Department of Transportation
Federal Aviation Administration
Aircraft Certification Service
Washington, D.C.

TSO-C153a
Effective
Date: 5/29/19

Technical Standard Order

Subject: INTEGRATED MODULAR AVIONICS (IMA) PLATFORM AND MODULES

1. PURPOSE. This technical standard order (TSO) is for manufacturers applying for a TSO authorization (TSOA) or letter of design approval (LODA). In it, we (the Federal Aviation Administration, (FAA)) tell you what minimum performance standards (MPS) your integrated modular avionics (IMA) platform and/or module must first meet for approval and identification with the applicable TSO marking.

2. APPLICABILITY. This TSO affects new applications submitted after its effective date.

a. TSO-C153 will also remain effective until November 29, 2020. After this date, we will no longer accept applications for TSO-C153.

b. Integrated Modular Avionics Hardware Elements approved under a previous TSOA may still be manufactured under the provisions of its original approval. Minor changes can be made under this provision.

3. REQUIREMENTS. New models of IMA platforms and/or modules identified and manufactured on or after the effective date of this TSO must meet the MPS qualification and documentation requirements in Appendix 2 of this TSO.

a. Functionality. This TSO's standards apply to equipment intended to perform the functions described in Appendix 1 of this TSO.

b. Failure Condition Classifications. There is no standard minimum failure condition classification for this TSO. The failure condition classification appropriate for the equipment will depend on the intended use of the equipment in a specific aircraft. Document the loss of function and malfunction failure condition classification for which the equipment is designed. Qualitative and safety mechanisms requirements for each Minimum Performance Standard class are specified in Appendix 2 of this TSO.

c. Functional Qualification. Demonstrate the required performance under the test conditions in Appendix 2 of this TSO.

d. Environmental Qualification. Demonstrate the required performance under the test conditions specified in Appendix 4 of this TSO, using standard environmental conditions and test procedures appropriate for airborne equipment. You may use a standard environmental condition and test procedure other than RTCA DO-160G, provided the standard is appropriate for the IMA platform and/or module.

> **Note:** The use of RTCA/DO-160D (with Changes 1 and 2 only, without Change 3 incorporated) or earlier versions is generally not considered appropriate and will require substantiation via the deviation process as discussed in paragraph **3.g** of this TSO.

e. Software Qualification. If the article includes software, develop the software according to RTCA, Inc. document RTCA/DO-178C, *Software Considerations in Airborne Systems and Equipment Certification*, dated December 13, 2011, including referenced supplements as applicable, to at least the software level consistent with the failure condition classification defined in paragraph **3.b** of this TSO.

You may also develop the software according to RTCA, Inc. document RTCA/DO-178B, dated December 1, 1992, if you follow the guidance in advisory circular (AC) 20-115C, *Airborne Software Assurance*, dated July 19, 2013, or later version.

f. Electronic Hardware Qualification. If the article includes complex custom airborne electronic hardware, develop the component according to RTCA, Inc. Demonstrate compliance with RTCA/DO-254, *Design Assurance Guidance for Airborne Electronic Hardware,* to at least the design assurance level consistent with the failure condition classification defined in paragraph **3.b** of this TSO. For custom airborne electronic hardware determined to be simple, RTCA/DO-254, paragraph 1.6 applies.

g. Configuration Management. Manufacturers must include design features in each hardware platform and/or module that support a robust automatic configuration management function. This functionality may not be fully operational until actual installation. However, the manufacturer must be able to show that, by either mechanical means or automatic electronic monitoring of the integrated assemblies, the higher-level assemblies will only be assembled according to the intended design or that incorrect assembly can be detected at power-up. Furthermore, for individual platforms and/or modules that require interfaces to other system equipment through a mechanical or electrical connector(s), the manufacturer must be able to show that each platform and/or module, by either mechanical means or automatic electronic monitoring of the higher level assembly, will either prevent an incorrect connection or that an incorrect connection will be detected before any dispatch. The manufacturer must consider failure of the configuration management design features in the safety assessment performed on the installed IMA system in each unique aircraft configuration.

h. Deviations. We have provisions for using alternate or equivalent means of compliance to the criteria in the MPS of this TSO. If you invoke these provisions, you must show that your equipment maintains an equivalent level of safety. Apply for a deviation pursuant to Title 14 of the Code of Federal Regulation (14 CFR) § 21.618.

4. MARKING.

a. Mark at least one major component permanently and legibly with all the information in 14 CFR § 45.15(b)

b. Also, mark the following permanently and legibly, with at least the manufacturer's name, subassembly part number, and the TSO number:

(1) Each component that is easily removable (without hand tools); and,

(2) Each subassembly of the article that you determined may be interchangeable.

c. If the article includes software and/or airborne electronic hardware, then the article part numbering scheme must identify the software and airborne electronic hardware configuration. The part numbering scheme can use separate, unique part numbers for software, hardware, and airborne electronic hardware.

d. You may use electronic part marking to identify software or airborne electronic hardware components by embedding the identification within the hardware component itself (using software) rather than marking it on the equipment nameplate. If electronic markings are used, they must be readily accessible without the use of special tools or equipment.

5. APPLICATION DATA REQUIREMENTS. You must give the FAA aircraft certification office (ACO) manager responsible for your facility a statement of conformance, as specified in 14 CFR § 21.603(a)(1) and one copy each of the following technical data to support your design and production approval. LODA applicants must submit the same data (excluding paragraph **5.g**) through their civil aviation authority.

a. A Manual(s) containing the following:

(1) Operating instructions and article limitations sufficient to describe the equipment's operational capability.

(2) Describe in detail any deviations.

(3) Installation procedures and limitations sufficient to ensure that the IMA platform and/or module, when installed according to the installation or operational procedures, still meet this TSO's requirements. Limitations must identify any unique aspects of the installation. The limitations must include a note with the following statement:

> "This article meets the minimum performance and quality control standards required by a technical standard order (TSO). Installation of this article requires separate approval."

(4) For each unique configuration of software and airborne electronic hardware, reference the following:

(a) Software part number including revision and development assurance level;

(b) Airborne electronic hardware part number including revision and development assurance level; and,

(c) Functional description.

(5) A summary of the test conditions used for environmental qualifications for each component of the article. For example, a form as described in RTCA/DO-160G, *Environmental Conditions and Test Procedures for Airborne Equipment*, Appendix A.

(6) Schematic drawings, wiring diagrams, and any other documentation necessary for installation of the Integrated Modular Avionics (IMA) platform and modules.

(7) List of replaceable components, by part number, that makes up the IMA platform and modules. Include vendor part number cross-references, when applicable.

b. Instructions covering periodic maintenance, calibration, and repair, to ensure that the IMA platform and/or module continue to meet the TSO approved design. Include recommended inspection intervals and service life, as appropriate.

c. If the article includes software include the plan for software aspects of certification (PSAC), software configuration index, and software accomplishment summary.

d. If the article includes simple or complex custom airborne electronic hardware include the plan for hardware aspects of certification (PHAC), hardware verification plan, top-level drawing, and hardware accomplishment summary (or similar document, as applicable).

e. A drawing depicting how the article will be marked with the information required by paragraph **4** of this TSO.

f. Identify functionality or performance contained in the article not evaluated under paragraph **3** of this TSO (that is, non-TSO functions). Non-TSO functions are accepted in parallel with the TSO authorization. For those non-TSO functions to be accepted, you must declare these functions and include the following information with your TSO application:

(1) Description of the non-TSO function(s), such as performance standards, assumed failure conditions, resulting Design Assurance Level (DAL) of the software, hardware, and the environmental qualification levels. Include a statement confirming that the non-TSO function(s) do not interfere with the article's compliance with the requirements of paragraph **3**.

(2) Installation procedures and limitations sufficient to ensure that the non-TSO function(s) meets the declared functions and performance standard(s) described in paragraph **5.f.(1)**.

(3) Instructions for continued performance applicable to the non-TSO function(s) described in paragraph **5.f.(1).**

(4) Interface requirements and applicable installation test procedures to ensure compliance with the performance data defined in paragraph **5.f.(1).**

(5) Test plans, analysis and results, as appropriate, to verify that performance of the hosting TSO article is not affected by the non-TSO function(s).

(6) Test plans, analysis and results, as appropriate, to verify the function and performance of the non-TSO function(s) as described in paragraph **5.f.(1).**

g. The quality system description required by 14 CFR § 21.608, including functional test standards. The quality system should ensure that you will detect any change to the approved design that could adversely affect compliance with the TSO MPS, and reject the article accordingly. (Not required for LODA applicants.)

h. Material and process standards list.

i. List of all drawings and processes (including revision level) that define the article's design.

j. Manufacturer's TSO qualification report showing results of testing accomplished according to paragraph **3.c** of this TSO.

6. MANUFACTURER DATA REQUIREMENTS. Besides the data given directly to the responsible ACO, have the following technical data available for review by the responsible ACO:

a. Functional qualification standards for qualifying each production article to ensure compliance with this TSO.

b. Article calibration procedures.

c. Schematic drawings.

d. Wiring diagrams.

e. Material and process standards.

f. The results of the environmental qualification tests conducted according to paragraph **3.d** of this TSO.

g. If the article includes software, the appropriate documentation defined in RTCA/DO-178B or RTCA/DO-178C specified in paragraph **3.e** of this TSO, including all data supporting the applicable objectives in RTCA/DO-178B Annex A, *Process Objectives and Outputs by Software Level*.

h. If the article includes complex custom airborne electronic hardware, the appropriate hardware life cycle data in combination with design assurance level, as defined in RTCA/DO-254, Appendix A, Table A-l. For simple custom airborne electronic hardware, the following data: test cases or procedures, test results, test coverage analysis, tool assessment and qualification data, and configuration management records, including problem reports.

i. If the article contains non-TSO function(s), you must also make available items **6.a** through **6.h** as they pertain to the non-TSO function(s).

7. FURNISHED DATA REQUIREMENTS.

a. If furnishing one or more articles manufactured under this TSO to one entity (such as an operator or repair station), provide one copy or on-line access to the data in paragraphs **5.a** and **5.b** of this TSO. Add any other data needed for the proper installation, certification, use, or for continued compliance with the TSO, of the IMA platform and modules.

b. If the article contains declared non-TSO function(s), include one copy of the data in paragraphs **5.f.(1)** through **5.f.(4).**

c. If the article contains software, include one copy of the OPR summary.

8. HOW TO GET REFERENCED DOCUMENTS.

a. Order RTCA documents from RTCA Inc., 1150 18th Street NW, Suite 910, Washington, D.C. 20036. Telephone (202) 833-9339, fax (202) 833-9434. You can also order copies online at www.rtca.org

b. Order SAE documents from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001. Telephone (724) 776-4970, fax (724) 776-0790. You can also order copies online at www.sae.org.

c. Order copies of 14 CFR parts 21 and 45 from the Superintendent of Documents, Government Printing Office, P.O. Box 979050, St. Louis, MO 63197. Telephone (202) 512-1800, fax (202) 512-2250. You can also order copies online at www.gpo.gov.

d. You can find a current list of technical standard orders and advisory circulars on the FAA Internet website Regulatory and Guidance Library at http://rgl.faa.gov/. You will also find the TSO Index of Articles at the same site.

Melvin J. Johnson
Aviation Safety
Deputy Director, Policy and Innovation Division
Aircraft Certification Service

APPENDIX 1

INTEGRATED MODULAR AVIONICS OVERVIEW, DEFINITION AND EXAMPLES

This Appendix provides:

- Chapter 1: An overview of Integrated Modular Avionics (IMA)
- Chapter 2: Applicable definitions
- Chapter 3: Definition of Minimum Performance Standard (MPS) classes
- Chapter 4: Examples of IMA platform using IMA modules

Chapter 1: Integrated Modular Avionics Overview

In this TSO, Integrated Modular Avionics is defined according to RTCA DO-297 (equivalent to the EUROCAE ED-124):

Integrated Modular Avionics (IMA): is a shared set of flexible, reusable, and interoperable hardware and software resources that, when integrated, form a platform that provides services, designed and verified to meet a defined set of safety and performance requirements, to host applications performing aircraft functions.

IMA architecture integrates many aircraft functions on the same platform, provided by several hosted applications that historically have been contained in functionally and physically separated 'boxes' or Line Replaceable Units (LRU).

IMA platforms are composed of modules, which are designed to be reusable in order to reduce development cost and occasionally facilitate certification programs. Some modules provide only mechanical functionality, such as cooling the supply of electrical power. Others include core software and associated computing capabilities.

The IMA modules are usually both generic and configurable, and the same platforms are adaptable for use on different aircraft models.

Chapter 2: Applicable definitions

Legend

- *[DO-297]:* Definitions from RTCA DO-297 (equivalent to the EUROCAE ED-124).
- *[TSO-C153a]:* Definitions defined in the context of the TSO.

Aircraft Function *[DO-297]*: A capability of the aircraft that is provided by the hardware and the software of the systems on the aircraft.

Application *[DO-297]*: Software and/or application-specific hardware with a defined set of interfaces that, when integrated with the platform, performs a specific function.

Cabinet *[TSO-C153a]*: Result of the integration of hardware modules mounted within one rack.

Characterization item *[TSO-C153a]*: Identified module characteristic towards which the IMA module developer needs to determine the module performance, with full verification and documentation in the user guide/installation manual as appropriate.

Component *[DO-297]*: A self-contained hardware, software part, database, or combination thereof that is configuration-controlled. A component does not provide an aircraft function by itself.

Configuration data *[DO-297]*: See paragraph 3.7.1.

Core Software *[DO-297]*: The operating system and support software that manage resources to provide an environment in which applications can be executed. Core software is a necessary component of a platform and is typically comprised of one or more modules (e.g., libraries, drivers, kernel, data-loading, boot, etc.).

IMA Platform *[DO-297]*: Module or group of modules, including core software, which manages resources in a manner sufficient to support at least one application. IMA hardware resources and core software are designed and managed in a way that provides computational, communication, and interface capabilities for hosting at least one application. Platforms by themselves do not provide any aircraft functionality. The IMA platform may be accepted independently of hosted applications.

IMA System *[DO-297]*: Consists of (an) IMA platform(s) and a defined set of hosted applications.

LRM (Line Replaceable Module) *[TSO-C153a]*: IMA platform element, identified in aircraft configuration and replaceable by aircraft line maintenance to restore the aircraft into an operational ready condition. An IMA LRM is stand-alone equipment that does not provide any aircraft function until Hosted applications are integrated.

LRU (Line Replaceable Unit) *[TSO-C153a]*: Element supporting an aircraft function, identified in aircraft configuration and replaceable by aircraft line maintenance to restore the aircraft into an operational ready condition. An LRU is usually stand-alone equipment such as a radio, Flight Management Computer, or any functional equipment.

IMA Module *[TSO-C153a]*: A component or collection of components that may be hardware or a combination of hardware and software, which provides resources to the IMA-hosted applications. Application and module configuration data are not covered by this definition. Modules may be distributed across the aircraft or may be co-located.

Operating System *[DO-297]:*

1) The same as executive software.
2) The software kernel that services only the underlying hardware platform.
3) Software that directs the operations of a computer, resource allocation and data management, controlling and scheduling the execution of computer-hosted applications, managing memory, storage, input/output, and communication resources.

Rack *[TSO-C153a]*: A physical package able to contain at least two hardware modules, which may provide partial protection from environmental effects (shielding) and may enable installation on and removal of the mounted modules from the aircraft without physically altering other aircraft systems or equipment.

Resources / Shared resources *[DO-297]*: Any object (processor, memory, software, data, etc.) or component used by an IMA platform or application. A resource may be shared by multiple applications or dedicated to a specific application. A resource may be physical (a hardware device) or logical (a piece of information).

Support software *[TSO-C153a]*: Embedded software necessary as a complement to the operating system to provide general services such as contributing to the intended function of resources sharing, handling hardware, drivers, software loading, health monitoring, boot strap, etc.

Unit *[TSO-C153a]*: Set of physical components (hardware and/or software) inside equipment in charge of providing a resource.

Usage Domain *[TSO-C153a]*: The usage domain of an IMA module is defined as an exhaustive list of conditions (configuration settings, usage rules, etc.) to be respected by the user(s) to ensure that the IMA module continues to meet the performance characteristics and requirements of the TSO Minimum Performance Standard. Compliance with usage domain ensures that:

- the module is compliant with its functional, performance, safety, and environmental requirements specified for all implemented intended functions.
- the module characteristics documented in the User Guide (as required by Appendix 2) are guaranteed by manufacturer.
- the module is compliant with the applicable airworthiness requirements (including continuing airworthiness aspects).

Chapter 3: Definition of Intended Function classes

To apply for TSO-C153a authorization, the IMA module shall comply with applicable common requirements and implement at least one Intended Function Class.

CLASS RH: Rack Housing

For TSO-C153a Class RH:

1.3. RH.1: IMA module is a physical package able to contain at least two hardware modules, that may provide protection from environmental effects (shielding, etc.) and enable installation and removal of those module(s) from the aircraft without physically altering other aircraft systems or equipment.

1.3. RH.2: IMA module may be a simple mechanical enclosure, or it may incorporate communication interfaces, backplanes for data and power supplies, active cooling, or any combination of these features.

1.3. RH.3: IMA module does not offer the capability to host applications, unless combined with Class PR approval.

1.3. RH.4: IMA module may be configurable.

CLASS PR: Processing

For TSO-C153a Class PR:

1.3. PR.1: IMA module contains processing component, memory component, interface devices, and associated Core Software which constitute one or several Processing Unit(s).

> ***Note:*** *Containing memory component or interfaces devices does not lead automatically to having class DS and/or IF in the certification basis, DS or IF classes need to be applied for only if concurrent access to these Interface or Data Storage resources is offered as a shared resource (as described in class DS and IF).*

1.3. PR.2: The intended function of such IMA module is to share Processing, Data, and Information between at least two hosted applications, modules, and/or components.

1.3. PR.3: IMA module offers the capability to host applications.

1.3. PR.4: IMA module may be an association of hardware and Core Software.

- Hardware may (or may not) contain resident (not field-loadable) software to enable electronic part marking and/or future loading of Field-Loadable Software parts.
- Core Software may be resident or a Field-Loadable Software Part.

1.3. PR.5: IMA module may be configurable.

CLASS GP: Graphical Processing

For TSO-C153a Class GP:

1.3. GP.1: IMA module contains graphical engine component and optional video engine component, memories, interfaces, and potentially associated Core Software which constitute one or several Graphical Unit(s).

1.3. GP.2: The intended function of such IMA module is to share graphics and optional video signal processing between at least two hosted applications, modules, and/or components.

1.3. GP.3: IMA module does not offer the capability to host Hosted applications, unless combined with Class PR approval.

1.3. GP.4: IMA module may be an association of hardware and Core Software.

- Hardware may (or may not) contain resident (not field-loadable) software to enable electronic part marking and/or future loading of Field-Loadable Software parts.
- Core Software may be resident or a Field-Loadable Software Part

1.3. GP.5: IMA module may be configurable.

CLASS DS: Data Storage

For TSO-C153a Class DS:

1.3. DS.1: IMA module contains memory (volatile or non-volatile), interface component, and potentially associated Core Software that constitute one or several Data Storage Unit(s).

1.3. DS.2: The intended function of such IMA module is to share stored data (e.g. databases, files, etc.) between several applications, modules, and/or components.

1.3. DS.3: IMA module does not offer the capability to host applications, unless combined with Class PR approval.

1.3. DS.4: IMA module may be an association of hardware and a Core Software.

- Hardware may (or may not) contain resident (not field-loadable) software to enable electronic part marking and/or future loading of Field-Loadable Software parts.
- Core Software may be resident or a Field-Loadable Software Part.

1.3. DS.5: IMA module may be configurable.

CLASS IF: Interface

For TSO-C153a Class IF:

1.3. IF.1: IMA module contains input/output component(s) and potentially associated Core Software which constitute one or several Interface Unit(s). These interfaces can be discrete, analog, serial interface, digital bus, etc.

1.3. IF.2: The intended function of such an IMA module is to share information between several aircraft functions or applications.

1.3. IF.3: IMA module does not offer the capability to host applications, unless combined with Class PR approval.

1.3. IF.4: IMA module may be an association of hardware and a Core Software.

- Hardware may (or may not) contain resident (not field-loadable) software to enable electronic part marking and/or future loading of Field-Loadable Software parts.
- Core Software may be resident or a Field-Loadable Software Part.

1.3. IF.5: IMA module may be configurable.

CLASS PS: Power Supply

For TSO-C153a Class PS:

1.3. PS.1: IMA module contains a set of components (hardware and/or software) which constitute one or several Power Supply Unit(s) in charge of managing, conditioning, and providing electrical power.

1.3. PS.2: The intended function of such IMA module installed into a rack (Class RH module) is to provide power supply from airborne electrical network to one or more hardware modules embedded into the same rack.

1.3. PS.3: IMA module does not offer the capability to host applications, unless combined with Class PR approval.

1.3. PS.4: IMA module may be configurable.

1.3. PS.5: IMA module may be an association of hardware and a Core Software.

- Hardware may (or may not) contain resident (not field-loadable) software to enable electronic part marking and/or future loading of Field-Loadable Software parts.
- Core Software may be resident or a Field-Loadable Software Part.

CLASS DH: Display Head

For TSO-C153a Class DH:

1.3. DH.1: IMA module contains a set of components (hardware and/or software) in charge of managing displayed area that constitute one or several Display Unit(s).

1.3. DH.2: The intended function of such IMA module is to offer the capability to depict graphical information received from IMA Application(s), component(s), and/or module(s) on one Display Area.

1.3. DH.3: IMA module does not offer the capability to host applications, unless combined with Class PR approval.

1.3. DH.4: IMA module may be an association of hardware and a Core Software.

- Hardware may (or may not) contain resident (not field-loadable) software to enable electronic part marking and/or future loading of Field-Loadable Software parts.
- Core Software may be resident or a Field-Loadable Software Part

1.3. DH.5: IMA module may be configurable

Chapter 4: Example of IMA platform using IMA modules

RTCA DO-297 contains some examples relating to the definition of IMA module and platform, which can be completed by some additional examples related illustrating Chapter 3 definitions.

Figure 1: Single LRU platform (as per RTCA DO-297).

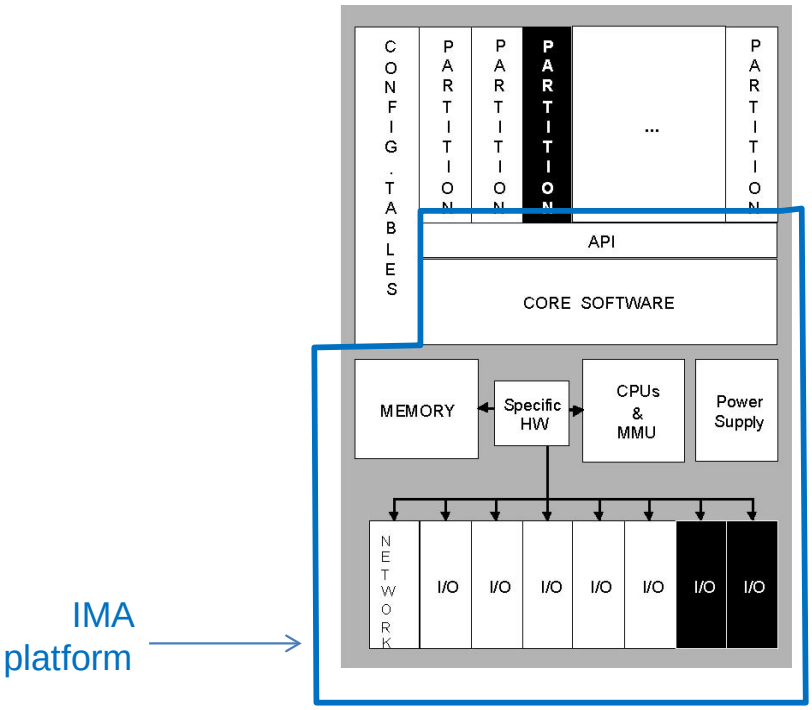
This figure illustrates the sharing of computational and Input/output (I/O) resources within a single Line Replaceable Unit (LRU). Such IMA system key characteristics include:

- Hosting of multiple applications (not part of the IMA platform).

  Note: The IMA platform includes all the components in the blue highlighted area.
- Platform configuration data and data loading.

- Defined API between the IMA platform and hosted applications.

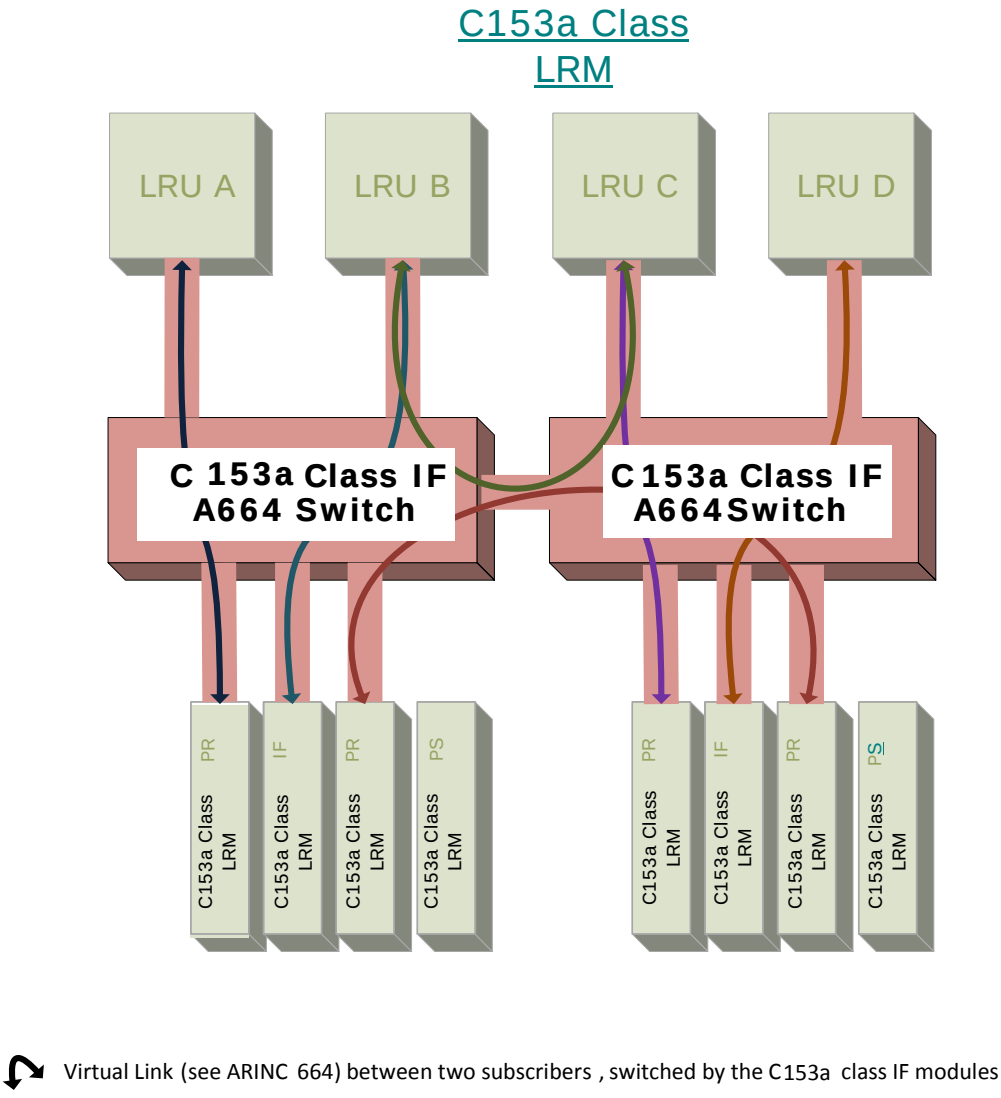
Figure 1 - Single LRU platform (as per RTCA DO-297)



At one level, this figure illustrates a single platform providing core computational resources. At another level, it illustrates a module to be used within a larger IMA platform.

If sharing of processing, memory, and I/O resources is implemented within the LRU, such single LRU platform will be eligible to CLASS PR, DS, and IF.

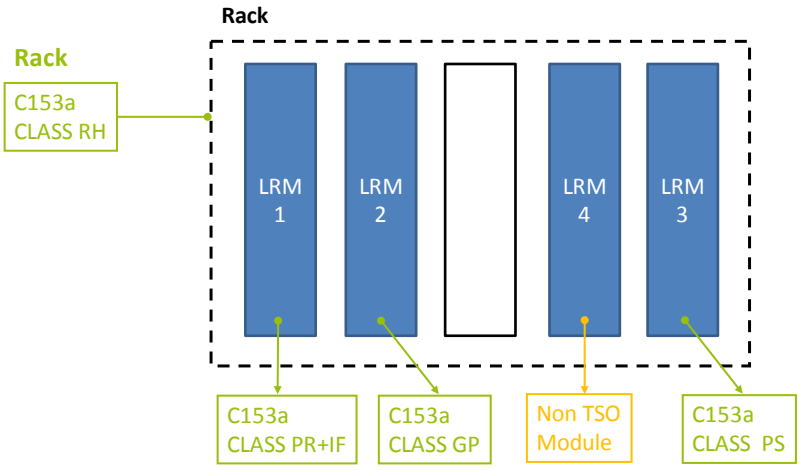
Figure 2: Single LRU A664 switch equipment
This figure illustrates the sharing of ARINC Standard 664 I/O resources within a single Line Replaceable Unit (LRU). Architecture based on two TSO-C153a modules IF module, each implementing an ARINC 664 switch.



In this architecture, the two TSO-C153a class IF modules are switching A664 frames, providing each of the subscribers a shared access to the network. Network subscribers can be other TSO-C153a modules as the lower row of modules shows, or non-IMA equipment (top row) such as displays, radio transceivers.

If sharing of ARINC Standard 664 I/O resources is implemented within the LRU, such single LRU platform shall be eligible to **CLASS IF**.

Figure 3: IMA modules installed in a Rack Module (Line Replaceable Module)



This figure illustrates the sharing of resources within several single Line Replaceable Modules (LRM) installed in a Rack:

- Rack: is an IMA module and will be eligible to **CLASS RH**;
- LRM 1: provides shared Processing and Input/Output and shall be eligible to **CLASS PR+IF**;
- LRM2: provides shared Graphical Processing and shall be eligible to **CLASS GP**;
- LRM3: provides shared Power Supply to LRM embedded into the same rack and shall be eligible to **CLASS PS**;
- LRM 4: does not provide shared resource. This module shall be considered as a non-TSO-C153a module.

All these modules are considered as parts.

APPENDIX 2

INTEGRATED MODULAR AVIONIC MODULE MINIMUM PERFORMANCE STANDARD (MPS)

This Appendix provides Specific Minimum Performance Standard for IMA modules.

Principle

An IMA module is composed of hardware components or hardware and software components performing the intended function(s) whose minimum performance requirements are specified in this Appendix 2.

This Minimum Performance Standard (MPS) is structured in a common requirements section and a set of classes specifying IMA module intended function(s):

- COMMON: Minimum Performance Standard applicable to whatever IMA module and whatever the implemented intended function class(s).
- CLASS RH: Rack Housing intended function.
- CLASS PR: Processing intended function.
- CLASS GP: Graphical Processing intended function.
- CLASS DS: Data Storage intended function.
- CLASS IF: Interface intended function.
- CLASS PS: Power Supply intended function.
- CLASS DH: Display Head intended function.

To apply for TSO-C153a authorization, IMA module shall comply with common Minimum Performance Standard and implement at least one Intended Function Class as defined in this Appendix 2.

When applying for TSO-C-153a authorization, the applicant shall include in the certification basis all classes for which the intended function is implemented in the IMA module/platform.

Verification Procedures:

For verification procedures, the following definitions and symbols are used in this Appendix:

Analysis (A)

Analysis is the method of verification which consists in comparing design with known scientific and technical principles, technical data, or procedures and practices to validate that the proposed design will meet the specified functional or performance requirements.

Demonstration (D)

Demonstration is the method of verification where qualitative versus quantitative validation of a requirement is made during a dynamic test of the system/equipment. In general, software functional requirements are verified by demonstration since the functionality shall be observed through some secondary media.

Inspection (I)

Inspection is the method of verification to determine compliance with requirements and consists primarily of visual observations or mechanical measurements of the system/equipment, physical location, or technical examination of engineering support documentation.

Test (T)

Test is the method of verification that shall exercise equipment functions and measure system/equipment performance under specific configuration and load conditions after the controlled application of known stimuli. Quantitative values are measured, compared against previous predicated success criteria, and then evaluated to determine the degree of compliance.

Y The test is mandated under the conditions indicated in the column.

m/n Either verification method ‘m’ or verification method ‘n’ shall be used to verify the requirement (i.e., D/A can be verified by Demonstration or Analysis).

m+n Both verification methods shall be used to verify the requirement (i.e., D+A means the requirement shall be verified by Demonstration and Analysis).

APPENDIX 2.1

INTEGRATED MODULAR AVIONIC MODULE
MINIMUM PERFORMANCE STANDARD (MPS)

COMMON: Applicable to all the IMA modules

1. Purpose and scope

This section contains a set of Minimum Performance Standards (MPS) applicable to any IMA module and to any implemented intended function class(s).

In the following standard, the term '*concurrent items*' designates the items that are using the shared resource of the IMA module. For example, *applications.* Depending on the module class, it means '*Processing element*' for PR class; '*thread*' for GP, IF and DH class; '*data storage element*' for DS class; and '*power rail*' for PS class.

2. Requirement

2.1. **Functional Requirements Common (CO) to all classes:**

CO.a) The IMA shall implement at least one Function Class.

The following requirements of this paragraph are applicable to all classes with some exceptions as described below:

CO.b) Except for the Housing function (F1) of the class RH (see Appendix 2.2 - paragraph 2.1.1), the IMA module shall provide at least the following control features to react to detected failures:

a. disable

b. reset

CO.c) Except for the Housing function (F1) of the class RH (see Appendix 2.2 - paragraph 2.1.1), each IMA module shall provide health management and reporting capability.

CO.d) Except for the Housing function (F1) of the class RH (see Appendix 2.2 - paragraph 2.1.1), the health management and reporting function shall detect, isolate, contain, and report faults in the shared resources and other resources that could adversely affect applications using the module resources or that could adversely affect the resources themselves.

CO.e) Except for class RH, the robust partitioning (as per RTCA DO-297 between 'concurrent items' sharing the resource shall be ensured by the IMA module.

CO.f) Except for class RH, robust partitioning shall not rely on any required behavior of any aircraft function or hosted application (as per RTCA DO-297 Section 3.5c).

CO.g) Except for class RH, the potential breaches in robust partitioning shall be identified. An appropriate process and means shall be implemented to ensure that such failures which result or may result in an unsafe condition are detected and reported.

CO.h) Except for class RH, the IMA module shall implement a fault containment mechanism to prevent fault propagation between 'concurrent items' using the shared resource elements and other IMA modules.

CO.i) reserved

CO.j) Except for the Housing function (F1) of the class RH (see Appendix 2.2 - paragraph2.1.1), the interface between the 'concurrent items' and the shared resource shall conform to characteristics as described by a standard (ARINC standards 653, 664, 600, for example).

2.2. Characterization Requirements:

CO.k) Each item of the characterization shall be documented in the User Guide / Installation Manual as appropriate.

CO.l) The IMA module standard shall be characterized. Figure 4 provides examples of characterization items. Some of the items in Figure 4 may not apply and items may be missing for functional class (defined in Appendix 2 - class RH, or PR, GP, DS, IF, PS, DH).

CO.m) Quantifiable characterized item shall be quantified with minimum, typical (when relevant), maximum values, and the associated accuracy.

Note: Influence of environmental or abnormal conditions should be considered when relevant.

CO.n) The characterization of IMA module shall be correct and complete. Completeness is achieved when all shared features of the IMA module have been characterized.

CO.o) The characterization shall identify the valid usage domain of the IMA module.

CO.p) The characterization shall provide all constraints on the usage domain and on the installation (including limitations and activities) to be respected by the users.

CO.q) The characterization shall provide the list of types of shared resource elements, the associated attributes, their configurability and their performances, and associated limit of use.

CO.r) The characterization shall include at least the following characteristics of the core software/programmable hardware:

a. Identification of the core software component(s) / programmable hardware (if any).

b. The IMA module functionality, performance, and safety requirements supported by the core software / programmable hardware.

c. External interfaces and associated data coupling/control coupling information.

d. Integration and loading procedure(s).

e. Development assurance level(s).

CO.s) When the IMA module is offering the capability to host software, the characterization shall provide any data needed to evaluate Worst Case Execution Time (WCET) of each concurrent item sharing the IMA module resource.

CO.t) The performances of each shared resource management mechanism including monitoring shall be characterized, in particular the range, timing aspects, transients, etc.

CO.u) For at least the following failure modes, the failure rate shall be provided:

a. Loss of the IMA module.

b. Erroneous behavior of the IMA module.

c. Loss of the shared resource element.

d. Erroneous behavior of shared resource element.

CO.v) The characterization shall include the monitoring coverage rate (PBIT, CBIT, etc.) for the identified failure modes of the IMA module (including shared and unshared resources, sharing mechanisms and robust partitioning mechanisms).

CO.w) The characterization shall address the safety aspects of bad sequencing, delay, corruption and impersonation, where applicable.

CO.x) The following health monitoring items shall be included in the characterization:

a. interface rules, constraints (including limitations) to be respected by the users,

b. list of Health Monitoring services,

c. list of monitored components, monitored services, monitored interfaces,

d. response to each type of fault,

e. fault reporting attributes (reporting refers to internal logging, indication to applications using the shared resources, indication outside of the module),

f. the configuration attributes, if any.

CO.y) If the IMA module is configurable, the characterization shall include, in addition, the following items:

a. The authorized configuration parameters (including range, type, and definition of combined parameters) in the usage domain.

b. The configuration activities to be conducted (including configuration procedures, means, and tools) by the user during application development (RTCA DO297 – Task 2) and IMA system (RTCA DO-297– Task 3 and 4) integration.

CO.z) If some tools are required for installation, these tools shall be characterized as follows:

a. Identification,

b. The user’s manuals of tools,

c. The activities related to those tools to be conducted during application development (RTCA DO-297 – Task 2) and IMA system (RTCA DO-297– Task 3 and 4) integration.

d. The proposed associated qualification credits that could be granted to the user of the tools.

e. The Category of the tool and the Development Assurance Level of the tool (if any) as defined in applicable Software Development assurance guidance Limitations and Open Problem Report (if any) on Tools that could affect the tool qualification credit and require analysis by the user.

f. Limitations and Open Problem Report (if any) on Tools that could affect the tool qualification credit and require analysis by the user.

CO.aa) The compatibility & mix ability information between hardware, software, tools and usage domain shall be part of the characterization. This characterization shall address at least the following:

a. How the authorized mixed combinations are verified.

b. The compatibility assessment process with authorized mixed combinations of interfacing modules (external mix ability).

c. Any preventative measures (design or procedures) to be developed by the user to prevent incorrect module combinations or software loads.

d. Information to be provided to maintenance personnel.

CO.bb) The control features (disable, reset, reload, etc.) of the IMA module to react to detected failures shall be characterized.

Figure 4: IMA module Characterization Categories

Characterization Category	**Characterization item**
General Information	
	Power Dissipation.
	Thermal characteristics.
	Temperature control (e.g., cooling) characteristics.
	Size and Weight.
	Input and Output (I/O) Connectors (including pin-out).
	Mating Connectors.
	Top-level drawings and Mechanical Interfaces.
	Mounting Mechanism and scheme.
	Clearance characteristics.
	Air Flow characteristics.
	Inter-Element Interfaces (such as Backplane interface).
	Grounding and Shielding Provisions.
	Separation and/or Isolation Provisions.
	Module Installation and Extraction Means.
	Backplane Interface.
	Start-up sequence
	Different operational modes (initialization, monitor, operational, etc.)
Interfaces	**Analog Input Standards For Each Analog Input**
	Type of Analog (e.g., differential, isolated, etc.)
	Range.
	Accuracy.
	Resolution.
	Null and Offset.
	Filtering.
	Input Impedance.
	Analog-to-Digital Conversion Speed.
	Steady State Voltage Rating.
	Transient Voltage Rating.
	Circuit Protection Techniques.
	Multiplexing.
	Latency Time.
	Bandwidth.
	Analog Output Standards For Each Analog Output
	Type of Analog (e.g., differential, isolated, etc.)
	Range.
	Accuracy.

Characterization Category	Characterization item
	Null.
	Linearity.
	Current Capacity.
	Output Impedance.
	Steady State Voltage Rating.
	Transient Voltage Rating.
	Circuit Protection Techniques.
	Multiplexing.
	Latency Time.
	Bandwidth.
	Discrete Input Standards For Each Discrete Input
	Trip Point.
	Hysteresis.
	Filtering.
	Input Impedance.
	Logic Sense.
	Maximum Logic-High Level.
	Maximum Logic-Low Level.
	Minimum Logic-High Level.
	Minimum Logic-Low Level.
	Steady State Voltage Rating.
	Transient Voltage Rating.
	Circuit Protection Techniques.
	Multiplexing.
	Discrete Output Standards For Each Discrete Output
	Voltage Levels.
	Current Source Capacity.
	Current Sink Capacity.
	Output Impedance.
	Circuit Protection Techniques.
	Multiplexing.
	Digital Communications For Each Input and Output
	Data Rates.
	Integrity Checks.
	Signal Levels.
	Current Sink and Source.
	Input Impedance.
	Output Impedance.
	Signal Rise and Fall Times.
	Filtering.

Characterization Category	Characterization item
	Stub Length Limits.
	Input and Output Capacitance.
	Isolation.
	Maximum Bit Error Rates.
	Circuit Protection Techniques.
	Resets.
	Monitors.
	Multiplexing.
Processing and Memory (including Graphical)	
	Included Software Services (Core Software) and associated performances: Data loading, Health Management, Operating System.
	Processing Unit (CPU, GPU, etc.) Component(s) Bus(s) and Core Clock Frequencies.
	Memory Size(s), Type(s), Control of Access, and Timing(s)
	Local data bus(s) Type(s) and Timings
	Start-up and Reset mechanisms and timings
Display and Rendering	
	Refer to SAE AS8034 ‘Minimum Performance Standard for Airborne Multipurpose Electronic Displays’ (revision as defined in the applicable release of TSO-C113)
Power Supply	
	Regulation.
	Input Voltage & Current range.
	Maximum Start-up (Input and Output In-rush) Current Rating.
	Hold-up Capacity.
	Restart.
	Transient Immunity.
	Short Circuit Management.
	Power Resets and Recovery.
	Circuit Protection Techniques.
	Slew rate at start-up.
	DC Output Ripple and Noise

The following list of terms summarizes the terminology for characterization items defined in previous figure applicable to this TSO, hardware element development, and application of Appendix 1 MPS development criteria. The terms are segregated into eight categories per the appropriate hardware element performance.

(1) General Terms

Air Flow Characteristic: Specific requirements to provide air movement into or onto a cabinet, LRU, or module (for example, air temperature, volume rate, and pressure)

Analog/Digital Conversion Speed: The time to perform one Analog-to-Digital (A-to-D) conversion. Typically, this is expressed as either the time for one analog conversion by the A-to-D converter device or the frequency at which all analog inputs are converted.

Circuit Protection Techniques: The electrical isolation or circuitry included on inputs or outputs to protect the functional circuits from external environments. An example is using transorbs to protect circuits from the indirect effects of lightning.

Current Source/Sink: The maximum current drawn by the output while pulling the signal to a zero volt (ground) level.

Current Source: The maximum current supplied by the output while driving the signal to a voltage level.

Clearance Characteristics: Additional spacing requirements in specific directions from the cabinet or rack beyond the outline dimensions. One example of this additional clearance is the area to allow proper airflow.

Design Assurance: All planned and systematic actions and data used to substantiate that hardware correctly performs its intended function(s) and that design errors have been identified and corrected such that the hardware satisfies the applicable certification basis.

Development Assurance: All planned and systematic actions and data used to substantiate that the system performs its intended function and that development errors have been identified and corrected such that the system satisfies the applicable certification basis.

Functional Software: Software applications that will be approved as part of a functional TSO authorization or as part of a type certification effort. This software is sometimes referred to as operational software, application software, or flight software.

Functional TSO: A TSO with a defined functionality (for example, Airborne Weather Radar, TSO-C63e). TSO-C153a is not considered a functional TSO, because IMA hardware elements typically do not have system-level functionality.

Grounding / Shielding Provisions: The electrical and/or mechanical details of the design which provide grounding of the element or which provide electromagnetic shielding. These are the design details usually associated with the Radio Frequency emission and susceptibility protection of the system.

Hardware Element: In this TSO, a hardware element is: (1) a hardware module, or (2) cabinets or racks that host hardware modules.

> **Note:** This definition may differ from terminology in other documents (for example, RTCA/DO-254).

Inter-Element Connections: The connector type standard and connector pin assignments specified to allow modules to be installed interchangeably in the cabinets or racks.

Inter-Element Interfaces: The definition of the electrical signals, timing requirements, and protocols used to communicate among modules or elements with the cabinet or system.

Module Extraction Means: The details of the mechanical design to enable removal of the module from the cabinet.

Module Mounting Scheme: The details of the mechanical design used to secure each module into the cabinet or rack.

Mounting Mechanism: The details of the mechanical mechanism(s) used to secure the module into the cabinet or rack on the aircraft.

Multiplexing: The design technique where multiple inputs are individually switched to one receiver (for example, multiple digital communication buses switched to serial receiver) or multiple outputs are individually supplied by the same circuit (for example, multiple analog outputs driven by one Digital-to-Analog converter through multiple sample-and-holds).

Separation/Isolation Provisions: The electrical and/or mechanical details of the design which provide physical or electrical means of reducing interference from one element to another.

Steady State Voltage Rating: The maximum voltage range that can be applied continuously to an input or output without resulting in damage.

Transient Voltage Rating: The maximum voltage that can be applied for a short period of time to an input or output without resulting in damage. The maximum duration of the transient must be included.

(2) Analog Input/Output Terms

Accuracy: The degree of conformity to the true value of the signal. This is usually expressed as a percentage of the reading or a percentage of the full-scale value of the signal.

Current Capacity: The maximum amount of current that can be sinked or sourced by the circuit.

Linearity: The error from the directly proportional expected value of the signal as the signal values vary over the entire range.

Null: The values of the signal for which a value of zero is identified. This is usually shown as positive and negative voltage values.

Offset: The indicated value of the signal (usually non-zero) when zero volts is applied.

Range: The least and greatest operating voltage extremes (full scale) of the signal; the voltage extremes between which the value of the signal is valid.

Resolution: The smallest measurable division of the numerical expression of the signal. This is usually identified as the number of binary bits used to express the value of the signal and/or the value in volts of the least significant binary bit (LSB).

(3) Discrete Input/Output Terms

Discrete Input: This is an input with only two states. Typical examples are “ground or open” and “28 volt and open” inputs.

Discrete Output: An output with only two states. Typical examples are “ground or open” and “28 volt and open” outputs.

(4) Input Terms

Hysteresis: The values of the input voltage lag when changing states. For example, if an input circuit has 0.2 volts of hysteresis and if the trip point is 2.0 volts then the circuit will change state as the input voltage reaches 2.0 volts but will not revert back to the original state until the input voltage drops below 1.8 volts.

Logic Sense: This is the functional interpretation of the discrete input states. A true or positive logic sense may identify the “ground” state as a ‘low” or binary “0”. An inverse or negative logic sense may identify a “ground” state as a “high” or binary “1”.

Maximum Logic-High Level: The largest voltage value that can be connected to the input for which the circuit will interpret as “high”.

Maximum Logic-Low Level: The largest voltage value that can be connected to the input for which the circuit will interpret as “low”.

Minimum Logic-High Level: The smallest voltage value that can be connected to the input for which the circuit will interpret as “high”.

Minimum Logic-Low Level: The smallest voltage value that can be connected to the input for which the circuit will interpret as “low”.

Trip Point: This is the input voltage value at which the input circuitry changes state.

(5) Output Terms

Current Sink Capacity: The maximum current drawn by the output while pulling the signal to a zero volt (ground) level (current flowing in the direction from the load to the element output).

Current Source Capacity: The maximum current supplied by the output while driving the signal to a voltage level (current flowing in the direction from the element output to the load).

Voltage Levels: The minimum and maximum voltages for each state of the output. The ground point that is to be used as the reference must be identified.

(6) Processor Terms

Backplane Interface: The definition of the electrical signals, buses, timing requirements, and protocols used to communicate among elements installed in a cabinet or rack.

Interrupts: The signals to the processor that stops execution of an ongoing process or application. These announce that a higher priority or asynchronous event is occurring.

Memory Management Unit: A specialized control circuitry, sometimes integrated within the microprocessor, which performs predictive reads of instruction (pre-fetch) for use by the processor. It also may perform structured or prioritized control of specific sections of memory internal to or external to the processor memory.

Monitors: Specific circuits which observe the normal operation of the processing system and alert the processor or user of an abnormal condition. Examples are power supply monitors, which reset the processor when a voltage is outside of its tolerance, and activity monitors which reset the processor when the processor is not performing a prescribed sequence.

Reset Structure: The architectural details of the various signals that stops execution of an ongoing process, or software application. They then restart the processor at a known state.

Central Processing Unit (CPU) Throughput: A measure of the number of processor instructions completed by the CPU per unit of time.

(7) Power Supply Terms

Hold-up Capacity: The capacity of the power supply to continue supplying output current after the input voltage drops below the minimum level. This is usually expressed as the time from the input voltage drop to the reset generated by the power supply to the processor.

Input Voltage & Current: The input voltage is specified as nominal and acceptable variation values. The input current is specified as maximum steady state current. For peak current see “in-rush current” below.

Maximum Start-up (In-rush) Current Rating: The maximum input current when the power supply is first becoming active as a result of the input voltage increasing to the minimum level.

Output Current Capacity: The continuously operating maximum current supplied for each output voltage.

Power Monitors & Status Outputs: Separate circuitry which checks the output voltage levels and current loading of the power supply. This circuitry will generate one or more binary signals that may be connected to the processor to alert it to the “out of spec” condition. These binary signals may also force the power supply to shut-down to prevent damage to power supply components.

Power Resets: A binary signal output from the power supply that is asserted when the output voltages are outside acceptable tolerances.

Regulation: The percentage of variation of the output voltages when subjected to changes in load, changes in temperature, and all input voltage transients and deviations.

Restart: The ability of the power supply or other circuit to return to the normal operating mode when the input voltage returns to or above the minimum level or when the tripped monitor indicates the “out-of-spec” condition has returned to normal.

Short Circuit Management: The circuitry that monitors for short circuits or over-current conditions in the power supply outputs. The results from this circuitry may shut down the affected output or the entire power supply.

Transient Immunity: The ability of the power supply to continue operating normally during variations in the input voltage. This is usually expressed as the length of time and the voltage level of the transient.

Voltage Outputs & Tolerances: The voltage levels and tolerances of the outputs produced by the power supply.

(8) Digital Communication Terms

Data Rates: The number of data bits transmitted in a time period. This is usually expressed in thousands of bits per second (Kbps) or millions of bits per second (Mbps).

Integrity Checks: The process that uses additional data accompanying the message information to validate that the message data was received without corruption or contamination. Examples are parity checks, checksums, data validity checks, and cyclic redundancy checks.

Maximum Bit Error Rates: The largest number of bit errors allowed in a message transmission before the receiver invalidates its ability to receive data from that source.

Monitors: Separate circuitry that checks either the continuing operation of a transmitter, or checks that the receiver responds to input data. This circuitry will generate one or more binary signals that may be connected to the processor, alerting it to the "failed" condition.

Resets: Conditions that result in the receiver or transmitter stopping operation, clearing all data, and restarting.

Signal Levels: The minimum and maximum voltages for each state of the input or output. Typically, tolerances, thresholds, and reference ground point are also identified.

Signal Rise and Fall Times: The signal rise time is the time for the output to transition from 10% of the amplitude to 90% of the amplitude. The signal fall time is the time for the output to transition from the 90% level to the 10% level.

Stub Length Limits: The minimum and maximum length requirements of the wiring connector from the main bus to the inputs of the element.

3. Verification requirements

CO.cc) Each requirement shall be verified.

CO.dd) Each characterization item of IMA modules and functions, their associated attributes, their configurability and their performances shall be verified commensurately to the Development Assurance Level.

CO.ee) Each characterization item of the IMA module shall be verified over the usage domain.

CO.ff) A set of verification procedures to demonstrate compliance of the IMA module with the applicable MPS shall be developed and proposed as part of the TSOA data package.

CO.gg) There is a distinction between demonstrating the capability of sharing and demonstrating the performance of that sharing function. When demonstrating the performance of the IMA module, a subset of the characterization items that allows guaranteeing the behavior of the complete IMA module over environmental testing shall be defined and submitted together with the Qualification Test Plan.

4. Test Software representativeness

IMA module is authorized without the functional software (Hosted applications) installed and operating.

Engineering analysis from the design holder shall determine that the test software (not the target functional software) is representative of the overall usage domain envelope of the module and related to the verification procedures.

Note: IMA module is authorized without the functional software (Hosted applications) installed and operating.

CO.hh)

5. Verification procedures

The following table gives verification method for each requirement; nevertheless, an alternative method may be proposed to the certification authority per section 3.h of the TSO.

Table 1 : Verification Acceptance Criteria

Requirement identifier	Verification method	Test under normal conditions	Test Functional Subset(1) under environmental conditions	Comment
CO.a)	I			
CO.b)	T	Y		
CO.c)	A			
CO.d)	T(A*)	Y	Y	
CO.e)	T(A*)	Y		
CO.f)	A			
CO.g)	T	Y		
CO.h)	T(A*)	Y		
CO.1	A			Reserved
CO.j)	T(A*)	Y		
CO.k)	I			

Requirement identifier	Verification method	Test under normal conditions	Test Functional Subset(1) under environmental conditions	Comment
CO.l)	A			
CO.m)	A			
CO.n)	A			
CO.o)	T(A*)		Y(2)	
CO.p)	A			
CO.q)	I			
CO.r)	I			
CO.s)	A			
CO.t)	A			
CO.u)	I+A			
CO.v)	I+A			
CO.w)	I+A			
CO.x)	A			
CO.y)	A			
CO.z)	A			
CO.aa)	A			
CO.bb)	A			
CO.cc)	I+A			
CO.dd)	T(A*)	Y	Y	
CO.ee)	T(A*)	Y	Y	
CO.ff)	A			
CO.gg)	A			
0	A			

(A*): means that verification by Analysis method is possible for items that cannot be tested.

Note 1:IMA module is authorized without the functional software (Hosted applications) installed and operating.

Note 2: Applicable for a Functional subset as defined in CO.gg).

Note 3: Usage Domain has to be taken into consideration during Environmental Qualification Testing in order to evaluate the robustness of the IMA module over the full Usage Domain (see Appendix 4 - Chapter 1)

APPENDIX 2.2

INTEGRATED MODULAR AVIONIC PLATFORM AND MODULE MINIMUM PERFORMANCE STANDARD (MPS)

CLASS RH: Rack Housing

1. Purpose and scope

1.1. Introduction

This appendix contains Minimum Performance Standards (MPS) for CLASS RH Intended Function: Rack Housing.

These standards specify module characteristics that are useful to designers, manufacturers, installers, and users of the IMA module.

1.2. Definitions

For TSO-C153a CLASS RH, IMA module is a physical package able to contain at least two hardware modules, which may provide partial protection from environmental effects (shielding, etc.) and enable installation and removal of those module(s) from the aircraft without physically altering other aircraft systems or equipment.

These IMA modules may be simple mechanical enclosures, or they may incorporate passive communication interfaces, passive interconnection for data and power, active or passive cooling unit or any combination of these features.

The following definitions are used:

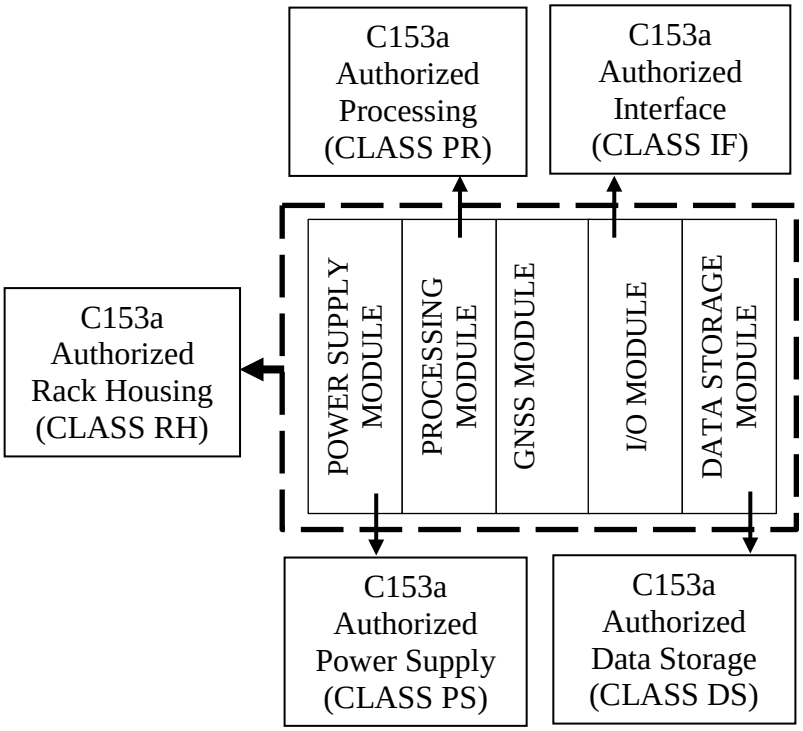
- Mounted: refers to another hardware module, installed and fixed inside the IMA Rack Module, after a human operation.
- Slot: a physical space inside the Rack Module, allocated to one hardware module.

These definitions are independent of the design choices made by the IMA module manufacturer.

Note:

- IMA module compliant to TSO-C153a CLASS RH MPS is only relevant in case of IMA platform architecture using a Cabinet.
- Hardware modules mounted inside the Rack Housing will be themselves IMA modules (compliant with TSO-C153a MPS other classes than RH) or non-IMA modules (i.e., non-IMA application specific hardware).

Figure 5 Illustration of IMA platform architecture based on Cabinet



1.3. **Intended function**

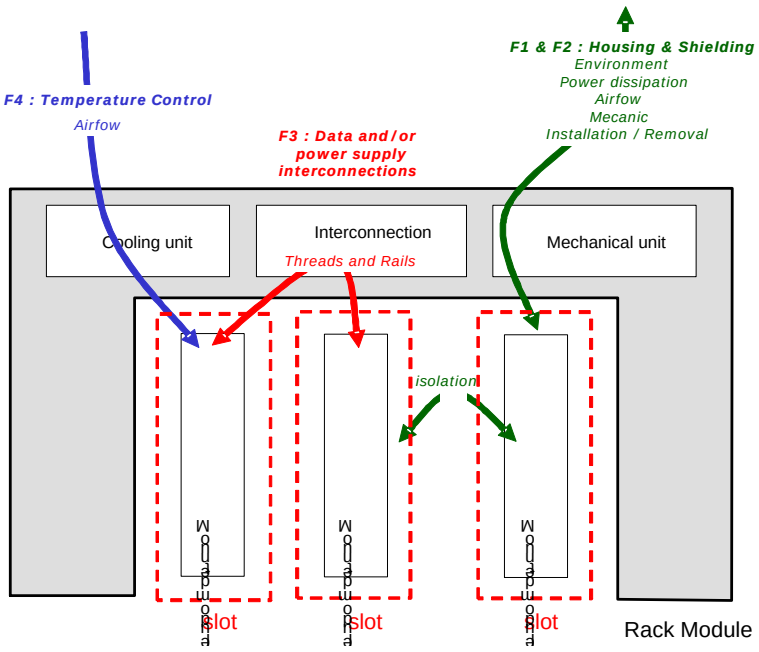
For TSO-C153a CLASS RH, the intended function is to provide the capability to share some housing services supplied by one mechanical unit.

This intended function can be divided into 4 sub-functions:

- F1 : Housing (mandatory);
- F2 : Shielding (optional);
- F3 : Interconnection (optional);
- F4: Temperature control (optional).

The following figure provides an overview of the previously mentioned Rack Housing Module intended functions and definitions.

Figure 6: IMA module overview for TSO-C153a CLASS RH



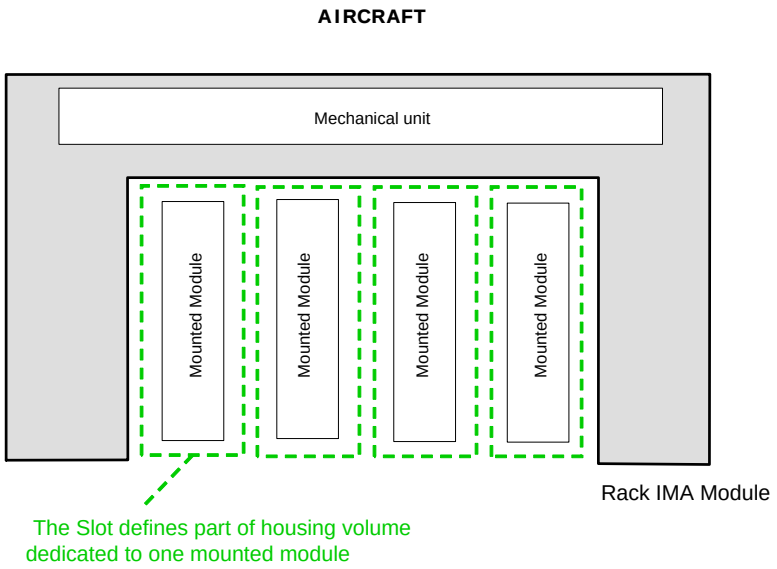
2. Requirements

2.1. Requirements for Housing (F1)

For TSO-C153a CLASS RH, IMA module provides shared resources for housing needs of hardware modules. This sub-function merges:

- The capacity to host at least two hardware modules inside at least two slots.
- The capacity to mount and dismount a hardware module in its slot directly in the aircraft thanks to a human (potentially tooled) intervention.

Figure 7: CLASS RH Housing function overview



2.1.1. Functional requirements for TSO-C153a CLASS RH (F1): Housing

RH.a) The Rack Housing shall permit the installation and attachment of at least two hardware modules, one of which (at least) being an IMA module, inside its mechanical structure.

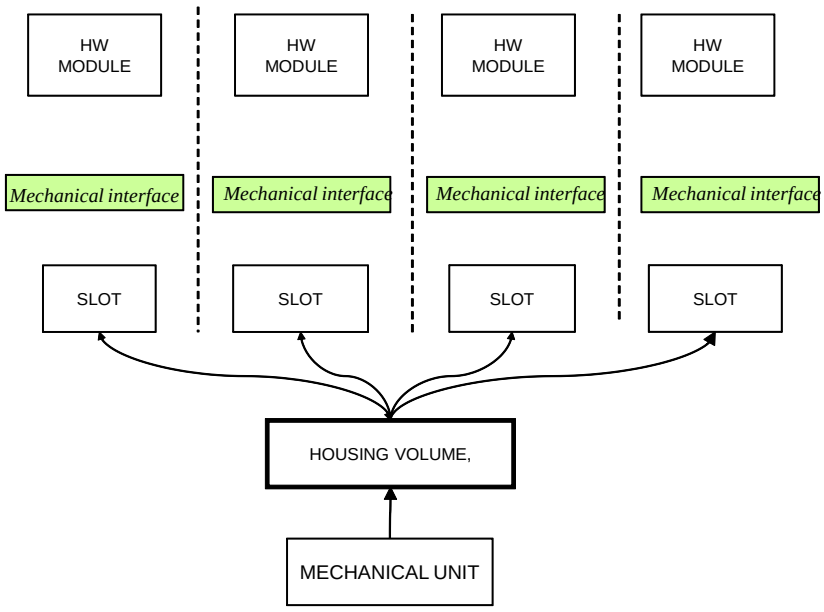
RH.b) The Rack Housing shall ensure the physical partitioning between the different mounted hardware modules.

RH.c) For each type of slot, a means to avoid installation of unintended hardware module or inappropriate installation shall be implemented (e.g., mechanical key).

RH.d) If compliance with MPS requires any additional mechanical component, in the case this component is separable; it shall be marked with its own unique Part Number.

RH.e) The external mechanical interface(s) of the Rack Housing module should conform to characteristics as described by a standard (e.g., ARINC600). Some characteristics of the slots may be configurable.

Figure 8: CLASS RH Housing elements relationship



2.1.2 Characterization Requirements for TSO-C153a CLASS RH (F1): Housing

RH.f) The following housing performances or housing characteristics of the Rack module shall be provided as part of the characterization:

1. Size, mass, and center of gravity;
2. Clearance scheme;
3. Top-level drawings and mechanical interfaces;
4. Module mounting scheme;
5. Installation and extraction mechanisms;
6. Temperature control (e.g., airflow, cooling, etc.) performances if function is implemented;

7. Lists of slots and associated performances (physical scheme, temperature profile, connector, etc.).

   Note: These characterization requirements are additional to those applicable in COMMON – Appendix 2.1).

RH.g) The characterization shall include the description of the mounted hardware module installation and extraction means and methods.

RH.h) The characterization shall provide the list of type of slots, the associated attributes, their configurability (if any) and their sizing dimensions (drawings).

This characterization shall include:

1. The list of authorized or predefined hardware modules (if any).
2. The list of minimum requirements that a hardware module shall comply with for its capacity to be inserted into the rack.
3. Slot mounting scheme (mechanical profile/drawings) and characteristics (torque, max number of insertions, etc.)
4. Power dissipation and airflow profile.

RH.i) The characterization, including the usage domain, shall be sufficiently accurate to permit standard and validation of the expected performance of the mounted hardware module.

RH.j) The characterization shall include configuration, weight, and geometric data that are needed to evaluate mass and center of gravity for a populated and partly populated rack.

RH.k) The characterization shall include the installation instructions of the additional mechanical component necessary to be compliant with MPS.

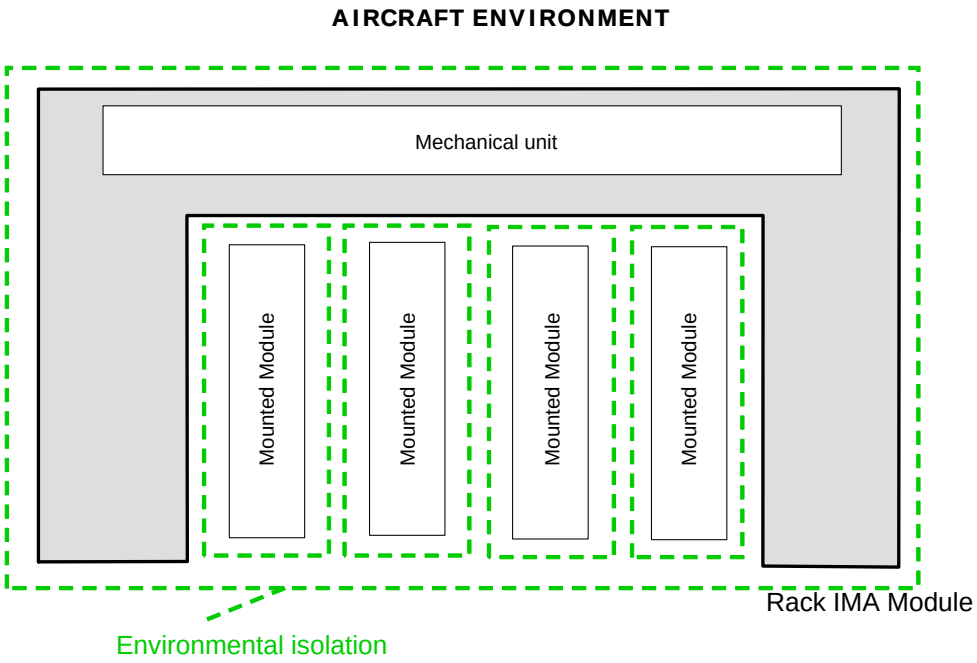
2.2. Requirements for Shielding (F2)

F2 is an optional sub-function of TSO-C153a CLASS RH.

In this case, IMA module provides shared resources in terms of protection of mounted hardware modules. This sub-function merges:

- A level of protection of the mounted hardware modules from aircraft environment (including but not only, High-Intensity Radiated Field (HIRF**) ,** and Lightning effects).
- A level of environmental isolation (shielding) between mounted hardware modules inside the rack.

Figure 9: CLASS RH Shielding function overview



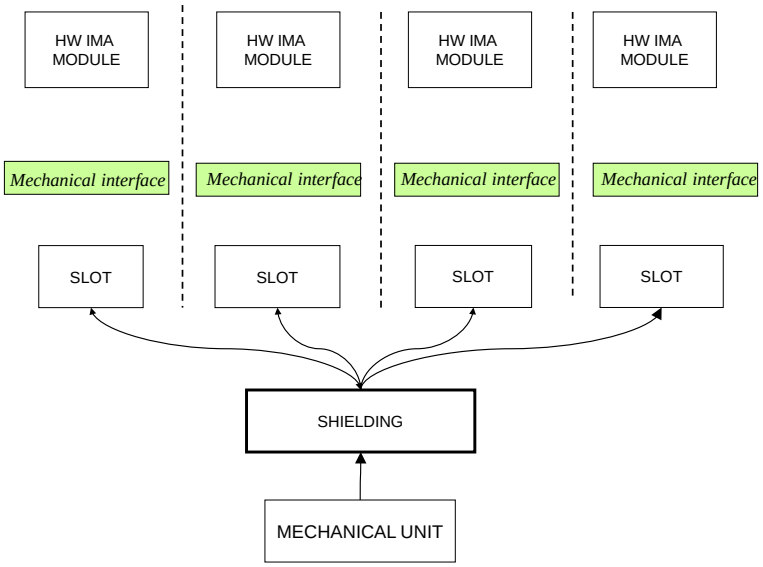
2.2.1 **Functional requirements for TSO-C153a CLASS RH (F2):**

RH.l) Shielding A level of environmental protection (shielding) for each mounted hardware module shall be ensured by the Rack Housing IMA Module. This protection shall take into account level and severity retained for RTCA DO-160 qualification of the IMA module (see Appendix 4) (outside the rack) and the interactions between the mounted hardware modules themselves (inside the rack).

RH.m) Protection performances of the IMA module (Rack module) shall be valued and guaranteed for each slot and for each RTCA DO-160 section.

RH.n) Reserved.

Figure 10: CLASS RH shielding elements relationship



2.2.2 Characterization Requirements for TSO-C153a CLASS RH (F2): Shielding

RH.o) The level of environmental protection (shielding) of each slot provided in Appendix 2.2 paragraph 2.2.1 shall be characterized, bounded, and documented in the installation manual.

RH.p) The characterization shall include the failure modes and rates of protection features (such as lightning protections, etc.) to support IMA system Safety Analysis (as per RTCA DO-279) at installation.

RH.q) The characterization shall include the list of type of slots and the associated characteristics in terms of environmental protection (shielding).

This shall include:

1. The list of authorized or predefined hardware modules (if any).
2. The list of minimum requirements that a hardware module shall comply with in order to be mounted into the rack.
3. Slot Mounting Scheme (mechanical profile/isolation/drawings).
4. Level of isolation and level of shielding per slot for each RTCA DO-160 section.

RH.r) The characterization shall include the list of environmental tests that can be granted to a hardware module (see Appendix 4 - EQT) mounted into the rack.

RH.s) The characterization shall include all the possible configurations allowed for the configurable slot.

RH.t) If the RH.l) shielding objective is met thanks to any additional mechanical element, its installation shall be specified in the installation manual.

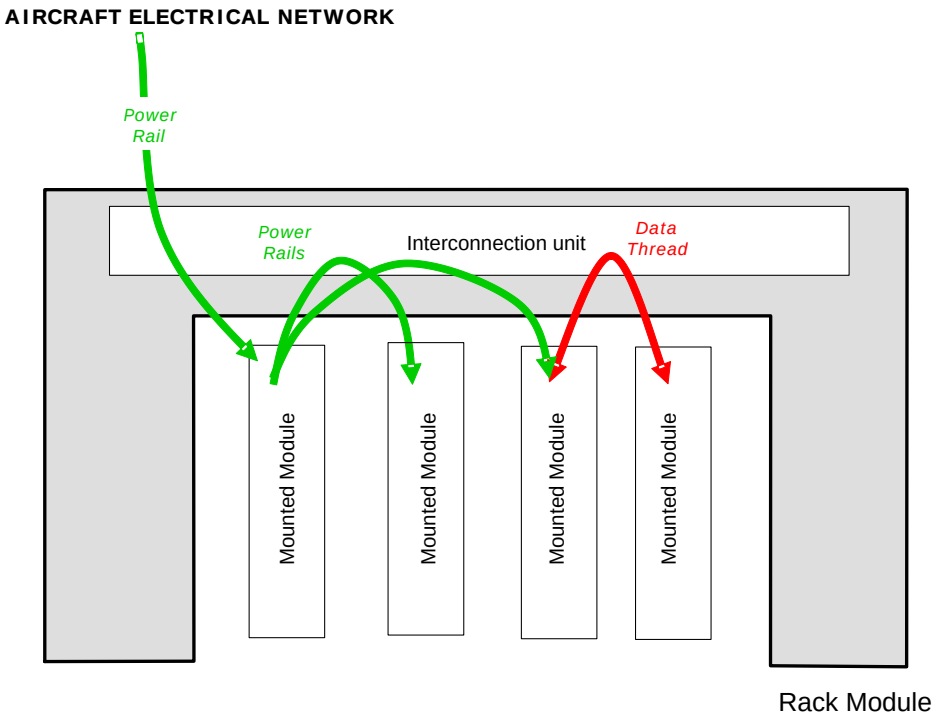
2.3. Requirements for Interconnection (F3)

F3 is an optional sub-function of TSO-C153a CLASS RH.

In this case, an IMA module provides the capacity to interconnect hardware modules together inside the Rack Module. This interconnection allows exchanging data or distributing power supply.

> **Note:** To ensure power supply exchange between mounted hardware modules at least one TSO-C153a CLASS PS module shall be mounted into a slot to deliver electrical energy to other hardware modules.

Figure 11: CLASS RH Interconnection function overview



2.3.1 Functional Requirements for TSO-C153a CLASS RH (F3): Interconnection

RH.u) The IMA module shall provide the capacity to interconnect mounted hardware modules through data or power supply buses available through an electrical interface(s) supplied by one or several interconnection unit(s). These buses shall be dedicated to:

a. data exchanges;

b. power supply exchanges.

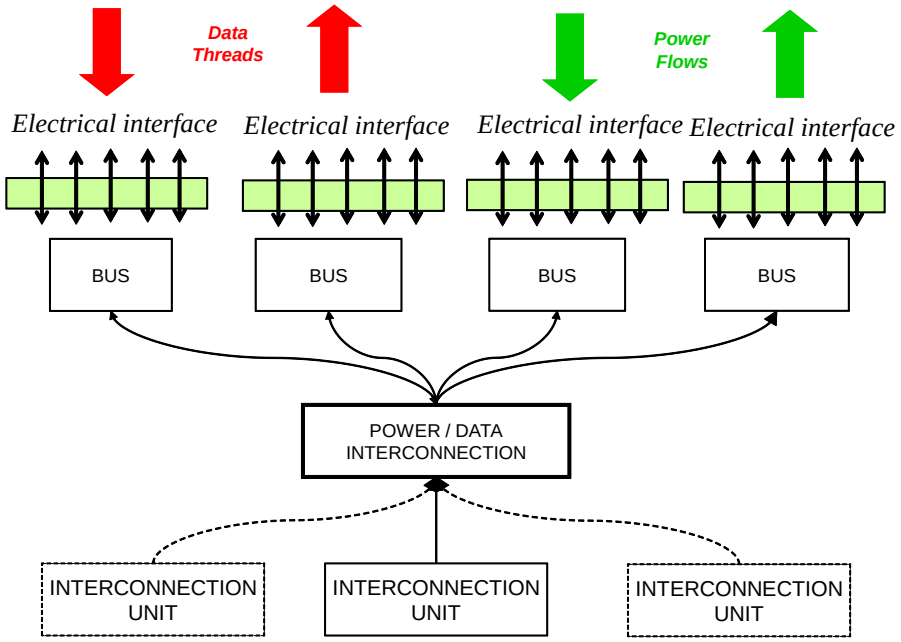
RH.v) If the IMA module provides more than one bus, the isolation between buses used by mounted hardware modules shall be ensured by the IMA module. This isolation shall be substantiated by a Partitioning Analysis and Environmental Qualification Testing.

RH.w) The interface(s) of the IMA module should conform to characteristics as described by a standard (e.g., ARINC 600 or ARINC 664).

RH.x) The data and power supply buses shall not degrade the transmitted signals below the characterized performance.

RH.y) For TSO-C153a CLASS RH, the IMA module shall ensure proper isolation on the interconnection function to prevent interferences between signals (data, discrete, power supply buses, etc.) that would affect data integrity, latency, and control.

Figure 2: CLASS RH Interconnection elements relationship



2.3.2 Characterization Requirements for TSO-C153a CLASS RH (F3) Interconnection

RH.z) The characterization shall include attenuation profiles, signal integrity, cross-talk and tolerance rates. These shall be valued.

RH.aa) The performances of each type of buses provided in RH shall be characterized and valued.

RH.bb) For at least the following failure modes, the failure rate shall be provided for:

a. Loss of the interconnection function;

b. Erroneous behavior of interconnection function.

RH.cc) The characterization shall address the safety aspects of sequencing, delay, corruption, and impersonation.

RH.dd) The characterization shall include the list of types of buses, the associated attributes, their configurability, and their sizing and performances.

2.4 Requirements for Temperature control (F4)

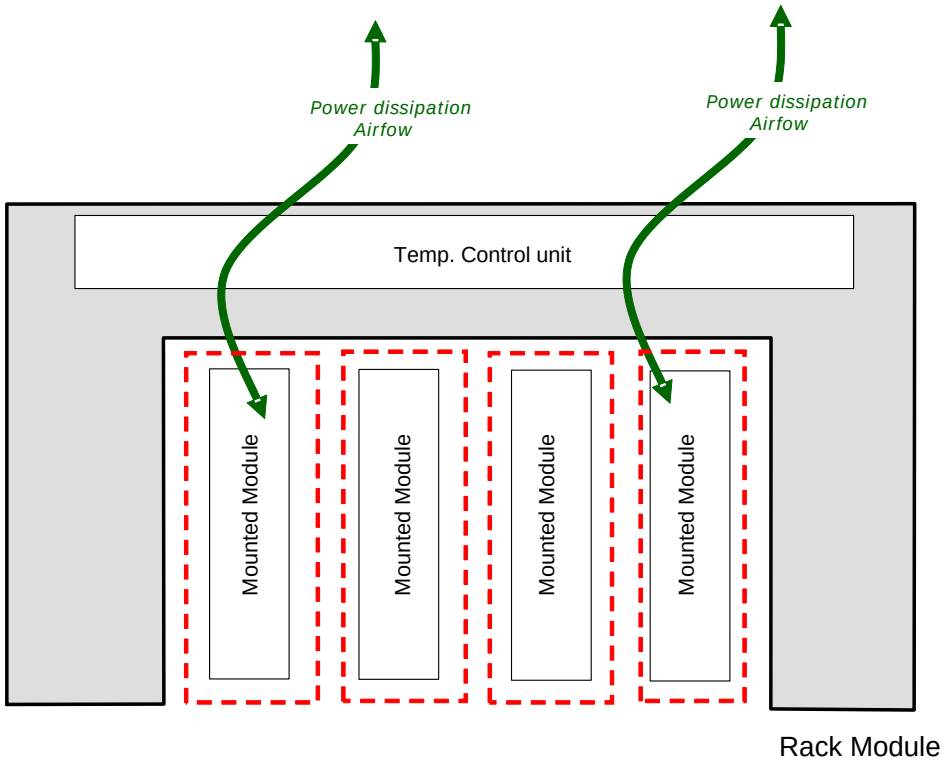
F4 is an optional sub-function of TSO-C153a CLASS RH (F4): Temperature control

In this case, IMA module provides the capacity to control temperature inside the Rack for each mounted module.

This control may be realized by:

- Distributing Airflow between aircraft environment (outside the rack) and the mounted hardware modules inside the IMA module (rack).
- Enforcing Airflow (convection) with cooling generation unit.
- Facilitating conduction between mounted hardware modules and heat sink part of the Rack module.

Figure 13: CLASS RH cooling function overview

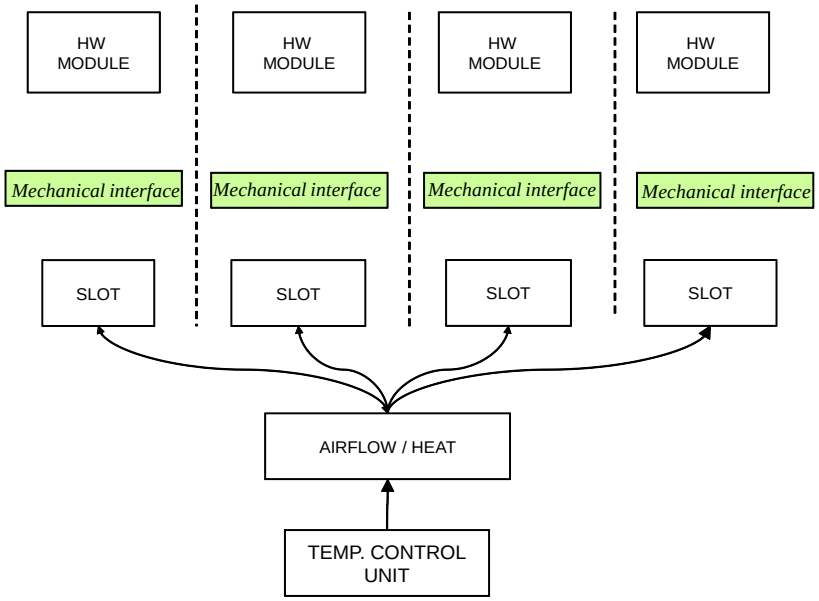


2.3.3 Functional Requirements for TSO-C153a CLASS RH (F4): Temperature Control

RH.ee) The IMA module shall provide a regulated temperature control of the mounted hardware module. This control shall be ensured per slot in a determined temperature range.

RH.ff) The IMA module may provide an active means – named temperature control unit – to control temperature between aircraft environment and the mounted hardware modules.

Figure 14: CLASS RH Cooling elements relationship



2.3.4 Characterization Requirements for TSO-C153a CLASS RH (F4)

RH.gg) The heat exchange performance of each slot provided shall be characterized and valued in the installation manual.

RH.hh) For at least the following failure modes, the failure rate shall be provided:

a. Loss of the active temperature control function;

b. Erroneous behavior of the active temperature control function.

RH.ii) Reserved.

RH.jj) Reserved.

3. Verification procedures

The following table gives the verification method for each MPS; nevertheless, an alternative method may be proposed to the certification authority per section 3 h. of the TSO:

Table 2 : Verification Acceptance Criteria for CLASS RH

Requirement identifier	Verification method	Test under normal conditions	Test under environmental conditions	Applicable DO-160DO-160sections
RH.a)	I+T	Y	Y(2)	no DO-160 section see (2)
RH.b)	T	Y	Y	DO-160 sections 4, 5, 7, 8
RH.c)	I+T		Y(2)	no DO-160 section see (2)
RH.d)	I			
RH.e)	I/A			
RH.f)	I			
RH.g)	I			
RH.h)	I+A			

Requirement identifier	Verification method	Test under normal conditions	Test under environmental conditions	Applicable DO-160DO-160sections
RH.i)	A			
RH.j)	I+T	Y		
RH.k)	I			
RH.l)	I			
RH.m)	T	Y	Y	Appropriate DO-160 sections addressing the shielding characteristics, and as a minimum sections 18, 19, 20, 22
RH.n				Reserved
RH.o)	I			
RH.p)	I			
RH.q)	I+A			
RH.r)	I			
RH.s)	T	Y	Y	Appropriate DO-160 sections addressing the shielding characteristics and as a minimum sections 18, 19, 20, 22
RH.t)	I			
RH.u)	T	Y	Y(1)	DO-160 sections 4, 5, 6, 7, 8, 16, to 22
RH.v)	A+T	Y	Y	DO-160 sections 16 to 22
RH.w)	T	Y	Y(1)	DO-160 sections 4, 5, 7, 16 to 22
RH.x)	T	Y	Y	DO-160 sections 4, 5, 7
RH.y)	A			
RH.z)	T(A*)	Y		
RH.aa)	T(A*)	Y(1)	Y(1)	DO-160 sections 4, 5, 7
RH.bb)	A	Y		
RH.cc)	T(A*)	Y(1)		
RH.dd)	I			
RH.ee)	T	Y	Y	DO-160 sections 4 and 5
RH.ff)	I+T	Y	Y	DO-160 sections 4 and 5
RH.gg)	I+T	Y	Y	DO-160 sections 4, 5, 6, 7
RH.hh)	A			
RH.ii)				Reserved
RH.jj)				Reserved

(A*): Means that verification by Analysis method is possible for the item that cannot be tested.

Note 1: Applicable for a functional subset → cf. CO.gg).
Note 2: Test to be completed after environmental testing.

APPENDIX 2.3

INTEGRATED MODULAR AVIONIC PLATFORM AND MODULE MINIMUM PERFORMANCE STANDARD (MPS)

CLASS PR: Processing

1. Purpose and scope

1.1. Introduction

This Appendix contains Minimum Performance Standards (MPS) for CLASS PR Intended Function: Processing (PR).

These standards specify characteristics that should be useful to designers, manufacturers, installers, and users of the IMA module.

1.2. Definitions

For TSO-C153a CLASS PR, IMA module provides shared resources in terms of processing between Hosted applications, modules, and/or components.

The following definitions are used:

- Processing Unit: set of physical components (hardware and/or software) in charge of carrying out the instructions of a computer program by performing the basic arithmetical, logical, and input/output operations of the Executable Object Code.
- Executable Object Code [RTCA DO-178C]: a form of code that is directly usable by the processing unit of the target computer and is, therefore, a compiled, assembled, and linked binary image that is loaded into the target computing hardware.
- Processing Element: well-defined set of instructions which is a primary form of Executable Object Code execution and for which a level of isolation would be guaranteed by the IMA module.

In the context of PR class, the ‘concurrent item’ defined in Appendix 2.1 paragraph 1 means ‘Processing Element’.

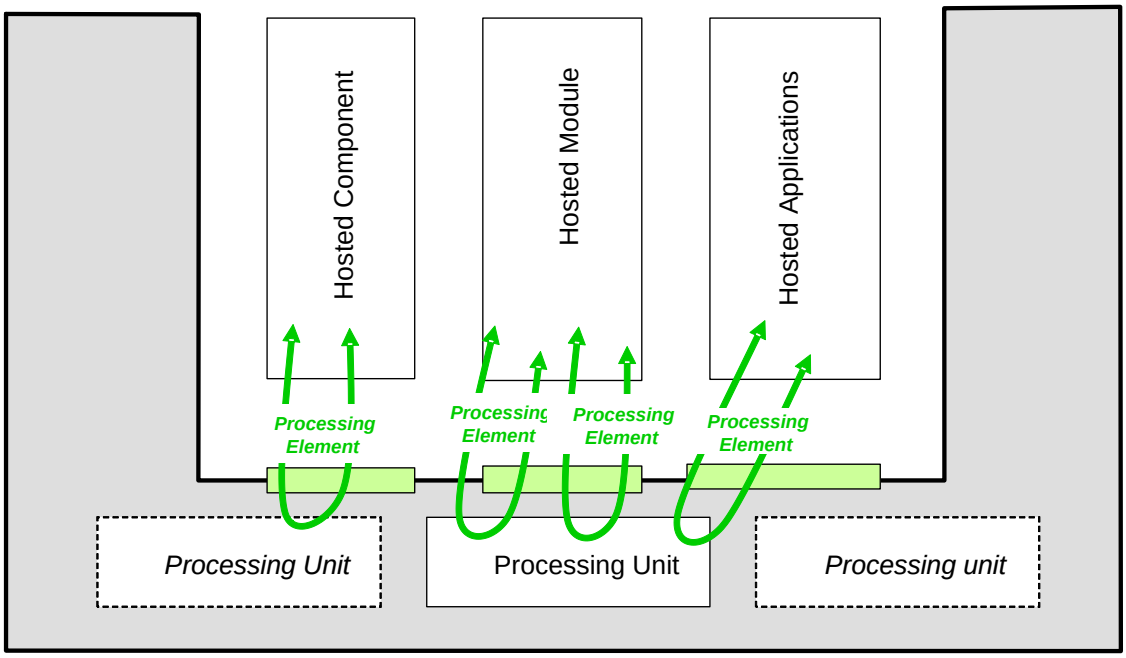
1.3. Intended Function

For TSO-C153a CLASS PR, the intended function is to provide the capacity to share processing supplied by one or several processing unit(s).

IMA module may include data storage and interfaces between Hosted applications, modules, and/or components; in this case, this class shall be combined with DS and IF classes.

The following figure provides an overview of the intended function of the previously mentioned IMA module and associated definitions:

Figure15: IMA module overview for TSO-C153a CLASS PR



2. Requirements

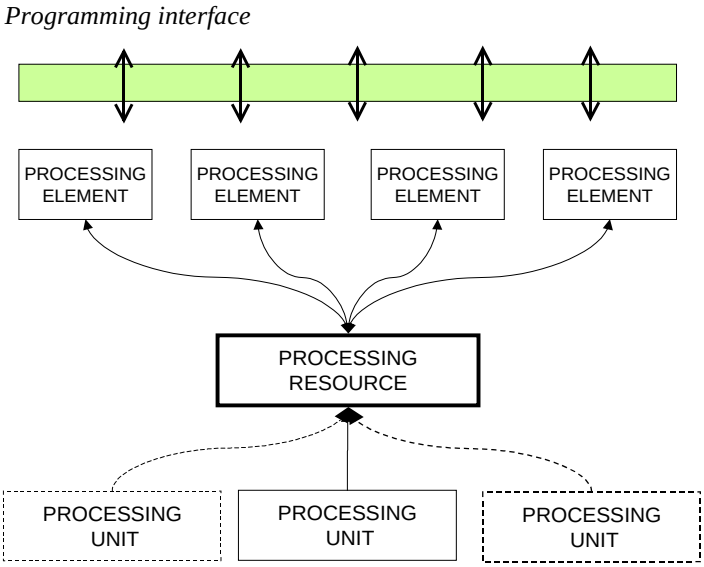
2.1. **Functional requirements for TSO-C153a CLASS PR**

PR.a) The IMA module shall provide to Hosted applications a Processing Resource which has the capacity to execute a set of instructions of a computer program by performing the basic arithmetical, logical, and input/output operations of their Executable Object Code(s);

PR.b) The IMA module shall be able to host applications and/or Executable Object Code(s) components.

PR.c) The IMA module shall provide the Hosted applications the capacity to share Processing Resource thanks to the Processing Elements that are managed through a logical interface (such as an API).

Figure 16: CLASS PR Processing elements relationship



2.2. **Characterization requirements for TSO-C153a CLASS PR**

PR.d) All processing performances of the shared Processing Unit of the IMA module shall be characterized, including but not limited to the following:

1. Processing Unit Throughput (performance capacities and timings).
2. Performances of User Software/Software Interface (Core Software) Mechanism(s), Protocol(s), and Service(s).
3. Performances of User Hardware/Software Interface Mechanism(s), Protocol(s), and Service(s).
4. Performances of supported Processing Element Type (e.g., application, partition, process, thread, etc.).
5. Performances of Interrupt mechanisms.
6. Performances of Memory Management, including cache and MMU.

Note: These performance requirements are additional to those applicable in COMMON - Appendix 2.1).

3. Verification procedures

The following table gives the verification method for each MPS: nevertheless, an alternative method may be proposed to the certification authority per section 3 h. of this TSO:

Table 3: Verification Acceptance Criteria for CLASS PR

Requirement identifier	Verification method	Test under normal conditions	Test under environmental conditions	Comment
PR.a)	T	Y	Y	
PR.b)	T	Y	Y	
PR.c)	T	Y	Y	
PR.d)	T (A*)	Y	Y(1)	

(A*): means that verification by Analysis method is possible for the item that cannot be tested.

Note: Applicable for a functional subset → cf. CO.gg)

APPENDIX 2.4

INTEGRATED MODULAR AVIONIC MODULE
MINIMUM PERFORMANCE STANDARD (MPS)

CLASS GP: Graphical Processing

1. Purpose and scope

1.1. Introduction

This Appendix contains Minimum Performance Standard (MPS) for CLASS GP Intended Function: Graphical Processing.

These standards specify characteristics that should be useful to designers, manufacturers, installers, and users of the IMA module.

1.2. Definitions

For TSO-C153a CLASS GP, the IMA module provides shared resources in terms of graphical conversion and graphical laying out between the Hosted applications, modules, and/or components based on commands coming from these Hosted applications, modules, and/or components.

The following definitions are used:

- Graphical Thread: Set of graphical (displayable) information for which a level of isolation would be guaranteed by the IMA module.
- Data Thread: Well-defined set of data which is a primary form of drawing directives received as input by the IMA module from Hosted applications (modules and/or components).
- Command Thread: Well-defined set of command directives received as input by the IMA module from the Hosted applications (modules and/or components) in order to change the conversion and laying out settings.
- Graphical conversion: Transformation of a set of data information that is the primary form of drawing directives (data thread) into a set of displayable basic information.
- Laying out: Operation consisting of a combination of merging or/and splitting actions on displayable basic information in order to build the final Graphical Thread to be rendered.
- Conversion Unit: Set of physical components (hardware and/or software) in charge of graphical conversion.
- Laying out Unit: Set of physical components (hardware and/or software) in charge of laying out.

> **Note:** Both units can be merged into one unit. The final rendering of the graphical thread(s) is out of the scope of this module (refer to CLASS DH).

In the context of GP class, the ‘concurrent item’ defined in Appendix 2.1 paragraph 1 means ‘Graphical and/or Command Thread’.

1.3. Intended Function

For TSO-C153a CLASS GP, the intended function is to provide the capability to share graphical conversion and graphical laying out supplied by one or several graphical conversion and graphical laying out unit(s).

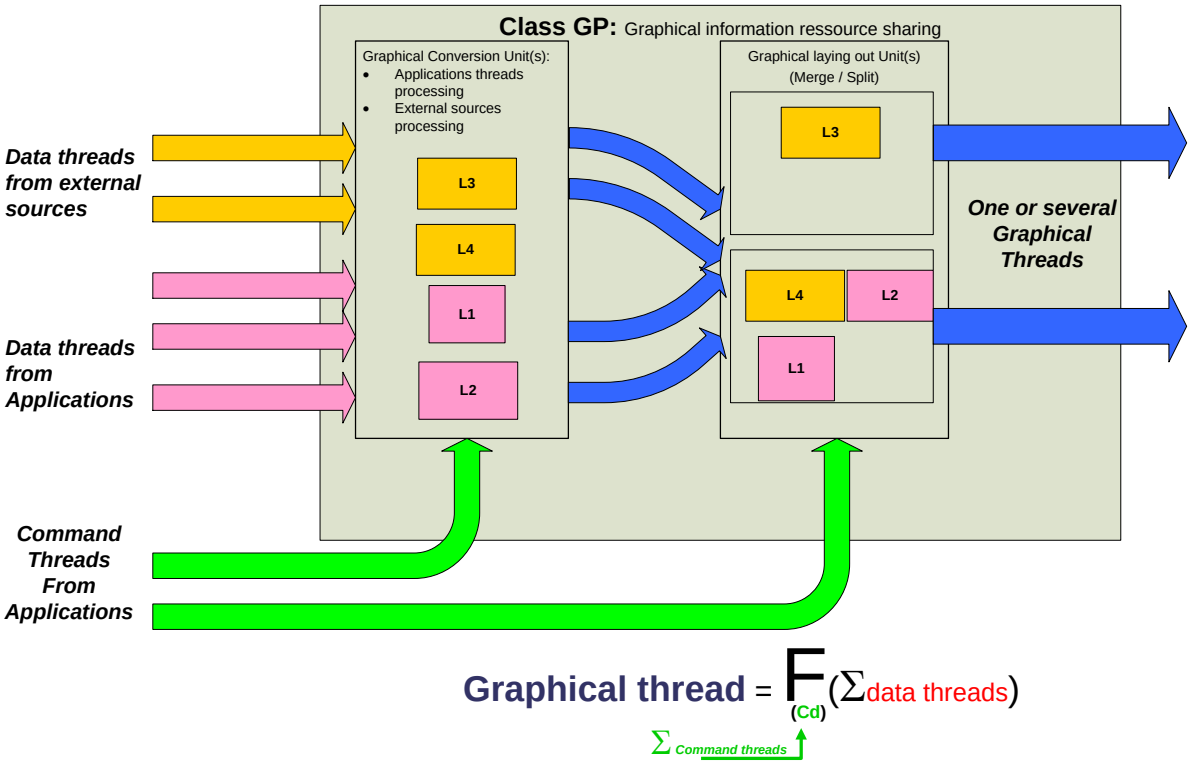
The function of the Graphical Processing Module is to receive commands from Hosted applications, modules, and/or components, and optionally receive video from external analog or digital sources, process them, and to generate a display image.

This intended function is Graphical Conversion and Laying out resource sharing composed of:

- Information acquisition & control,
- Information conversion and laying out,
- Information forwarding & control.

The following figure provides an overview of the previously mentioned IMA module intended function and associated definitions:

Figure17: IMA module overview for TSO-C153a CLASS GP



2. Requirements

2.1. Functional requirements for TSO-C153a CLASS GP:

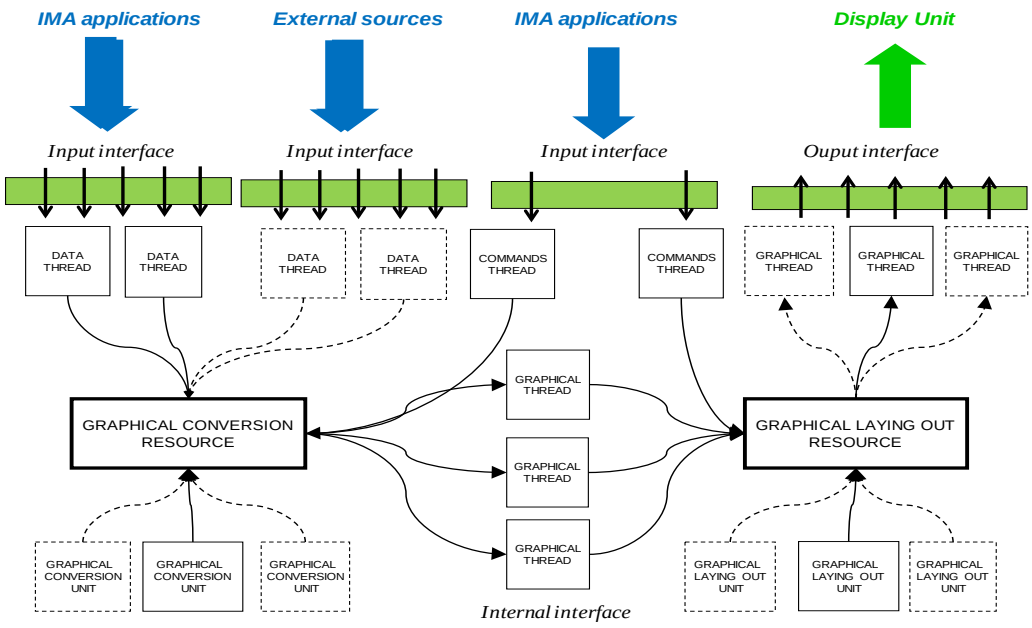
GP.a) The IMA module shall provide to Hosted applications a Graphical Conversion Resource that has the capability to transform a set of drawing directives into a set of displayable basic information.

GP.b) The IMA module shall provide to the Hosted applications, a Graphical Laying out Resource which has the capability to merge and/or split displayable basic information to build the final Graphical Thread(s) to be rendered.

GP.c) The IMA module shall provide to the Hosted applications, modules and/or components the capability to change the graphical conversion and laying out settings through command threads.

GP.d) The IMA Module shall provide to the Hosted applications, modules and/or components the capability to share a Graphical Conversion Resource and a Graphical Laying out Resource based on command threads managed through logical and/or physical interface(s).

Figure18: CLASS GP Graphical Processing (GP) elements relationship



2.2. Characterization requirements for TSO-C153a CLASS GP:

GP.e) Following the Graphical Unit(s) performances that the IMA module shall be valued at:

1. Graphical Unit(s) Throughput (performance capacities and timings: response time, graphical update).
2. Performances of the User Software/Software Interface (Core Software) Mechanism(s), Protocol(s), and Service(s).

3. Performances of the User Hardware/Software Interface Mechanism(s), Protocol(s), and Service(s).
4. Establishment of Worst Case Graphical Elaboration Time
5. Performances of Interrupt mechanisms.
6. Performances of supported Data Thread types.
7. Performances of supported Graphical Thread types.
8. Performances of supported Command Thread types.

Note: These performance requirements are additional to those applicable in COMMON - Appendix 2.1).

GP.f) In addition to Common Requirement(CO.w), particular emphasis shall be given to precluding or mitigating failures which could result in hazardously misleading information. Undetected loss of information, incorrect information, or frozen information could contribute to hazardously misleading information.

Note: This is applicable to all GP module functionalities including the implementation of image windowing, superimposition, etc.

3. Verification procedures

The following table gives the verification method for each MPS; nevertheless, an alternative method may be proposed to the certification authority per section 3 h. of this TSO:

Table 4: Verification Acceptance Criteria for CLASS GP

Requirement identifier	Verification method	Test under normal conditions	Test under environmental conditions	Comment
GP.a)	T	Y	Y	
GP.b)	T	Y	Y	
GP.c)	T	Y	Y	
GP.d)	T	Y	Y	
GP.e)	T(A*)	Y	Y(1)	
GP.f)	I			

(A*): means that verification by Analysis method is possible for the item that cannot be tested.

Note: Applicable for a Functional subset → cf. CO.gg).

APPENDIX 2.5

INTEGRATED MODULAR AVIONIC PLATFORM MODULE MINIMUM PERFORMANCE STANDARD (MPS)

CLASS DS: Data Storage (DS)

1. Purpose and scope

1.1. Introduction

This appendix contains Minimum Performance Standards (MPS) for CLASS DS Intended Function: Data Storage.

These standards specify characteristics that should be useful to designers, manufacturers, installers, and users of the IMA module.

1.2. Definitions

For TSO-C153a CLASS DS, IMA module provides shared resources in terms of data storage between the Hosted applications, modules and/or components.

Data Storage refers to the storage of data in a persisting and machine-readable mode. Data Storage module that records data may access both separate portable (removable) recording component and/or permanent component to store and retrieve data.

Following definitions are used:

- Storage Unit: set of physical components (hardware and/or software) in charge of supplying and managing recorded data resource (e.g., memory components, and associated interfaces, etc.)
- Data Storage Element: completely defined set of data storage which is a primary form of recorded data for which a level of isolation would be guaranteed by the IMA module.

In the context of DS class, the ‘concurrent item’ defined in Appendix 2.1 paragraph 1 means ‘Data Storage Element’.

1.3. Intended Function

For TSO-C153a CLASS DS, the intended function is to provide the capability to share recorded data or data storage space supplied by one or several storage unit(s).

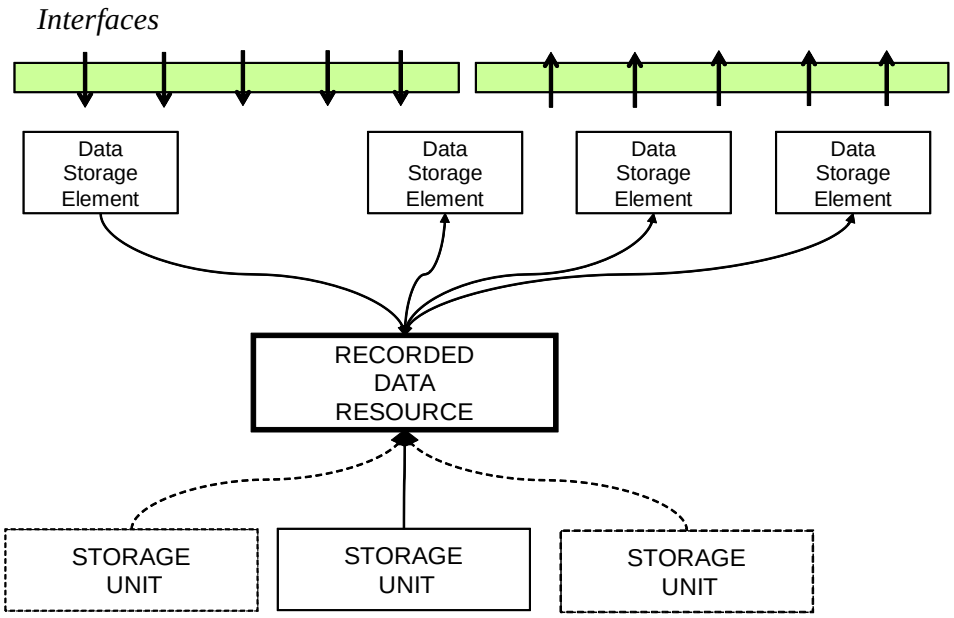
2. Requirements

2.1. Functional requirements for TSO-C153a CLASS DS:

DS.a) The IMA module shall provide to the Hosted applications, modules, and/or components Data Storage Resource which has the capacity to record or to retrieve a set of data on/from a storage unit by performing the data-retaining operations.

DS.b) The IMA module shall provide the Hosted applications, modules, and/or components the capacity to use shared recorded data resource thanks to data storage elements accessible through a logical and/or physical interface(s).

Figure 19: CLASS DS Data Storage elements relationship



2.2. Characterization requirements

DS.c) All Data Storage performances of the shared Storage Unit of the IMA module shall be characterized including but not limited to the following:

1. Performances of Memory Management, including cache and Memory Management Unit (e.g. storage capacity, cache performances, etc.).
2. Performances of User Interface Mechanism(s), Protocol(s), and Service(s) (e.g., access timings and throughputs, etc.)
3. Performances of supported Data Storage Element Type (e.g., namespace, address scheme, arbitrary principles for multiple access, throughputs, timings, data space, etc.).

Note: These performance requirements are additional to those applicable in COMMON - Appendix 2.1.

3. Verification procedures

The following table gives the verification method for each MPS; nevertheless, an alternative method may be proposed to the certification authority per section 3 .h of this TSO:

Table 5: Verification Acceptance Criteria for CLASS DS

Requirement identifier	Verification method	Test under normal conditions	Test under environmental conditions	Comment
DS.a)	T	Y	Y	
DS.b)	T	Y	Y	
DS.c)	T(A*)	Y	Y(1)	

(A*): Means that verification by Analysis method is possible for the item that cannot be tested.

Note: Applicable for a functional subset → cf. CO.gg).

APPENDIX 2.6

INTEGRATED MODULAR AVIONIC MODULE MINIMUM PERFORMANCE STANDARD (MPS)

CLASS IF: Interface

1. Purpose and scope

1.1. Introduction

This Appendix contains Minimum Performance Standards (MPS) for CLASS IF Intended Function: Interface.

These standards specify characteristics that should be useful to designers, manufacturers, installers, and users of the IMA module.

1.2. Definitions

For TSO-C153a CLASS IF, IMA module provides shared resources in terms of interfaces between the Hosted applications, modules, and/or components.

Following definitions are used:

- Interface Unit: set of hardware and/or software components in charge of supplying and managing a shared information resource.
- Data Thread: well-defined set of data which is a primary form of information and for which a level of isolation would be guaranteed by the IMA module.

Each data thread handled by the Interface, if so desired by the applicant, may be bidirectional or symmetrical between interconnected components, modules, or the Hosted applications.

In the context of IF class, the ‘Concurrent item’ defined in Appendix 2.1 paragraph 1 means ‘Data Thread’.

1.3. Intended Function

For TSO-C153a CLASS IF, the intended function is to provide the capability to share information supplied by one or several interface units.

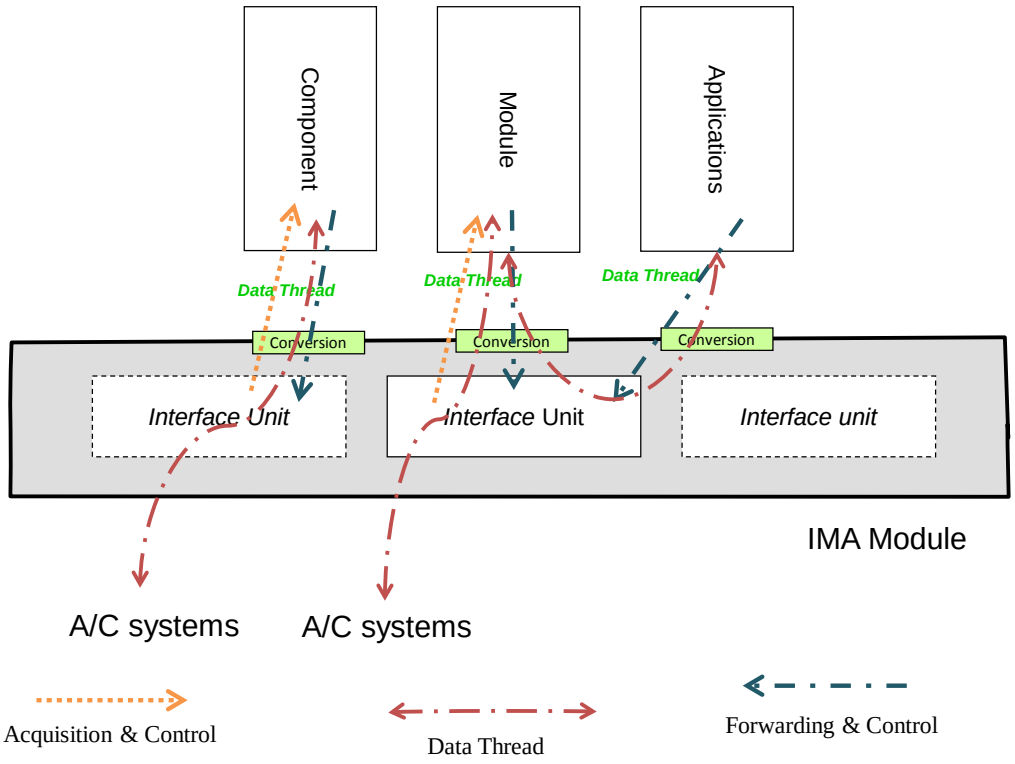
This intended function is Information Sharing composed of:

- information acquisition & control,
- information conversion, and
- information forwarding & control.

The information-forwarding and control function is the means that allows sharing information between components, modules, and/or the Hosted applications.

The following figure provides an overview of the previously mentioned intended function and associated definitions:

Figure 3: IMA module overview for TSO-C153a CLASS IF



2. Requirements

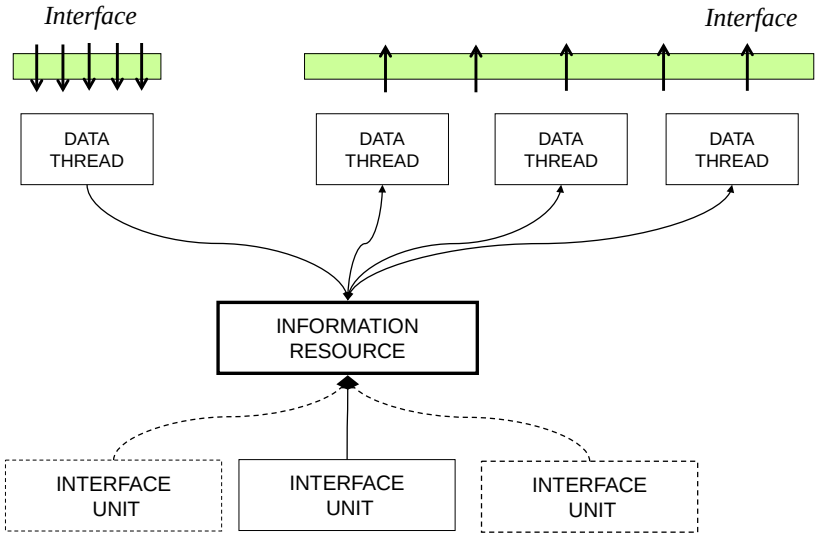
For TSO-C153a CLASS IF, IMA module provides shared resources for communication needs of the Hosted applications, modules, and/or components.

2.1. **Functional requirements for TSO-C153a CLASS IF:**

IF.a) The IMA module shall provide to Hosted applications, modules, and/or components Information Resource which has the capacity to acquire or to forward a set of data from/to an interface unit by performing the information coding and decoding operations.

IF.b) The IMA module shall provide to the Hosted applications, modules, and/or components the capacity to use shared Information Resource thanks to Data Threads handled through logical and/or physical interface(s).

Figure21: CLASS IF Interfaces (IF) elements relationship



1.1. Characterization requirements for TSO-C153a CLASS IF:

IF.c) All performances of the shared Interface Unit of the IMA module shall be characterized including but not limited to the following:

1. Performances of each Interface, including throughput, acquisition speed, forwarding speed, latency, jitter, coding rate, and decoding rate.
2. Performances of User Interface Mechanism(s), Protocol(s) and Service(s) (e.g., socket timing, communication port timing, technological time delay, etc.).
3. Performances of supported Data Thread Type (e.g., virtual link, channel, pipe-and-filter, physical connection pin, etc.).

Note: These performance requirements are additional to those applicable in COMMON - Appendix 2.1).

IF.d) In addition to Common Requirement CO.w), the characterization shall address the safety aspects of frozen data.

2. Verification procedures

The following table gives the verification method for each MPS; nevertheless, an alternative method may be proposed to the certification authority per section 3 h. of this TSO:

Table 6: Verification Acceptance Criteria for CLASS IF

Requirement identifier	Verification method	Test under normal conditions	Test under environmental conditions	Comment
IF.a)	T	Y	Y	
IF.b)	T	Y	Y	
IF.c)	T(A*)	Y	Y(1)	
IF.d)	T or A*			

(A*): means that verification by Analysis method is possible for the item that cannot be tested.

Note: Applicable for a functional subset → cf. CO.gg).

APPENDIX 2.7

INTEGRATED MODULAR AVIONIC PLATFORM MODULE MINIMUM PERFORMANCE STANDARD (MPS)

CLASS PS: Power Supply (PS)

1. Purpose and scope

1.1. Introduction

This Appendix contains Minimum Performance Standards (MPS) for CLASS PS Intended Function: Power Supply (PS)

These standards specify module characteristics that should be useful to designers, manufacturers, installers, and users of the module.

1.2. Definitions

For TSO-C153a CLASS PS, IMA module is a module - mounted into a rack or the rack itself - able to supply power received from aircraft electrical network to one or more hardware modules mounted in the same rack.

Following definitions are used:

- Power supply unit: set of physical components (hardware and or software) in charge of managing a power supply (or a part of the power supply) resource.
- Power supply resource: obtained electrical energy from aircraft electrical network to be distributed to electrical loads which are modules mounted into the rack
- Power rail: part of supplied electrical energy for which a level of isolation would be guaranteed by the IMA module.
- Mounted: refers to another hardware module, installed and fixed inside the IMA Rack Module, after a human operation.
- Slot: a physical space inside the Rack Module, allocated to one hardware module
- Hold-up Capacity: The capacity of the power supply to continue supplying output current after the input voltage drops below the minimum level. This is usually expressed as the time from the input voltage drop to the reset generated by the power supply to the processor.
- Output Current Capacity: The continuously operating maximum current supplied for each output voltage.
- Power Monitors & Status Outputs: Separate circuitry which checks the output voltage levels and current loading of the power supply. This circuitry will generate one or more binary signals that may be connected to the processor to alert it to the “out of spec” condition. These binary signals may also force the power supply to shut-down to prevent damage to power supply components.
- Power Resets: A binary signal output from the power supply that is asserted when the output voltages are outside acceptable tolerances.

- Regulation: The percentage of variation of the output voltages when subjected to changes in load, changes in temperature, and all input voltage transients and deviations.
- Transient Immunity: The ability of the power supply to continue operating normally during variations in the input voltage. This is usually expressed as the length of time and the voltage level of the transient.
- Voltage Outputs and Tolerances: The voltage levels and tolerances of the outputs produced by the power supply.

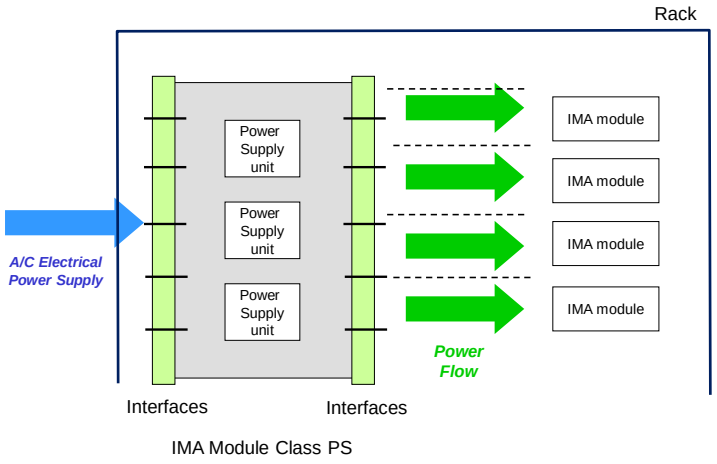
In the context of PS class, the “concurrent item” defined in Appendix 2.1 paragraph 1 means ‘Power Rail’.

1.3. Intended Function

For TSO-C153a CLASS PS, the intended function is to provide the capability to share Power Supply resource(s) supplied by one or more Power Supply unit(s).

The following figure provides an overview of the previously mentioned intended function and definitions where A/C is aircraft:

Figure 22: IMA module overview for TSO-153c CLASS PS



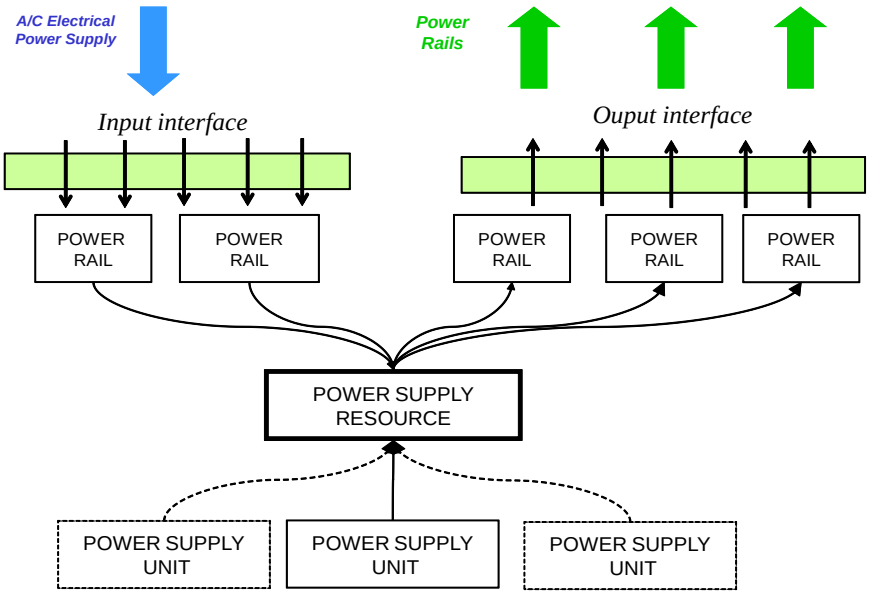
2. Requirements

2.1. Functional requirements for TSO-C153a CLASS PS:

PS.a) The IMA module shall provide to hardware modules, mounted into the same rack, Power Supply Resource which has the capacity to deliver a quantity of electrical energy from the power supply unit(s) to the hardware modules while performing the regulation operations.

PS.b) The IMA module shall provide to hardware modules, which are mounted into the same rack, the capacity to share power supply resource on power rails accessible through physical interface(s).

Figure23: CLASS PS (PS) elements relationship



2.2. Characterization requirements

PS.c) All Power Supply performances of the shared Power Supply Unit of the IMA module shall be characterized including but not limited to the following:

1. Needed input power budget characteristics (e.g., in function of Temperature and load)
2. Performances of Output Current and Tolerances;
3. Performances of Hold-up Capacity;
4. Performances of Power Monitors and Status Outputs;
5. Performances of Power Resets;
6. Performances of Regulation;
7. Performances of Transient Immunity;
8. Performances of Voltage Outputs and Tolerances;
9. Performances of User Interface Mechanism(s), Protocol(s) and Service(s);
10. Performances of supported Power rail Type;
11. Input and Output impedance;
12. Capacitive load

Note: These performance requirements are additional to those applicable and dictated by the design of IMA module itself (according to COMMON Requirement in Appendix 2.1).

PS.d) In addition to Common Requirement CO.w), the characterization shall address the safety aspects of events such as too low voltage or current, and too high voltage or current. Transient as well as permanent effects shall be characterized if relevant.

PS.e) The characterization shall provide any data needed to evaluate power profile characteristics (e.g., Maximum Value, In-Rush current) of managed power rails and IMA module power on/power off behavior characteristics.

3. Verification procedures

The following table gives the verification method for each MPS; nevertheless, an alternative method may be proposed to the certification authority per section 3 g. of this TSO:

Table 7 Verification Acceptance Criteria for CLASS PS)

Requirement identifier	Verification method	Test under normal conditions	Test under environmental conditions	Comment
PS.a)	T	Y	Y	
PS.b)	T	Y	Y	
PS.c)	T(A*)	Y	Y(1)	
PS.d)	T(A*)	Y		
PS.e)	A			

(A*): Means that verification by Analysis method is possible for the items that cannot be tested.

Note: Applicable for a functional subset → cf. CO.gg).

APPENDIX 2.8

INTEGRATED MODULAR AVIONIC PLATFORM MODULE MINIMUM PERFORMANCE STANDARD (MPS)

CLASS DH: Display Head

1. Purpose and scope

1.1. Introduction

This Appendix contains Minimum Performance Standards (MPS) for CLASS DH Intended Function: Display Head.

These standards specify characteristics that should be useful to designers, manufacturers, installers, and users of the module.

1.2. Definitions

For TSO-C153a CLASS DH, IMA module provides shared resources in terms of display area between the Hosted applications, components, and/or modules.

The following definitions are used:

- Display Unit: Set of physical components (hardware and/or software) in charge of managing a display area (or a part of a display area).
- Display Area: Surface where some visual information can be depicted by one or several Display Unit(s) based on received Graphical Threads.
- Graphical Thread: Set of graphical information received as input by the Display Head from one or more IMA Application(s), component(s) and/or module(s).
- Display Thread: Set of depiction information for which level of isolation would be guaranteed on the Display Area by the Display Head.

In the context of DH class, the ‘Concurrent item’ defined in Appendix 2.1 paragraph 1 means ‘Display Thread’.

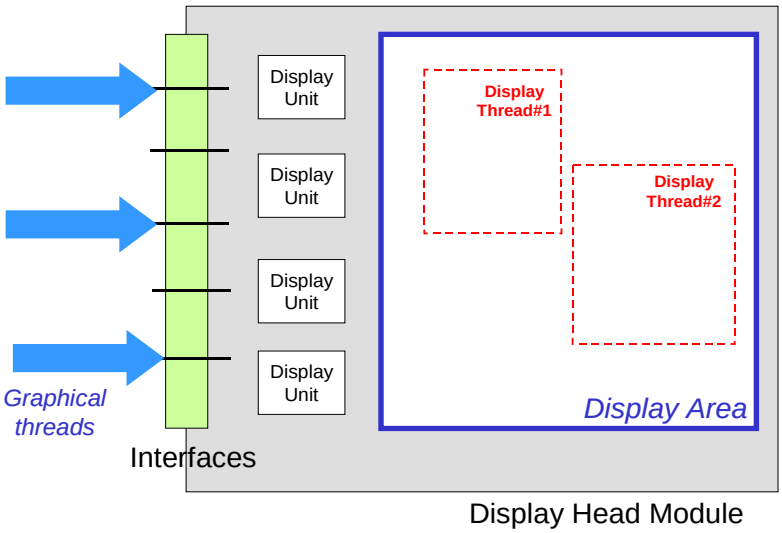
1.3. Intended Function

For TSO-C153a CLASS DH, the intended function is to provide the capability to share one display area supplied by one or several display unit(s).

The intended function of such IMA module is to offer the capability to depict graphical information received from IMA Application(s), component(s) and/or module(s) on one Display Area.

The following figure provides an overview of the previously mentioned intended function and associated interfaces:

Figure 24: IMA module overview for TSO-C153a CLASS DH



2. Requirements

2.1. Functional requirements for TSO-C153a CLASS DH:

DH.a) The IMA module shall provide the Hosted applications, modules and/or components Display Area Resource that has the capability to render visual graphical information.

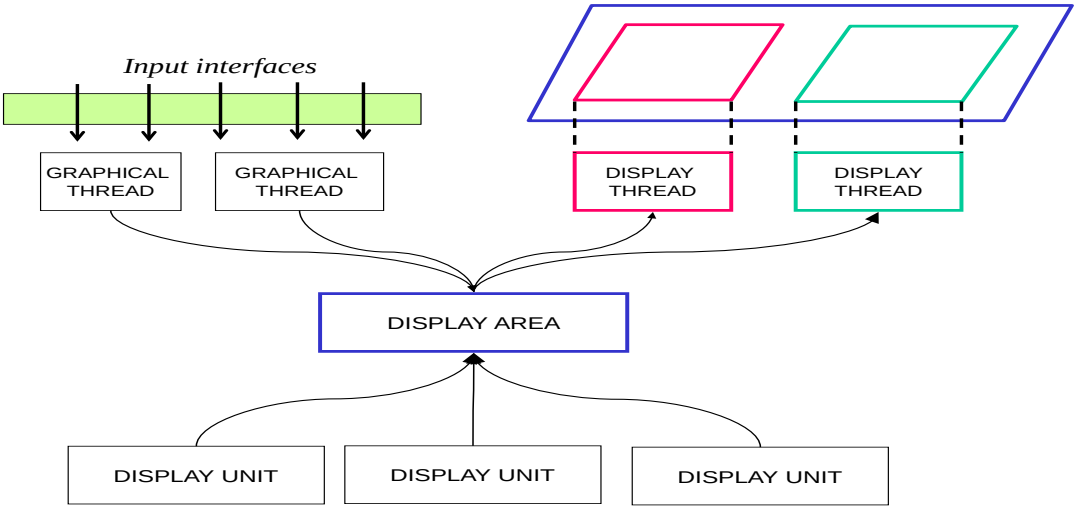
DH.b) The IMA module shall be compliant (fully or partially) to MPS from applicable release of TSO-C113.

Note 1: These performance requirements are additional to those applicable in COMMON - Appendix 2.1.

Note 2: For Display Head module without Graphics generation function, compliance demonstration to some TSO-C113 requirements might not be possible. In such cases the applicant shall submit in the compliance data package the list of requirements that requires further demonstration to TSO-C113 requirements with relevant justification.

DH.c) The IMA module shall provide to the Hosted applications, modules, and/or components, the capability to share a Display Area resource **that is managed** through a logical or physical interface.

Figure 25: CLASS DH Display Head elements relationship



2.2. Characterization requirements for TSO-C153a CLASS DH:

DH.d) In addition to Common Requirement CO.w), the characterization shall address the safety aspects of delay and/or frozen information.

DH.e) In addition to Common Requirement CO.s), the characterization shall include any data needed to evaluate Worst Case Display Elaboration Time of managed threads and characteristics required by applicable release of SAE AS8034 (per applicable revision of TSO-C113).

DH.f) The additional activities performed by the user related to the applicable release of TSO-C113 compliance demonstration completeness shall be included in the characterization for gap identification.

3. Verification procedures

The following table gives a verification method for each MPS; nevertheless, an alternative method may be proposed to the certification authority per section 3 h. of this TSO:

Table 8: Verification Acceptance Criteria for CLASS DH

Requirement identifier	Verification method	Test under normal conditions	Test under environmental conditions	Comment
DH.a)	T	Y	Y	
DH.b)	(2)	(2)	(2)	
DH.c)	T	Y	Y	
DH.d)	T/A*	Y		
DH.e)	A			
DH.f)	A			

(A*): Means that verification by Analysis method is possible for the item that cannot be tested.

Note 1: For the functional subset see CO.gg).

Note 2: Applicable revision of TSO-C113 is defining the verification requirements of a display function.

APPENDIX 3

INTEGRATED MODULAR AVIONIC MODULE DATA REQUIREMENTS

For IMA module authorization, as mentioned in paragraph 2.2 of the core document, additional technical data shall be available or submitted. This data will be documented into a set of documents for the TSO authorization (qualification plans, compliance evidences, etc.) and for the IMA module users such as Application developers, Integrator, or Type Certificate applicant (User Guide, Usage domain, etc.) in the following format:

- Chapter 1 - IMA module DO-297 documentation
- Chapter 2 – Specific User Guide and Installation Manual contents
- Chapter 3 – Core software
- Chapter 4 – Health management and reporting
- Chapter 5 – Usage domain
- Chapter 6 – Configuration
- Chapter 7 – Tools
- Chapter 8 – Compatibility & mix ability information

Chapter 1 – IMA module DO-297 documentation

IMA system approval can be made incremental by introducing intermediate acceptance steps. TSO-C153a authorization is a first intermediate step dedicated to authorize IMA platform or IMA modules (independent of any specific aircraft installation).

RTCA DO-297 contains guidance for Integrated Modular Avionics (IMA) developers, application developers, integrators, certification applicants, and those involved in the approval and continued airworthiness of IMA systems in civil certification projects.

To prepare the integration of the TSO-C153a IMA module, consider the Task 1 development objectives that are defined in RTCA DO-297 (Table A-1 objectives).

The following data are available (A) or submitted (S) as part of the TSO-C153a authorization data package:

Table 9: DO-297 List of Documentation

RTCA DO-297 Life Cycle Data	RTCA DO-297Life Cycle Section	Available/Submitted (A)/ (S)
Module Acceptance Plan	4.2.3	S
Module Requirements Standards	4.2.4	A
Traceability Data	4.2.5	A
Module Design Data	4.2.4	A

RTCA DO-297 Life Cycle Data	RTCA DO-297Life Cycle Section	Available/Submitted (A)/ (S)
Module Failure Analyses and Safety Analyses	4.2.12b	S
Module Tool Qualification Data	4.2.12c	S
Partitioning Analysis Data (1)	4.2.4i	S
V&V data	4.2.5	A
Module Acceptance Data Sheet	4.2.10	S
Interface Standards	4.2.4f	A
Module User Guide	4.2.12e	S(2)
Module QA Records	4.2.6	A
Module CM Records	4.2.8	A
Module Acceptance Accomplishment Summary	4.2.9	S
Module Acceptance Configuration Index	4.2.7	S
Module Open Problem Reports	4.2.11	S

Note 1: This Partitioning Analysis shall include the verification results obtained for demonstration of compliance of CO.e), CO.f), CO.g), CO.h).

Note 2: Only for User Guide content used for TSO compliance demonstration.

Chapter 2 – Specific User Guide and Installation Manual contents

As provided in DO-297, IMA module User's guide shall be provided by the IMA module manufacturer to both the module users and the FAA.

This User Guide includes all information for users, integrators, and certification applicants to successfully interface or integrate the module such:

- Guaranteed behavior and characteristics in accordance with CO.k
- System Interfaces (including physical mapping of Interface)
- Limitations and Open Problem Reports (OPRs) (1) (including tools)
- Worst Case Execution Time (WCET) analysis elements
- Applicable Failure Mode Effect Analysis / Failure Mode Effect Summary (extracts) necessary for higher level safety analysis
- Core Software (see Appendix 3 – Chapter 3)
- Fault management and Health Monitoring (See Appendix 3 – Chapter 4)
- Usage Domain (See Appendix 3 – Chapter 5)
- Configuration Aspects (See Appendix 3 – Chapter 6)
- Tools Aspects (See Appendix 3 – Chapter 7)
- Compatibility and mix ability information (See Appendix 3 – Chapter 8)

- Remaining activities to be conducted by Module user to complete the IMA module qualification (Environment, etc.)
- Requirements recommendations for Applications (e.g., data for the qualification of the application, service available for applications, etc.)
- Requirements recommendations for System Integration

Note: (1) A detailed description of IMA module Open Problem Report (OPR) root cause and effect is necessary to support the IMA Module user and aircraft manufacturer in their assessment of the effect of OPR on the aircraft function.

The Installation Manual includes all data necessary for the proper installation and use of the IMA module (including marking aspects).

Each item of the characterization and functional requirements are addressed in the User Guide (or possibly in the Installation Manual, if appropriate).

The User Guide defines the usage domain for which the module acceptance data are valid.

The information includes recommendations and may also include examples for correct use. In addition, the guide highlights any warnings or limitations for integrating or interfacing the module to avoid potential incorrect or unintended use.

The User Guide may be completed by the IMA module manufacturer with:

- Information on Single Event Upset (SEU) effects;
- A Validation and Integration Kit for application developers and system integrators;
- Development and In-Service support;
- Some training.

The Installation Manual includes information as required in MPS appendix or reference subsequent applicable chapter of the User Guide. In this case, the User Guide chapter will be submitted to the Airworthiness Authority (see note (1) above).

The User Guide may be included in the Installation Manual of the IMA module (e.g., Annexes) or a separated document referenced by the Installation Manual.

Chapter 3 - Core software

As defined in Appendix 1, IMA module may be an association of Hardware and Core Software.

The Core Software is constituted by the operating system and the support software that manage resources to provide an environment in which the intended function is performed. Core software is typically comprised of one or more component(s). Core Software may be resident or a Field-Loadable Software Part.

If IMA module contains Core Software, Core Software characteristics required by CO.r) in Appendix 2 are documented in the IMA module User Guide.

Chapter 4 - Health management and reporting

Data requirement related to Health Management and reporting is listed in CO.x).

Chapter 5 - IMA module usage domain

TSO-C153a authorization relies on the concept of Usage Domain (See Appendix 1 - Chapter 2 Definitions).

The usage domain is defined at the IMA module level, and used at the Application and IMA system level. The definition of the usage domain includes consideration of the module functionality, performance, and safety requirements, and its required environmental performance.

Pursuant to 14 CFR parts 23, 25, 27, and 29, IMA modules manufactured to comply with TSO-C153a may be used to support other TSOs or systems. These TSO authorizations, IMA system approvals, and aircraft-level approvals are not covered by TSO-C153a but will rely on the fact that compliance with Usage Domain documented in the User Guide is correctly implemented.

Chapter 6 - Configuration

IMA modules may need to be configured before installation in the IMA system (See RTCA DO-297 Task 2, 3, and 4).

Data requirement related to configurability are listed in CO.y) in Appendix 2.

Chapter 7 - Tools

IMA modules may need to use some tools during installation in the IMA system (See RTCA DO-297 Task 2, 3, and 4). These tools may be used by:

- Application developers,
- Integrator(s),
- Type Certificate (TC) or Supplemental Type Certificate (STC) Applicant.

These tools may address:

- Software development (Hosted applications);
- Configuration development;
- Network architecture and configuration;
- Debug, data-loading;
- WCET analysis and measures;

In cases where tools are used, the User Guide shall reference each tool and the data listed in Appendix 2 CO.z). Qualification data are considered as data to be submitted to the FAA as part of the TSO C-153a authorization.

Chapter 8 - Compatibility and mix ability information

The IMA module manufacturer provides compatibility and mix ability information between hardware, software, tools, and usage domain in the User Guide, as required per Appendix 2 CO.aa).

APPENDIX 4

INTEGRATED MODULAR AVIONIC MODULE ENVIRONMENTAL QUALIFICATION REQUIREMENTS

Perform Environmental testing in accordance with the appropriate revision to RTCA DO-160.

For TSO-C153a, certain aspects have to be addressed:

- The Test Software representativeness,
- The Applicable Test Procedures,
- The Parameters needing monitoring during the Environmental Qualification Test.

Chapter 1: Test Software representativeness

In the case where an IMA module is qualified without the functional software installed and operating, engineering analysis from the manufacturer must determine that the Test Software (not the target functional software) is representative of the usage domain stress envelope for the environmental tests (i.e. dissipated temperature, power consumption, radiated field radiation, etc.)

Develop Test Software to require the Hardware to perform the environmental tests in the worst-case conditions. The Test Software must evaluate the Hardware in its most sensitive configurations in order to evaluate the robustness of the IMA module over the full Usage Domain. For example, Test Software should exercise all physical interfaces with the maximum number of applications or input, with the filter values, set to the domain boundary which would be the most transparent to input electrical interferences.

Chapter 2: Applicable Test Procedures

For TSO-C153a authorization, an IMA module may be a single LRU platform or may be a module located into a Rack (Line Replaceable Module).

Depending on the IMA module characteristics, consider one of the listed cases:

- Case 1: The IMA module is a single LRU platform,
- Case 2: The IMA module is a module designed to be located in a Rack at installation.

> **Note:** Rack Housing module is not addressed in this generic appendix but is addressed in Appendix 2.2 Class RH - Rack Housing.

Chapter 2.1: The IMA module is a single LRU platform

In this case, the environmental sections defined in the Table below are applicable to the IMA module.

The usage domain of IMA module must be defined and maintained so that all these environmental qualification tests produce a complete credit for other functional TSOs authorization at the Type-Certificate level.

Figure 26 Environmental Qualification for TSO-C153a in case of single LRU platform

Environmental Test	DO-160section	Requirement for TSO-C153a
Temperature	4.5	Mandatory
Altitude	4.6	Mandatory
Temperature Variation	5.0	Mandatory
Humidity	6.0	Mandatory
Shock (operational)	7.2	Mandatory
Shock (Crash Safety)	7.3	Optional
Vibration	8.0	Mandatory
Explosion Atmosphere	9.0	Optional
Waterproof	10.0	Optional
Fluids Susceptibility	11.0	Optional
Sand and Dust	12.0	Optional
Fungus Resistance	13.0	Optional
Salt Fog	14.0	Optional
Magnetic Effect	15.0	Mandatory
Power Input	16.0	Mandatory
Voltage Spike	17.0	Mandatory
Audio Frequency Conducted Susceptibility—Power Input	18.0	Mandatory
Induced Signal Susceptibility	19.0	Mandatory
Radio Frequency Susceptibility (Radiated and conduced)	20.0	Mandatory
Emission of Radio Frequency Energy	21.0	Mandatory
Lightning Induced Transient Susceptibility	22.0	Mandatory
Lightning Direct Effects	23.0	Optional
Icing	24.0	Optional
Electro Static Discharge (ESD)	25.0	Mandatory
Fire, Flammability	26.0	Mandatory

Chapter 2.2: The IMA module is a module designed to be located into a Rack at installation or the rack itself.

In this type of installation, only a minimal subset of environmental conditions is applicable to the IMA module. This minimal subset is defined as mandatory in the table below (See Figure 27.)

Test sections identified as optional are not required for TSO-C153a application, but may be subjected to these test conditions on a voluntary basis. When optional sections are not tested, they shall be marked as X.

Complete the Environmental Qualification Testing after the cabinet integration in the frame of other TSO authorizations (functional ones) and during Type Certificate.

Define and maintain the usage domain of the IMA module to allow the subset of qualification tests to provide credit for other TSOs authorization and Type-Certificate programs.

It is acceptable to perform the environmental qualification on the intended rack installation equipped with mounted IMA module(s). The TSO-C153a IMA module should be set in worst-case configurations. Doing so, the set of Qualification documents (Qualification Test Plans, Procedures and Reports) may be common to the rack and module TSO-C153a authorizations. These documents should demonstrate that the considered configurations (which may be different depending on RTCA DO-160 section) are the worst-cases for the set of authorized configurations of modules within the rack. Whatever the qualification method, the authorized configuration should be specified in the installation manual(s).

Such documented authorized configurations include any installation limitations taken as hypothesis for Environmental Qualification Testing (rack part number(s), slot number(s), blade neighborhood(s), and temperature to be guaranteed) to be specified in the Installation Manual and respected by the integrator to take credit of the Environmental Qualification Testing performed at module level.

Figure 4 Environmental Qualification Testing minimum subset
for TSO-C153a in case of Cabinet architecture

Environmental Test	DO-160 section	Requirement for TSO-C153a
Temperature	4.5	Mandatory When module performance over environmental conditions is dependent on the host rack, it is the responsibility of the applicant to adapt DO-160DO-160 temperature high and low values and temperature variations cycle to the intended IMA module installation context.

Environmental Test	DO-160 section	Requirement for TSO-C153a
		For example, in case of temperature testing (RTCA DO-160 DO-160 section 4.0), the temperature environment of the module (inside a rack) may be much higher or lower than the equipment level condition expressed in RTCA DO-160 DO-160 section 4.0. The applicant may therefore qualify their IMA module based on a chosen intended environment, and, finally, indicate in the installation manual the temperature range for which the good operation of the IMA module is guaranteed.
Altitude	4.6	Mandatory
Temperature Variation	5.0	Mandatory As for section 4.5, when module performance over environmental conditions is dependent on the host rack, it is the responsibility of the applicant to adapt DO-160DO-160 temperature high and low values and temperature variations cycle to the intended IMA module installation context. As for section 4.5, for example, in case of temperature testing (RTCA DO-160 DO-160 section 4.0), the temperature environment of the module (inside a rack) may be much higher or lower than the equipment level condition expressed in RTCA DO-160 DO-160 section 4.0, the applicant can qualify their IMA module based on a chosen intended environment, and, finally, indicate in the installation manual the temperature range for which the good operation of the IMA module is guaranteed.
Humidity	6.0	Mandatory
Shock (operational)	7.2	• This testing is not performed as part of this TSO. • Mark the TSO environmental qualification form Category X (not tested) for this section. • Perform these tests as part of a functional TSO application or as part of a type certification program.
Shock (Crash Safety)	7.3	To mark the TSO environmental qualification form for this section: • The manufacturer must install equivalent weights or actual modules in all module positions. • Since applying crash safety tests may damage

Environmental Test	DO-160 section	Requirement for TSO-C153a
		equipment under test, this test may be conducted last.
Vibration	8.0	• This testing is not performed as part of this TSO. • Mark the TSO environmental qualification form Category X (not tested) for this section. • Perform these tests as part of a functional TSO application or as part of a type certification program. **Note:** the IMA module technology should be assessed for further DO-160DO-160 vibration qualification. This preliminary assessment could consider the IMA module components technology diversity, integration density and number of layers of the circuit boards within the IMA module. The assessment could be confirmed with testing on a module representative of the IMA module technology used in the product under certification. This preliminary assessment under vibration of the IMA module technology doesn't constitute a credit of the qualification testing of the module integrated into the rack.
Explosion Atmosphere	9.0	• This testing is not performed as part of this TSO. • Mark the TSO environmental qualification form Category X (not tested) for this section. • Perform these tests as part of a functional TSO application or as part of a type certification program
Waterproof	10.0	• This testing is not performed as part of this TSO. • Mark the TSO environmental qualification form Category X (not tested) for this section. • Perform these tests as part of a functional TSO application or as part of a type certification program
Fluids Susceptibility	11.0	• This testing is not performed as part of this TSO. • Mark the TSO environmental qualification form Category X (not tested) for this section. • Perform these tests as part of a functional TSO application or as part of a type certification program
Sand and Dust	12.0	• This testing is not performed as part of this TSO. • Mark the TSO environmental qualification form Category X (not tested) for this section. • Perform these tests as part of a functional TSO application or as part of a type certification program
Fungus Resistance	13.0	• This testing is not performed as part of this TSO. • Mark the TSO environmental qualification form Category X (not tested) for this section.

Environmental Test	DO-160 section	Requirement for TSO-C153a
		• Perform these tests as part of a functional TSO application or as part of a type certification program
Salt Fog	14.0	• This testing is not performed as part of this TSO. • Mark the TSO environmental qualification form Category X (not tested) for this section. • Perform these tests as part of a functional TSO application or as part of a type certification program
Magnetic Effect	15.0	• This testing is not performed as part of this TSO. • Mark the TSO environmental qualification form Category X (not tested) for this section • Perform these tests as part of a functional TSO application or as part of a type certification program
Power Input	16.0	Mandatory for IMA module interfaces directly connected to aircraft power distribution. **Note:** IMA module interfaces not directly connected to aircraft power distribution will be tested after cabinet integration phase as part of another TSO application or as part of a Type-Certification program.
Voltage Spike	17.0	Mandatory for IMA module interfaces directly connected to aircraft power distribution. **Note:** IMA module interfaces not directly connected to aircraft power distribution will be tested after cabinet integration phase as part of another TSO application or as part of a Type-Certification program.
Audio Frequency Conducted Susceptibility—Power Input	18.0	Mandatory for IMA module interfaces directly connected to aircraft power distribution. **Note**: IMA module interfaces not directly connected to aircraft power distribution will be tested after cabinet integration phase as part of another TSO application or as part of a Type-Certification program.
Induced Signal Susceptibility	19.0	Mandatory for IMA module interfaces directly connected to aircraft wiring. **Note:** IMA module interfaces not directly connected to aircraft wiring will be tested after cabinet integration phase as part of another TSO application or as part of a Type-Certification program.
Radio Frequency Susceptibility (Radiated and conducted)	20.0	Mandatory for conducted susceptibility of IMA module interfaces directly connected to aircraft wiring.

Environmental Test	DO-160 section	Requirement for TSO-C153a
		Note: IMA module interfaces not directly connected to aircraft wiring will be tested after cabinet integration phase as part of another TSO application or as part of a Type-Certification program.
Emission of Radio Frequency Energy	21.0	Mandatory for conducted emission of IMA module interfaces directly connected to aircraft wiring. **Note:** IMA module interfaces not directly connected to aircraft wiring will be tested after cabinet integration phase as part of another TSO application or as part of a Type Certification program.
Lightning Induced Transient Susceptibility	22.0	Mandatory for IMA module interfaces directly connected to aircraft wiring. **Note:** IMA module interfaces not directly connected to aircraft wiring will be tested after cabinet integration phase as part of another TSO application or as part of a Type Certification program.
Lightning Direct Effects	23.0	• This testing is not performed as part of this TSO. • Mark the TSO environmental qualification form Category X (not tested) for this section. Perform these tests as part of a functional TSO application or as part of a type certification program
Icing	24.0	• This testing is not performed as part of this TSO. • Mark the TSO environmental qualification form Category X (not tested) for this section. • Perform these tests as part of a functional TSO application or as part of a type certification program
Electro Static Discharge (ESD)	25.0	Mandatory for all areas subject to human contact during IMA module operation.
Fire, Flammability	26.0	Mandatory

Chapter 3: MPS compliance during Environmental Qualification Testing

When required by the test condition and procedure (by 'DETERMINE COMPLIANCE WITH EQUIPEMENT PERFORMANCE STANDARDS' statement), IMA module manufacturers must determine compliance with the MPS as defined in column 'Test under environmental conditions' of each individual class in Appendix 2:

Figure 5 - MPS verification under environmental conditions

MPS CLASS	MPS paragraph under Environmental Qualification Testing
All Classes (Common)	Appendix 2.1 paragraph 5
RH (Rack)	This Appendix 4 is not applicable to this class. See Appendix 2.2 paragraph 3 columns 'Test Under Environmental conditions' and 'Applicable DO-160DO-160 sections'.
PR (Processing)	Appendix 2.3 paragraph 3
GP (Graphical Processing)	Appendix 2.4 paragraph 3
DS (Data Storage)	Appendix 2.5 paragraph 3
IF (Interface)	Appendix 2.6 paragraph 2
PS (Power Supply)	Appendix 2.7 paragraph 3
DH (Display Head)	Appendix 2.8 paragraph 6