communication of WOBAN systems should not be adversely affected by aircraft typical, non-intentional (spurious) interference levels in the WOBAN system's operating frequency range.

3.4.2.3.4 **Susceptibility to intentional interference**

WOBAN systems should not be adversely affected by intentionally radiated emissions of other wireless systems using the same or partly the same frequency spectrum. This aspect of sharing a common medium among multiple wireless systems is commonly known as coexistence. For further information on this aspect refer to paragraph 4.3.3.2.

3.4.2.4 **Data security assessment**

Aircraft and aircraft systems are subject to human interaction, some of which have the intention to misuse or disrupt the system. This interaction can lead to the loss of information security. In this document, the term "information security" refers to:

"The protection of information and information systems from unauthorized access, use, disclosure, disruption, modification, or destruction in order to provide confidentiality, integrity, and availability." [24]

There are already several, internationally recognized standards, which cover aspects of information security on a multitude of abstraction levels and industries. For a list of standards relevant in aeronautics please refer to Appendix D of ED-202A/DO-326A [9].

The further development of standardization of aeronautical information systems security is assigned to EUROCAE working group WG-72 and the RTCA special committee SC-261. In this context, the following documents are or will be available in the future:

- ED-201 – Aeronautical Information System Security (AISS) Framework Guidance (issued December 2015) [8]
- ED-202A/DO-326A – Airworthiness Security Process Specification (issued June 2014 / August 2014) [9], [19]
- ED-203/DO-356 – Airworthiness Security Methods and Considerations (issued September 2015 / September 2014) [10], [21]
- ED-204/DO-355 – Information Security Guidance for Continuing Airworthiness (Issued June 2014) [11], [20].

The work of WG-72 and in particular its work on the airworthiness security PS ED-202A [9], is applicable to WOBAN systems. As defined in paragraph 2.2, a WOBAN system provides communication links for applications which form parts of one or multiple aircraft function(s). Hence, WOBAN systems contribute to the airworthiness of an aircraft which makes it an "asset" according to ED-202A. This implies that WOBAN systems have to be part of the airworthiness security process. This process contains several activities which are centered on the security risk assessment. The security risk captures the possible impact of adverse interaction with the system, as well as the likelihood of such an interaction happening. The magnitude of the security risk in turn determines the amount of effort which has to be invested in protecting the corresponding assets.

In order to establish and maintain airworthiness of an aircraft containing WOBAN systems the applicant should establish information security processes in accordance with the process specification of ED-202A and other applicable standards during the whole lifecycle. 0 presents, in accordance with the approach of ED-202A, particular security aspects applying to WOBAN systems.

Data security may be assessed using alternative means of compliance, not included in the mentioned EUROCAE EDs. Such alternative means should be accepted by the airworthiness authorities. Alternative means may be used for aircraft types based on Certification Specifications CS-23 and CS-27.

3.4.2.5 Health risks determination

Use of the WOBAN system must not generate RF emissions that can have possible adverse health effects within aircraft areas occupied by passengers or personnel that operate and maintain the aircraft. Possible effects have been analyzed on behalf of several international organizations. The International Commission on non-ionizing Radiation Protection (ICNIRP) published the “*Guidelines for limiting Exposure to time-varying electric, magnetic and electromagnetic Fields*” to provide protection against known adverse health effects. These guidelines propose reference levels for the exposure to time-varying electric and magnetic fields which are used as basis for the most common environmental electromagnetic compatibility (EEMC) standards. The designer of the WOBAN system should ensure that the radiated emissions including all amplifying effects (e.g. multiple equipment emitting at the same time in a network) comply with the reference levels derived from international standards related to human health for the general public.

Consideration should be given to any potential effect on medical equipment carried by the aircraft operator as a part of or supplementary to the first aid kit, including Automatic External Defibrillators (AEDs). This will need to be reflected in aircraft operator material made available to passengers and used in the creation of cabin crew procedures and training. Whilst Airworthiness Authorities can give no credit to the performance of these devices, the applicant may need to consider providing the aircraft operator with advice regarding the use of these devices whilst any element of the WOBAN system is operational.

Furthermore, the system under normal operating, or fault conditions should not present a hazard to occupants of the aircraft from fire, smoke, or noxious fumes.

3.4.2.6 Physical protection

In addition to electronic interaction with the WOBAN system, physical means of disrupting wireless communications should be addressed. Possible interactions affecting the availability of a WOBAN system include:

- direct physical access to one or more nodes with the goal of destroying or disabling the node or inhibiting the wireless communication link and
- indirect means of inhibiting the wireless communication link, e.g., by placing absorbent material in front of one or more nodes.

The *Certification Applicant* should consider any constraints introduced by the installation of WOBAN components. An installation inspection should include the review that such constraints have been adequately addressed.

3.4.2.7 Usage of batteries

WOBAN components, if powered by batteries should provide the containment of any hazardous products of the failure of its internal battery without the need of any additional external containment devices other than the mounting bracket.

Any battery-powered equipment shall comply with the applicable airworthiness requirements and associated compliance guidance. The *WOBAN Component Developer* and/or the *Certification Applicant* should also develop a means to prevent inadvertent opening of WOBAN components with failed batteries that may be under internal pressure. This may include voltage or external temperature checks prior to opening the device. It may also be required to include appropriate Cautions/Warnings and to document procedures in manuals mentioned in paragraph 3.5.2.

3.4.2.8 Environmental qualification aspects of certification

The environmental qualification of installed equipment should be compliant with applicable sections of ED-14G [3]/DO-160G [13]. Test categories or levels should be chosen according to the envisaged installation environment.

Justification of conformance for the equipment under test with the criteria specified in ED-14G/DO-160G should be provided. Frequency ranges in which the equipment under test is intentionally transmitting are not subject to justification of conformance with respect to chapters 20 and 21 of ED-14G/DO-160G.

The ability of the WOBAN components to meet the environmental requirements should be verified during the equipment environmental qualification tests.

3.4.2.9 Software and complex hardware aspects of certification

The certification plan should include certification aspects of hardware, including complex hardware, and software, including configuration files.

E.g., ED-12C [2]/DO-178C [14] and AMC 20-115C [49] are acceptable means of compliance for CS-25.1301 and CS-25.1309 for software aspects of certification. Clarification on some interpretation of ED-12C/DO-178C can be found in ED-94C [6]/DO-248C [15].

Configuration tables and databases, developed by the *WOBAN System Integrator*, should be presented to the *Certification Authority* who will provide guidance for the approval process.

If the WOBAN component contains a complex Application-Specific Integrated Circuit or complex programmable logic (e.g. Programmable Array Logic components, Field-Programmable Gate Array components, General Array Logic components, or Erasable Programmable Logic Devices) summarized as Complex Electronic Hardware to accomplish the function, development should be in accordance with EUROCAE ED-80 [5]/RTCA DO-254 [16].

Supplemental guidance material for all other airborne electronic hardware (including design of electronic circuit boards and use of COTS devices) included in the ETSO article may be found in EASA Certification Memorandum, EASA CM – SWCEH – 001, “Development Assurance of Airborne Electronic Hardware” [50].

3.4.2.10 Configuration management

The *Certification Applicant* should provide information regarding the configuration management process for the WOBAN system and equipment. The information should include details of the hardware and software part numbering system to be employed for new and modified equipment.

Commercial off the Shelf (COTS) components whose specifications can be changed without notice should be subjected to a change control plan. This is needed to demonstrate that configuration control is maintained by the *Certification Applicant*. The *WOBAN Component Developer* has to provide appropriate design data, including changes, to the *Certification Applicant* in order to control the WOBAN system configuration.

3.4.2.11 Aircraft Test Plan

The *Certification Applicant* should submit a ground and flight test plan (in case flight test is necessary) outlining the proposal for testing prior to certification. This plan should address testing system operation and interference during all applicable operating conditions and flight phases to establish representative field conditions, especially during instrument approach to the highest category approved for the aircraft, when approval of wireless system operation during these flight phases is sought.

After the first aircraft installation, all subsequent aircraft of the same type that are subject to this airworthiness certification should be assessed to determine whether they are “identical” to the “certified configuration” (that of the first aircraft), to determine the validity of the initial safety assessment.

If the next aircraft is not sufficiently “identical”, further analyses and/or tests shall be conducted to achieve the compatibility demonstration as required.

NOTE: *"Identical" = Sufficiently similar such that the certificated configuration's safety assessment remains valid for the considered aircraft; i.e. all assumptions and verification data remain valid.*

3.4.2.12 Aircraft Flight Manual

The Aircraft Flight Manual (AFM) should identify the phases of flight in which the WOBAN system shall be inhibited. It should also provide crew procedures, following loss or misbehavior of the WOBAN system, to restore normal operation of the aircraft. See also paragraph 3.5.2.

3.4.2.13 Operational aspects

The *Certification Applicant* should issue procedures and criteria for operators explaining the wireless system concept and its limitations.

The *Certification Applicant* should issue flight crew and cabin crew procedures concerning the use and the limitations of the WOBAN system.

The design and installation of the WOBAN system should be such that impact upon operational procedures is minimized. However, if credit is taken for flight crew or cabin crew procedures to show compliance with the airworthiness requirements, these procedures should be included in the approved AFM and other crew manuals as appropriate. These procedures should be acceptable to the responsible *Certification Authority*. Also see section 3.5.

3.4.2.14 Aircraft design changes following the initial approval of a WOBAN system

Due to the variability in aircraft model configuration, the *Certification Applicant* should present a plan for either testing or performing an analysis for aircraft that have major interior installation changes resulting in wireless system repositioning on which the system is installed under the STC.

An EMI and WOBAN system performance reassessment should be conducted for the following cases:

- a new aircraft system that includes an external antenna is installed (e.g. GPS system),
- in case of significant antenna relocations, or
- when a new frequency band or a new modulation scheme is allocated to an aircraft system.

3.4.2.15 Shared communication resources

A WOBAN system may provide communication services to multiple aircraft functions which will result in the sharing of WOBAN components by different aircraft applications. Therefore, such WOBAN components and the communication links between them will become shared resources. It is anticipated that airworthiness authorities would issue Interpretative Material or Advisory Circulars in order to clarify aspects associated with the approval of shared communication resources. For similar purposes EASA and FAA have issued guidance material related to the use of shared data busses (e.g. Avionics Full Duplex Switched Ethernet (AFDX)) and for the incremental certification of systems that make use of this type of shared resource.

3.4.3 Guidance for safety assessment

The safety assessment should follow aeronautical standards as provided by SAE ARP4761 [23].

The installation and operation of the WOBAN system shall ensure that it does not adversely affect the aircraft's equipment and systems required by CS-25.1309 [1], i.e. those required for type certification or by the operating rules, or whose improper functioning would reduce safety throughout the entire flight cycle. The flight cycle starts at the moment of passenger door closure on departure and lasts till passenger door opening upon arrival.

The safety objectives will depend on the severity of system failures introduced as a result of the use of a wireless network. It is obvious that such level of severity will be determined by the Functional Hazard Assessment (FHA) of the aircraft functions that will make use of the wireless communication links provided by a WOBAN system.

The *Certification Applicant* should summarize possible failure conditions and present a set of safety objectives to the *Certification Authority*. This will usually be included in the system level FHA (see next paragraph).

3.4.3.1 Functional hazard assessment

For compliance with CS-25.1309 [1], the system and individual equipment failure condition classifications shall be identified by performing a safety analysis, including an FHA.

The FHA should contain an assessment of all potential failures and respective effects to the aircraft function. This shall include such failures that are induced by the WOBAN system itself.

The FHA should identify the aircraft and system level safety objectives that must be considered in the system's architecture development and the assignment of the Functional Development Assurance Level (FDAL) for the WOBAN system and the Item Development Assurance Level (IDAL) for the equipment. Particular attention will need to be given to the risks of multiple failures of systems that could result in "Catastrophic", "Hazardous", "Major" and "Minor" aircraft-level functional failure conditions. It should include effects identified through an RF and EMI assessment of system normal and abnormal operation.

Any functionality performed using software or digital devices or making use of databases would need to be developed to an appropriate level of rigor. The assurance levels of any software, digital devices and databases used within the system equipment must be compatible with the system safety analysis.

3.4.3.2 Safety assessment for a typical WOBAN system

As mentioned in paragraph 3.4.3.1, the FHA should contain a systematic determination of failure conditions and effects and a determination of safety and reliability objectives, design objectives and expected probabilities. Failure conditions can be divided into categories and individual events which trigger possible failures. Typical categories are:

- Loss of single or combination of network components (e.g. WOBAN node): This category is mainly a result of hardware failure of the concerned component. Internal failures could also be caused by hardware or software design errors of WOBAN components.
- Loss of communication capabilities, including transmission of erroneous data on a single or multiple communication link(s): Failures of this category may affect all communication links (total loss of communication capabilities).

Failures from the second of the above categories are triggered by conditions and events external to the WOBAN system and are not caused by the WOBAN components themselves. Such events could result in the loss of communications or degradation in performance. Events external to the WOBAN system are independent and could be due to the following:

- Increased radio propagation loss for individual or a combination of WOBAN system's communication links through physical obstacles,
- Single event effects (SEE) caused by atmospheric radiation which could affect the electronic components of the WOBAN system,
- External electromagnetic sources leading to EMI and violating coexistence conditions by other networks (same frequency band), or by other members of the WOBAN system. Jamming requires specific consideration,

NOTE: *Jamming cannot be managed like other events because no recognized calculation method of probability exists. For this case refer to paragraph 3.5.2 as well as Appendix C.*

- Mechanical damage of accessible parts of WOBAN nodes (e.g. antennas) installed in passenger accessible areas,
- Electrical power loss, i.e., loss of power to the WOBAN node(s),

NOTE: *If the safety assessment identifies any issues associated with the wireless system in the event of an aircraft rapid decompression, then either the wireless system should be certificated in accordance with the rapid decompression environmental condition or it should be automatically deactivated in the event of a rapid decompression of the aircraft.*

If it is required to perform a safety assessment based on quantified probabilities, standard methods provided by SAE ARP4761 [23] shall apply (e.g. FTA, FMEA, FMECA). For each event a calculation of failure probability should be performed applying recognized methods.

3.4.3.3 Safety effects and mitigations

The safety assessment should take into consideration design features that would reduce or eliminate effects of failures. Following capabilities are usually part of the basic design:

- Embedded error detection/correction means in the network components which are typically transparent to applications (e.g. forward error correction coding),
- Means for monitoring the link quality on individual WOBAN system's communication links and for adapting link parameters accordingly (e.g. change of modulation and forward error correction coding schemes) and
- Application-level error detection and correction means.

However, based on the severity of the failure effects, the following additional means should be made available in order to support detection and awareness including partial or complete loss of wireless communication:

- Make the flight crew aware of the failure, dependent on the failure effects (e.g. flight deck warning) and associated crew actions,
- Means for the flight crew to remove power from the wireless system, if the safety assessment identifies such a need and
- Means for the flight crew to detect external events which lead to loss of wireless communication, (e.g. to detect jammers).

NOTE: *To avoid an increase in workload only those actions required to ensure safe flight and landing of the aircraft should be included in the flight crew's operational procedures.*

3.4.3.4 Item development assurance level determination

The FDALs identified through the FHA should be used, in conjunction with system architecture considerations, to determine the IDALs (including the design assurance level and software level). These levels must be assigned for the development of airborne electronic hardware and software, identifying the rigor of the development processes used. Guidance may be found within ED-79A [4] and SAE ARP 4754A [22].

3.4.3.5 Diversity of development assurance level in WOBAN systems

WOBAN systems are used to enable communication between different aircraft functions that could have different criticalities and different DALs. The application inherits its DAL from the aircraft function it is belonging to. In case multiple applications will be connected to one WOBAN Node (refer to [FIGURE 3](#)), the DAL of this node should correspond to the highest DAL of the applications which this node is connected to. Failures propagation, affecting the data traffic between components of a WOBAN system should be prevented. Segregation of the communication links could prevent such failure propagation (refer to paragraph 4.3.2.1).

3.4.4 Continued airworthiness process

The *Certification Applicant* should submit Instructions for continued airworthiness associated with the WOBAN system installation. Special consideration should be given to performance degradation, in service modifications and data security. The *Certification Applicant* should refer to CS-25.1529 and CS-25.1729 [1], if included in the certification basis.

3.4.4.1 Performance degradation

In order to ensure continued airworthiness, the *WOBAN Component Developer* and *WOBAN System Integrator* should propose periodic and unscheduled maintenance tasks and inspections. The *Certification Applicant* should be aware that, depending on the criticality of the WOBAN system and the associated applications, the implementation of an inherent monitoring system might be required to achieve continued airworthiness. It is expected that built-in monitoring functions will detect unacceptable performance degradations. In any case, based on the *WOBAN System Integrator's* proposal, the *Certification Applicant* should establish appropriate maintenance instructions to maintain airworthiness. It is highly recommended to include a Built-In-Test function into the WOBAN system which should be capable of measuring relevant performance metrics storing them and making them available for instance as a maintenance inspection report. If this is technically impossible because an interface to the on-board maintenance reporting system is not foreseen, a dedicated system interface should be made available to provide the results of the Built-In-Test.

3.4.4.2 Guideline for in-service modification of RF propagation environment

As mentioned above, changes to the aircraft interior such as changes to the cabin layout may lead to a modification of the RF propagation environment significant enough to impact the WOBAN system's performance (refer to the description of development scenario 5 in paragraph 3.3.5). The *Certification Applicant* should provide guidance material to support such in-service changes. At least such guidance shall include information on limitations of conversion that will lead to significant loss of required performance. The location of the WOBAN nodes must be clearly identified. This guidance shall also include procedures to enable a post-change assessment to determine that the performance of the WOBAN system is still at an acceptable level.

3.4.4.3 Guideline for in-service installation of additional wireless networks

If an upgrade is envisaged to provide additional wireless networks (for instance wireless in-flight entertainment equipment), operating within the same frequency band as the existing WOBAN system, the *Certification Applicant* should provide guidance material to ensure coexistence and non-interference with the installed WOBAN system. Such guidance should contain information about installation constraints to be considered by the installer of the additional wireless network, for instance minimum distance between existing WOBAN system and new wireless network equipment. It may also contain constraints about resource usage and performance limitations as well as procedures to enable a post-change assessment to determine that the existing WOBAN system's communication link performance is still at an acceptable level.

3.4.4.4 Instructions for continued airworthiness regarding cyber security

A WOBAN system should be designed to be secure against possible cyber security attacks. However, new threats may emerge after issuing the TC/STC, or the security measures provided may have become compromised. The management of vulnerabilities, which are disclosed after issuing the TC/STC is an integral part of the ICA activities regarding data security. Therefore, the *Certification Applicant* should follow ED-204 [11]/DO-355 [20]. These documents provide information on the activities that should be performed during operation and maintenance of the aircraft to address the threat of unauthorized interaction.