# EQUIPMENT TECHNICAL SPECIFICATION

## Deliverable: WP7.1.2a2

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|---|---|
| **EQUIP. SPEC. N°**: | X27SP1244250 |
| **A/C EFFECTIVITY**: | A320 / NSA |
| **SYSTEM**: | FLIGHT CONTROLS |
| **EQUIPMENT**: | SPOILER ROTARY EMA |
| **SUPPLIER**: | UTC ACTUATION SYSTEMS |
| **AIRWORTHINESS CATEGORY** : | CRITICAL |

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SIGNATURE:

| Purchaser | Supplier |
|---|---|

# RECORD OF REVISIONS

| ISSUE | DATE | EFFECT ON | | REASONS FOR REVISION |
|---|---|---|---|---|
| | | PAGE | PARA | |
| 1.0 | 13/12/2013 | | | First issue – Deliverable Number WP7.1.2a1 |
| 2.0 | 13/02/2014 | | | Second issue - Deliverable Number WP7.1.2a2 |

# TABLE OF CONTENTS

# Introduction

Airbus is currently engaged in a R&T effort to prepare for the Primary Flight Control Actuation the Electromechanical Actuator (EMA) and the centralized actuation electronic (APMU) technologies.

The studies objectives are:

- The demonstration of EMA technology maturity,
- The electrical actuators reliability improvement,
- The system weight saving,
- The electrical actuators cost reduction.
- The power management optimisation of flight control actuation,

The All-Electric Aircraft is a major target for the next generation of aircraft to lower consumption of non-propulsive power and thus fuel burn.

To remove hydraulic circuits, pumps and reservoirs, EMA technology is promising but need to be optimized to meet the aircraft manufacturer requirements (performances, lifetime, reliability, weight, space envelop, cost,…).

The WP7 GENOME objectives are to bring APMU and EMA family (Linear and Rotary) to the maturity TRL6.

This document is associated to the Deliverable Number WP7.1.2a2 of the GENOME project.

Nota:

This technical specification is achieved on the basis of All Electric Aircraft type NSA and applicable For the A320 demonstration platform:

- o The specific requirements are defined in this technical specification and identified by (*) *Italic,*
- o The ECU functions shall be integrated inside the APMU. Impacts on requirements are clarified in ACTUATION 2015 specifications “Power Drive Electronics Module Technical Specification” ref. 2015-AI-F-DEL.D16.19-001-R4.1 and “D16.18.S2 – Standard Motor Technical Specification (Size 2)” ref. A2015-AI-F-DELD16.18.S2-001-R2.1).

# 1 General Requirements

## 1.1 Purpose/Scope/Objectives

The first purpose of this specification is to define the technical requirements and design data applicable to the actuator to be used to power the main primary surfaces of the flight control system studied into CORAC GENOME project.

The description of the unit shall be:

**SPOILER ROTARY ELECTRO-MECHANICAL ACTUATOR (EMA)**

All **TBA** shall be answered by the manufacturer.

The equipment, the Supplier and the processes applied must comply with ABD0100 and any applicable documents.

This document is considered to be the property of AIRBUS and the equipment manufacturers are requested not to disclose the information contained into the document. The equipment manufacturer responses will be treated with same degree of confidentiality by AIRBUS.

## 1.2 Terms, Definitions and Abbreviations

- **Terms and definitions :**

The symbol § is used to indicate a section or a paragraph.

Variant: Is a specific model definition, e.g. modified design weight.
Model: Designates a series with a particular engine installation.
Series: Designates specific structure and system design characteristics within an aircraft type, e.g.: A310-200, A310-300, etc.

To control torques means to maintain resistive torques at a fixed EMA position (static cases).
To generate torques means to actuate resistive or aiding torques under EMA speed required (dynamic cases).

The use of "shall", "should", "must", "will" and "may" within the PTS shall observe the following rules:

- The word SHALL in the text denotes a mandatory requirement of the PTS. Deviation from such a requirement is not permissible without formal agreement.
- The word SHOULD in the text denotes a recommendation or advice on implementing such a requirement of the document. Such recommendations or advice is expected to be followed unless good reasons are stated for not doing so.

- The word MUST in the text is used for legislative or regulatory requirements (e.g. Health and Safety) and shall be complied with. It is not used to express a requirement of the PTS.
- The word WILL in the text denotes a provision or service or an intention in connection with a requirement of the PTS.
- The word MAY in the text denotes a permissible practice or action. It does not express a requirement of the PTS.

➢ **Abbreviations:**

| | |
|---|---|
| A/C | Aircraft |
| ABD | Airbus Directive and Procedure |
| APMU | Actuator Power Management Unit |
| ATP | Acceptance Test Procedure |
| BC | Bus Controller |
| CDR | Critical Design Review |
| CMS | Code Matière Société |
| CoG | Centre of Gravity |
| COTS | Component Off The Shelf |
| CPU | Central Processing Unit |
| CRI | Certification Review Item |
| DAL | Development Assurance Level |
| DDP | Declaration of Design and Performance |
| DDR | Detailed Design Review |
| ECU | Electronic Control Unit |
| EFCS | Electric Flight Control System |
| EM | Electric Motor |
| EMA | Electromechanical Actuator |
| EMC | ElectroMagnetic Compatibility |
| EMI | Electro-Magnetic Interference |
| FC | Flight Cycle |
| FCC | Flight Control Computer |
| FCS | Flight Control System |
| FH | Flight Hour |
| FMEA | Failure Modes and Effects Analysis |
| FMES | Failure Modes and Effects Summary |
| FPGA | Field-Programmable Gate Array |
| FTA | Fault Tree Analysis |
| GBA | Gear Box Assembly |

| | |
|---|---|
| HIRF | High Intensity Radiated Field |
| HPE | High Power Electronics |
| HVDC | High Power Direct Current |
| H/W | Hardware |
| I/O | Input/Output |
| IEEE | Institute of Electrical and Electronic Engineers |
| LRI | In Line Replaceable Item |
| LRU | In Line Replaceable Unit |
| MFR | Supplier's Manufacturer Code |
| MME | Maintainability/Maintenance Evaluation |
| MTBF | Mean Time Between Failure |
| MTBUR | Mean Time Between Unscheduled Removals |
| M/H | Man-Hours |
| NFF | No Fault Found |
| NSR | New Short Range |
| NVM | Non Volatile Memory |
| N/A | Not applicable |
| PBS | Product Breakdown Structure |
| PCB | Printed Circuit Board |
| PFCS | Primary Flight Control System |
| P/N | Part Number |
| PNR | Part Number |
| POST | Power On Safety Test |
| PSSA | Preliminary System Safety Assessment |
| PTS | Purchaser Technical Specification |
| QTP | Qualification Test Procedure |
| QTR | Qualification Test Report |
| RAM | Random Access Memory |
| RT | Remote Terminal |
| SBTU | Speed Brake Transducer Unit |
| SDP | Supplier Development Plan |
| SER | Serial number |
| SES | Supplier Equipment Specification |
| SRU | Shop Replaceable Unit |
| SSA | System Safety Assessment |
| S/W | Software |

| | |
|---|---|
| **TBA** | To Be Answered (by the Supplier) |
| **TBC** | To Be Confirmed (and agreed with Supplier) |
| **TBD** | To Be Defined (and agreed with Supplier) |
| TN | Technical Note |
| UUT | Unit Under Test |

## 1.3 Language

The working language for all documentation, meetings and discussions shall be English Language using Aeronautical Terminology in common use, as requested in ABD0100.3.0 §1.2.

## 1.4 Contract authority

N/A

## 1.5 Supplier Response to the RFP (Answer / Offer document or SES)

N/A

## 1.6 Referenced and applicable documents

It is essential that the Supplier requests from the Purchaser any required information that is not already provided.

Under supplier request, the Purchaser will provide documents identified in this section except the external standards available on the market.

It should be noted that any referenced documents are for information only.

If a document is identified as applicable then the Supplier shall comply with it.

The requirements of this PTS have precedence over the ABDs. The ABDs have priority over any referenced International standards. Where conflict occurs between referenced documents the Supplier shall obtain clarification from the Purchaser.

### 1.6.1 Applicable documents

The equipment shall comply with the applicable documents listed in the following sub-section tables and any applicable documents referenced in them.

It is essential that the Supplier requests from the Purchaser any required information that is not already provided.

### 1.6.1.1 ABD100 (Parts 0 & 1) Product Related Documents

| ABD0100 MODULE | ISS | TITLE/CONTENT | APPLICABILITY |
|---|---|---|---|
| ABD0100 | I | General Table Of Content | Yes |
| ABD0100.0.0 | D | General | Yes |
| ABD0100.1.1 | E | General technical requirements applicable to all technical domains | Yes |
| ABD0100.1.2 | G | Environmental conditions and tests requirements associated to qualification | Yes |
| ABD0100.1.3 | E | Safety - reliability - requirements | Yes |
| ABD0100.1.4 | F | Maintainability requirements | Yes |
| ABD0100.1.5 | F | Off - aircraft test and testability requirements | Yes |
| ABD0100.1.6 | D | Materials requirements | Yes |
| ABD0100.1.7 | E | Mechanical requirements | Yes |
| ABD0100.1.8.1 | C | Electrical and installation requirements | Yes |
| ABD0100.1.9 | H | Electronic equipment design and parts requirements | Yes |
| ABD0100.1.10 | G | Software requirements related to product | Yes |
| ABD0100.1.11 | C | Optical and installation requirements | No |
| ABD0100.1.12 | B | Conventional instruments requirements | No |
| ABD0100.1.13 | A | Cabin requirements | No |
| ABD0100.1.14 | B | Obsolescence Management | Yes |
| ABD0100.1.15 | A | Supportability Engineering | Yes |
| ABD0100.1.16 | A | Functional Robustness | Yes |

### 1.6.1.2 ABD100 (Part 2) Design Process Related Document

| ABD0100 MODULE | ISS | TITLE/CONTENT | APPLICABILITY |
|---|---|---|---|
| ABD0100.2.1 | C | Purchaser-Supplier relations requirements | Yes |
| ABD0100.2.2 | F | Supplier organization requirements | Yes |
| ABD0100.2.3 | E | Equipment general design assurance process | Yes |
| ABD0100.2.4 | G | Software design assurance process | Yes |
| ABD0100.2.5 | D | Hardware design assurance process | Yes |
| ABD0100.2.6 | B | Sub-contracted item design assurance | Yes |
| ABD0100.2.7 | G | Design validation/verification process and reviews | Yes |
| ABD0100.2.8 | F | Formal qualification and Purchaser acceptance process | Yes |
| ABD0100.2.9 | G | Configuration management process | Yes |

| | | | |
|---|---|---|---|
| ABD0100.2.10 | A | Design quality assurance | Yes |
| ABD0100.2.11 | C | Electronic hardware design assurance process | Yes |

### 1.6.1.3 ABD100 (Part 3) Documentation Requirements

| ABD0100 MODULE | ISS | TITLE/CONTENT | APPLICABILITY |
|---|---|---|---|
| ABD0100.3.0 | H | Life Cycle data requirements | Yes |

### 1.6.1.4 ABD0200 Specific Guidelines

N/A.

### 1.6.1.5 Other ABD Documents

| DOCUMENT REFERENCE | ISS | TITLE/CONTENT | APPLICABILITY |
|---|---|---|---|
| ABD0012 | G | Suppliers – Tool and Test Equipment | Yes |
| ABD0013 | D | Equipment – Electrical Power Supply | Yes |
| ABD0024 | E | Aircraft MFR – Tool and Test Equipment | Yes |
| ABD0029 | C | Maintainability Requirements | Yes |
| ABD0031 | F | Fire worthiness Requirements Pressurized Section of Fuselage | No |
| ABD0046 | D | Units of Measurement | Yes |
| ABD0048 | C | Equipment Electronics Maintainability | Yes |

### 1.6.1.6 Other General Requirements Documents

| GRESS AP1013 | ISS | TITLE/CONTENT | APPLICABILITY |
|---|---|---|---|
| Module 0 | C | General | N/A |
| Module 1 | C | Project Management | N/A |
| Module 2 | C | Design Requirements and Directives | N/A |
| Module 3 | C | Engineering For Manufacturing | N/A |
| Module 4 | C | Supply Chain | N/A |
| Module 5 | C | Performance Metrics, Deliveries and Associated Services | N/A |
| Module 6 | C | Airline & Military Customer Support | N/A |
| Module 7 | C | General Documentation Requirement List | N/A |

#### 1.6.1.7 Quality Documents

| DOCUMENT REFERENCE | ISS | TITLE/CONTENT | APPLICABILITY |
|---|---|---|---|
| IQDA-09.26 | B | Duplicate inspection procedure | Yes |

#### 1.6.1.8 ARINC Documents

N/A.

#### 1.6.1.9 EUROCAE and RTCA Documents

| DOCUMENT REFERENCE | ISS | TITLE/CONTENT | APPLICABILITY |
|---|---|---|---|
| EUROCAE ED14/ R.T.C.A D0160 | G | Environmental Conditions and Test Procedures for Airborne Equipment | Yes |
| EUROCAE ED12/ R.T.C.A D0178 | B | Software Considerations in Airborne Systems and Equipment Certification | Yes |
| EUROCAE ED80/ R.T.C.A D0254 | - | Design Assurance guidance for Airborne electronic hardware | Yes |

#### 1.6.1.10 S.A.E. Documents

| DOCUMENT REFERENCE | ISS | TITLE/CONTENT | APPLICABILITY |
|---|---|---|---|
| SAE-ARP 4761 | 1996-12 | GUIDELINES AND METHODS FOR CONDUCTING THE SAFETY ASSESSMENT PROCESS ON CIVIL AIRBORNE SYSTEMS AND EQUIPMENT | Yes |
| SAE-ARP 4754 | - | Certification Considerations for Highly Integrated or Complex Aircraft System | N/A |
| SAE-AS 4111 | - | Validation test plan for the digital time division command/response multiplex data bus remote terminals | Yes |
| SAE-AS 4112 | - | Production test plan for the digital time division command/response multiplex data bus remote terminals | Yes |

#### 1.6.1.11 Military Standards

| DOCUMENT REFERENCE | ISS | TITLE/CONTENT | APPLICABILITY |
|---|---|---|---|
| MIL- STD 704 | E | Aircraft Electric Power Characteristics | Yes |
| MIL-STD-810 | F | Environmental Engineering | Yes |

| | | | |
|---|---|---|---|
| | | Considerations and Laboratory Tests | |
| MIL-STD-202 | | Electronic and Electrical components parts, test methods | Yes |
| MIL-I-81969 | | Plastic and Metal Tools | Yes |
| MIL-S-8879 | | Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification | Yes |
| MS-33540 | | Safety Wiring | Yes |
| MIL-HDBK-217 | | Reliability Prediction of Electronic Equipment | Yes |
| MIL-L-7808 | | Lubricating Oil, Aircraft Turbine Engine, Synthetic Base | Yes |

### 1.6.1.12 Regulations

Certification bases (FAR or CS and additional requirements) can be subject to changes until certification. In particular, additional special conditions (which constitute a new regulation) or interpretative materials (which define acceptable means of compliance to regulations) can be notified through CRIs and Issue papers. The rules to be applied are those notified at the time of the certification.

| ***DOCUMENT REFERENCE*** | ***ISS*** | ***TITLE/CONTENT*** | ***APPLICABILITY*** |
|---|---|---|---|
| CS 25 & advisory material | 4 | European Regulations (EASA) | Yes |
| FAR 25 & advisory material | 123 | US Regulations (FAA) | Yes |
| CRI-…**TBD** | - | EASA Certification Review Item | Yes |
| IP- … **TBD** | - | US Regulation (FAA Issue Paper) | Yes |
| CS AWO<br>For equipment linked with automatic pilot | | All Weathers Operation | Yes |
| JTSO- …**TBD** | | Joint Technical Standard Order | Yes |
| FAA TSO | | FAA Technical Standard Order | Yes |
| CS OPS | | CS Operational Regulation | Yes |
| FAR 121 | | US Operational Regulation | Yes |
| CS OPS | | European Operational Regulation (equivalent to FAR 121) | Yes |

### 1.6.1.13 Miscellaneous Documents

| ***DOCUMENT REFERENCE*** | ***ISS*** | ***TITLE/CONTENT*** | ***APPLICABILITY*** |
|---|---|---|---|
| AP2080 | C | Airbus Reference Language | Yes |
| AP2616 | B | Safety and Reliability Handbook | Yes |
| AP2027 | | Interchangeability process | Yes |
| AP2633 | B | Integration and Exchange of Simulation Models | Yes |
| A5000 | G | Manage Procedural Referential Documentation | Yes |
| AP2610 | C | Identification of Product Models and Parts | Yes |

| DOCUMENT REFERENCE | ISS | TITLE/CONTENT | APPLICABILITY |
|---|---|---|---|
| NSA 9000 | - | Identification plate | Yes |
| AM2212 | | Functional Item Number (FIN) | Yes |
| AM2232 | A mod 2 | CAD layers organization | Yes **(TBC)** |
| AM2226 | | Guideline for DMU exchange convention with equipment supplier | Yes **(TBC)** |
| EN3645 | P1 | Connectors, electrical, circular, scoop proof, triple start threaded coupling, operating temperature 175℃, or 200 ℃ continuous. | Yes |
| CSDD | | Common Support Data Dictionary | Yes |
| ABS2219 | - | Connectors, electrical, circular, plug, coupled by threaded ring, fire-resistant or non-fire-resistant, for high voltage, low pressure application.<br>Operating temperatures – 65℃ to 260℃ peak | Yes |
| ABS2220 | - | Connectors, electrical, circular, receptacle, coupled by threaded ring, fire-resistant or non-fire-resistant, for high voltage, low pressure application.<br>Operating temperatures – 65℃ to 260℃ peak | Yes |
| ABS2221 | - | Connectors, electrical, circular, scoop-proof, triple start threaded coupling.<br>Operating temperature 175℃ or 200℃ continuous. Non release plug with grounding ring | Yes |
| ABS2222 | - | Connectors, electrical, circular, scoop-proof, triple start threaded coupling.<br>Operating temperature 175℃ or 200℃ continuous. Wall-mount receptacle | Yes |
| ISO2669 | 2 | Environmental Tests for Aircraft Equipment - Part 3.2: Steady State Acceleration | Yes |
| ISO2671 | 1 | Environmental Tests for Aircraft Equipment - Part 3.4: Acoustic Vibration | No |
| ISO2685 | 2 | Aircraft – Environmental Test Procedure for Airborne Equipment – Withstanding to Fire in Designated Fire Zones | **TBD** |
| D05019086 | 1 | Special Requirements for A350 Equipment Design for Electrical Equipment, which is intended to be used in Carbon Fiter Composite Sections. | Yes |
| AM2257 | B | Method for modeling equipment in CATIA V5 | Yes |
| MM-00020 | | Convention d'échange de données numériques | Yes **(TBC)** |
| IEC TS62239 | - | Process Management for Avionics - Technical Specification for Preparing an Electronic Components Management Plan | Yes |
| FM0501594 | | Fault Detection Specification template | **TBD** |
| X00UG0500160 | 3 | MME User Guide | Yes |
| X00FM0500302 | 1 | Maintainability and Maintenance Evaluation document | Yes |
| V00RP0602539 | | Maintainability Standard Hand Tools List | Yes |
| N24RP1219645 | | Electrical Characteristics of HVDC load equipment - Summary | Yes |

#### 1.6.1.14 Complementary Specification Documents

To this PTS are associated the following complementary documents that will be provided by the Purchaser to the Supplier according to the program.

| | |
|---|---|
| CRI F7 | (Solid State Power Contactors) |
| ABS 1340 issue 2 | (electrical connectors) |
| NSA 936020 | (bonding jumper) |
| AP 2043 | (Consumable Material List) |
| V27ME0736372_V1 | (SABER model requirements) |
| V24RP0607448_V2 | (Electrical system virtual prototyping SABER model requirements) |
| V2790SP0706282 | (Application S/W language Specification) |
| Kit µAFD | Kit µAFDX |

### 1.6.2 Referenced Documents

| DOCUMENT REFERENCE | ISS | TITLE/CONTENT | APPLICABILITY |
|---|---|---|---|
| EUROCAE ED-94B /DO-248 | B | Final report for clarification of ED12B-DO178B | Yes |

### 1.6.3 Guideline Documents

The documents listed hereafter are given as guidelines. Their use by the Supplier is not mandatory, unless specified.

| DOCUMENT REFERENCE | Iss | TITLE/CONTENT |
|---|---|---|
| RG.Aero00029 | - | Guide for defining and performing highly accelerated tests |

## 1.7 Equipment manufacturer responsibility

This specification defines the technical requirements that the equipment shall fulfil.

Upon accepting an order from the aircraft manufacturer:

- The equipment manufacturer shall be contractually responsible for the design, development, qualification, supply of the unit to a standard that fully meets the requirements of this specification and the documents listed in §*1.6 - Referenced and Applicable Documents.* The aircraft manufacturer's approval of drawings or documents in no way relieves the equipment manufacturer of this responsibility,
- Considering that the equipment manufacturer is a professional of actuator technology, it shall ask the aircraft manufacturer for any additional information required for making the unit complying with this specification if it is not provided in this specification, and, if necessary, shall advise the aircraft manufacturer,

- If requested by the aircraft manufacturer, the equipment manufacturer shall participate to the unit development during the rig test,
- If requested by the aircraft manufacturer, the equipment manufacturer shall collaborate with the aircraft manufacturer and other equipment manufacturers in order to ensure the correct operation of the flight control system. This collaboration may involve performing design work and/or tests concerning the coupling of the unit or one of its sub-assemblies with associated computers, aircraft systems or aircraft components,
- If requested by the aircraft manufacturer, the equipment manufacturer shall provide the aircraft manufacturer with the elements of the manufacturing drawings (including blanks) production processes, component or material specifications required for solving any technical problem that might occur.

### 1.7.1 Penalties

N/A

### 1.7.2 Confidentiality

See GENOME cooperative agreement.

## 1.8 Evolution of the definition

The technical proposal in the frame of GENOME project is considered as the basis for project development phase.

Any change shall be submitted to the Purchaser prior to its introduction.

The Supplier shall comply with modification procedure as defined in ABD 0100 Part 2 chapter 9.

# 2 Product Design Requirements

The requirements defined in this chapter shall be fulfilled at any time of the flight or ground stages (§2.1.6.4 – *Duty Cycles*) during the whole specified service life (§2.5.1.2.2 – *Service and useful life*) and under the normal operating conditions specified (§2 - *Environmental Requirements)* unless otherwise specified. Possible downgrading that may result from extreme environmental conditions or severe use shall be identified by the supplier and shall be submitted to Purchaser agreement.

## 2.1 Product Characteristics and Functions to be Performed

### 2.1.1 General Description

#### 2.1.1.1 System Overview

The aircraft (A/C) is fitted with five (5) pairs of spoiler surfaces, all shared symmetrically on each side of the wing (see §5.1 - *Appendix 1 – NSA Primary Flight Control System Architecture Synoptic)*.

*(*) For the A320 demonstrator, The EMA will be installed on Spoiler n°2 of the left wing (see §5.1 - Appendix 1 – A320 Flight test Platform FCSA).*

Each spoiler surface is powered by one (1) electromechanical actuator (EMA) in active mode.

The actuators constitute the power elements of the Spoiler surface closed loop control.

Flight Control Computers (FCC) provide the surface position orders to EMA.

Position servo loop is performed at EMA level within Electronic Control Unit (ECU).

In normal operation, EMA is electrically powered by the network (A/C or EFCS) with one (1) high power supply (540 VDC) and one (1) low power supply (28 VDC).

#### 2.1.1.2 Equipment Overview

The terminology used in the supplier documentation shall be based on this description.

The unit shall include as a minimum component list:

- a body with mechanical interfaces to link the actuator to the A/C structure (*)
- a mechanical output lever with its connecting rod to link the actuator to the surface,
- a sealed Electronic Control Unit (ECU),
- electrical connectors,
- an electrical motor,
- an anti-extension device,

- a maintenance device,
- a torque limitation function,
- non jamming end stops,
- a mechanical output position sensor,
- a torque sensor,
- a non-volatile memory,
- a jack catcher (*),
- lubrication,

*(*) For the A320 demonstrator, EMA body with mechanical interfaces will be linked to an adaptation part.*
*(*) For the A320 demonstrator, EMA shall not include jack catcher*

Mechanical Interfaces:

- Actuator mechanical output shall be composed by one (1) actuator output lever and one (1) connecting rod.
- Actuator body shall include structural attachments to connect the actuator body to the A/C fixed structure. (*)
- Connecting rod shall include one (1) sealed self-lubricated spherical bearing to be connected to the A/C moving surface.
- Supplier is in charge of actuator with its structural attachments and its output lever, connecting rod and the link between actuator output lever and connecting rod.(*)
- Purchaser is in charge of the link between actuator body and the A/C fixed structure and the link between connecting rod and moving surface.
  *(*) For the A320 demonstrator, EMA body will be fixed on an adaptation part. Design of adaptation part can be proposed by the supplier.*

Electronic Control Unit (ECU):

- Actuator shall comprise one (1) ECU controlled by FCC via µAFDX data bus and supplied by one (1) 540 VDC and one (1) 28 VDC.
- The ECU shall be designed as a sealed LRI.
- The ECU shall be self-contained fire in both normal and failure conditions.
- The ECU shall comprise two (2) computation units called command lane (COM) and monitor lane (MON) and one (1) High Power Electronics lane (HPE):
- COM lane functions shall be to:
  - Perform actuator position servo loop according to FCC messages,
  - Collect, compute and provide data (sensor values, Booleans, ...) to FCC via µAFDX data bus,
  - Perform action (enabling, inhibit actuator servo loop...) in response to FCC messages.
- MON lane functions shall be to:
  - Collect and send sensor and computation values to FCC via µAFDX data bus,
  - Perform action (inhibit actuator servo-loop...) in response to FCC messages,
  - Perform Health-monitoring function.
- HPE lane functions shall be to:
  - Manage the electrical power of the motor.
- COM and MON lanes shall be able to exchange data via Internal Data Bus.
- The ECU shall comprise a dedicated NVM to store key parameters.

- ECU shall provide internal links to communicate and transfer data to ECU, to ECU non-volatile memory (NVM) and actuator NVM.
- The ECU shall include a wireless connection that allows data loading during a maintenance task from and to the actuator NVM.
- The ECU shall be equipped with a RFID device.
- Electrical and mechanical segregation between COM and MON units of ECU shall be achieved.
- Electrical segregation between high and low power parts of ECU shall be achieved.
- The ECU COM and MON lane designs shall ensure the non -propagation of the oscillations coming from a same external power supply.
- High power elements of the ECU shall be compliant to Corona effects.
- The ECU sealing against ambient pressure cycling (breathing effects), humidity, moisture and icing shall be demonstrated by tests. The sealing principle and design shall be supported by risk mitigation tests on an adequate demonstrator.
- The ECU shall be equipped with temperature sensors on hot points approved by purchaser.
- The ECU temperature measurements shall be provided to FCC via µAFDX data bus
- ECU overheating shall be monitored and detected by FCC at temperatures of over TBA℃.
- The supplier shall provision a mean to update COM and MON lane softwares using spare pins of COM interface and MON interface connectors.
- Any insulation loss (e.g. between high power voltage bar and housing) or any chafing between internal wires and other internal devices (e.g. housing) shall be avoided. Where it is not possible, it shall be minimized with additional attachment points or additional mechanical protections.

<u>Electrical harnesses</u>:(if applicable)

- Cables shall be secured at appropriate intervals to prevent chafing or other damage.
- All wires and bundles shall be supported sufficiently so that strain or load at the terminal(s) cannot cause joint failures.
- Cable bundles shall not be tied to adjacent electrical components or sub-assemblies.
- Wire size shall be chosen to be compatible with current carrying and voltage drop.
- All cable backshell shall be oriented downward.
- Any cable shall end with a drip loop before entering electrical panels, boxes, equipment and connector plates.
- High power harnesses shall be compliant to Corona effects.
- All harnesses shall be arc-tracking resistant.
- The electrical cable length, routing and/or the connector definition shall prevent cross connection.
- Any cable shall sustain:
  - a load of 50 daN during at least one minute at each point of the harness which can be used for a handhold;
  - a load of 100 daN during at least one minute at each point of the harnesses which can be used for a hanging man.

<u>Electric Motor (EM):</u>

- High power elements of the EM shall be compliant to Corona effects.

- The EM shall be equipped with temperature sensors on hot points approved by purchaser.
- The EM temperature measurements shall be provided to FCC by ECU via communication bus.
- EM overheating shall be monitored and detected by FCC at temperatures of over TBA℃.
- Any insulation loss (e.g. between phases or between a phase and housing) or any chafing between internal wires and other internal devices (e.g. housing) shall be avoided. Where it is not possible, it shall be minimized with additional attachment points or additional mechanical protections.

Anti-extension device:

- The anti-extension device shall be sized to sustain anti-extension activation when EMA is moving at its maximum speed.
- The anti-extension device shall be able to sustain any torque without exceed the limit torque specified.

Mechanical output position sensor:

- The mechanical output position sensor shall be supplied by the ECU COM lane.
- Measurements of mechanical output position sensor shall be transmitted to the FCC via µAFDX data bus.

Mechanical End Stops:

- Mechanical end stop devices shall dynamically stop the EMA mechanical transmission and its associated inertia in case of surface manipulation on ground.
- An impact of the EMA mechanical transmission onto end stop shall not cause a jamming of the actuator.

Torque limitation device:

- If the torque limitation device is based on strain gauges load information, the mechanical part on which strain gauges are installed shall be a LRU part.

Non-Volatile Memories (NVM):

- The Non Volatile Memories shall be read/write type and managed by the ECU,
- The Actuator NVM shall be able to store data (Health Monitoring, electrical rigging, EMA key parameters, …) during the whole actuator life.
- The ECU NVM shall be able to store data (P/N, S/N, Off/On/Off sequences, ECU key parameters,…) during the whole ECU life.

Gear Box assembly:

- The Gear Box assembly (GBA) shall transmit the rotation of the motors output to mechanical output.

### 2.1.2 Architecture

Where the architecture of the equipment is not specified by the purchaser, the Supplier will be responsible to establish the requirement architecture to meet the product requirements.

### 2.1.3 Location

The ten (10) spoiler EMA are installed at the interfaces of the wing structure and the spoiler surfaces, one per surface in non-pressurized area (see §5.1 - *Appendix 1 – NSA Primary Flight Control System Architecture Synoptic)*.

*(*) For the A320 demonstrator, The EMA will be installed on Spoiler n°2 of the left wing (see §5.1 - Appendix 1 – A320 Flight test Platform FCSA Synoptic).*

The environmental characteristics of these defined locations, within which the actuators must operate, are identified in sub-chapter §2.2 - *Environmental requirements* of this PTS.

### 2.1.4 Aircraft Series, Models and Variants

N/A

### 2.1.5 Functions to be performed

#### 2.1.5.1 Operational Functions

Each EMA spoiler actuates a spoiler surface numbered from 1 to 5 (the number 1 being the closest from the fuselage) on the left side and on the right side of the wing :

- the spoiler n°1 will be used for the de-lift,
- the spoilers n°2, 3 et 4 will be used for the roll, the airbrake and the de-lift,
- the spoiler n°5 will be used for the de-lift and the roll,

*(*) For the A320 demonstrator, The EMA will be installed on Spoiler n°2 of the left wing (see §5.1 - appendix 1 – A320 Flight test Platform FCSA).*

EMA shall be able to operate in four (4) modes: the active mode, the anti-extension mode, the maintenance mode and the re-centring mode (*) .
*(*) For the A320 demonstrator only.*

<u>Active mode:</u>

The EMA shall automatically switch into active mode when:

- Electrical high power supply is available, and
- Electrical low level electrical power supply , and
- COM and MON ECU lanes are in Operational Mode, and
- Specific FCC mode command sent via µAFDX bus.

In the active mode the actuator shall be in closed loop position control with position order commanded by FCC via µAFDX data bus.

In normal operation, one (1) unit in Active mode actuates the moving Spoiler surface.

Anti-extension mode:

The EMA shall automatically switch into anti-extension mode,

- In the event of loss of high level electrical power supply,
- Or loss of low level electrical power supply,
- Or on a specific FCC mode command sent via µAFDX bus

In this mode the actuator mechanical output shall move in response to external downward torque and shall passively resist to external upwards torque all along the actuator stroke.

Maintenance mode:

The unit shall include a device to enable the surface to be manually moved for maintenance purpose, with no danger for the ground personnel.

Maintenance mode engagement and disengagement shall not be possible in case the actuator is commanded to active mode.

*Re-centring mode (*) For the A320 demonstrator only.*

*The EMA shall automatically switch into re-centring mode further to the loss of the FCC.*

*In re-centring mode, the EMA shall move from its initial position to neutral position and shall control itself at neutral position (at 0° spoiler surface d eflection).*

Limitation Functions:

The actuator shall limit its power and torque in accordance to *§2.1.6.1 – Normal Operation Performances*.

Surface end stops:

The unit shall mechanically limit the stroke in accordance to *§ 2.1.9.1 – Installation and Kinematic* and § *2.1.6.4 – Duty Cycles*.

Mode Status Reporting
Actuator mode status shall be reported to the FCC via µAFDX data bus according to paragraph §2.1.9.3.2.4 – *Mode Indication.*

### 2.1.5.2 Reset Function

#### 2.1.5.2.1 Automatic Resets

No auto-reset mechanism shall be implemented.

#### 2.1.5.2.2 Resets from FCC

The resets shall be performed without anomalous behaviour at temperatures as low as -55℃ or as high as +70℃.

ECU hardware reset behaviour shall comply with ABD01000.1.9.

Software behaviour after reset is described in § 2.1.8 – *Software Behaviour*.

A hardware reset shall be initiated after each ECU power up. This reset shall be used to initialise all the hardware in order to run the actuator properly.

Maximum time between power on and disposal of stabilised inputs/outputs shall not exceed the initialisation duration described in § 2.1.8 – *Software Behaviour.* (Objective < 120 ms).

Otherwise specified for safety reasons, it shall not be possible for reset signal to be masked by an ECU internal logic.

After a reset, the ECU shall be fully re-initialised, and shall wait for the first µAFDX command.

### 2.1.5.3 Protection and Monitoring Functions

#### 2.1.5.3.1 General

The Supplier shall provide the Purchaser with the specification of all monitoring and testing capabilities, all detectable faults, confirmations rules, applicable accommodation for a given failure within the Fault Detection Specification (FDS) for approval.

The Supplier shall consider a process for validation and accomplishing all fault detection definitions. During this iterative process the Purchaser will meet the Supplier several times in order to review and evolve the FDS until the approval.

The failures will be evaluated according to their impact on safety, operability and maintainability.

For each failure the degradation of the unit will be analysed with its consequence for the system and aircraft by the Purchaser.

If tests are needed at system level, the Supplier shall provide documentation, in order to enable the Purchaser to establish the technical repercussions to other PTS, their reasons, the affected LRI, as well as the induced signals external to the system, or exchanged within the system.

#### 2.1.5.3.2 Fault Management

The supplier shall define the equipment tolerances to faults and show compliance with the requirements for safety.

The actuators internal monitoring (implemented in the operating S/W) which have an action on the actuator operation must be minimized (objective : none) and limited to system safety aspects ( e.g. processor integrity... ). The introduction of internal monitoring shall be submitted to the Purchaser for approval.

In case of failure, if processor integrity is not guaranteed, and if needed for safety reasons, the variable BFSYS shall be set to TRUE to report the failure, otherwise it shall be set to FALSE.

#### 2.1.5.4 Data Loading

N/A

#### 2.1.5.5 Health Monitoring (HM) Function

Each actuator shall allow performing an Health Monitoring (HM) function based on internal sensor measurements and specific algorithms.

The objective of the health monitoring is to predict and prevent any abnormal behaviour of the equipment (jamming, degraded performances, etc…)

The supplier shall propose Health monitoring solutions for flight control actuation that can fulfill the following expectations and functions:

- To anticipate jamming
- To identify and locate failures
- To identify and anticipate predictive maintenance tasks T
- To estimate the remaining life time of the unit (based on life cycles, …)
- To store maintenance operations historical
- To store a working historical (Flight Hour, Flight Cycle, ON/OFF cycles, …)
- To store the configuration and the location of the equipment (equipment type, P/N, S/N, …)

##### 2.1.5.5.1 Main Functions Description

The requirements defined in this chapter shall be met for each actuator at any time of the flight, during the whole Aircraft life.

The Health monitoring main functions shall comply with the following requirements:

- To anticipate jamming

By using the EMA sensors, this anti jamming function shall detect and analyse any performance deviation of actuator (e.g wear impact, efficiency decrease,…) or any failure that could lead to an actuator jamming.

- To identify and locate failures

By using the EMA sensors, this Health monitoring function shall detect and analyse any deviation on nominal actuator behaviour (internal or external) or any failure that could lead to the loss of the actuator integrity.
Main equipment pieces identification and its associated failure rates shall be performed in order to tailor the monitoring efficiency and robustness.

- To identify and anticipate predictive maintenance failures

By using the EMA sensors, this Health monitoring function shall detect and analyse any internal or external abnormal actuator behaviour ( e.g  temperature sensor failure, lubrication level…) that could lead to a predictive maintenance task prior the loss of the actuator integrity.
A preliminary analysis shall be used to identify which failures can be considered as part of predictive maintenance tasks.
Based on data stored in the Health Monitoring memory and the settled Health monitoring algorithm results, this Health monitoring function shall anticipate failures that could have an impact on actuator integrity.
Using dedicated messages, this Health Monitoring function shall inform the Flight Control computer about the identified predictive maintenance task to perform.

- To estimate the remaining life time

Based on data stored in the Health Monitoring memory and the settled Health monitoring algorithm results, this Health monitoring function shall provide a correct estimation of the remaining life time of the actuator and its main pieces. This estimation may be based on life cycles, ...(e.g. reference damage criterion compared to measured one from f(t) or life cycles). This Health Monitoring may lead to dedicated status messages available for Flight control computer.

- To store maintenance operation historical

Using embedded or separated memory, the Health monitoring status shall at least integrate actuator and main pieces maintenance operations, A/B/C checks, …

- To store a working historical (Flight Hour, Flight Cycle, ON/OFF cycles, …)

Using embedded or separated memory, the Health monitoring status shall at least integrate actuator and main pieces Flight Hour, Flight Cycle, ON/OFF cycles,… so that a reliable working historical can be established.

- To store the configuration and the location of the equipment.

Using Hardware or Software pin programming, this Health Monitoring function shall be able to check the consistency between identification data from Flight control computer and data from the actuator. This function shall also include at least actuator and main sub-assemblies configuration (e.g. actuator P/N and S/N, main pieces P/N and S/N, list of LRIs…).and its type location (e.g. Left Inboard Spoiler actuator).

#### 2.1.5.5.2 Health Monitoring Algorithms

The following types of Health Monitoring algorithms shall be assessed and if relevant they shall be developed, integrated in the Health Monitoring function and validated by the Supplier :

- Fatigue damaging computation,
- Endurance severity computation,
- Maximum mechanical backlash exceeding,

- Global mechanical efficiency degradation,
- Abnormal vibratory signature,
- Friction and damping coefficient degradation,
- Electric motor damaging,
- Anticipated electronic component ageing,
- Etc…

The health monitoring algorithms shall be able to perform :
- Diagnosis: detection of degradation before the failure is effective,
- Prognosis: assessment of LRU or LRI remaining life before the failure is effective.

All the algorithms integrated into the Health Monitoring function shall be detailed and substantiated by the supplier and then agreed with the purchaser.

All the necessary EMA sensors information used to perform Health Monitoring algorithms shall be sent to the FCC via communication bus.

The performance degradation detected at actuator level by one of the Health Monitoring algorithms shall not induce a reduction or a stop of the EMA operation. This decision shall be taken at A/C level by the Flight Control Computers.

#### 2.1.5.5.3 Health Monitoring Data Memory Integration

The Health Monitoring device shall contain two sub-parts :
- The Health Monitoring algorithms computation part
- The Health Monitoring memory that compile every Health Monitoring algorithm results

Depending on HM algorithms size and needed Central Processing Unit (CPU) capacity, the HM computation part can be embedded either inside the ECU or at A/C system level inside FCC.

The HM memory shall be embedded inside or plugged on the mechanical part of the EMA.
It shall not be considered as LRI so that HM results will be linked to the actuator during its whole life.

The memorized data shall also be available at A/C level in order to be analysed and used to trigger HM alerts and to take relevant decisions to ensure the A/C safety.

The supplier shall perform a trade-off to propose the best integration solutions to comply with previous requirements. This trade off shall particularly take into account the following non-exhaustive list of design rules:
- Electrical and Mechanical segregation rules (power/signal, COM/MON, …),
- EMI susceptibilities,
- Thermal constraints (ambient within a confined volume and potentially local overheat),

Depending on the failure to monitor, the supplier shall:
- demonstrate if the detection can be efficient on ground and/or in flight conditions,
- demonstrate if a recorded “golden measurement » is needed to compute some Health Monitoring algorithms,

- propose a memory mapping architecture and its associated read/write protocol that can self-prevent any recording failure.

#### 2.1.5.5.3.1 Health Monitoring Data Memory Mechanical Interfaces

**TBA**

Either plugged or embedded in the mechanical part of the EMA, the supplier shall minimize the Health monitoring data memory size.

#### 2.1.5.5.3.2 Health Monitoring Data Memory Electrical Interfaces

Health monitoring signals shall be transmitted to the FCC via the communication bus.

The specific electrical data (power supply and signals) are **TBA**.

#### 2.1.5.5.3.3 Health Monitoring Function Performances

The health monitoring functions and associated thresholds shall not affect the actuator MTBF.

The performance objectives are the following ones :

- To anticipate jamming :
  - ⇨ the anti-jamming function shall detect 100% of the potential failure which can lead to a jamming.
  - ⇨ the jamming failure rate at actuator level including Health monitoring function shall be lower than $10^{-9}$.

- To identify and locate failures :
  - ⇨ this function shall identify and locate at least **TBD** of the failures that can lead to actuator loss of integrity.

- To identify and anticipate predictive maintenance tasks :
  - ⇨ this function shall identify and anticipate at least **TBD** of the predictive maintenance failures that can lead to actuator loss of integrity.

- To estimate the remaining life time of the unit (based on life cycle, …) :
  - ⇨ the remaining life time function shall have **TBA**% (objective: < 5%) accuracy of real value.

- To store maintenance operations historical :
  - ⇨ This function shall record 100% of the maintenance operations historical.

- To store a working historical (Flight Hour, Flight Cycle, ON/OFF cycles (i.e. higher than the transparency time) , …)
  - ⇨ This function shall record 100% of the working historical.

- To store the configuration and the location of the equipment (equipment type, …) :
  - ⇨ This function shall propose a deterministic way (100%) to determine the function and the location of the unit and shall record 100% of the actuator configuration.

The Supplier shall ensure a 100% of robustness for each health monitoring algorithm developed to anticipate failure or maintenance task. This means that the algorithms shall not trigger false alert to the FCC.

#### 2.1.5.5.3.4 Health Monitoring Function Power Consumption

The electrical consumptions for the actuator Health Monitoring functions shall be minimized.

In case the actuator is in a non-active mode (damping mode), the Supplier shall determine whether the Health Monitoring function and necessary EMA sensors shall continually be powered during the in-flight phases and the on-ground phases. If yes, the associated specific needs shall be identified.

#### 2.1.5.5.3.5 Health Monitoring Design Requirements

The design requirements specified in the paragraph 2 - *Product Design Requirements* shall be considered for the Health Monitoring device.

#### 2.1.5.5.3.6 Health Monitoring Data Memory Operating Conditions

##### 2.1.5.5.3.6.1 HM Data Memory Electrical Power Supply and Wiring

The HM function will be supplied by low power supply or from an actuator internal power supply (+15VDC, +5VDC, …).

The Health monitoring function shall be effective even if 540VDC is not supplied.

The supplier shall propose the best voltage supply compromise and define the following parameters in accordance with Health Monitoring function expectations:

- A power interrupt lower than **TBA** ms (objective >10ms) shall not affect the performance of the equipment.
- After a power interrupt higher than **TBA** ms (identical to above power interrupt objective) and lower than **TBA** ms (objective >200 ms), the unit shall be able to operate up to 50 ms.

- The steady state power supply voltage range shall be **TBD** to **TBD** VDC at the unit level for full performances.
- The voltage source from which Health Monitoring function is supplied shall comply with the transient power supply voltage defined in ABD0100.1.8 Issue C, and shall not affect the good operation of the unit.

#### 2.1.5.5.3.6.2 HM Data Memory Duty Cycles

The number of the low power supply OFF/ON/OFF sequences is 2 per flight.

#### 2.1.5.5.3.6.3 HM Data Memory Environmental Conditions

All the environmental requirements defined in paragraph 3.2 – *Environmental Requirements* shall be applied on the Health Monitoring device.

### 2.1.5.5.3.7 Health Monitoring Data Memory Maintainability

In case of plugged Health Monitoring device, the unit shall not incorporate any component of which life is lower than the specified service life and shall not be subjected to any Time Between Overhauls (TBO).

The maintenance practice of the plugged HM device shall be identified and frozen for the program duration and agreed by the Purchaser.

The checks and maintenance operations at the actuator level required to meet the reliability and life requirements are as follows:

- Automatic power-on and supply-on tests are possible with an interval of 20 FH. They shall not require nor generate surface movements,
- Manual test performed from the cockpit: HM device check interval is possible at A checks (minimum 750 FH),
- Manual test maintenance operation or servicing requiring access to the unit are possible at C checks (minimum 24 months).

### 2.1.5.5.3.8 Health Monitoring Data Memory Reliability and Safety

The HM device MTBF shall be higher than **TBA** FH (objective 500000 FH)
The MTBF shall be reviewed every year.
MTBUR calculation rules are defined in paragraph 2.6.4 – *MTBUR Objectives.*
Failure rates are subjected to an in service follow up with a periodicity of two years maximum; failure modes to be considered are agreed between the Purchaser and the Supplier.

### 2.1.5.5.3.9 Health Monitoring Data Memory Software Requirements

The software level, as identified by the System Safety Process, is Level A according to DO178 classification.

The development and management of the software shall be in accordance with RTCA/EUROCAE DO-178/ED-12 Level A.

Requirements defined in the paragraph 2.4 - *Equipment Specific Software Requirements* are applicable to the Health Monitoring device.

#### 2.1.5.5.3.10 Health Monitoring Data Memory Hardware Requirements

The development and management of the hardware of the Health monitoring function shall be in accordance with RTCA/EUROCAE DO-254/ED-80.

Requirements defined in the paragraph 2.3 - *Equipment Specific Hardware Requirements* are applicable to the Health Monitoring device.

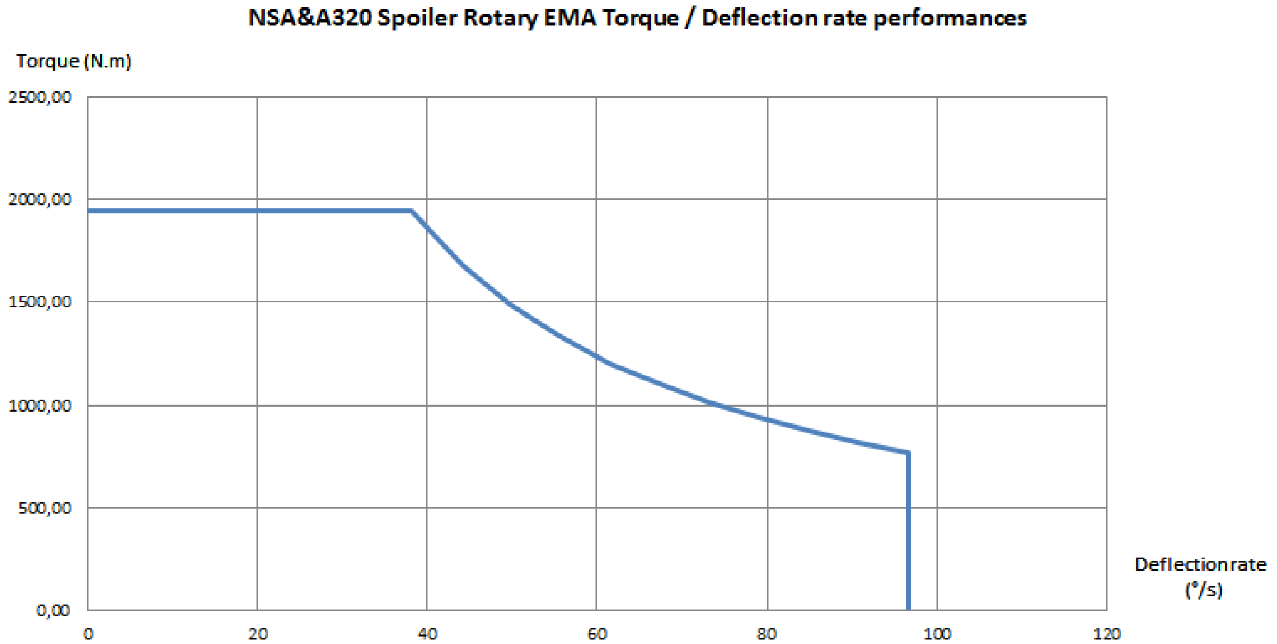
## 2.1.6 Performance Characteristics

### 2.1.6.1 Normal Operation Performances

Unless otherwise specified, all performance requirements shall be fulfilled for specified design service goals ( § 2.5.1.2.2 – *Service and Useful life*), specified spoiler actuator installation ( § 2.1.9.1 – *Installation and Kinematic)* and specified environmental conditions ( § 2.2 – *Environmental requirements).*

Unless otherwise specified, performance requirements are specified for one (1) actuator at actuator mechanical output level.

#### 2.1.6.1.1 Torque and Deflection Rate Performances




The actuator shall be able to control and to generate a maximum torque of 1942 N.m with a deflection rate up to **TBA °/s** (objective ≥ 38,2 °/s).

The actuator shall be able to generate a minimum deflection rate of 97°/s under an external torque of **TBA daN** (objective ≥ 764 N.m).

The actuator shall be able to generate a deflection rate of 200 °/s under an aiding aerodynamic torque of **TBA daN** (objective < 550 N.m).

The actuator shall be able to control a constant torque of 927 N.m between the spoiler surface at 0° and the flap.

Limitation functions:

Maximum input power limitation:

The actuator maximum input power shall be limited to **TBA** W (Objective ≤ 4 kW) through a power limitation function.
The Supplier shall ensure that the maximum mechanical power (**TBA** W) can be provided under this maximum input power limitation.

Torque limitation:

Whatever the deflection rate, the limit torque of the actuator in active mode shall not exceed 2331 N.m (1,2 times of NSA maximum torque).

*(*) For the A320 demonstrator, the limit torque of the actuator in active mode shall be adjustable:*

- *In laboratory conditions, the limit torque shall not exceed 2331 N.m (1,2 times of NSA maximum torque),*
- *In Flight Test conditions, the limit torque shall not exceed 1380 N.m (1,2 times of A320 maximum torque).*

Thermal performances:

The actuator shall be able to perform the specific thermal duty cycles described in § 2.1.6.4 – *Duty Cycles* and § 5.5 – *Appendix 5 : Duty Cycles.*

The actuator shall be able to control the permanent torque of 927 N.m without any time limitation and whatever the torque direction.

The actuator shall be able to control the permanent torque of 1690 N.m during 6 min.

The actuator shall be able to control the maximum hinge moment of 1942 N.m during TBA min (objective ≥ 60 min).

The actuator shall be able to generate a +/- 4,4° sinusoidal movement at 0.5Hz under aerodynamic torque of 927 N/m without any time limitation.

Note: the thermal performances shall be demonstrated by the supplier under laboratory conditions (20°C, sea level, natural convection, horizontal actuator position) with order taking into account oscillatory signal defined in § 2.1.6.4 – *Duty Cycle.* Success criteria have to be defined in accordance with requirement in paragraph 2.1.6.1.9 – *Maximum Skin Temperature.*

#### 2.1.6.1.2 Anti-extension Performances

In flight, the actuator in anti-extension mode shall be able to move in response to external downward hinge moment and shall passively resist to external upwards hinge moment whatever the actuator position, for any external torque.

The actuator shall be designed to perform ten (10) anti-extension mode activations over the A/C life whatever the EMA speed and the EMA torque.

Torque limitation:

Whatever the deflection rate, the limit torque of the actuator in anti-extension mode shall not exceed 2331 N.m (1,2 times of NSA maximum torque).

*(*) For the A320 demonstrator, whatever the deflection rate, the limit torque of the actuator in* anti-*extension mode shall not exceed 1380 N.m (1,2 times of A320 maximum torque).*

#### 2.1.6.1.3 Maintenance Mode Performances

On the ground, the actuator shall be able to be manually moved under an external torque lower than 45 N.m.

Torque limitation:

Whatever the deflection rate, the limit torque of the actuator in maintenance mode shall not exceed 2331 N.m (1,2 times of NSA maximum torque).

*(*) For the A320 demonstrator, whatever the deflection rate, the limit torque of the actuator in maintenance mode shall not exceed 1380 N.m (1,2 times of A320 maximum torque).*

#### 2.1.6.1.4 Re-centring Mode Performances (*)

*(*) For the A320 demonstrator only.*

*In flight, the actuator in re-centring mode shall be able to move from its initial position to its neutral position (at 0° spoiler surface deflection) whatever the actuator initial position, for any external torque. Then, actuator shall control itself at neutral position (at 0° spoiler surface deflection).*

*Torque limitation:*

*whatever the deflection rate, the limit torque of the actuator in maintenance mode shall not exceed 1380 N.m (1,2 times of A320 maximum torque).*

#### 2.1.6.1.5 Additional Mode Performances

N/A

#### 2.1.6.1.6 Electric Servo-loop Performances and Stability

Unless otherwise specified the following requirements shall be met under an aerodynamic torque up to 50 % of the maximum torque capability of the actuator.

##### 2.1.6.1.6.1 Computer Electrical gain

The supplier shall propose and substantiate the gain and filters possibly required to be implemented in the unit taking into account the Application software definition as described in § 2.1.8 – *Software Behaviour*.
Refer to § 2.1.8 – *Software Behaviour* to see how the computer electrical gain is implemented into the servo-loop.

##### 2.1.6.1.6.2 Static accuracy

The contribution of the unit to the servo-loop position error (without mechanical interfaces backlashes) shall be lower than values provided in the table below.

Resolution :

| | With constant torque (in value and direction) | Without torque |
|---|---|---|
| new | Objective ≤ 0.11° | Objective ≤ 0.11° |
| After 100% specified life | Objective ≤ 0.22° ( **TBC**) | Objective ≤ 0.22° ( **TBC**) |

Hysteresis :

| | With constant torque (in value and direction) | Without torque |
|---|---|---|
| new | Objective ≤ 0.22° | Objective ≤ 0.22° |
| After 100% specified life | Objective ≤ 0.44° ( **TBC**) | Objective ≤ 0.44° ( **TBC**) |

Overall position error at neutral (with error compensation) :

| | With constant torque (in value and direction) | Without torque |
|---|---|---|
| new | Objective ≤ +/- 0.22° | Objective ≤ +/- 0.22° |
| After 100% specified life | Objective ≤ +/- 0.22° | Objective ≤ +/- 0.22° |

overall position error at full functional extension / retraction stroke (with error compensation) :

| | With constant torque (in value and direction) | Without torque |
|---|---|---|
| new | Objective ≤ +/- 0.44° | Objective ≤ +/- 0.44° |
| After 100% specified life | Objective ≤ +/- 0.44° | Objective ≤ +/- 0.44° |

### 2.1.6.1.6.3 Frequency response

The acceptable fields of phase lag and output to input amplitude ratio are defined in the table below, in the respect of the following operating conditions:

- Electrical servo loop described in § 2.1.6.1.6 – *Control Laws,*
- Actuators installed according to § 2.1.9.1 – *Installation and Kinematic*
- under an aerodynamic torque of 50 % of maximum torque.

| Amplitude | Frequency | Output to Input amplitude ratio (dB) | | Phase lag (°) |
|---|---|---|---|---|
| | | Min | Max | Max |
| +/- 1° | 0.5 Hz | **TBA** dB<br>(objective > -3 dB) | **TBA** dB<br>(objective < 0 dB) | **TBA** °<br>(objective < 45°) |
| | 2 Hz | **TBA** dB<br>(objective> -4.8 dB) | **TBA** dB<br>(objective < 0 dB) | **TBA** °<br>(objective < 45°) |
| +/- 3,8° | 0.5 Hz | **TBA** dB<br>(objective > -3 dB) | **TBA** dB<br>(objective < 0 dB) | **TBA** °<br>(objective < 45°) |
| | 2 Hz | **TBA** dB<br>(objective> -4.8 dB) | **TBA** dB<br>(objective < 0 dB) | **TBA** °<br>(objective < 45°) |
| +/- 9,3° | 0.5 Hz | **TBA** dB<br>(objective > -3 dB) | **TBA** dB<br>(objective < 0 dB) | **TBA** °<br>(objective < 45°) |
| | 2 Hz | **TBA** dB<br>(objective >- 4.8 dB) | **TBA** dB<br>(objective < 0 dB) | **TBA** °<br>(objective < 45°) |

### 2.1.6.1.6.4 Stability

The adjacent actuator being disconnected from the surface and whatever actuator position, actuator torque, air and lubrication temperatures:

- the gain margin shall be higher than 10 dB,
- the phase margin shall be higher than 60°,
- the output to input amplitude ratio at the resonance frequency shall be lower than 0 dB ,
- there shall be neither sustained position nor oscillations after the application of any input signal whatsoever.

With any static command position , no erratic rod position oscillation is acceptable.

#### 2.1.6.1.7 Mode commutation conditions

Whatever the environmental requirements (§2.2 – *Environment requirements*) and electrical nominal power supply conditions (§2.1.9.3.1 – *Power Supply*) defined in this PTS, the actuator mode shall remain in a stable state corresponding to the controlled one.

Active to Anti-extension mode:
The unit being controlled in a fixed position **TBD°** under an external hinge moment of **TBD** N.m, the time interval between powering off and the stop of the mechanical output movement shall be lower than **TBA** ms (objective < 100 ms).

*Active to Re-centring mode (*):For the A320 demonstrator only.*
*The time interval between the beginning of the mechanical output movement of the unit shall be lower than **TBA** ms (objective < 100ms) with a nominal power voltage of 540 VDC and whatever the external torque.*

Active to maintenance mode:
The switch from active to maintenance mode shall be physically impossible.

Anti-extension to Active mode:
The time interval between the powering up and the beginning of the mechanical output movement of the unit, shall be lower than **TBA** ms (objective < 40ms) with a nominal power voltage of 540 VDC, whatever the external torque and with the maximum deflection order.

*Anti-extension to Re-centring mode: (*) For the A320 demonstrator only.*
*The time interval between the powering up and the beginning of the mechanical output movement of the unit shall be lower than **TBA** ms (objective < 40ms) with a nominal power voltage of 540 VDC and whatever the external torque.*

Anti-extension to Maintenance mode :
An external manual tool shall enable the operator to switch the actuator from anti-extension to maintenance mode. The torque required to manually move this external tool shall be lower than **TBD** N.m.

*Re-centring to active mode: (*) For the A320 demonstrator only.*
*The time interval between the beginning of the mechanical output movement of the unit shall be lower than **TBA** ms (objective < 100ms) with a nominal power voltage of 540 VDC, whatever the external torque and with the maximum deflection order.*

Maintenance to anti-extension mode :
N/A

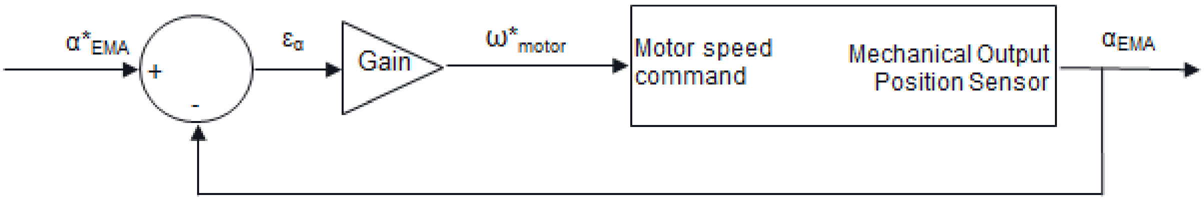
Maintenance to active mode:
The switch from maintenance to active mode shall be physically impossible.

*Maintenance to re-centring mode: (*) For the A320 demonstrator only.*
*The switch from maintenance to re-centring mode shall be physically impossible.*

#### 2.1.6.1.8 Control Laws

The unit will be controlled and monitored by the FCC.

The servo loop principle is described in the schema hereafter :




With:

- $\alpha^*_{EMA}$ Mechanical Output position order,
- $\alpha_{EMA}$ Mechanical Output position information,
- $\omega^*_{motor}$ Motor position order,
- $\varepsilon_{\alpha}$ Mechanical Output position error.

The servo loop shall be integrated inside the ECU through SCADE sheets defined and provided by the Purchaser.

The supplier shall provide a set of SCADE parameters **TBA** in order to check compliance with servo loop performances and stability requirements (refer to § 2.1.6.1.4 – *Electric servo-loop Performances and Stability*) and with the SCADE sheets example given in § 5.8 – *Appendix 8 – SCADE Sheet Examples*.

The relation between current demand and motor speed (rpm/mA) shall be clearly identified by Supplier in document “Interface Control Data” (§ 5.6 – Appendix 6 - *Documentation Requirement List* ).

The position order in degrees will be sent from the FCC to the unit every 2 ms.

*(*) For A320 Demonstrator, The position order in degrees will be sent from the FCC to the unit every 20 ms.*

In normal active mode, on all actuator stroke range, electronic rigging value shall be used in the ECU application S/W control servo loop to offset position order.

The electronic rigging value authority shall be limited to +/- 2,2° by the application S/W.

#### 2.1.6.1.9 Maximum skin temperature

The maximum skin temperature shall not exceed **TBA** (Objective ≤ 100 °C).

Mechanical protection may be considered depending on max skin temperature value.

#### 2.1.6.1.10 Electronic module sealing

Electronic module shall be sealed, i.e. no leakage under inside/outside differential pressure of 1 bar.
Thermal impact shall be taken into account.

#### 2.1.6.1.11 Run-up time

The run up time is the time needed by powered actuator to achieve specified FCC orders (mode and position order) under the specified aerodynamic torque.

The aerodynamic torque shall be antagonistic regarding the actuator command direction (extension or retraction).

Initial configuration :

- COM and MON ECU lanes are in Operational Mode,
- Actuator is alone (no parallel actuator),
- Actuator is in damping mode,
- Actuator stroke is at mechanical end-stop,
- Stabilized ambient temperatures (ambient air) are:
    - o - 40℃ for normal operating temperature,
    - o - 55℃ for extreme operating temperature,

At time t0, simultaneously:

- Electrical supply is going from 0 VDC to 540 VDC,
- Mode signal is sending via µAFDX data bus. Active mode Boolean is going from OFF to ON,
- Step position order of full stroke is sending via µAFDX data bus,
- Configuration 1: Under Aerodynamic torque of 550 N.m:

| Normal (-40℃) | | Extreme (-55℃) | |
|---|---|---|---|
| Run up time [ms] | Reached speed [°/s] | Run up time [m s] | Reached speed [°/s] |
| **TBA (**objective ≤ 200) | **TBA (**objective ≥ 97) | **TBA** | **TBA** |

- Configuration 2: Under Aerodynamic torque of 1380 N.m:

| Normal (-40℃) | | Extreme (-55℃) | |
|---|---|---|---|
| Run up time [ms] | Reached speed [°/s] | Run up time [m s] | Reached speed [mm/s] |
| **TBA (**objective ≤ 200) | **TBA (**objective ≥ 54) | **TBA** | **TBA** |

#### 2.1.6.1.12 Inertia

The equivalent moment of inertia of the unit (**TBA** kg.m²) calculated at the mechanical output shall be provided by the supplier.

#### 2.1.6.2 Abnormal Operation Performances

N/A

#### 2.1.6.3 Operator Misuse

N/A

#### 2.1.6.4 Duty Cycles

F(t):

Dedicated duty cycles for fatigue, endurance and thermal sizing are given in *§5.5 - Appendix 5 – Duty Cycles.*

Duty cycles called "F(t)" are deflection order and hinge moment as function of time.

Hinge moment are provided at Spoiler surface level.

Supplier shall use specified kinematic in § 2.1.9.1 – *Installation and Kinematic* to calculate aerodynamic torque at actuator level.

The supplier shall add torques induced by actuator itself (inertial torques…).

The life requirement of actuator in active mode, taking into account specified duty cycles shall be the earlier between:

- 30 years,
- 100 000 flights/150 000 flight hours (100% of the specified life in § 2.5.1.2.2 – Service and Useful Life)

The life of the actuator in anti-extension mode taking into account specified duty cycles shall be shall be:

- 20 000 flights / 30 000 flight hours (TBC) (flight duration is 1.5 hour).

The duty cycle data will be periodically updated during the life of the programme:

- The first delivery design shall be based on the duty cycle revision available at the DDR
- Life justification shall be based on the duty cycle revision available at the Certification of Airworthiness (CoA)

Further duty cycle revisions shall be systematically covered by a revision of the fatigue and endurance and thermal life justification analysis.

Methodologies of F(t) treatment in order to design and qualify the actuator for fatigue, endurance and thermal aspects shall be defined by the Supplier and shall be submitted to the purchaser approval before the signature of the PTS.

The airbus' method of duty cycle damage estimation is presented in §5.5 - *Appendix 5 – Duty Cycles* This method will be used to treat all evolutions of duty cycles at Airbus level.

Addition cycles:

In addition to the F(t) provided in Appendix 5, supplier shall consider cycles described below:

- 2 high power supply OFF/ON/OFF sequences per flight,
- 2 anti-extension/active/anti-extension mode sequences per flight.
- 2 low power supply OFF/ON/OFF sequences per flight,
- Maintenance cycles described in paragraph 2.5.7.2 – *Safety tests*
- Surface Manipulation on Ground cycles described below:

| | | Speed of actuator | Actuator Torque | Number of cycles per A/C life |
|---|---|---|---|---|
| Surface Manipulation on ground | At the extension end-stop | Null speed | 346 N.m | 100 |
| | and At the retraction end-stop | Null speed | 256 N.m | 100 |

- Inadvertent manoeuvre on ground :

| | | Speed of actuator | Number of cycles per A/C life |
|---|---|---|---|
| Inadvertent Manoeuvre on ground | Maximum extension stroke (50°) to retraction end-stop | Maximum deflection Rate | 10 |
| | and | | |
| | Maximum retraction stroke (-12°) to extension end-stop | Maximum deflection Rate | 10 |

When transition from anti-extension mode to active mode is required, the following typical sequence is considered:

- Set mode selection signal to active mode,
- Wait for mode commutation confirmation,
- Start to control the unit via position command signal.

When transition from active mode to anti-extension mode is required, the following typical sequence is considered:

- Stop the unit control (position command signal at 0),
- Wait for mode commutation confirmation,
- Set mode selection signal to anti-extension mode.

The transition sequences are typical but other sequences could be used.

Commanded Oscillation:

The unit is controlled by a digital FCC which generates discontinuity on the control signal according to the principle defined in § 2.1.6.1.6. – *Control Laws.*

A permanent commanded oscillation may be generated by the FCC on the active channel order (superimposed to position command signal). The oscillation that shall be considered is the last bit (LSB) on overall µAFDX bus frequency range.

In case of internal Analog to Digital and Digital to Analog conversions, the supplier shall demonstrate that potential digital oscillations will have no impact on the design performance, reliability and integrity.

Note: Supplier test bench shall be able to add oscillatory signal as mentioned above.

A zero hold order with a sampling rate at 40ms shall be consider at control loop input.

## 2.1.7 Expansion Requirements and Capabilities

See ABD100.1.9.
Any significant conflict between the expansion requirements of the PTS and the unit cost requirements should be identified to the Purchaser.

## 2.1.8 Software Behaviour

### 2.1.8.1 General Description

The ECU software consists in two different softwares:

- Operating software,
- Application software.

**Operating software** shall be developed by the Supplier. It shall control the ECU and provides;

- Application software execution,
- Acquisitions treatment and emission,
- ECU monitoring,
- Mode management based on FCC or Application S/W commands,
- Non-volatile memories management,
- Inter lane exchanges,
- Test software (safety test, cyclic test…),
- Configuration software.

**Application software** shall be specified by the Purchaser and activated by the Operating software. It shall be specified with a set of symbols and shall contain:

- Generic servo control loop,
- Generic monitoring.
- Activation of Test and Configuration modes.

In order to treat a specific actuator position, generic servo loop and monitoring are customized by constants send by the EFCS and treat by the Configuration software.

Generic servo loop and monitoring constants shall be stored in the ECU non-volatile memories and used by the operating software.

The ECU shall provide 4 different modes

- ECU Initialisation,
- Operational mode,
- Configuration mode,
- Test mode.

#### 2.1.8.2 ECU Hardware Initialisation

Both ECU lanes initialisation shall be activated after each hardware RESET.
During initialisation all ECU application S/W variables shall be initialized, Booleans to false, reals to 0.0, integers to 0 and vectors to 0(h).

During initialisation, pin program shall be evaluated to determine ECU µAFDX address.
In case of wrong parity, the default µAFDX address (**TBD**) shall be used and an indication shall be sent to the opposite ECU lane (COM or MON lane) by setting the Boolean variable BFPPOPP to true, otherwise it shall be set to false.

During initialisation, ECU hardware and/or software shall not take into account previous memorised failure before reset.

Initialisation duration shall be **TBA** (objective < 80ms).

A µAFDX command received before end of initialisation shall be ignored (no response).

At the end of initialisation, sensors status and output shall be available for reporting.

At the end of initialisation, all inputs of the ECU shall be available for application software.

During and at the end of initialisation sequence, all ECU switching devices dedicated to motor control and solenoid supply shall be open.

During hardware initialisation, hardware, operating software and application software shall be checked (checksum / CRC).

During hardware initialisation, configuration data integrity shall be checked (checksum /CRC).
In case of failure, the ECU shall not enter in operational mode.

During initialisation, pin program shall be acquired and stored in ECU non-volatile memory.

#### 2.1.8.3 Operational Mode

Operational mode shall be activated only after initialisation.

In Operational mode, ECU shall be considered as an execution platform, which provides acquisitions and generation facilities to Application software.

In operational mode application software shall be activated simultaneously (t<1 ms) between COM and MON lanes of the ECU.

If the synchronisation of the activation of application software fails, application software shall be activated on each ECU lane after a timeout **TBA** since power up (objective < 80ms).

Each lane that activates its application software upon a timeout shall indicate it to application software by setting the Boolean variable BTIMEOUT to true, else it shall be set to false.

On each ECU lane, message refresh indication shall be activated after reception of the first message.

Refresh indication shall be available to application software through the µAFDX acquisition symbol (**TBD**).

Application software cycle duration shall be **TBA** ms (objective ≤ 5ms).

Application software cycle duration accuracy shall be better than 1/1000 of cycle duration.

Operating software shall ensure that cycle is not overflowed.

In case of cycle overflow, the faulty lane shall send an indication to the other lane (COM or MON) via the Boolean variable BWDOK set to false.

ECU Hardware identification shall be a **TBD** bit word variable.

ECU hardware identification shall be extracted from each lane memory and made available on each lane for application software on HARDIDENT word variable (**TBD** bits word different from 0000h) at the first and at each application software cycles.

The state of the last fully executed safety test (if used) shall be extracted from actuator memory and made available to application software on the Boolean variable BFSAFETYTEST at the first and at each application software cycles.

During initialisation Electronic rigging data value (**TBD** bits word) shall be extracted from actuator memory and shall be available for application software on each lane on ELECRIG word variable at the first and at each application software cycles.

During initialisation, electronic rigging data validity (parity check) shall be extracted from actuator memory and shall be available for application software on BFELECRIG Boolean variable.
If the extracted ELECRIG word is valid then BFELECRIG shall be set at false, else, it shall be set at true at the first and at each application software cycles.

During initialisation, the electronic rigging extraction methodology shall be compliant with the description provided in § 2.1.8.1.4 – *Test Mode.*

#### 2.1.8.4 Test Mode

Test mode shall be activated on application software demand TEST MODE ACTIVATION (BTESTACT) variable is set at true on both ECU lanes.

Test mode shall allow testing ECU software and hardware.

Test mode shall allow reading and writing data in the actuator memory.
Test mode shall allow checking the integrity of the data that are stored in the actuator memory.

Test mode activation shall be effective at most 50ms after the COM and MON lanes have received the demand.

At each test mode activation, the actuator memory data shall be evaluated as described in §2.1.8.1.5 – *Actuator Memory.*

The only way to exit the test mode shall be a hardware reset (power supply cut).
During test mode, integrity of memorised data shall be verified (operating software, application software, configuration data, electronic rigging data, and health monitoring data (**TBD**)).
In case of bad integrity specific bit shall be set to false (**TBD** bit name).

##### 2.1.8.4.1 Actuator memory

###### 2.1.8.4.1.1 Actuator memory management

Data that are stored on the actuator memory and accessed during test mode or initialisation mode are composed of **TBA** words of **TBD** bits each.

The actuator memory size shall be **TBA** (objective > 1 Kbyte).

Data (all words) integrity shall be protected, at least, by a parity bit (odd parity).

At first delivery, the actuator memory data (data1 to data**TBA**) shall be set to 0000h except data10, data11, data23 and data24.

These words (DATA1 ... DATA**TBA**) shall be arranged within three fields:

- ✓ FLIP-FLOPS :
  - ⇨ FLIP-FLOP1 : DATA1
  - ⇨ FLIP-FLOP2 : DATA14
  - ⇨ FLIP-FLOP3 : DATA27
- ✓ INTEGRITY: DATA28
- ✓ TABLES:
  - ⇨ TAB0: DATA2 to DATA13
  - ⇨ TAB1: DATA15 to DATA26

The data layout and characteristics shall comply with those listed within the following table:

| Fields | Data n° | Size | Designation | Var Name | Coding | Range |
|---|---|---|---|---|---|---|
| FLIP-FLOP | DATA 1 | TBA bits | STATE1 | STATE1 | SPECIFIC | N/A |
| TAB0 | DATA 2 | TBA bits | Electronic Rigging | ERDATA0 | BNR | 8 |
| | DATA 3 | TBA bits | Health Monitoring | HMDATA0 | BNR | 1 |
| | DATA 4 | TBA bits | Flight Cycles | FCDATA0 | BNR | 1 |
| | DATA 5 | TBA bits | Flight Hours | FHDATA0 | BNR | 1 |
| | DATA 6 | TBA bits | Total Stroke | TSDATA0 | BNR | 1 |
| | DATA 7 | TBA bits | Activation number | ACTDATA0 | BNR | 1 |
| | DATA 8 | TBA bits | Spare0 | | | |
| | DATA 9 | TBA bits | FIN | FNDATA0 | SPECIFIC | N/A |
| | DATA 10 | TBA bits | Coded P/N | PNDATA0 | SPECIFIC | |
| | DATA 11 | TBA bits | Coded S/N | SNDATA0 | SPECIFIC | |
| | DATA 12 | TBA bits | Spare1 | | | |
| | DATA 13 | TBA bits | Spare2 | | | |
| FLIP-FLOP | DATA 14 | TBA bits | STATE2 | STATE2 | SPECIFIC | N/A |
| TAB1 | DATA 15 | TBA bits | Electronic Rigging | ERDATA1 | BNR | 8 |
| | DATA 16 | TBA bits | Health Monitoring | HMDATA1 | BNR | 1 |
| | DATA 17 | TBA bits | Flight Cycles | FCDATA1 | BNR | 1 |
| | DATA 18 | TBA bits | Flight Hours | FHDATA1 | BNR | 1 |
| | DATA 19 | TBA bits | Total Stroke | TSDATA1 | BNR | 1 |
| | DATA 20 | TBA bits | Activation number | ACTDATA1 | BNR | 1 |
| | DATA 21 | TBA bits | Spare0 | | | |
| | DATA 22 | TBA bits | FIN | FNDATA1 | SPECIFIC | N/A |
| | DATA 23 | TBA bits | Coded P/N | PNDATA1 | SPECIFIC | |
| | DATA 24 | TBA bits | Coded S/N | SNDATA1 | SPECIFIC | |
| | DATA 25 | TBA bits | Spare1 | | | |
| | DATA 26 | TBA bits | Spare2 | | | |
| FLIP-FLOP | DATA 27 | TBA bits | STATE3 | STATE3 | SPECIFIC | N/A |
| INTEGRITY | DATA 28 | TBA bits | INTEGRITY | INTEGDATA | SPECIFIC | N/A |

The data28 shall be used to pack integrity information as shown in the following table:

| VAR NAME | POSITION | DESIGNATION |
|---|---|---|
| BFDATA2 | LSB=bit 1 | Integrity fault of data2 |
| BFDATA3 | bit 2 | Integrity fault of data3 |
| BFDATA4 | bit 3 | Integrity fault of data4 |
| BFDATA 5 | bit 4 | Integrity fault of data5 |
| BFDATA 6 | bit 5 | Integrity fault of data6 |
| BFDATA 7 | bit 6 | Integrity fault of data7 |
| BFDATA 8 | bit 7 | Integrity fault of data8 |
| BFTAB0 | bit 8 | Integrity fault of data2 to data13 (LOGICAL OR) |
| BFDATA 15 | bit 9 | Integrity fault of data15 |
| BFDATA16 | bit 10 | Integrity fault of data16 |
| BFDATA17 | bit 11 | Integrity fault of data17 |
| BFDATA18 | bit 12 | Integrity fault of data18 |

| | | |
|---|---|---|
| **BFDATA19** | **bit 13** | **Integrity fault of data19** |
| **BFDATA20** | **bit 14** | **Integrity fault of data20** |
| **BFDATA21** | **bit 15** | **Integrity fault of data21** |
| **BFTAB1** | **MSB=bit 16** | **Integrity fault of data15 to data26 (LOGICAL OR)** |

The three FLIP-FLOP fields (data1; data14; data27) shall serve to produce a **TBD** bits word called STATE following the algorithm below:

*IF* STATE1 and STATE2 and STATE3 == 0000…h (**TBD**)
*THEN*
STATE := 0000…h (**TBD**)
*ELSE*
*IF* STATE1 or STATE2 or STATE3 == FFFF…h (**TBD**)
*THEN*
STATE := FFFF…h (**TBD**)
*ELSE*
STATE := 0F0F…h (**TBD**)
*END IF*
*END IF*

Based on the variables values, Operating Software shall elect one table field (either TAB0 or TAB1) only to read in.

The remaining table field shall be used only to write in.

Read only table field election shall comply with the following logical table: **TBD**

#### 2.1.8.4.1.2 Parameters data memorisation

Parameters data shall be stored in the elected write only field table (if any).

If there is no elected write only field table, no data shall be written on the actuator memory.

If there is no elected read only table field, the bits PARAMETERS MEMORISATION TERMINATED and BFNVM shall be set to 1 (true) on both ECU lanes (refer to §2.1.9.3.3.4 – µAFDX Message Description).

Parameters data memorisation shall be launched on µAFDX specific command on the MON lane (refer to §2.1.9.3.3.4 – µAFDX Message Description) upon a rising edge (transition from false to true) of the bit START PARAMETERS MEMORISATION.

Parameters data memorisation activation shall be effective at most 50ms after the MON lane has received the demand.

During parameters data memorisation processing,
- PARAMETERS MEMORISATION TERMINATED bit shall be set at 0 (false) on both lanes. (refer to §2.1.9.3.3.4 – µAFDX Message Description),
- The FCC will repeat the same message (demand and data unchanged),
- Each ECU lane shall respond to a µAFDX command.

Integrity of memorised parameters data shall be computed, stored (BFTAB0 or BFTAB1 update in the integrity data) and checked. In case of bad integrity, the bit BFPARAMDATA shall be set to TRUE. Otherwise, it shall be set to FALSE. (refer to §2.1.9.3.3.4 – µAFDX Message Description)

After the memorisation and in case of good integrity of the write only field table, the FLIP-FLOP fields shall be updated and stored in accordance with the following logical table: **TBD.**

When the parameters data memorisation and integrity check of the write only field table and the update of the FLIP-FLOP fields are ended (refer to §2.1.9.3.3.4 – µAFDX Message Description):

- BFNVM and BFPARAMDATA bits shall be updated on both ECU lanes.
- PARAMETERS MEMORISATION TERMINATED bit shall be set at 1 (true)on both lanes.

Parameters data memorisation and check duration shall be **TBA** ms (Objective ≤ 200 ms).

### 2.1.8.4.2 Internal safety test

Internal safety test requirements shall be considered only if safety test are needed by the supplier to comply with safety objectives.

Internal safety test shall be agreed by the purchaser.

Internal safety test shall be launched on µAFDX specific command (refer to §2.1.9.3.3.4 – µAFDX Message Description) with the bit START SAFETYY TEST set to true.

Internal safety test will be launched one time at each flight after landing.

Internal safety tests activation shall be effective within 5ms after the COM and MON lanes have received the demand (logical AND).

Internal safety test shall be launched simultaneously (better than 10 ms) on the COM and MON lanes.

ECU internal safety test duration shall be less than 5s.

During internal safety test processing, TEST TERMINATED bit shall be set at 0 (false). During this phase FCC will repeat the same message (demand and data unchanged)

During internal safety test, ECU shall respond to specified µAFDX test mode messages.

When the internal safety tests are ended, µAFDX shall be activated in order to exchange messages with FCC.

Result of internal safety test shall be sent on specific message (refer to §2.1.9.3.3.4 – µAFDX Message Description).

At the end of internal safety test, TEST TERMINATED bit shall be set at 1 (true) (refer to §2.1.9.3.3.4 – µAFDX Message Description).

At the end of safety test, the result (a Boolean value) shall be stored in the ECU non-volatile memory. This bit shall be set at FALSE if safety test ended successfully with no detected failure. Else, it shall be set at TRUE

BFSAFETYTEST bit shall be set at FALSE if safety test ended successfully with no detected failure. Else, it shall be set at TRUE (refer to §2.1.9.3.3.4 – µAFDX Message Description).

During internal safety test, integrity of memorized data shall be verified (operating software, application software, configuration data, electronic rigging data, health monitoring data).
In case of bad integrity specific bit shall be set to TRUE using the following mapping (refer to message description):

- the bits BFOPERSOFT and BFAPPLISOFT shall be set to FALSE if there is no integrity fault detected during operating software check (checksum / CRC) , otherwise it shall be set to TRUE.
- Configuration data: the bit BFCONFDATA shall be set to FALSE if there is no integrity fault detected during configuration data table check (checksum / CRC) , otherwise it shall be set to TRUE.
- Parameter data: the bit BFPARAMDATA shall be set to FALSE if there is no integrity fault detected during parameter data check (checksum / CRC) , otherwise it shall be set to TRUE.

During internal safety test, hardware shall be checked. In case of a hardware failure, the bit BFHARD shall be set to TRUE . Otherwise it shall be set to FALSE (refer to §2.1.9.3.3.4 – µAFDX Message Description).

During safety test, actuator memory shall be checked. In case of failure, the bit BFNVM shall be set to TRUE . Otherwise it shall be set to FALSE (refer to §2.1.9.3.3.4 – µAFDX Message Description).

### 2.1.8.5 Configuration Mode

#### 2.1.8.5.1 Configuration mode general requirements

This mode shall be used to configure Application Software

Configuration mode shall be activated on application software demand CONF MODE ACTIVATION (BCONFACT) variable is set at true on both ECU lanes.

Configuration mode activation shall be effective within 50ms after the two ECU lanes have received the demand.

The only way to exit the Configuration mode shall be a hardware reset (power supply cut).

#### 2.1.8.5.2 Configuration mode data memorization

Each COM and MON lane shall be able to store at least **TBD** configuration data word (**TBD** bits word).

**TBD** configuration messages shall be received with **TBD** configuration data per message.

At first delivery and after repair, the word Configuration data 1 shall be set at 0000..h (**TBD**)

Configuration memorization sequence shall be initiated by reception of the first configuration message (pointer equal to 0 ).

Configuration memorization sequence shall be terminated by reception of the last configuration message (pointer equal to **TBD**)

Configuration data memorization sequence duration shall be lower than 100ms per message (**TBD** data memorization per message).
During this phase FCC will repeat the same message (pointer and data unchanged).

As soon as the memorization of the last message data (pointer equal to **TBD**), each unit shall compute a global checksum with retention of the global table (data1 up to data**TBD**) and compare the most significant bits with data**TBD** and the less significant bits with data**TBD.**

Configuration data 1 shall be used as an identifier ( CONFIDENT).
In case of loss of message (missed pointer) or global checksum error, CONFIDENT (data1) shall be set to 0000…h (**TBD**) and the configuration sequence shall be aborted.

Configuration data**TBD** shall be used as an actuator identification data.

Configuration data**TBD** ( CHECKSUMMSB) shall be used as the most significant bits of the global table (data1 up to data**TBD**) checksum with carry.

Configuration data**TBD** (CHECKSUMLSB) shall be used as the less significant bits of the global table (data1 up to data**TBD**) checksum with carry.

#### 2.1.8.5.3 Data affectation in configuration mode

Operating software shall process and utilize configuration data in order to run Application software.

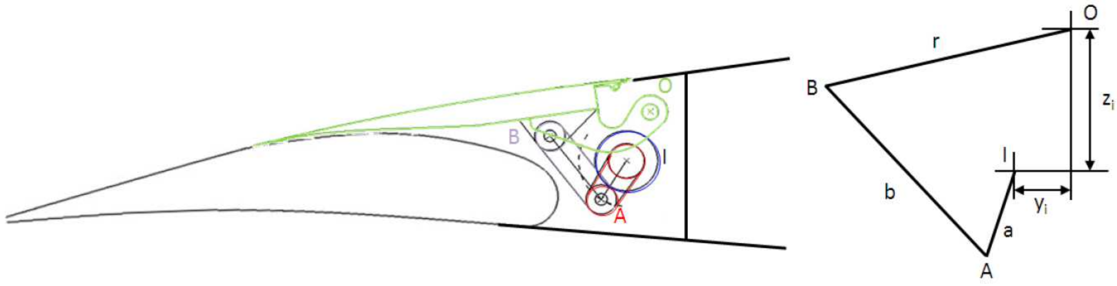
Operating software shall process and utilize configuration data (range application, Boolean treatment...) in configuration mode and prior to store them

After computation, configuration data shall be protected by a global checksum.

### 2.1.9 Interface Characteristics

#### 2.1.9.1 Installation and Kinematic

The following sketch presents the kinematic arrangement of the NSA Spoiler Rotary EMA.



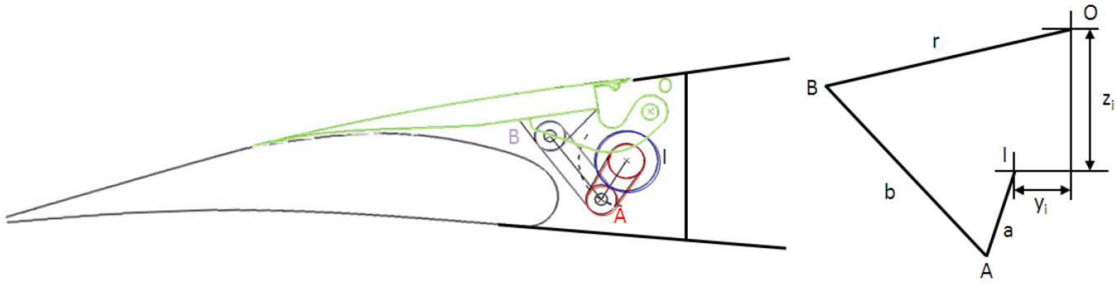

Off-hinge rotary EMA kinematic parameterization

The NSA Spoiler off-hinge rotary EMA baseline kinematic parameters are :

- the flight control surface hinge line
- I the rotary EMA hinge line
- A the rod attachment to the EMA lever
- B the rod attachment to the flight control surface
- zi = 83 mm: distance between O and I on z axis
- yi = - 3 mm: distance between O and I on y axis
- r = 225 mm: distance between O and B
- a = 62 mm: distance between I and A (EMA lever length)
- b = 240 mm: distance between A and B (EMA connecting rod length),
- Angle BOz = 82.1° at actuator neutral position,

Refer to §5.3 – *Appendix 3 - Mechanical Interfaces and Space Allocation* concerning the space envelop.

*(*) For the A320 demonstrator,Spoiler Off-hinge Rotary EMA kinematic is described below:*




Off-hinge rotary EMA kinematic parameterization

*The A320 Spoiler off-hinge rotary EMA baseline kinematic parameters are*

- *the flight control surface hinge line*
- *I the rotary EMA hinge line*

*- A the rod attachment to the EMA lever*
*- B the rod attachment to the flight control surface,*
*- z axis is vertical axis,*
*- zi = 98,8 mm: distance between O and I on z axis*
*- yi = 58,7 mm: distance between O and I on y axis*
*- r = 215 mm: distance between O and B*
*- a = 75 mm: distance between I and A (EMA lever length)*
*- b = 200 mm: distance between A and B (EMA connecting rod length,*
*- Angle BOz = 81.5° at actuator neutral position,*

The EMA space envelope shall comply with drawing provided in §5.3 - *Appendix 3 – Mechanical Interfaces and Space allocation*).

Functional stroke:

- Nominal extension stroke will be 97,33° (associated to + 50° UP surface deflection)
- Nominal retraction stroke will be 27,97° (associated to - 12° DOWN surface deflection)

The functional stroke is limited by the FCC.
The EMA shall send a BOOLEAN to the FCC to inform it if the functional stroke has been exceeded.

Neutral position adjustment:

The actuator neutral position adjustment shall be performed by electronic rigging within the FCC. The electronic rigging authority shall be limited to +/- 2,2° by the application software.

Mechanical stroke:

- Mechanical extension stroke shall not exceed 100,48° (associated to + 51,68° UP surface deflection)
- Mechanical retraction stroke shall not exceed 31.84° (associated to – 13,54° DOWN surface deflection)

Actuator over-strokes shall be defined to enable:
- the EMA neural position adjustment,
- In case of soft end stops, end stops deformation (cf. § 2.1.6.4 – *Duty cycle*)

Total EMA backlash:

Under torque of +/- 150 N.m, the total EMA backlash shall be lower than
- **TBA °** for new equipment (objective ≤ 0,22°)
- **TBA °** at 100% of the specified life (objective ≤ 0,66°).

Backlash measurement methodology shall be submitted to the Purchaser for approval.

Dynamic stiffness (in active mode):

In controlled position (neutral position), and without taking into account the structural stiffness effect, the dynamic stiffness of the actuator (including servo loop effect) shall not be lower than **TBA** N.m/° whatever the amplitude of the aerodynamic mo ment applied at surface hinge (comprised between 1% and 100 % of the maximum torque) and whatever its frequency.

Mechanical stiffness:

In case of rigid end stops, actuator on its internal end stops, the mechanical stiffness shall be higher than :

- **TBA** N.m/° on extension end stop
- **TBA** N.m/° on retraction end stop

In case of soft stops, these stiffnesses shall be measured with soft stops being removed or with specific tools replacing them.

Supplier shall provide a curve for actuator backlash/stiffness vs. torque up to limit torque.

The stiffness values shall be verified during qualification program.

Surface moment of inertia:

1 $kg.m^2$

Attachment stiffnesses:

**TBD**

### 2.1.9.2 Mechanical Interfaces

The unit shall be designed to permit the installation of a holding collar between the actuator body and the output lever. The maximum reacted torque will be the actuator maximum torque. (**TBC**)

The EMA axial loads due to a +/- 3° ( **TBC**) misalignment of the connecting rod shall not result in any permanent deformation neither in any rupture of EMA parts.

The unit shall be fitted with jack catcher devices (*) for associated stress requirements defined in § 2.1.12.1 – Stressing and Loading.

*(*) For the A320 demonstrator, EMA shall not include jack catcher*.

The EMA interfaces and space envelope shall comply with drawing provided in §5.3 - *Appendix 3 – Mechanical Interfaces and Space allocation*.

## 2.1.9.3 Electrical Interfaces

### 2.1.9.3.1 Power Supply

#### 2.1.9.3.1.1 Equipment Electric Power Supply and Wiring

Unless otherwise specified, the unit shall comply with ABD0100.1.8. (*)

*(*) For the A320 demonstrator, 28 VDC Supply shall comply with ABD0013*

##### 2.1.9.3.1.1.1 540 VDC power supply

HPE and ECU COM lanes shall be supplied by the high power supply (540 VDC).

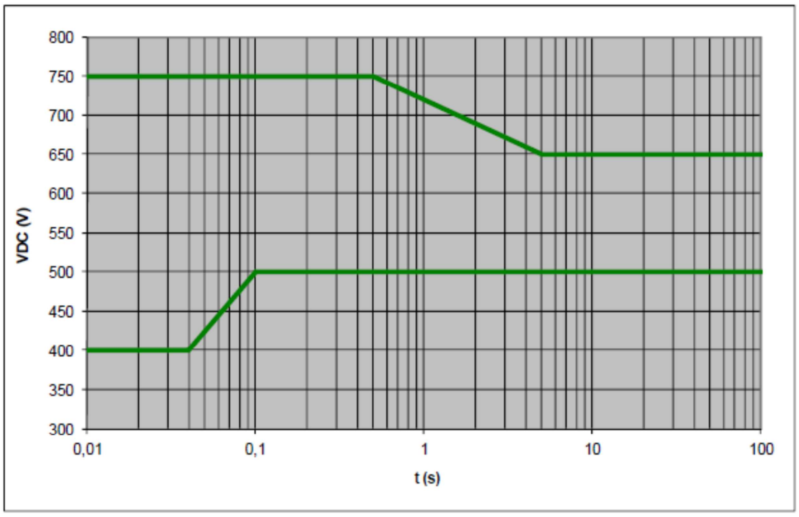
ECU 540 VDC input impedance shall be:
R = **TBA** Ohms +/-**TBA**%,
L = **TBA** mH +/-**TBA**%,
C = **TBA** µF +/- **TBA** %

The ECU High Power and COM electrical connectors are defined in §5.4 – *Appendix 4 – Electrical Connections for DC supply.*

The ECU shall be compliant with following 540 VDC power supply characteristics:

<u>Steady rate:</u> The steady state power supply voltage range is 500 VDC to 650 VDC at the unit level for full performances (see figure hereafter).

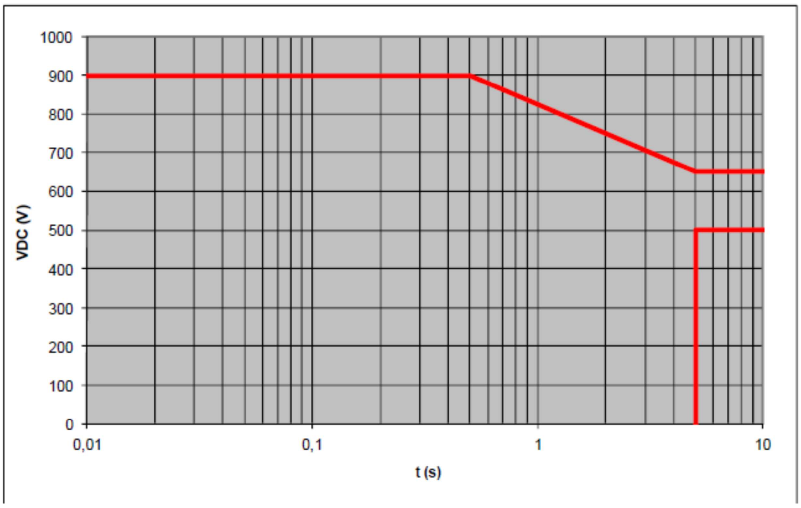
<u>Normal voltage transients:</u> The transient power supply voltage according to N24RP1219645 (400 VDC to 750 VDC) shall not affect the good operation of the unit (nominal performance), (see figure hereafter).




| Duration (s) | Voltage (V) |
|---|---|
| Lower limit | |
| 0.04 | 400 |
| 0.1 | 500 |
| Upper limit | |
| 0.5 | 750 |
| 5 | 650 |

**<u>Differential mode voltage excursion (steady rate and transient conditions)</u>**

Abnormal voltage: The transient power supply voltage according to N24RP1219645 (900 VDC) shall not affect the good operation of the unit (nominal performance) (see figure hereafter).
The unit shall not suffer damage or cause an unsafe condition. Neither unit reliability nor its lifetime shall be affected.




| Duration (s) | Voltage (V) |
|---|---|
| Lower limit | |
| ≥5 | 500 |
| Upper limit | |
| 0.5 | 900 |
| 5 | 650 |

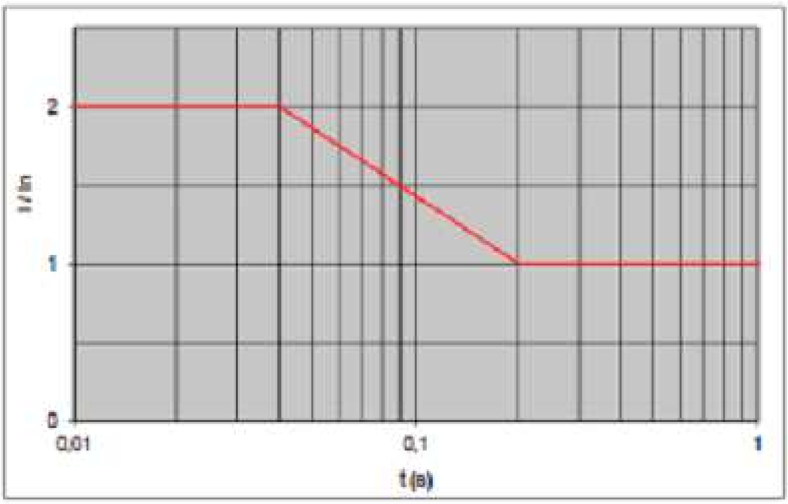
**Differential mode voltage excursion (abnormal conditions)**

Inrush current: Unless otherwise specified in the equipment PTS, the average value of the inrush current shall not exceed the limit of the hereafter figure, which defines the ratio of the inrush current over the equipment nominal current.

The maximum average current shown on the figure below shall not be exceeded even during shorter durations (<10 ms).

Note 1: Inrush current requirement applies not only to power cut conditions, but also to any transient operations equipment in normal conditions.

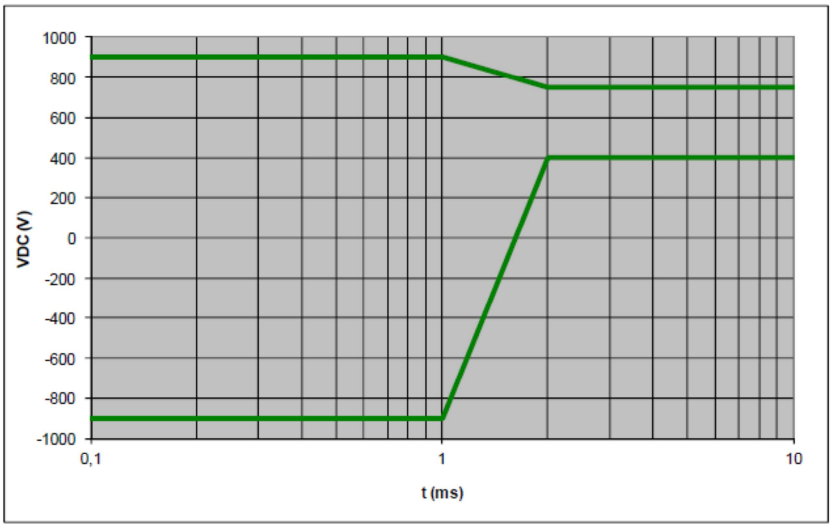
Note2: Challenge of inrush current amplitude and duration requirements may be proposed and provided for Purchaser approval.




| Duration (ms) | Current (p.u.) |
|---|---|
| 40 | 2 |
| 200 | 1 |

**Inrush current enveloppe**

Voltage spikes: The unit shall withstand without degradation the voltage spikes shown on figure hereafter.




| Duration (ms) | Voltage (V) |
|---|---|
| Lower limit | |
| 1 | -900 |
| 2 | 400 |
| Upper limit | |
| 1 | 900 |
| 2 | 750 |

**Voltage spike envelop**

Voltage decrease without power supply: When the equipment is not connected, voltage across any component storing energy shall decrease below 50 V in less than 3 minutes.

Reverse Polarity: Reverse polarity voltage application on equipment shall be prevented by fool-proof design.
In case of permanent reverse voltage application (e.g. erroneous wiring installation) equipment may be damaged but it shall not cause an unsafe condition.
Appropriate monitoring may be implemented to provide diagnostic of reverse polarity application.

Power generation: The supplier shall define the maximum peak power reversed by the equipment owner various time durations (100 ms, 1 s, 10 s...) for any normal or abnormal operating condition:

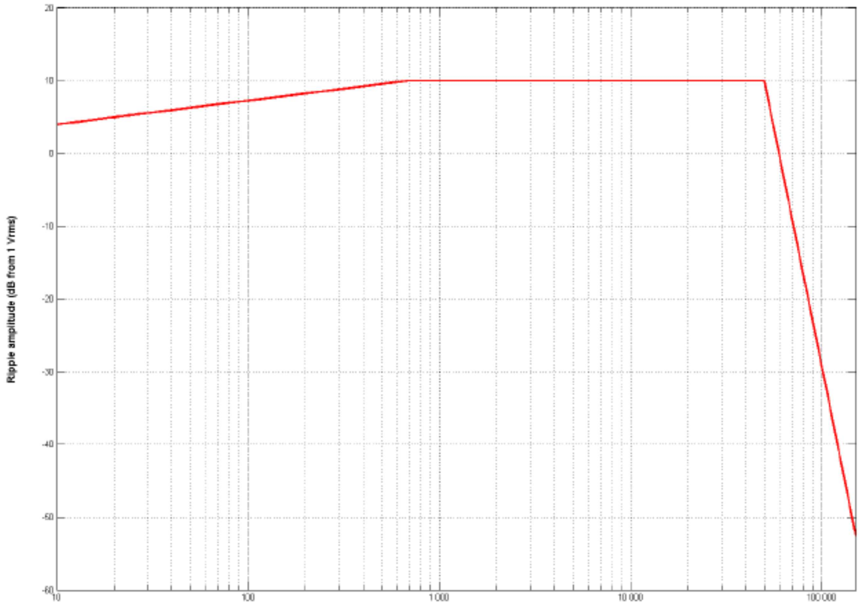
- **TBA** W during **TBA** s
- **TBA** W during **TBA** s
- ...

Current unbalance: During normal operation in steady-state conditions, current unbalance between +270VDC and -270 VDC terminals shall not exceed 2A.

Voltage ripple:

- **Normal conditions:**

The unit shall demonstrate full operating performance when supplied with a voltage ripple within the limits of figure and table hereafter.




| Frequency □Hz) | Voltage ripple (dB) |
|---|---|
| 10 | 4 |
| 700 | 10 |
| 50000 | 10 |
| □50000 | -58 |

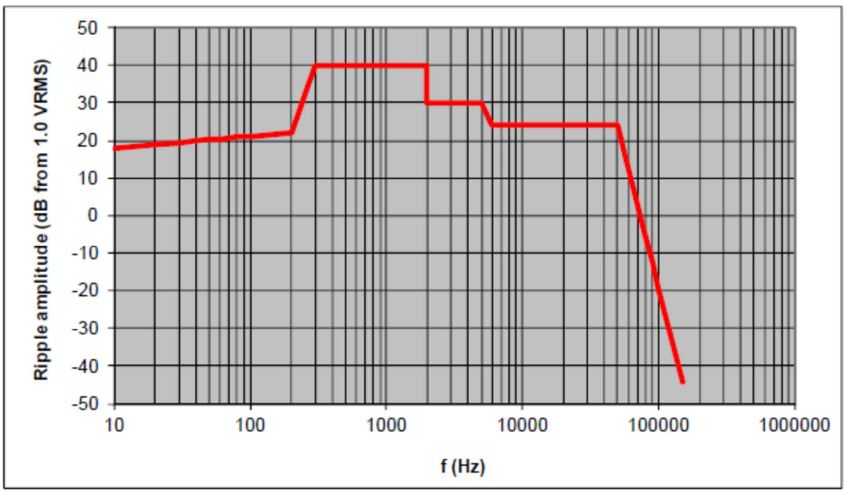
**Voltage ripple envelope (normal conditions)**

| <$V_{DC}$> | $V_{AC\ RMS}$ | $V_{RMS}$ |
|---|---|---|
| 500 V | 12 V | 500.144 V |
| 540 V | 12 V | 540.133 V |
| 650 V | 12 V | 650.111 V |

**Voltage ripple limits (normal conditions)**

- **Abnormal conditions**

The unit shall demonstrate full operating performance when supplied with a voltage ripple in abnormal conditions within the limits of figure and table hereafter.



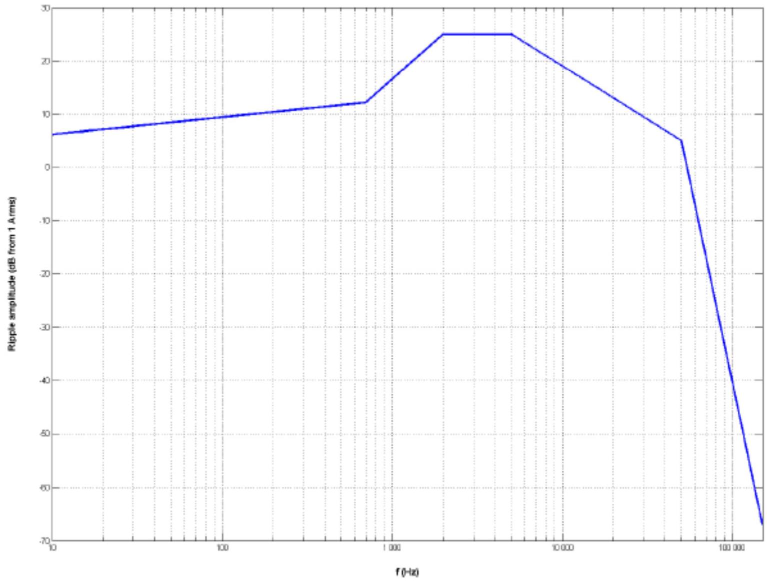

| Frequency (Hz) | Voltage ripple (dB) |
|---|---|
| 10 | 18 |
| 200 | 23 |
| 300 | 40 |
| 2000 | 30 |
| 6000 | 24 |
| 150000 | -44 |

**Voltage ripple enveloppe (abnormal conditions)**

| $<V_{DC}>$ | $V_{AC\ RMS}$ | $V_{RMS}$ |
|---|---|---|
| 500 V | 110 V | 512.0 V |
| 540 V | 110 V | 551.1 V |
| 650 V | 110 V | 659.2 V |

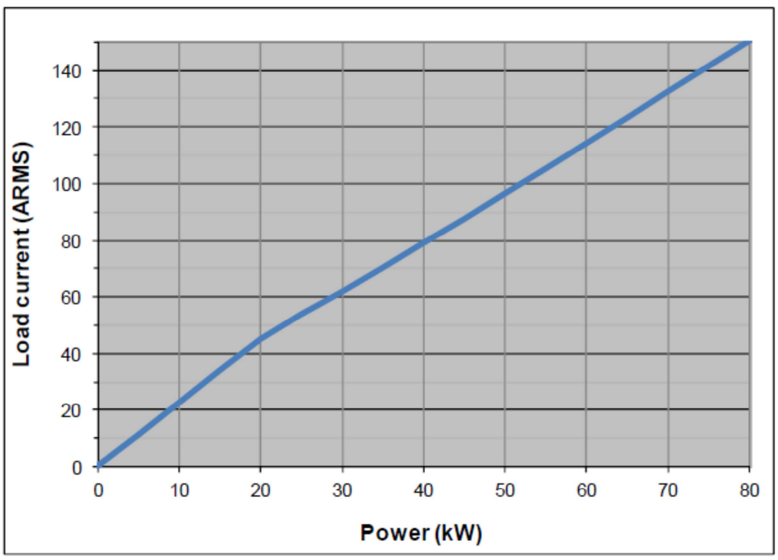
**Voltage ripple limits (abnormal conditions)**

Current ripple : In steady-state conditions, the current ripple at unit input shall be within the limits of figure and table hereafter.



| Frequency (Hz) | Current ripple (dB) | Current ripple (dBµA) |
|---|---|---|
| 10 | 6.1 | 126.1 |
| 700 | 12.1 | 132.1 |
| 2000 | 25.0 | 152.0 |
| 5000 | 25.0 | 152.0 |
| 50000 | 5.0 | 127.0 |
| 150000 | -67.0 | 53.0 |

**Current ripple envelop (adnormal conditions)**




| Nominal power | $<I_{DC}>$ | $I_{ACRMS}$ | $I_{RMS}$ |
|---|---|---|---|
| 1 kW | 1.85 | 1.31 | 2.27 |
| 10 kW | 18.5 | 13.1 | 22.7 |
| 20 kW | 37.0 | 26.2 | 45.4 |
| 30 kW | 55.6 | 27.0 | 61.8 |
| 80 kW | 148 | 27.0 | 151 |

Formula:

| Nominal power | $I_{RMS}$ |
|---|---|
| $P_N \leq 20$ kW | $2.27xP_N$ ($A_{RMS}$) |
| $P_N > 20$ kW | $1.78xP_N+8.48$ ($A_{RMS}$) |

**Current ripple limits**

Differential-mode current unbalance: During normal operation in steady state conditions, current unbalance between +270 VDC and -270 VDC terminals shall not exceed 2% of the nominal current.

Stability: The supplier shall demonstrate the stability of his equipment when supplied by an ideal voltage source (impedance output of 0 ohm), with an equivalent series inductance defined in paragraph 2.1.9.3.1.1.3 – *Wiring.*
In particular, when performing a load impact at the equipment nominal power with the maximum dynamics allowed by the equipment performances, the current drawn by the equipment shall comply with the current transient requirements.

#### 2.1.9.3.1.1.2 28 VDC Supply

*(*) For the A320 demonstrator, 28 VDC Supply shall comply with ABD0013*

Damage due to inadvertent application of 28VDC, or ground on one or more pins of a connector shall be limited to inputs/outputs involved.

The ECU lane will be supplied by one (1) dedicated low power supply (28 VDC).

The ECU shall be designed to be tolerant to installation and removal under power.

EMA ECU electronics parts shall be isolated from EMA housing.

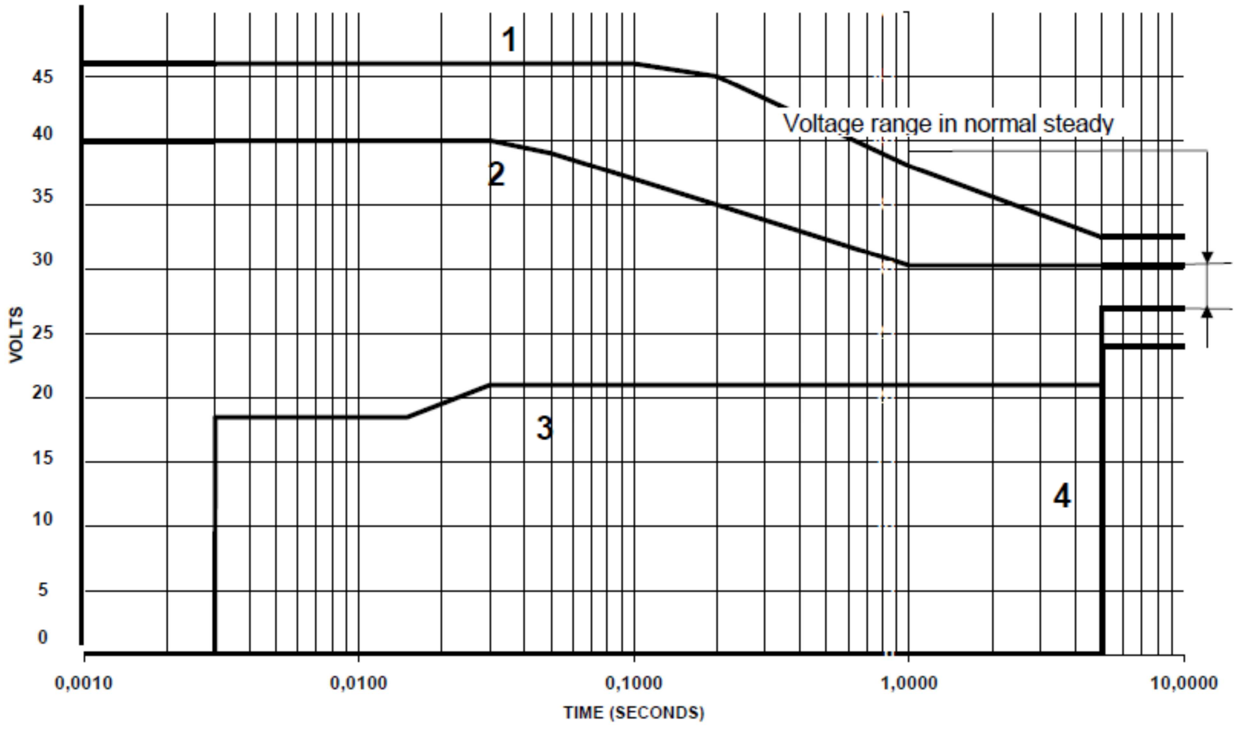
Internal supplies shall be galvanically isolated from the 28 VDC.

ECU MON connector is defined in §5.4 – *Appendix 4 – Electrical Connections for DC supply.*

The ECU shall be compliant with following 28 VDC supply characteristics:

Steady rate: See figure in the next page.

| Steady State Characteristics | Normal | Abnormal | Emergency |
|---|---|---|---|
| Voltage (VDC) | 27-30.3 | 24-32.5 | 21-32.5 |




1 & 4 ABNORMAL TRANSIENT LIMITS

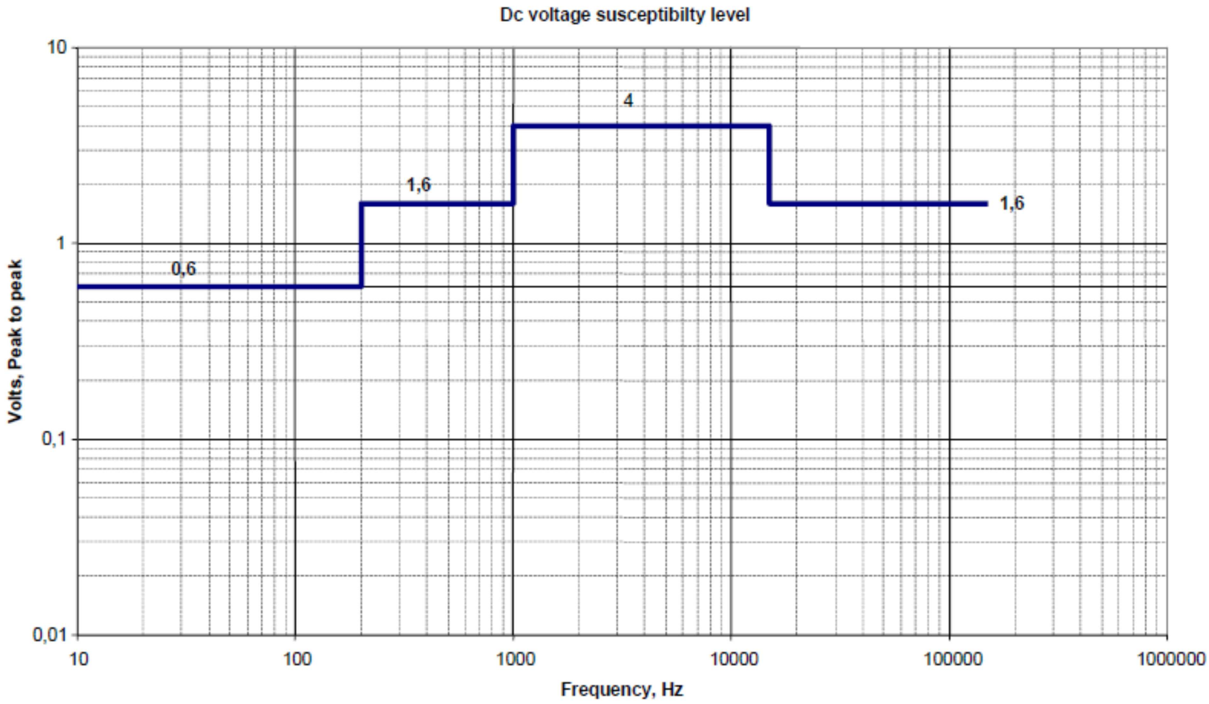
2 & 3 NORMAL TRANSIENT LIMITS

| Time (sec.) | Limit 1 (V) | Limit 2 (V) | Limit 3 (V) | Limit 4 (V) |
|---|---|---|---|---|
| **0 to 0.001** | **46** | **Between t = 0 and t = 0.00299 s, the voltage may vary, at random, between 0 and 46 V** | | **0** |
| 0.002 | 46 | 40 | 0 | 0 |
| 0.003 | 46 | 40 | 0/18.5* | 0 |
| 0.01 | 46 | 40 | 18.5* | 0 |
| 0.015 | 46 | 40 | 18.5* | 0 |
| 0.03 | 46 | 40 | 21* | 0 |
| 0.05 | 46 | 39 | 21* | 0 |
| 0.1 | 46 | 37 | 21* | 0 |
| 0.2 | 45 | 35 | 21* | 0 |
| 1 | 38 | 30.3 | 21* | 0 |
| 5 | 32.5 | 30.3 | 21*/27* | 0/24* |
| ≥ 10 | 32.5 | 30.3 | 27* | 24* |

*(*) Note: Subtract 2.5 V (voltage drop) to get voltage limits at equipment terminals.*

**Transient voltages for a 28VDC supply**

Ripple voltage:




The above curve corresponds to the frequency spectrum envelope of voltage ripple in DC network.

| Frequency KHz | Voltage ripple Volts, peak to peak |
|---|---|
| 0.01 | 0.6 |
| 0.2 | 0.6/1.6 |
| 1 | 1.6/4.0 (*) |
| 15 | 4.0/1.6 (*) |
| 150 | 1.6 |

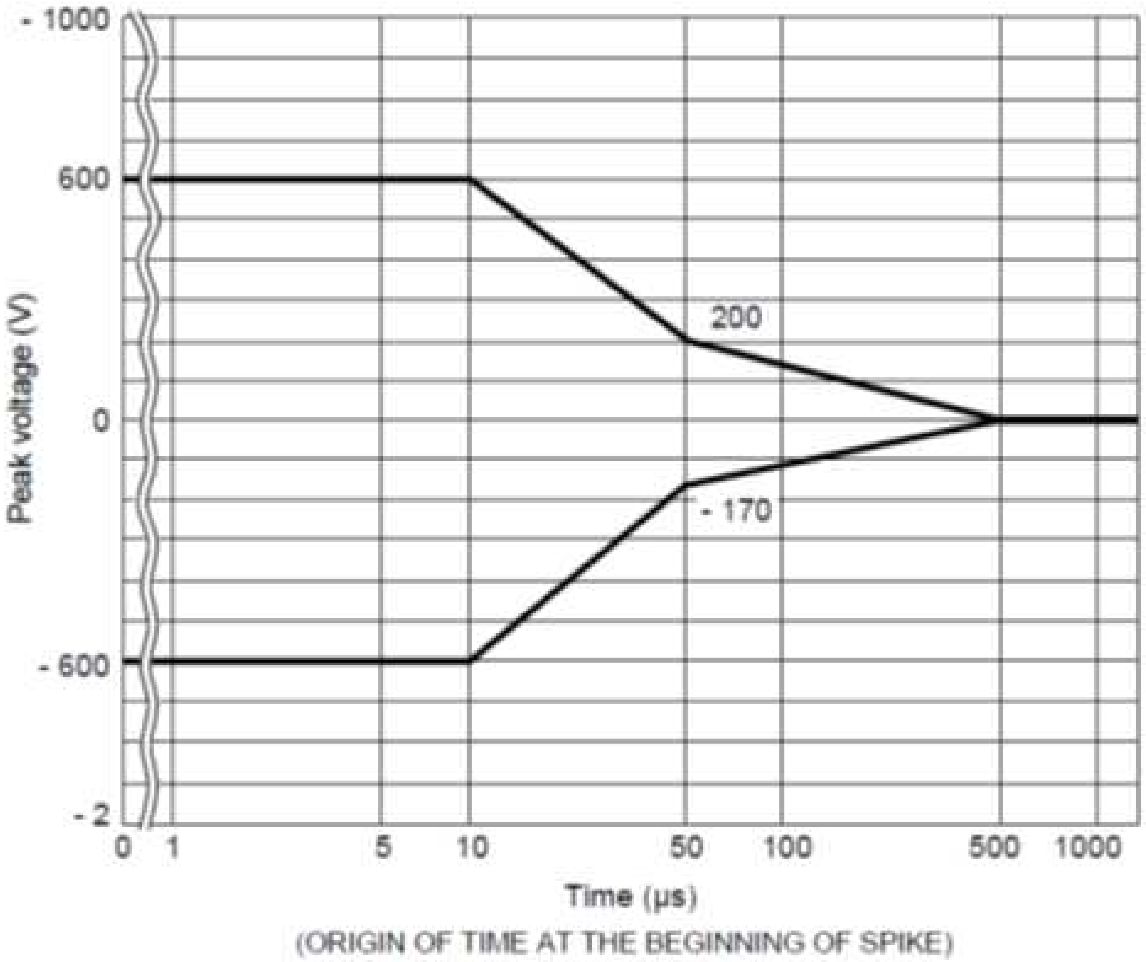
(*) **Caution**: The maximum voltage ripple level (i.e. 4 V, peak to peak) applies if the mean level of the DC voltage at equipment terminals is above or equal 22V; if not, it shall be reduced to 2V, peak to peak.

**Ripple voltage for a 28VDC supply**

Power interruption:

| | **Normal** | **Abnormal** | **Emergency** |
|---|---|---|---|
| **Power interrupt** | | | |
| Maximum duration | 3 ms (see note 2 below) | 5 s | 3 ms |
| Note 2: *This limit applies to any DC distribution busbar except the DC busbar dedicated to APU starting that may be subjected to power interruptions up to 200 ms.* | | | |

Voltage spikes:




| Time (µs) | Amplitude of positive spike (Volts) | Amplitude of negative spike (Volts) |
|---|---|---|
| 0 | 600 | 600 |
| 10 | 600 | 600 |
| 20 | 428 | 415 |
| 30 | 327 | 306 |
| 50 | 200 | 170 |
| 100 | 140 | 119 |
| 200 | 80 | 68 |
| 300 | 44 | 38 |
| 500 | 0 | 0 |

**Voltage spikes for a 28VDC supply**

#### 2.1.9.3.1.1.3 Wiring

540VDC:

Power line impedance will be **TBD** µH (50 µH max) with a resistance of 1 Ohm (max). Power cable length is maximum 40m.

The electrical components will be connected to the computers via twisted gauge 24 wires that may be shielded.

The wires will be twisted in pairs and, as far as the position transducers are concerned, pairs twisted together.

The capacitance between two twisted wires is 0.05 nF/m.

The capacitance between two wires of two separate twisted pairs is 0.005 nF/m.

28VDC:

FCC/ECU wiring will be equivalent to an impedance of 1 to 2 Ohm and 80 to 130 µH.

The maximum cable length will be of 40 m.

The capacitance between two twisted wires is 0.05 nF/m.

The capacitance between two wires of two separate twisted pairs is 0.005 nF/m.

### 2.1.9.3.1.2 Equipment Behaviour following low Power Interrupt

During transients (< 3.5ms) on 28VDC, the behaviour of the EMA ECU shall remain in normal operation.

Maximum time between 28V power loss and all outputs in inactive state shall not exceed **TBA** ms (Objective ≤ 10ms).

Maximum time between 28V power recovery and disposition of stabilised inputs/outputs (µAFDX communication) shall not exceed **TBD** ms (Objective ≤ 250ms).

Maximum hold up time shall be **TBA** ms **(**Objective < 20ms).

In case of power interrupt duration between min and max hold up time, ECU behaviour shall be deterministic.

After power interrupt higher than 3.5 ms discrete mode signal acquired by application software and associated variable (**TBD**) will change from True to False (if applicable).

#### 2.1.9.3.1.3 Internal Rules Segregation

COM and MON lanes shall be electrically and mechanically segregated.

The µAFDX data bus shall be isolated galvanically from the HVDC power supply.

#### 2.1.9.3.1.4 Power Consumption

The unit shall be operational (§ 2.1.5.1 – *Operational Function*) for any supplied voltage higher or equal to **TBA** VDC (objective ≤ 400 VDC).

The electrical consumption shall be minimized.

The Supplier shall minimize the power consumption variations due to temperature influence (all operating temperature range shall be considered)

Whatever the dynamic phases (power up of the unit, high frequency of surface deflection) the maximum current shall be lower than **TBA** A in continuous (normal functioning) and **TBA** A during transient phases (at power up).
The inrush current at power up is lower than **TBA** A and lasts less than **TBA** ms.

In case of no movement of the unit, the maximum line current under aircraft supply voltage of 540 VDC shall be lower than:

| Load conditions | | Maximum current consumption without movement |
|---|---|---|
| Without torque | | **TBA** ADC |
| Under maximum external torque | Positive torque | **TBA** ADC |
| | Negative torque | **TBA** ADC |

Input power shall be limited by a dedicated function in normal, abnormal and emergency conditions of electrical system operation

Power consumption in normal or abnormal electrical system operation shall be less than **TBA** kW at equipment input terminals whatever power supply conditions (voltage and frequency) according to § 2.1.9.3.1 – *Power Supply* and whatever the dynamic phases (high frequency of surface deflection).

Power consumption in emergency condition shall be less than **TBA** kW at equipment input terminals whatever emergency power supply conditions (voltage and frequency) according ABD0100.1.8.1.

When application software variable BPWRLIM is set to true in COM lane, power limitation shall switch from nominal value to emergency value.

The maximum current demanded (inrush included) by the equipment should not exceed **TBD** Apeak.

#### 2.1.9.3.1.5 Internal Power Supplies

COM lane internal power supplies shall be galvanically isolated from the HVDC. A high impedance resistor (100K to 10 M) is allowed between COM return and HVDC return to limit isolated ground potential differences.

MON lane internal power supplies shall be galvanically isolated from the 28 VDC. A high impedance resistor (100K to 10 M) is allowed between MON return and 28 VDC return to limit isolated ground potential differences.

COM and MON lane internal power supplies shall be galvanically isolated with allowance of high impedance resistance.

#### 2.1.9.3.1.6 Circuit Breaker Characteristics

The overall ECU operation, and particularly the inrush current, shall be compatible with an aircraft circuit breaker with characteristics described in § 5.9 - *Appendix 9 – Circuit Breaker Tripping Characteristics*.

The HVDC network wiring is protected by a specific breaker of calibre 10A.

The LVDC network wiring is protected by a specific breaker of calibre 3A.

Note: The purpose of the circuit breaker is not to protect the ECU but the associated power supply wiring.

#### 2.1.9.3.1.7 Input / Output Protections

The equipment Inputs/Outputs shall be protected from any load short-circuits (see ABD0100.1.9).

The equipment shall be protected against inadvertent application of 28VDC, 115 VAC, 540 VDC or ground on one or more pins of the connectors (see ABD0100.1.9).

A failure induced by the above inadvertent application of power supply on one or several I/Os shall be limited to these I/Os.

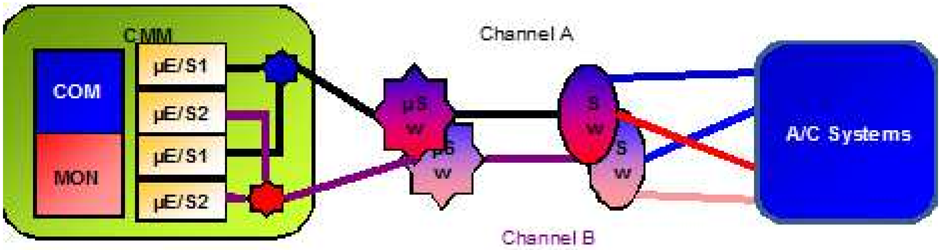
The equipment shall be protected against internal power supply failure (see ABD0100.1.9).

#### 2.1.9.3.2 µAFDX Interface

#### 2.1.9.3.2.1 µAFDX requirements

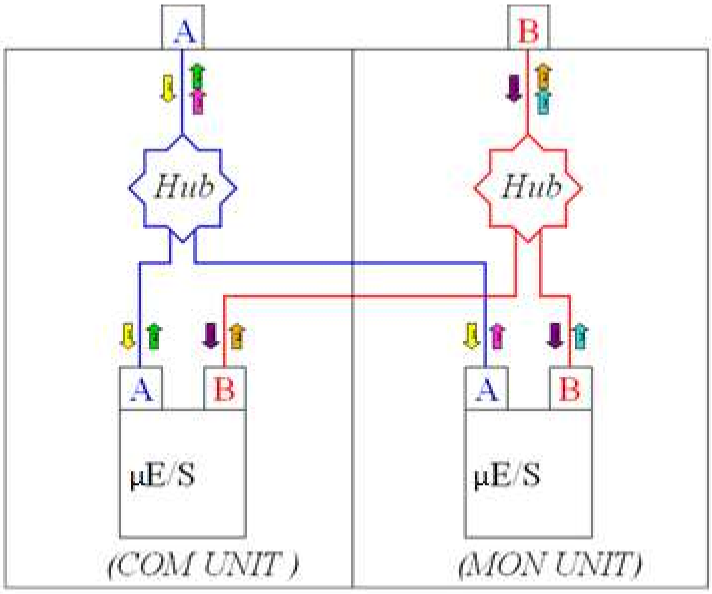
The EMA ECU shall comply with requirements defined in “AFDX Micro End/System Detailed Functional Specification” ref. N4230SP0910610.

Both COM and MON lanes shall be interfaced with two redundant µAFDX channels as per the following figure:




**µADFX communication**

COM and MON lanes shall implement a Single Bus Interface (SBI) with one upstream port and two downstream ports in order to multiplex the messages between ECU lanes and both µAFDX channels (refer to the following figure for details).




COM and MON units shall check the integrity of the frames received on both micro End/System (.

If the µAFDX frames are received valid, COM lane shall use data from Channel A by default.

If the µAFDX frames are received valid, MON lane shall use data from Channel B by default.

If case of single Channel failure (frame integrity check failed), data from the remaining Channel shall be used.

Ethernet links between COM and MON units shall be galvanically isolated.

The lag induced by the word acquisition process shall be less than 1ms.

The acquisition system shall indicate to the microprocessor whether messages have been refreshed. Refresh rate shall have a maximum jitter of 1ms.

COM and MON lanes shall implement two micro End Systems able to receive (resp. transmit) messages from (resp. to) both µAFDX channels.

#### 2.1.9.3.2.2 Input / output processing frequency

Input / Output processing frequency shall be defined in accordance with " AFDX Micro End-System Detailed Functional Specification" ref. N4230SP0910610.

ECU processing frequency is fixed by a cycle at **TBA** ms.

Cycle duration accuracy shall be better than 1/1000 of the cycle duration.

#### 2.1.9.3.2.3 Input / output processing performance

Input / Output processing performance shall be defined in accordance with " AFDX Micro End-System Detailed Functional Specification" ref. N4230SP0910610.

The performances provided below shall be achieved whatever environmental and supply ECU conditions (except during high-energy radio frequency and during lightning strike pulses).

Considering the operating range of each input, the Supplier shall make sure that computation saturation is avoided.

Considering the application software cycle of each analogue input, the Supplier shall make sure that aliasing problems are avoided.

All acquisition shall remain into their requirements.

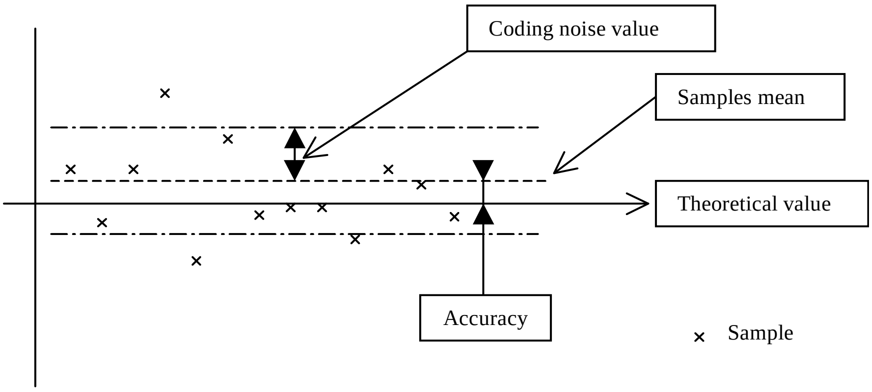
The anti-aliasing feature shall be software adjustable considering the application software cycle.
Accuracy, resolution, stability, coding noise, lag, filter, phase and attenuation requirements shall be considered at the input / output of application software.

For each analogue input/output type, the Supplier shall provide an analysis document concerning signal-processing design (from (to) physical input to (from) application software).

For each type of analogue input/output, the Supplier shall provide on request a mathematics simulation model (MATLAB) of the acquisition behaviour (from (to) physical input to (from) application software).

Analogue input / output accuracy shall be obtained by the difference between the theoretical value and the mean of the different samples at the application software cycle.

Coding noise shall be obtained by the standard deviation.

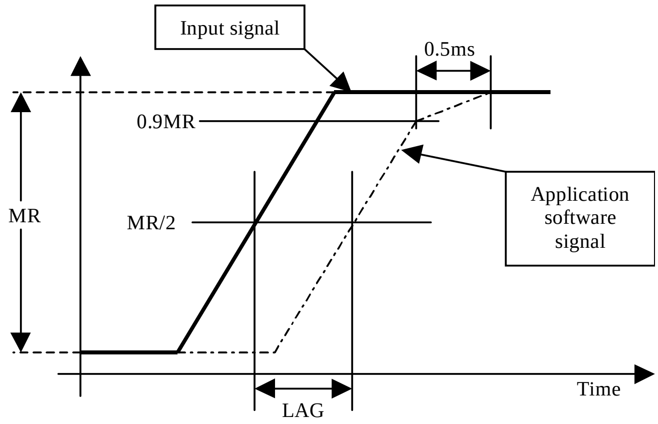



The Supplier shall provide the method used to compute these previous parameters to the Purchaser for agreement.

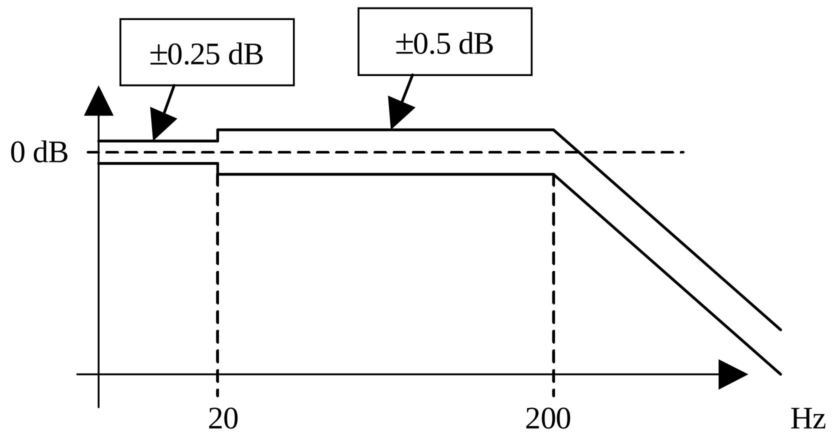
Measurement range (MR) is the measurement interval of a sensor.
Sensor displacement (L) is obtain by the following formula: Sensor current position / MR

Acquisition lag shall be the difference between an input signal, which is a ramp of MR at maximum speed, and the answer in the application software measured at 50% of the ramp.

This lag shall be considered as a maximum for all points of the ramp between 0 and 90% of MR (see curve).




For all inputs the gain / frequency response shall be better than ±0.25dB in the interval [0,20Hz], ±0.5dB in the interval [20, 200Hz] and after the curve shall be monotone decreasing.



For all inputs, the phase lag ($\Delta\varphi$) shall be in accordance with the acquisition lag up to 200Hz.

For higher frequency (f) the phase lag shall be monotone increasing ($\Delta\varphi = 2.\pi.f.\Delta t$ and $\Delta t \leq Lag$).

#### 2.1.9.3.2.4 Mode Indication

The equipment shall include a signal associated to the COM lane for mode indication.

Mode indication shall permit to detect the following states (one bit for each state):

- Active mode,
- Anti-extension mode,
- *Re-centring mode (*) For the A320 demonstrator only*,
- Undefined mode,
- Sensor failure (cut wire…).

Maximum lag between physical mode and associated software variables (sent on µAFDX buses or used for computation in application software) shall be less than 10 ms.

The selected mode shall be obtained by the application software using following variables:

- BACT for active mode,
- BANTIEXT for anti-extension mode,
- BREC for re-centring mode *(*) For the A320 demonstrator only*,
- BUNDEF for undefined mode,
- **TBD** for Sensor failure.

Each state of the mode indication shall be provided on µAFDX COM data bus on FCRTBCA message.

#### 2.1.9.3.2.5 Mechanical Output position Information

One (1) mechanical output position sensor is required.

The sensor shall be supplied by the ECU COM lane and shall send its information to the ECU COM lane which shall transfer it to the ECU MON lane via the ECU internal bus.

Mechanical output position information shall be obtained by the application software using POS variable.

ECU COM lane mechanical output position information shall be provided to FCC via COM µAFDX data bus on FCRTBCA message.

MON lane mechanical output position information shall be provided to FCC via MON µAFDX data bus on FMRTBCA message.

A positive mechanical output position information sent via µAFDX bus or POS variable shall be associated to an aileron surface downward movement.

A negative mechanical output position information sent via µAFDX bus or POS variable shall be associated to an aileron surface upward movement.

COM lane mechanical output position information accuracy, resolution, coding noise and bandwidth (including lag between physical position and associated software variable sent via µAFDX data bus or used for application software) shall meet requirements defined in §5.10 – *Sensor and Associated Treatment Performances.*

Coding noise of each computed EMA position acquisition shall be < **TBA** at the input (frequency) of the application software.

Maximum speed of each computed EMA position acquisition shall be at least MR in **TBA** ms.

Maximum lag between physical EMA position and associated software variable (sent via µAFDX data buses or used for computation) shall be less than **TBA** ms.

EMA position acquisition system shall permit to detect any cut wire.

EMA position coding stabilization time after reset shall be < **TBA** ms.

A monitoring shall be defined by the supplier in order to be able to detect cut wire or supply problem (like oscillatory failure).

Sensor wire cut and oscillatory monitoring could be implemented within the FCC or the ECU.

This monitoring shall not impact EMA operation and shall be agreed by the purchaser.

#### 2.1.9.3.2.6 Motor position Information

Two (2) motor position sensors are required.

One (1) sensor shall be supplied by the ECU COM lane and shall send its information to the ECU COM lane which shall transfer it to the ECU MON lane via the ECU internal bus.

One (1) sensor shall be supplied by the ECU MON lane and shall send its information to the ECU MON lane.

ECU COM lane motor position information shall be provided to FCC via COM µAFDX data bus on FCRTBCA message.

ECU MON lane motor position information shall be provided to FCC via MON µAFDX data bus on FMRTBCA message.

Motor position information shall be available for application software on each lane using MSPD variable.

COM lane motor position information accuracy, resolution, coding noise and bandwidth (including lag between physical position and associated software variable sent via µAFDX bus or used for application software) shall meet requirements defined in §5.10 – *Sensor and Associated Treatment Performances.*

MON lane motor position information accuracy, resolution, coding noise and bandwidth (including lag between physical position and associated software variable sent via µAFDX bus or used for application software) shall meet requirements defined in §5.10 – *Sensor and Associated Treatment Performances.*

A monitoring shall be defined by the supplier in order to be able to detect cut wire or supply problem (like oscillatory failure).

Sensor wire cut and oscillatory monitoring could be implemented within the FCC or the ECU.

This monitoring shall not impact EMA operation and shall be agreed by the purchaser.

#### 2.1.9.3.2.7 EMA Torque Information

One (1) torque sensor is required.

The sensor shall be supplied by the ECU COM lane and shall send its information to the ECU COM lane which shall transfer it to the ECU MON lane via the ECU internal bus.

ECU COM lane torque information shall be provided to FCC via COM µAFDX data bus on FCRTBCA message.

ECU MON lane torque information shall be provided to FCC via MON µAFDX data bus on FMRTBCA message.

Torque information shall be available for application software on each lane using LOAD variable.

COM lane torque information accuracy, resolution, coding noise and bandwidth (including lag between physical position and associated software variable sent via µAFDX data bus or used for application software) shall meet requirements defined in §5.10 – *Sensor and Associated Treatment Performances.*

MON lane torque information accuracy, resolution, coding noise and bandwidth (including lag between physical position and associated software variable sent via µAFDX data bus or used for application software) shall meet requirements defined in §5.10 – *Sensor and Associated Treatment Performances.*

A monitoring shall be defined by the supplier in order to be able to detect cut wire or supply problem (like oscillatory failure).

Sensor wire cut and oscillatory monitoring could be implemented within the FCC or the ECU.

This monitoring shall not impact EMA operation and shall be agreed by the purchaser.

#### 2.1.9.3.2.8 EMA Motor Current Information

At least, Two (2) motor current sensors are required.

All sensors shall be supplied by the ECU COM lane and shall send their information to the ECU COM lane which shall transfer them to the ECU MON lane via the ECU internal bus.

ECU MON lane motor current information shall be provided to FCC via MON µAFDX data bus on FMRTBCA message.

Motor current information shall be available for application software on each lane using MCURx variable (x being the number of the considered current sensor).

MON lane motor current information accuracy, resolution, coding noise and bandwidth (including lag between physical position and associated software variable sent via µAFDX data bus or used for application software) shall meet requirements defined in §5.10 – *Sensor and Associated Treatment Performances.*

A monitoring shall be defined by the supplier in order to be able to detect cut wire or supply problem (like oscillatory failure).

Sensor wire cut and oscillatory monitoring could be implemented within the FCC or the ECU.

This monitoring shall not impact EMA operation and shall be agreed by the purchaser.

#### 2.1.9.3.2.9 EMA ECU Internal Temperature Information

Two (2) temperature sensors are required per ECU hot point.

The ECU hot point location shall be determined by the Supplier and agreed with the Purchaser.

One (1) sensor shall be supplied by the ECU COM lane and shall send its information to the ECU COM lane which shall transfer it to the ECU MON lane via the ECU internal bus.

One (1) sensor shall be supplied by the ECU MON lane and shall send its information to the ECU MON lane.

ECU COM lane ECU temperature information shall be provided to FCC via COM µAFDX data bus on FCRTBCD message.

ECU MON lane ECU temperature information shall be provided to FCC via MON µAFDX data bus on FMRTBCD message.

ECU temperature information shall be available for application software on each lane using ECUTEMP variable.

COM lane ECU temperature information accuracy, resolution, coding noise and bandwidth (including lag between physical position and associated software variable sent via µAFDX bus or used for application software) shall meet requirements defined in §5.10 – *Sensor and Associated Treatment Performances.*

MON lane ECU temperature information accuracy, resolution, coding noise and bandwidth (including lag between physical position and associated software variable sent via µAFDX bus or used for application software) shall meet requirements defined in §5.10 – *Sensor and Associated Treatment Performances.*

Design shall be robust regarding the loss of one temperature sensor.

A monitoring shall be defined by the supplier in order to be able to detect cut wire or supply problem (like oscillatory failure).

Sensor wire cut and oscillatory monitoring could be implemented within the FCC or the ECU.

This monitoring shall not impact EMA operation and shall be agreed by the purchaser.

#### 2.1.9.3.2.10 EMA Motor Temperature Information

Two (2) temperature sensors are required per motor hot point.

The motor hot point location shall be determined by the Supplier and agreed with the Purchaser.

One (1) sensor shall be supplied by the ECU COM lane and shall send its information to the ECU COM lane which shall transfer it to the ECU MON lane via the ECU internal bus.

One (1) sensor shall be supplied by the ECU MON lane and shall send its information to the ECU MON lane.

ECU COM lane motor temperature information shall be provided to FCC via COM µAFDX data bus on FCRTBCD message.

ECU MON lane motor temperature information shall be provided to FCC via MON µAFDX data bus on FMRTBCD message.

EMA Motor temperature information shall be available for application software on each lane using MTRTEMP variable.

COM lane ECU temperature information accuracy, resolution, coding noise and bandwidth (including lag between physical position and associated software variable sent via µAFDX bus or used for application software) shall meet requirements defined in §5.10 – *Sensor and Associated Treatment Performances.*

MON lane ECU temperature information accuracy, resolution, coding noise and bandwidth (including lag between physical position and associated software variable sent via µAFDX bus or used for application software) shall meet requirements defined in §5.10 – *Sensor and Associated Treatment Performances.*

Design shall be robust regarding the loss of one temperature sensor.

A monitoring shall be defined by the supplier in order to be able to detect cut wire or supply problem (like oscillatory failure).

Sensor wire cut and oscillatory monitoring could be implemented within the FCC or the ECU.

This monitoring shall not impact EMA operation and shall be agreed by the purchaser.

#### 2.1.9.3.2.11 RVDT Surface Position Information

One (1) RVDT surface position sensor shall be supplied by the ECU MON lane.

The sensor shall send its information to the ECU MON lane and shall transfer it to the FCC via MON µAFDX data bus on FMRTBCA message.

RVDT Surface Position information shall be available for application software on each ECU lane using PSURF variable.

MON lane RVDT Surface Position Information accuracy, resolution, coding noise and bandwidth (including lag between physical position and associated software variable sent via µAFDX bus or used for application software) shall meet requirements defined in §5.10 – *Sensor and Associated Treatment Performances.*

A monitoring shall be defined by the supplier in order to be able to detect cut wire or supply problem (like oscillatory failure).

Sensor wire cut and oscillatory monitoring could be implemented within the FCC or the ECU.

This monitoring shall not impact EMA operation and shall be agreed by the purchaser.

*(*) For the A320 demonstrator, There is no RVDT surface position sensor.*

#### 2.1.9.3.2.12 Power Limitation Mode

When application software variable BPWRLIM is set to true in COM lane, power limitation shall switch from nominal value to emergency value.

Each COM and MON lane shall report the actuator power limitation status by using the Boolean variable BPWRLIMENG.

BPWRLIMENG shall be set to True if the power limitation is engaged on the actuator. Else, it shall be set to False.

Actuator power limitation status shall be provided via µAFDX COM data bus on FCRTBCA message.

Actuator power limitation status shall be provided via µAFDX MON data bus on FMRTBCA message.

Maximum lag between engagement of emergency power limitation mode (sent via µAFDX data bus) and power limitation status associated software variable (sent via µAFDX data buses and used for computation) shall be less than 7,5 ms.

*(*) For the A320 demonstrator, There is no Power Limitation Mode.*

#### 2.1.9.3.2.13 Motor Control Order

COM lane application software shall be able to disable the control of the motor by using BK1 variable .

EMA Motor speed control order shall be obtained by the application software using EMACTLORD variable.

Maximum lag from application software disable order variable BK1 to motor control order computation shall be less than **TBD** ms.

Resolution of motor control order application shall be < **TBA**.
MR = Measurement range = **TBA** rpm.

#### 2.1.9.3.2.14 HVDC Power Supply Indication

The unit shall monitor the presence of HVDC (540 VDC) power supply.

HVDC power supply presence shall be made available to the application software on each ECU lane through the Boolean variable BHVDC.

If HVDC power supply is available, the Boolean variable BHVDC shall be set to TRUE. Else, BHVDC shall be set to FALSE.

#### 2.1.9.3.3 Actuator Non Volatile Memory

The Non Volatile Memory fitted on actuator shall be read/write type and managed by the ECU.

The Non Volatile Memory required within the actuator shall be able to store EMA key parameters, Health Monitoring and electrical rigging data during the whole actuator life.

Non Volatile Memory shall be sized for 1 Health Monitoring data writing cycle / Flight Cycle.

Non Volatile Memory shall be sized for 1 Health Monitoring reading cycle / Flight Cycle.

<u>Data stored by the Supplier prior to delivery:</u>

The following data shall be stored in the Non Volatile Memory prior to equipment delivery:

- The Part Number:
- The Serial Number:
- EMA key parameters: They have to be defined by the Supplier and approved by the Purchaser.

#### 2.1.9.3.4 ECU Non Volatile Memory

The Non Volatile Memory fitted on ECU shall be read/write type and managed by the ECU.

The Non Volatile Memory required within the ECU shall be able to store EMA key parameters during the whole ECU life.

<u>Data stored by the Supplier prior to delivery:</u>

The following data shall be stored in the Non Volatile Memory prior to the ECU delivery:

- The ECU Part Number,
- The ECU Serial Number,
- The number of high power supply OFF/ON/OFF sequences,
- The number of low power supply OFF/ON/OFF sequences,
- ECU key parameters: They have to be defined by the Supplier and approved by the Purchaser.

#### 2.1.9.3.5 Pin Programming

The supplier shall propose a robust ECU H/W pin programming strategy in order to comply with safety objectives.

The ECU address shall be programmable using dedicated pin program on the A/C plugs.

Each pin program will be achieved by a strap between 2 points on the A/C plug.

The two points strapped shall be considered as an active Pin Program (Value = True (1)).

The two points not strapped shall be considered as an inactive Pin Program (Value = False (0)).

Pin PROGRAM value shall be obtained by the application software using BPPx (x=0 to 6) variable on each ECU lane (COM and MON lanes).

Seven pins program (PP0 to PP6 and PP7 to PP13) shall define the EMA position in the A/C.

ECU position will be used for µE/S configuration during ECU initialization and may be used by application software.

Detail µAFDX configuration will be provided by an ICD for each position..

The seventh pin program of each ECU lane (PP6 and PP13) shall be used as parity (odd parity).

COM lane shall acquire seven (7) pin program (PP0 to PP6)

MON lane shall acquire seven (7) pin program (PP7 to PP13)

In case of bad pin programming parity, the ECU shall start with micro End/System (µE/S) disabled. Inter unit bus shall remain available.

### 2.1.10 Grounding and Bonding

The equipment shall comply with the bonding and grounding requirements defined in ABD0100.1.8.1.

The equipment shall comply with figure C of ABD100.1.8.1 §6.3.2 and § 6.3.2.12.

The power supply interface shall have a galvanic insulation from the mechanical housing.
Electronic circuits shall be insulated from the mechanical housing (0V reference not connected to equipment casing).

540 VDC power shall have a galvanic insulation from 28 VDC power and from secondary circuits.

The equipment shall be lightning insulated as defined in ABD0100.1.8.1 § 6.3.3.4, in particular, no protection device such a diodes, tranzorb shall be connected between an insulated circuit or line and the mechanical housing. Only lightning protection connected between two lines is allowed.

For insulated circuits, the impedance between the circuit and the mechanical housing shall be superior to 100 Ohms over the frequency range [DC- 10 kHz]. As a consequence the total capacitance between the circuit and the mechanical housing shall be less than 150 nF.

The unit shall be capable of discharging the electrostatic loads and electric loads due to possible short circuits and lightning strike.

The fixed body of the unit shall be connected to the aircraft structure by a bonding wire through the connector, and a bonding jumper according to the space envelope drawing (§ 5.3 – *Appendix 3 – Mechanical Interfaces and Space Allocation*).

A threaded hole provision shall be made for bonding connections between the aircraft structure and the EMA body. This threaded hole will be used to connect a bonding strap to the unit. The bonding strap, NAS6704U1 bolt and NAS1149C0463R washer will be provided by the Purchaser.

All the components fitted to it including the socket of the connector, shall be grounded to the actuator body.

The resistance between any part of the actuator and the bonding wire pin or jumper attachment shall not exceed 10 mOhms

All equipment subparts shall be together grounded.

Connectors shall be of conductive shell type.

### 2.1.11 Physical Requirements

The installation attitude of the unit shall not affect the functioning of the unit, whatever the A/C and equipment operation configuration.

All sub-assemblies consisting of electrical components shall be environmentally static sealed, i.e. no air leakage under inside / outside differential pressure of 1 bar.

All physical aspects shall comply with the material requirements of ABD0100.1.6 and ABD0100.1.7

The equipment shall comply with electrical installation requirements of ABD0100.1.8.1.

#### 2.1.11.1 Equipment Finish and Colour

If painted, the equipment colour will be agreed with the purchaser.

#### 2.1.11.2 Mechanical Connections

The EMA interfaces and space envelope shall comply drawing provided in §5.3 - *Appendix 3 – Mechanical Interfaces and Space allocation*. A detailed 3D CAD (Computer Aided Design) file will be provided to the supplier.

EMA 3D CAD files provided to the supplier take into account baseline kinematic and the clearance needed between this space envelope and the A/C parts at extreme kinematic positions. In case of kinematic optimization, this space envelope shall be adapted by the supplier and validated by the purchaser.

The equipment manufacturer's outline drawing/CAD file shall be kept fully representative of the external geometry of the unit and no change can be made to it without the prior approval of the aircraft manufacturer.

The swivelling torque transmitted to the structure due to EMA weight and mechanical transmission inertia shall be minimized.

The anti-rotation torque due to mechanical transmission torque reaction transmitted to the surface structure shall be minimized.

#### 2.1.11.3 Electrical Connections

Unless otherwise specified, refer to ABD0100.1.7 §6.17

Wires leading to different connectors shall be segregated as far as possible.

Unused connectors (objective: none) shall be caped and the caps shall be sealed and shall be secured.

Suitable protection shall be provided to electrical connectors against fluids and products (refer to § 2.1.14.3 – *Fluids and Products used on Aircraft*).

Connectors with fool-proofing means, such as connector polarization and Index Pin Coding shall be used in order to prevent erroneous installation on the aircraft.

Connectors shall be fitted with all its pins.

The equipment shall support to be unplugged at any time, even if it is powered, except for power supply connectors.

All the actuator connectors shall be identified. The identification of the interface connectors between the actuator and the A/C shall be identified with letter A, B, C, etc... for signals connectors and P for the power connector.

Electrical Connections are described in §*5.4 – Appendix 4 – Electrical Connections.*

#### 2.1.11.4 Mass and Centre of Gravity

The Supplier shall state the guaranteed mass (dry and wet) and the precise centre of gravity location on the equipment full of fluid at neutral position (see ABD0100.1.7 §6.17). Where appropriate, the mass shall be specified by the Supplier as a maximum guaranteed value.

The guaranteed maximum weight of the unit full of lubricant shall be **TBA** kg (Objective ≤ 12 kg).

The guaranteed maximum weight of the LRIs shall be (if applicable, full of lubricant) :

| LRI | Mass |
|---|---|
| ECU | **TBA** (Objective ≤ 1,5kg) |
| Other | **TBA** |

A detailed weight breakdown and the precise centre of gravity location on the equipment shall be delivered and the individual equipment / component weight (s) shall be quoted on each drawing and shall be approved by the purchaser.

The EMA inertia matrix shall be determined by the supplier and provided to the purchaser.

The equipment weight increase due to the test function, for laboratory or FAL, shall be identified and submitted to Purchaser for acceptance.

#### 2.1.11.5 Heat Dissipation

The supplier shall provide a Thermal Analysis as described in ADB0100.1.9 §2.3.2.

The Supplier shall comply with ABD0100.1.7§4 Overheat Protection and ABD0100.1.9 §2.3.1 Heat Dissipation.

Equipment design shall optimize heat dissipation (subcomponents layout, fins, housing colour…).

Equipment design shall minimize heat production.

The Supplier shall provide a thermal model (MATLAB SIMULINK interface) to cover :

- The temperature distribution inside the unit, in normal operating conditions,
- The heat dissipation (Initial value, value for a mature equipment, value for worst case, e.g. failure case such as short circuits), depending on thermal environment parameters such as ambient temperature, convection coefficient, radiative environment or heat fluxes; the format and the level of detail of which will be defined by Airbus during concept and development phases.

The maximum skin temperature of the mechanical parts shall not exceed 100℃ (see § 2.1.6.1.9 – *Maximum Skin Temperature*) during a complete flight without extra-ventilation.

The maximum skin temperature of the electronic housing shall not exceed 100℃ (see § 2.1.6.1.9 – *Maximum Skin Temperature*)during a complete flight without extra-ventilation.

Temperatures in failure conditions shall be provided to Purchaser for approval.

Environmental conditions are defined in paragraph 2.2 – *Environmental Requirements*.

#### 2.1.11.6 Cooling, Ventilation, Pressure Drop and Flow Rate

N/A

#### 2.1.11.7 On Board Replaceable Module

N/A

#### 2.1.11.8 Locking of Parts and bonding (adhesive)

Equipment shall comply with ABD0100.1.8.1.

The locking of mechanical parts shall not be achieved by gluing process.

Locking devices for any equipment subassembly or/and components shall be designed as a mechanical positive locking.

Each removable bolt, screw, nut, pin or other removable fastener shall incorporate two separate locking devices if:

- Its loss could result in a reduction of performances or lead to a malfunctioning;
- Its loss could have a non-negligible impact on the unit safety or reliability.

The detailed locking policy shall be provided to the purchaser for approval

#### 2.1.11.9 Protection Devices

All electromagnetic components (e.g. coils, relays, inductors, actuators, pumps, motors, etc.) shall be fitted with protection devices to minimize the generation of voltage transients during their operation.

These protection devices shall be selected to ensure that these transient voltages do not damage any sensitive control and switching circuits.

#### 2.1.11.10 Lightning and EMC Protection Devices

The unit shall not be damaged, and its operation shall not be disturbed when subjected to the specified level of induced voltage and current resulting from lightning strikes and external radiations.

Refer to paragraph 2.2.24 – *Electromagnetic environmental test requirements* for common mode protection.

### 2.1.12 Mechanical requirements

The Supplier shall comply with ABD0100.1.7 Mechanical Requirements.

#### 2.1.12.1 Stressing and Loading

The application of the limit torque shall not result in any permanent deformation

The application of the ultimate torque (1.5 times the limit torque) shall not result in any rupture.

The limit load corresponds to 1.2 times maximum operational load, with or without movement, generated by the unit with taken into account of any load limitation function possibly incorporated.

As a pass/fail criteria:
The EMA has to be able to withstand limit torque without any permanent deformation.
The EMA has to be able to withstand ultimate torque without any rupture.

The EMA axial loads due to a +/- 3° ( **TBC**) misalignment of the connecting rod shall not result in any permanent deformation neither in any rupture of EMA parts.

In case of actuator disconnection, jack catcher devices shall be able to withstand the load induced by actuator weight while submitted to 3g vertical acceleration without damage.

The unit shall not be damaged by reaching its stop in the event of Surface Manipulation on ground under loads defined in § 2.1.6.4 – Duty Cycles.

The unit shall not be damaged by reaching its stop in the event of Inadvertent Manoeuvre on ground under loads defined in § 2.1.6.4 – Duty Cycles.

#### 2.1.12.2 Fatigue life

Each component submitted to fatigue stress shall be covered by test.

The life of the unit shall comply with the design service goals specified in paragraph 2.5.1.2.2 – *Service and Useful Life.*

The life of the unit in active mode taking into account specified duty cycles shall be
- 30 years,
- Or 100 000 flights/150 000 flight hours.

Duty cycles are described in § 2.1.6.4- *Duty Cycles* and provided in § 5.5 - *Appendix 5 Duty Cycles.*

Any electrical oscillation that might be produced by internal unit devices shall be taken into account.

The equipment shall be designed to accommodate thermal fatigue that will accumulate over the life of the aircraft especially for Electronics components.

Fatigue life calculations or equivalent damage calculations shall be based on obviously conservative S/N curves (eg: no fatigue limit, slope depending on material) unless other specific agreement.

The crack free fatigue life shall not be lower than the design service goals specified in paragraph 2.5.1.2.2 – *Service and Useful Life.*

Fatigue life duration of the components shall not depend on a specific surface treatment like shot peening or other artificial fatigue improving processes.

Fatigue life calculations methodology shall be provided to the purchaser for approval.

Manual pre-flight check or other maintenance task as described in paragraph 2.5.7 – *Safety/Reliability Tests* shall be considered.

Safety tests as described in paragraph 2.5.7 – *Safety/Reliability Tests* shall be taken into account.

#### 2.1.12.3 Endurance

Each component submitted to rolling contact fatigue stress shall be covered by test.

The life of the unit shall comply with the design service goals specified in paragraph 2.5.1.2.2 – *Service and Useful Life.*

The life of the unit in active mode taking into account specified duty cycles shall be

- 30 years,
- Or 100 000 flights/150 000 flight hours.

Duty cycles are described in § 2.1.6.4- *Duty Cycles* and provided in § 5.5 - *Appendix 5 Duty Cycles.*

Rolling contact fatigue life calculations or equivalent damage calculations shall be based on obviously conservative S/N curves (eg: no fatigue limit, slope depending on material) unless other specific agreement.

The crack free fatigue life shall not be lower than the design service goals specified in paragraph 2.5.1.2.2 – *Service and Useful Life.*

Endurance life calculations methodology shall be provided to the purchaser for approval.

Manual pre-flight check or other maintenance task as described in paragraph 2.5.7 – *Safety/Reliability Tests* shall be considered.

Safety tests as described in paragraph 2.5.7 – *Safety/Reliability Tests* shall be taken into account.

#### 2.1.12.4 Lubrication

The oil used shall be per MIL-L-7808.

The grease used shall be per AIMS 09-06-002.

The use of all greases qualified to AIMS 09-06-002 shall not impact the actuator life and performances and shall be validated by appropriate tests.

All lubricated components shall be lubricated for the whole aircraft service life, except for the roller bearing which could be re-lubricated according to time interval as defined in paragraph 2.6.6 – *Scheduled Maintenance.*

Refer also to ABD0100.1.4; ABD0100.1.7 and ABD01001.12.

### 2.1.13 Ergonomic and human factors

Refer to paragraph 3.2.6 - *Maintainability.*

### 2.1.14 Materials

All materials used for manufacturing the unit and the production processes shall be in accordance with the material requirements of ABD0100.1.6.

For any deviation to the above mentioned requirements the Supplier shall submit them to the Purchaser for acceptance.

#### 2.1.14.1 Material Characteristics

Bolts and nuts shall be made from stainless steel.

Threaded caps that must be unscrewed during maintenance operations must not be made from aluminium alloy.

Magnesium alloys shall not be used.

The use of electrical wires insulation with PVC (polyvinyl-chloride) or polyamide materials or polyimide alone (Kapton) shall not be used.

Aluminium alloy for structural parts may be proposed as an alternative solution. This proposition shall be associated with a risk mitigation plan (based on in-service experience, analysis, tests...).

#### 2.1.14.2 Materials Technologies and Production Processes

Cadmium and chromates shall not be used unless otherwise agreed by the purchaser.

Tin soldering shall not be used.

Particular attention shall be paid to minimising the detrimental effects of contamination during equipment design.

The use of conformal coatings, isolation of contamination sensitive elements, etc. shall be considered for the design.

For protection against corrosion, the environmental conditions as described in § 2.2.2 - *Environmental Conditions and Test Requirements Associated to Qualification* and products defined in § 2.1.14.3 - *Fluids and Products used on Aircraft* shall be considered.

Corrosion protection

The unit shall be protected from corrosion throughout the service life of the aircraft.

For this purpose material shall be either corrosion resistant or suitably protected.

The supplier shall undertake to define any modification that might prove necessary in the event of appearance of corrosion in service.

The Supplier shall provide the list of materials, treatments and protections against galvanic corrosion.

#### 2.1.14.3 Fluids and Products used on Aircraft

Suitable protection to the fluids identified in the table below shall be provided for the equipment.

| | | |
|---|---|---|
| Fuel | FU01 | Applicable |
| Hydraulic fluid | HY02 | Applicable |
| Lubricating oil | LO01 | Applicable |
| Common grease | CG01 | Applicable |
| Common grease | CG02 | Applicable |
| Anti-icing and De-icing materials | AD01 | Applicable |
| Cleaning agent | CA01 | Applicable |
| Cleaning agent | CA02 | Applicable |
| Cleaning agent | CA04 | Applicable |
| Disinfectants | DE01 | Applicable |
| Extinguishing agents | EA01 | Applicable |
| Extinguishing agents | EA02 | Applicable |
| Extinguishing agents | EA03 | Applicable |

| | | |
|---|---|---|
| Extinguishing agents | EA04 | Applicable |
| Insecticides | IN01 | Applicable |
| Drinks | DR01 | Applicable |
| Heat Transfer fluid | HT01 | Applicable |

Hazardous elements and processing requirements are identified in ABD0100.1.6. The required method for the Supplier to identify intention to use hazardous material/elements shall be specified from those methods identified in ABD0100.

The Supplier shall provide a material technical data sheet. Refer to ABD0100.1.6.

#### 2.1.14.4 Fluid Temperature and Pressure

N/A

#### 2.1.14.5 Fire Propagation, Flammability, Smoke and Toxic Emissions

The equipment shall be compliant with ABD0100.1.6.

All electrical parts shall be self-contained fire (ECU, electric motor...).

### 2.1.15 Internal Parameters Accessibility

#### 2.1.15.1 Inter Unit Bus

EMA ECU shall provide a COM to MON and a MON to COM bus in order to exchange data.

Inter unit bus shall be implemented inside the ECU.

The bus type shall be chosen by the Supplier and agreed by the Purchaser.

Inter unit bus shall comply with defined mechanical and electrical segregation between COM and MON.

For Application Software, each bus bandwidth shall allow (at least) exchanging **TBA** messages with a **TBD** bits data every **TBA** ms.

Inter Unit Bus messages integrity shall be protected at least by a parity bit for each message.

Messages refresh rate shall be checked for each message with the following value: **TBA** ms.

Inter unit bus data shall be accessed by Application Software (input / output) using a specific symbol and IUBDxxIN variable for input and IUBDxxOUT variable for output (xx=1 to **TBA**).

When a message IUBDxx(IN or OUT) (xx = 1 to **TBA**) is used as a TBD Booleans data, a specific bit in this message shall be accessed using BIUBDxxByy(IN or OUT) Boolean variable with yy in [01..**TBD**].

Inter unit bus data refresh indication shall be accessed by application software (input / output) using the BIUBDxxNR boolean variable (xx = 1 to **TBA**).

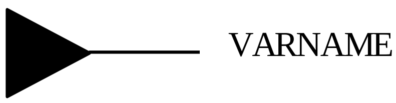
BIUBDxxNR (xx = 1 to **TBA**) shall be set to false if the message xx data is not older than 50ms, else it shall be set to true.

Inter unit bus integrity shall be indicated to Application Software (input) using BIUBDNNO Boolean variable. BIUBDNNO shall be set to false if the inter bus integrity is OK, else it shall be set to true.

### 2.1.15.2 Application Software/Operating Software Interface

#### 2.1.15.2.1 Discrete input

The following table gives the discrete input variable names used in INPUT BLACK ARROW symbol

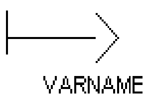



| DSI Identification | Variable identification (VARNAME) | PTS § | Description |
|---|---|---|---|
| Pin programming 0 (*) | BPP0 | 2.1.9.3.5 | Pin programming 0 of the actuator |
| Pin programming 1 (*) | BPP1 | 2.1.9.3.5 | Pin programming 1 of the actuator |
| Pin programming 2 (*) | BPP2 | 2.1.9.3.5 | Pin programming 2 of the actuator |
| Pin programming 3 (*) | BPP3 | 2.1.9.3.5 | Pin programming 3 of the actuator |
| Pin programming 4 (*) | BPP4 | 2.1.9.3.5 | Pin programming 4 of the actuator |
| Pin programming 5 (*) | BPP5 | 2.1.9.3.5 | Pin programming 5 of the actuator |
| Pin programming 6 (*) | BPP6 | 2.1.9.3.5 | Pin programming 6 of the actuator |
| Pin programming fault (*) | BFPPOPP | 2.1.8.2 | Opposite ECU lane pin program fault |
| Electronic rigging data validity KO | BFELECRIG | 2.1.8.3 | Validity of the extracted ELECRIG word |
| Cycle overflow OK | BWDOK | 2.1.8.3 | Cycle overflow indication |
| Active mode | BACT | 2.1.9.3.2.4 | Active mode |
| Anti-extension mode | BANTIEXT | 2.1.9.3.2.4 | Anti-extension mode |
| Recentring mode(**) | BREC | 2.1.9.3.2.4 | Recentring mode |
| Undefined mode | BUNDEF | 2.1.9.3.2.4 | Undefined mode |
| Sensor failure mode (cut wire…) | **TBD** | 2.1.9.3.2.4 | Sensor failure mode (cut wire…) |
| Operational mode upon timeout | BTIMEOUT | 2.1.8.3 | Entry in Operational mode upon timeout |
| Result of last fully executed safety test KO | BFSAFETYTEST | 2.1.8.3 | If used, state of safety tests |
| HVDC presence | BHVDC | 2.1.9.3.2.14 | HVDC monitoring indication |
| HVDC power limitation engaged | BPWRLIMENG | 2.1.9.3.2.12 | HVDC power limitation indication |

*(*) Not Applicable for the A320 demonstrator. (**) For the A320 demonstrator only*,

#### 2.1.15.2.2 Word input

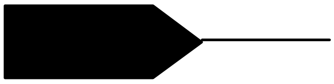
The following table gives the word input variable names used in INPUT BLACK ARROW symbol



| Word Identification | Variable identification (VARNAME) | PTS § | Description |
|---|---|---|---|
| Electronic rigging word | ELECRIG | 2.1.8.1.3 | Word stored on actuator NVM |
| Hardware identification | HARDIDENT | 2.1.8.1.3 | Word |

### 2.1.15.2.3 Analogue inputs

The following table gives the Analogue input variable names used in INPUT BLACK ARROW symbol

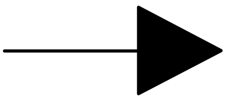
VARNAME 

| Analogue Input | Variable identification (VARNAME) | PTS § |
|---|---|---|
| Mechanical Output Position | POS | 2.1.9.3.2.5 |
| Surface Position (*) | PSURF | 2.1.9.3.2.11 |
| Motor Position | MPOS | 2.1.9.3.2.6 |
| Motor Current | MCURx | 2.1.9.3.2.8 |
| Torque | LOAD | 2.1.9.3.2.7 |
| ECU Temperature measurement | ECUTEMP | 2.1.9.3.2.9 |
| Motor Temperature measurement | MTRTEMP | 2.1.9.3.2.10 |

*(*) Not Applicable for the A320 demonstrator.*

### 2.1.15.2.4 Discrete output

The following table gives the discrete output variable name used in OUTPUT BLACK ARROW symbol.

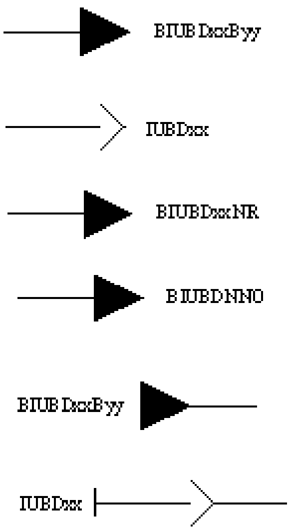
 VARNAME

DSO identification

| DSO Identification | Variable identification (VARNAME) |
|---|---|
| TEST MODE activation | BTESTACT |
| CONFIGURATION MODE activation | BCONFACT |
| 540 VDC power limitation activation | BPWRLIM |
| Motor switch control | BK1COM |
| Not used | BK1MON |
| Active/Anti-Extension switch control | BK2 |
| **TBD** | **TBD** |

### 2.1.15.2.5 Inter unit bus

The following table gives the Input / Output variable names for the inter unit bus used in INPUT / OUTPUT BLACK ARROW symbol.

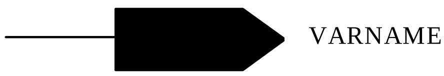



| Data identification | Variable identification (VARNAME) | PTS § | Description |
|---|---|---|---|
| Message xx | IUBDxx (xx=01 to **TBD**) | 2.1.15.1 | **TBD** bits data |
| Associated refresh indication xx | BIUBDxxNR (xx=01 to **TBD**) | 2.1.15.1 | Boolean |
| Bit yy of the data xx | BIUBDxxByy (yy=01 to **TBD**) | 2.1.15.1 | Boolean |
| Inter unit bus normal operation | BIUBDNNO | 2.1.15.1 | Bus integrity indication |

When a message IUBDxx (xx=01 to **TBD**) is used as a Boolean data, a specific bit in the variable, shall be accessed using: BIUBDxxByy with xx from 01 to TBD and yy from 01 to 16.

#### 2.1.15.2.6 Actuator order

The following table gives the actuator speed order variable name used in OUTPUT BLACK ARROW symbol.




| Order output identification | Variable identification (VARNAME) | PTS § | Unit & span |
|---|---|---|---|
| Motor Order Output | EMACTLORD | 2.1.9.3.2.13 | TBD |

### 2.1.15.3 Parameter Selection and Modification

#### 2.1.15.3.1 Predefined internal parameters accessibility

**TBD**

##### 2.1.15.3.2 Upon request internal parameters accessibility

**TBD**

##### 2.1.15.3.3 Configuration modification commands

**TBD**

#### 2.1.15.4 Fault Injection

**TBD**

#### 2.1.15.5 External Parameter Recording

**TBD**

### 2.1.16 Interchangeability, Mixed configuration operation

Mixed Operation (also referred to as Interchangeability) shall comply with ABD0100.2.9 §4 and AP2027.

### 2.1.17 Special uses

N/A

### 2.1.18 Miscellaneous design requirements

The list of mated parts is **TBA** (objective: none).

No Glue part in contact with the hydraulic fluid and/or lubrication fluid.

Screws with diameter smaller than 6.35 mm shall not be used where failure of a screw could lead to malfunctioning.

All LRIs fixing bolts/screws shall be unloosen bolts/screws.

Ball bearings that are not fitted in a sealed housing shall be of a sealed type.

Fluid immersed ball bearings shall not be sealed nor shielded.

Staking of housing shall not be the primary means to retain bearing.

Snap rings, external clips and non-caged needle bearings shall not be used.

The wire ways shall be either fully potted or sealed.

Plugs of different standards shall not be used to seal drilled holes within the same piece of equipment.

Coils shall not be made with wires of a diameter smaller than 0.07 mm.

Solenoids, relays and power switches shall be equipped with diodes for protection against overvoltage.

Variable transformers and variable differential transformer shall not include any electronic component, even passive ones.

Split back up rings shall not be used.

Minimum wall thickness at min tolerance shall be higher than 2.5 mm for all the pressurized parts of the unit, including LRI's.

Resolver, RVDT, LVT and LVDT wires shall be shielded and the shield has to be connected to the sensor body itself.

Cable assemblies shall be designed for minimum conductor lengths.

Cables shall be secured at appropriate intervals to prevent chafing or other damage

All wires and bundles shall be supported sufficiently so that strain or load at the terminal(s) cannot cause joint failures.

Cable bundles shall not be tied to adjacent electrical components or sub-assemblies.

Wire size shall be chosen to be compatible with current carrying and voltage drop.
All cable backshell shall be oriented downward.

Any cable shall end with a drip loop before entering electrical panels, boxes, and equipment and connector plates.

Electronic component attachment holes on cards shall be bonded.

Electronic components life duration shall not be guaranteed by a minimum power on frequency, included in storage conditions.

Aluminium capacitors with non-solid electrolyte and tantalum capacitors shall be avoided whenever possible.

Optocouplers shall be avoided whenever possible.

The power electronic components shall be chosen in minimum 1200 V withstanding voltage class whenever possible.

Self-extinguishing materials (cables) shall be used.

Micro-switches shall not be used.

### 2.1.19 Identification and Labelling

The unit and all its LRI shall be fitted with an identification plate and marking complying with ABD0100.1.9 §4.4 and §4.5, ABD0100.2.9 §2, completed with the mention of the CMS number for the equipment and bar code.

The bar code fields shall be verified before delivering to the Purchaser.

The name of the unit on identification plate shall be : “SPOILER ROTARY EMA”

The inscriptions shall be photo engraved or made by electroetching and only English shall be used.

The inscriptions shall be permanent and legible.

The connectors shall be identified by 4 mm high engraved capital letters A, B…

According to ABD0100.2.9 §2, markings as nameplates, PNRs shall remain legible during A/C life and shall be arranged so that they are clearly readable by the human eye and also machine readable by data scanning equipment when installed in the aircraft.

The identification label (including LRIs) shall be attached by mechanical means plus glue or Laser etching considering the application / environment in which the equipment is used.

The identification plate affixed to the equipment shall always be visible when the equipment is installed on the aircraft (except for Instruments and Indicators).

Placards and markings shall be capable of withstanding exposure to consumable fluids used in the corresponding Aircraft zone.

Detachable sub-units and Modules shall be provided with individual part number and serial number for maintenance and record purposes, especially for those, which require more maintenance actions than the equipment on which they are installed.

Removable components weighting more than 12kg shall have its weight marked on the item such that it is visible when installed on the A/C.

Loaded software shall be considered as an LRI and then identified following ABD0100.2.9. and AM2212.

Hoisting provisions shall be furnished for components weighing 25 kg or more, and hoisting provisions shall be considered on a case by case basis where components of 15 kg or more require a lift to be performed at arms’ length.

### 2.1.20 Electrostatic Discharge Warning Labels

ESD Warning labels shall be in accordance with ABD0100.1.9 §2.5.

### 2.1.21 RFID

Each EMA shall include a RFID tag.

Where feasible, each EMA RFID tag shall be attached close to the EMA nameplate.

The EMA RFID tag shall be qualified following SAE AS5678.

EMA RFID tag with a higher reading distance capability shall be considered as the preferred choice where their larger size is feasible.

The EMA RFID Data content shall be configured according to ATA Spec 2000 Chapter 9.5.

The EMA RFID Data content shall be subjected to Purchaser agreement.

The EMA RFID shall be of UHF High memory type with minimum of 12 Kilo Bytes storage capability.

The repair shop performing the EMA RFID tag replacement and programming shall ensure consistency between the EMA nameplate data and the EMA RFID tag data.

The supplier shall define the installation/removal & verification procedures of the EMA RFID tag in the associated CMM.

The loss of one EMA RFID tag will not lead to the removal of the corresponding EMA.

### 2.1.22 Electrostatic Protection

Electrostatic protection shall be in accordance with ABD0100.1.9 §2.5.

## 2.2 Environmental requirements

The location and orientation of the equipments are described in paragraph 2.1.3 – *Location.*

The equipments are located in an unventilated area where fuel fumes can occur.

The equipment shall function normally and without degradation under the environmental conditions experienced by the equipment and aircraft through its service life, in active and applicable passives mode(s), unless otherwise stated in this specification.

The performances and the life of the actuators shall not be impacted by those environmental conditions.

### 2.2.1 General

The actuators covered by this PTS shall function in accordance with this PTS under the environmental conditions identified in ABD0100 and specified in this PTS.

#### 2.2.1.1 Acceptance criteria

Pass/Fail criteria: For each subchapter of the Environmental Requirements section, in addition to specific requirements (if any), there shall be no deviation on equipment performances before and after the test whatever the environmental conditions.

The pass/fail criteria shall be defined in the individual qualification test procedures.

#### 2.2.1.2 Equipment standard

Environmental testing used as evidence of compliance with environmental requirements shall only be carried out on production build standard equipment and with EIS standard software if any, unless otherwise agreed with the Purchaser.

Any deviation from the requirements of this PTS shall be agreed by the Purchaser.

The build standard of the equipment to be tested shall be officially documented and monitored by the suppliers' normal quality procedures and be subjected to a quality release note.

The supplier shall agree with the purchaser how many units will be used in the test programme (See paragraph 4.1 - *Equipment*) and the sequences of testing to be performed on each unit.

#### 2.2.1.3 Support Equipment

Test sets, simulators and support equipment designed to represent other elements of the system around the equipments under test shall be designed to ensure that during environmental testing any error or upset that occurs can only be due to the equipments under test.

Performance characteristics of A/C equipments under testing in environmental conditions shall be representative of those which may be encountered in airborne operation of the equipments.

Description of this support equipment shall be included in the QTP and QTR.

All stimuli and measurement equipments used to perform the tests shall be identified in the test report (model, serial number…).

As part of the Qualification Test Report, the calibration expiry date and/or the valid period of calibration shall be supplied.

When appropriate, all test equipment calibration standards shall be traceable to national and/or international standards.

#### 2.2.1.4 Qualification Tests Monitoring

##### 2.2.1.4.1 Tests witnessing

The Supplier shall provide a minimum of six weeks formal notification of any environmental testing which is to be used as evidence of compliance with environmental requirements in order to arrange Purchaser witnessing of all Supplier's and the Supplier's sub-contractors test and quality activities.

##### 2.2.1.4.2 Equipment parameters

The equipment parameters to be monitored during any formal environmental tests shall be described in the QTP.

### 2.2.2 Environmental conditions and Test requirements associated to Qualification

In the event of any dispute over the test procedures used in order to demonstrate compliance, the identified environmental test document will be the reference procedure, except when specified differently below.

### 2.2.3 Temperature

The equipment shall meet the requirements of EUROCAE ED14/ RTCA DO160 Section 4, Cat. D2.

#### 2.2.3.1 Operational Conditions (Ground/Flight/High/ Low)

In accordance with RTCA/DO-160, Category D2, the following operating temperatures shall be considered:

- Normal operating temperature (ambient air) : - 40℃ to + 70℃
- Extreme operating temperature (ambient air) : - 55℃ to + 70℃
- Extreme temperature with actuator not operating (ambient air): - 60℃ to + 85℃

Those test levels are defined in the Tables 1.1-3 and 1.1-4 of the ABD0100.1.2:

Start-up and active mode selection shall be possible for an air temperature of -55℃.

#### 2.2.3.2 Short-Time Operating Low/High Temperature

The equipment shall comply with its applicable performance standards during and after testing to the conditions defined in EUROCAE ED14/ RTCA DO160 Section 4, Cat. D2.

The test levels are those defined in the Tables 1.1-5 and 1.1-6 of the ABD0100.1.2:

- -55°C to + 70°C

#### 2.2.3.3 Ground Survival Temperature

The equipment shall comply with its applicable performance standards after testing to the conditions defined in EUROCAE ED14/ RTCA DO160 Section 4, Cat. D2.

The test levels are those defined in the Tables 1.1-7 and 1.1-8 of the ABD0100.1.2:

- -55°C to + 85°C

#### 2.2.3.4 In Flight Loss of Ventilation

N/A

#### 2.2.3.5 Equipment Thermal Integration and Thermal Environment

This equipment shall be designed so that the internal heat power is dissipated only by natural heat convection and radiation to the ambiences.

Preliminary Aircraft conditions for thermal sizing shall be considered as follows:

- The maximum ambient air temperature around the unit at the electrical power ON: + 70°C;
- No heat conduction of the unit with the A/C structure shall be considered;
- For hot day condition, the external air temperature shall follow the ISA+35°C profile.

Laboratory conditions shall be considered as follows:

- Ambient air temperature: +20°C;
- No heat conduction of the unit with the structure shall be considered;
- No forced convection is considered.

### 2.2.4 Atmospheric pressure/Altitude requirements

#### 2.2.4.1 Steady state – Altitude

The equipment shall meet the requirements of EUROCAE ED14/ RTCA DO160 Section 4, Cat. D2 (Unpressurized area).

#### 2.2.4.2 Decompression

N/A

#### 2.2.4.3 Overpressure

N/A

### 2.2.5 Temperature variations

The equipments shall meet the requirements of EUROCAE ED14/ RTCA DO160 Section 5, Cat. A.

### 2.2.6 Humidity

The equipments shall meet the requirements of EUROCAE ED14/ RTCA DO160 Section 6, Cat. B.

### 2.2.7 Shocks and Crash safety

#### 2.2.7.1 Operational shock and Crash safety

The equipments shall meet the requirements of EUROCAE ED14/ RTCA DO160 Section 7, Cat. D.

Only “operational shocks” shall be considered, the unit shall operate during the test with ref. to ABD0100.1.2, paragraph 1.5.1.

#### 2.2.7.2 Shock due to Fan Blade Out

**TBD**

#### 2.2.7.3 Bench Handling Shock

The equipments shall meet the requirements of MIL STD 810F Method 516.5 Procedure VI.

#### 2.2.7.4 Shipping Container Shock

The equipments shall meet the requirements of MIL STD 810F Method 516.5 Procedure II.

### 2.2.8 Vibrations

#### 2.2.8.1 Operational Vibrations

The equipment shall meet the requirements of EUROCAE ED14 / RTCA DO160 Section 8, Cat R, Curve E & E1 (3 hours Endurance level (repeat in all 3 axes)).

#### 2.2.8.2 Vibrations due to Engine Fan Blade Loss

##### 2.2.8.2.1 High power condition

The equipment shall operate and meet its functional requirements during and after the High-Level Short-Duration vibration test, defined in EUROCAE ED14 / RTCA DO160, section 8, Cat H, Curve P.

The purchaser will confirm the level defined in EUROCAE ED14 / RTCA DO160.

##### 2.2.8.2.2 Windmilling condition

**TBD**

#### 2.2.8.3 Vibrations due to Nose Wheel Imbalance

N/A

#### 2.2.8.4 Acoustic Fatigue

N/A

### 2.2.9 Explosion

The equipment shall meet the requirements of EUROCAE ED14/ RTCA DO160 Section 9, Cat. H, environment type II in normal operation and in failure mode.

Any failure with a failure rate >1E-09/FH shall neither lead to a skin temperature over 200℃ nor enable external spark.

The equipment shall be self-contained fire.

### 2.2.10 Waterproofness

The equipment shall meet the requirements of EUROCAE ED14/ RTCA DO160 Section 10, Cat. S.

The Waterproofness Pass/Fail criteria shall be : **TBD.**

### 2.2.11 Fluid susceptibility

The equipment shall meet the requirements of EUROCAE ED14/ RTCA DO160 Section 11, Cat. F, after testing to the conditions defined in ABD100.1.6 - "Fluid Susceptibility" with Fluids identified in the "Fluids and Products used on Aircraft" chapter of this PTS.

Fluid susceptibility Pass/Fail criteria shall be **: TBD**

### 2.2.12 Sand and Dust

The equipment shall meet the requirements of EUROCAE ED14/ RTCA DO160 Section 12, Cat. S. 6 directions shall be considered.

The Sand and Dust Pass/Fail criteria shall be : **TBD**

### 2.2.13 Fungus resistance

The equipment shall meet the requirements of EUROCAE ED14/ RTCA DO160 Section 13, Cat. F.

The Fungus Resistance Pass/Fail criteria shall be**: TBD**

### 2.2.14 Salt spray

The equipment shall meet the requirements of EUROCAE ED14/ RTCA DO160 Section 14, Cat. T. The minimum duration of exposure to salt spray shall be 120 hours.

**Pass/Fail criteria:** In addition to EUROCAE ED14/ RTCA DO160 Section 14 success criteria, the equipment shall not show any sign of corrosion after the test. Otherwise, the supplier shall redesign the affected zone (material, protection or else) and the salt spray test shall be performed again.

### 2.2.15 Magnetic effect

The equipment shall comply with its applicable performance standards after testing to the conditions defined in EUROCAE ED14/ RTCA DO160 Section 15, Cat. A.

### 2.2.16 Icing

The equipment shall meet the requirements of ABD0100.1.2 and EUROCAE ED14/ RTCA DO160 Section 24, Cat. B.

**200** cycles shall be applied.

The insulation resistance shall be monitored, at least each **25** cycles.

The insulation resistance shall not vary during the test. Any variation shall be considered stabilized at least 50 cycles before the end of the **200** cycles and shall be analysed by Supplier and submitted to Purchaser for approval.

In addition, the insulation resistance measure during the test shall also be done at ambient temperature (+ 20℃).

### 2.2.17 Hermeticity of sealed equipment

The item of equipment shall comply with the requirements defined in ABD100.1.2 - Section 1.14, cat. B (∆P of 1 bar).

### 2.2.18 Fire

N/A

### 2.2.19 Flammability/Toxicity/Smoke/Gas emission

N/A

### 2.2.20 Hail

N/A

### 2.2.21 Constant acceleration

The equipment shall meet the requirements of ISO 2669 Cat. B functional test only with the levels defined in the following table:

| | Acceleration for arbitrarily mounted equipment (*) | Acceleration for non-arbitrarily mounted equipment(**) | | | | |
|---|---|---|---|---|---|---|
| | | FWD | AFT | UP | DOWN | LATERAL |
| Functional Test Category B | 16g | 16g | | | | |

(*) Note: If the mounting position is unknown or if the equipment is mounted in different positions, use the acceleration for arbitrarily mounted equipment.

(**) Note: The directions defined in the tables correspond to the aircraft directions. The equipment directions can be different, so the equipment position in the aircraft should be taken into account.

### 2.2.22 Aircraft attitude

Equipment operation shall remain within specification limits if it is subjected to any of the following real aircraft operating attitudes in earth axes specified below :

Real aircraft attitudes in earth axes:

- Roll — 67° max right and left
- Normal Descent (pitch) — 15° nose down
- Emergency Descent (pitch) — 15° nose down
- Climb (pitch) — 30° nose up

### 2.2.23 Electrical

The equipment shall be compliant with ABD0100 1.2 and ABD0100.1.8.1

#### 2.2.23.1 Power consumption

The Supplier shall include a measurement of the power consumption (expressed in VA if AC source, in W if DC source) for each voltage line connected to the equipment for each operating modes.

For AC equipment, the Supplier shall include a measurement of the power factor for each voltage phase connected to the equipment and for each of its operating modes.

AC equipment shall be compliant with ABD100.1.8.1.
If the consumption varies with time or duty cycle then additional measurements shall be made to fully characterise these variations (acceleration phase, torque, speed at torque).

Power line switch-on surges shall be characterized (current and voltage waveform).

Exported power to loads and sensors shall be measured separately.

#### 2.2.23.2 Equipment – Supply Related Requirements

For the electrical equipment, the requirements identified in ABD100.1.8.1 §6 shall be met.

#### 2.2.23.3 Dielectric and Insulation Resistance Testing

The Supplier shall demonstrate compliance with ABD0100.1.8.1 §6.3.3.

#### 2.2.23.4 Electrical bonding and power supply returns requirement

These requirements apply to all equipment with electrical components or wiring. The Supplier shall demonstrate compliance with ABD0100.1.8.1.

### 2.2.24 Electromagnetic environmental test requirements

#### 2.2.24.1 General

This sub-chapter deals with the tests specification related to the electrical/electronic equipment in electromagnetic environment:

- Lightning direct and indirect effects,
- HIRF (High Intensity Radiated Field),
- On board equipment electromagnetic environment including intentional radio transmission inside aircraft,
- Electro-Static Discharges

The following subjects are in:

| | ABD100 Chapter |
|---|---|
| System Interface Circuit Diagram | 1.1 “Interface requirements” |
| Electromagnetic effect | 1.2 "Electromagnetic effect" |
| Maintenance | 1.4 "Maintainability requirements" |
| EMC on power | 1.8 “Electrical and Installation Requirements” |
| Modification | 2.9 "Equipment changes: basic rules and classification" |

##### 2.2.24.1.1 Tests / Analysis

The justification that the equipment meets the requirements shall be done by test.

Indeed, the straightforward demonstration that the equipment complies with the protection requirements is to test the equipment with the specified test method and levels and to prove that in such conditions, the specified functional acceptance criteria are verified.
The calibration dates, PNR and SNR of the used test equipment shall be provided in the Qualification Test Report (QTR).

#### 2.2.24.1.2 Equipment Categories for Lightning and HIRF

The equipment category for Lightning direct and indirect effects and HIRF is category A.

#### 2.2.24.1.3 Location of Equipment and Equipment wiring

The equipment and its wiring are located in exposed area

### 2.2.24.2 Lightning

#### 2.2.24.2.1 Lightning Direct Effects

Test to be carried out on equipment consists in a voltage breakdown test and a high current transfer test.

The intention of the voltage breakdown test is to determine whether the actuator internal insulating interfaces are able to withstand the predicted induced voltage that will be developed at these interfaces during a lightning strike.

If this test fails a high current transfer test will be carried out to assess whether the actuator is able to withstand the passage of lightning current without suffering unacceptable damage.

##### 2.2.24.2.1.1 High voltage breakdown test

The test shall be performed to check the intrinsic electrical insulation of the actuator between the EMA body and the attachment to the surface (bonding braid between the EMA body and the wing structure not installed).

The test shall be carried out under dry conditions. If no breakdown occurs test shall be repeated in wet conditions.

The test shall be repeated five times with both polarities.

The voltage breakdown test shall consist in:
- A short wave form (waveform 2 according DO-160/ED-14 Section 22 WF2) at a level of 9kV,
- A long waveform (waveform 4 according DO-160/ED-14 Section 22 WF4) at a level of 400V.

The output current shall be at least 1 A peak, but the action integral INT ($I^2$ dt) shall not exceed 1000 $A^2s$.

**Pass / fail criteria:**
- The EMA has passed the test if high voltage breakdown did not occur (no visual evidence during test and no trace found after strip examination),

- As soon as one breakdown occurs, the test is considered as failed. In such a case, high voltage breakdown test can be stopped and high current transfer test shall be done.

#### 2.2.24.2.1.2 High current transfer test

This test shall be performed only if the actuator has failed the high voltage breakdown test.

The EMA shall be fitted with the A/C bonding braid installed between the EMA body and the wing structure.

The test shall consist in applying:
- A high current pulse with a peak of 20 kA and following the Waveform 1 per DO-160/ED-14 Section 22,
- A continuous current of 35A with a transfer charge of 9C and with the component C as per EUROCAE ED-84.

Remark: the current amplitude and duration could be changed as far as the transfer charge criteria is met

**Pass / fail criteria:**
- Test is passed if no actuator damage occurred (after detailed investigation),
- Test is failed if at least one damage is reducing fatigue life potential,
- Test is failed if one damage is reducing endurance life potential and is not detectable during visual inspection of the actuator in situ,
- Test is failed if one damage is reducing endurance life potential so that it is less than **TBA** FH (target > 25000 FH), whatever is the already consumed endurance potential of the actuator.

Test details are to be agreed with purchaser.

#### 2.2.24.2.2 Lightning Indirect Effects

Equipment located in exposed area and in composite structure shall have a common mode isolation of loads:
- No use of common mode clamping devices between each input/output (power and signals) and chassis;
- Capacitance between the power supply or signal I/O and the piece of equipment casing lower than 150 nF.
- if grounding optional wire is used for internal voltage reference, in addition to the above lightning insulation requirements, no use of common mode clamping devices between each input/output (power and signals) and grounding is allowed.

#### 2.2.24.2.2.1 Lightning Indirect Effects - Damage testing

The Supplier shall demonstrate compliance with ABD0100.1.2.

The Supplier shall use the Pin injection test method.

Power shall be applied on equipment under testing.

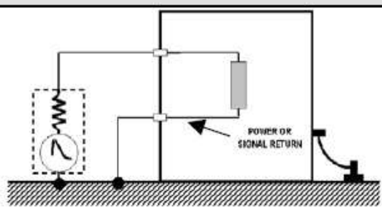
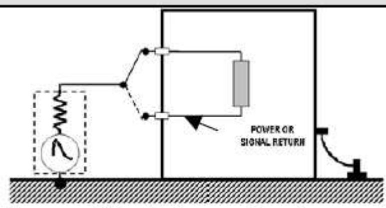
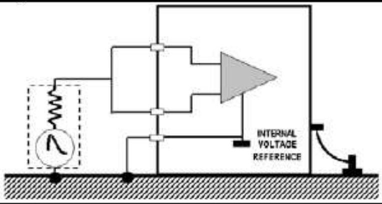
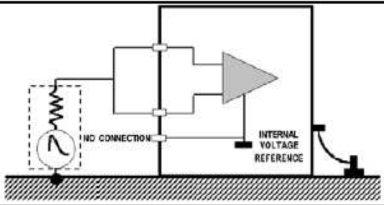
Refer to RTCA DO160E /EUROCAE ED14E Section 22 for waveforms definition.

| Equipment Category | Inputs/outputs category | Short wave voltage wave form 2<br>(1) Fig 22-3 | Oscillatory wave voltage / current wave form 3<br>(1) Fig 22-4 | Long wave Voltage wave form 5A (**TBC**)<br>(1) Fig 22-6 | |
|---|---|---|---|---|---|
| | | | | First method | Second method |
| **Category A Critical equipment** | **Power Supply**: 540 VDC | *1600V / 107A* | *1500V / 60A* | *NA* | *1500V / 1500A* |
| | **Signal**: 28 VDC (exposed area differential signal– electronic bay to wing | *1600V / 107A* | *1500V / 60A* | *500V / 500A (N/A if grounding wire is not used)* | *1500V / 1500A* |
| | **Signal**: other signals than 28 VDC (exposed area differential signal- wing to wing) | *1600V / 107A* | *1500V / 60A* | *N/A* | *1500V / 15A* |

The test level shall be applied between each pin and the ground.

For equipment installed in composite zone, the qualification test procedure shall follow the requirements below:

Depending on equipment grounding design (use of optional wire) and waveform, a common mode or a differential mode procedure as described below shall be used during the test.

| Equipment located in Wings/S19/ HTP/VTP/LG/ Externally mounted | WF2; WF3 and WF5A first Lightning Level from Table 3.2-9 to Table 3.2-15 | WF5A Second Lightning level from Table 3.2-9 to Table 3.2-10 and Table 3.2-14 to Table 3.2-15 |
|---|---|---|
| Ground referenced signals, Common mode signal, power |   NB: Power or Signal return not locally grounded shall be tested. |   NB: Power or Signal return not locally grounded shall be tested. |
| Differential signals |   |   |

For WF2, WF3, and WF4, when performing pin injection on:

- Any power pin, the corresponding power return pin shall be electrically bonded to the equipment housing, or to the case ground pin (Common Mode injection).
- Common mode signal pins (like discretes for instance), the signal return pin must be bonded to the equipment housing, or the case ground pin (Common Mode injection).

For WF5:

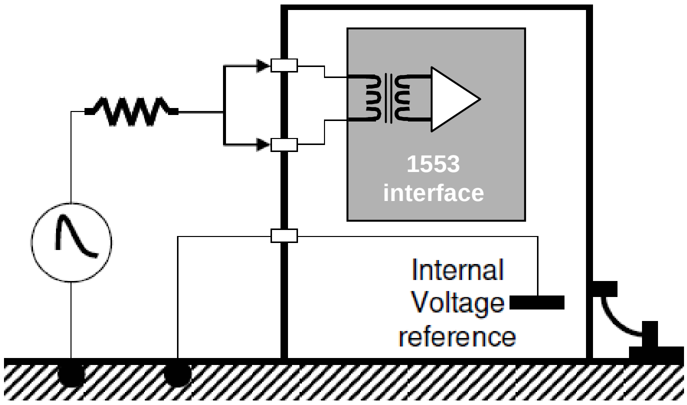
- Any power pin and its associated power return pin must be tested simultaneously, i.e. injections on both the power "direct" and return pins (Differential injection).
- Any signal (like discretes for instance) and return pins must be tested simultaneously (Differential injection).

The Pass/Fail criteria shall be the following: when the equipment is submitted to the above-defined environment, no permanent failure shall occur i.e. any permanent modification of the electrical and dielectric characteristic of any component of the equipment during and after the test.

#### 2.2.24.2.2.2 Lightning Indirect Effect – Damage testing

The equipment shall pass the tests defined in ABD0100 1.2 Damage testing.

The method used for testing shall be pin injection using "differential mode procedure for WF2; WF3 and WF5A first Lightning Level" defined in ABD0100.1.2 F §3.2.2.2.1. The internal voltage reference, if present on a connector terminal shall be connected to the ground plane.




**Pass/Fail criteria:** When the equipment is submitted to the above defined environment no permanent failure shall occur; i.e. no permanent modification of the electrical and dielectric characteristic of any component of the equipment.

#### 2.2.24.2.3 Functional Upset Testing (Multiple Stroke/Burst)

The equipment shall pass the tests defined in ABD0100.1.2, chapter 3.2.2.2.2 “Functional upset testing (Multiple stroke/burst)”.

The equipment shall be operational during the test.

The following table gives the test level of the transient to be applied on each group of wires and on the power supply for equipment of categories A, B and C that cannot be reset from the cockpit or cannot be automatically reset.

This test shall use the cable bundle injection technique.

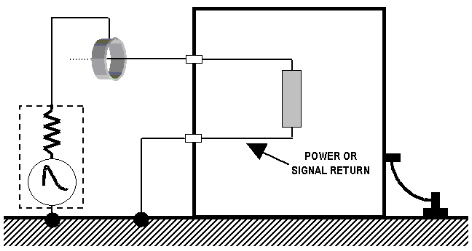
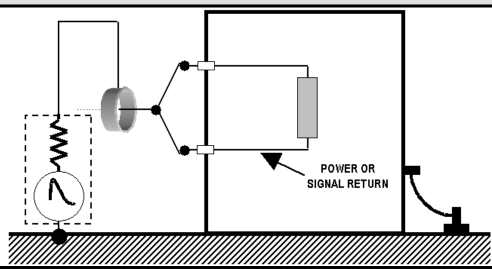
Multiple stroke definition: Two levels are defined: one for the first stroke and a lower one (divided by 2 for WF3 and divided by 4 for WF5.A) for the 13 subsequent stroke. Compliance can be demonstrated by injecting during two separate tests, a first test using a pulse at the higher level, and a second test using 13 pulses at the lower levels.

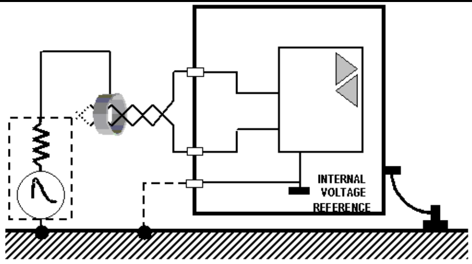
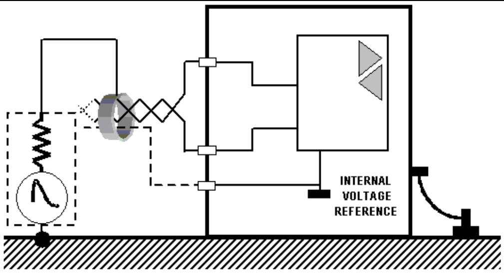
| CATEGORY | | LIGHTNING UPSET ENVIRONMENT | | | |
|---|---|---|---|---|---|
| **EQUIPMENT CATEGORY** | **INPUTS/OUTPUTS CATEGORY** | **MULTIPLE STROKE LONG WAVE VOLTAGE WAVE FORM 5A (1ST) (1) FIG 22-6** | **MULTIPLE STROKE LONG WAVE VOLTAGE WAVE FORM 5A (2ND) (1) FIG 22-6** | **MULTIPLE STROKE OSCILLATORY VOLTAGE / CURRENT WAVE FORM 3 (1) FIG 22-4 (2)** | **MULTIPLE BURST OSCILLATORY VOLTAGE / CURRENT WAVE FORM 3 (1) FIG 22-4 (2)** |
| **Category A Critical equipment** | **Power Supply**: Power supply 2 (Only routes located in composite area: wing and associated pylon and engine, HTP, VTP, section 19) | 1st: 500V / 500A 13 Sub: 125V / 125A | 1st: 1500V / 1500A 13 Sub: 375V / 375A | 1st: 1500V / 60A 13 Sub: 750V / 30A | 300V / 12A |
| | **Signal**: Composite Wing Exposed Area (Only routes located in composite wing) | 1st: 500V / 500A 13 Sub: 125V / 125A | 1st: 1500V / 1500A 13 Sub: 375V / 375A | 1st: 1500V / 60A 13 Sub:750V / 30A | 300V / 12A |

Note 1: Refer to RTCA DO160E / EUROCAE ED14E Section 22 for waveforms definition.

Note 2: An analysis shall be carried out to determine if a specific frequency between 1 MHz and 30 MHz could disturb the specified equipment. If specific frequencies are identified, these frequencies (at least two different ones) shall be considered for the tests with the oscillatory waveform. If there is no specific frequency two frequencies 1 MHz and 10 MHz will be applicable for the oscillatory waveform.

Depending on equipment grounding design (use of optional wire) and waveform, a common mode or a differential mode procedure as described below shall be used during the test.

| **Equipment located in Wings/S19/HTP/ VTP/LG/Externally mounted** | **WF3 and WF5A first Lightning Level from Table 3.2-19 to Table 3.2-24** | **WF5A Second Lightning level from Table 3.2-19 to Table 3.2-20 and Table 3.2-23 to Table 3.2-24** |
|---|---|---|
| **Ground referenced signals, Common mode signal, power** |   |   |

| | | |
|---|---|---|
| **Differential signals** |   *NB: The internal voltage reference conditions of grounding shall be representative of the aircraft installation.* |   *NB: If the internal voltage reference is grounded in the A/C, it shall be tested.* |

The test shall be run individually on each bundle.

For each of these bundles, group of wires shall be tested separately in accordance to the wire categories defined in the specification.

For equipment installed in composite zone, the qualification test procedure shall follow the requirements below:

For WF2, WF3

- The power "direct" leads (i.e. without the return wires) shall be tested independently from any other cabling. If the equipment has several power supplies (28 VDC and 540 VDC), all the "direct" leads might be tested together, i.e. grouped under the injection probe, provided all other wires are not under the injection probe.
- The common mode signals shall be tested independently from the signal return wire(s). The common mode signals can be tested along with the differential mode signals.
- The signal return wire shall be tested grouped with the power supply return wires.
- The entire bundle assembly, i.e. all but the case ground, shall be grouped under the injection probes and test performed at the highest applicable level.

For WF5

- The power supply direct and return leads shall be tested together, grouped under the injection probe. AC and DC power supplies can be tested together.
- The common mode signals wires and the signal return wires shall be tested together, grouped under the injection probe. The common mode signals and signal return wires can be tested along with the differential mode signals.

The entire bundle assembly, i.e. all but the case ground, shall be grouped under the injection probes and test performed at the highest applicable level.

For Multiple Strokes and Multiple Burst bundle injection, the shield of any shielded cable of the bundle shall be disconnected from ground and any other point.

Where several cable bundles connect to equipment under test, simultaneous injection on all bundles is the normal practice. If this is not practicable, then, with the agreement of the Purchaser (shall be defined in the Control Plan), successive injection on each bundle in turn will be accepted with the provision that an additional injection test on the entire interconnection bundling is carried out at the highest level required in the specification.

**Pass/Fail criteria:** The required equipment functional behaviour that shall be exhibited by the equipment both during exposure to the environment and after the environmental threat removal, shall be in agreement with the following rules:

Corresponding function must not be adversely affected during and after the test on the equipment.

For 'Lightning Indirect Effects - Functional upset testing', in the case a functional failure is detected before the maximum test levels are reached and that this failure is considered acceptable (within the requirement pass/fail criteria), the test shall be completed up to the maximum level and the behaviour of the equipment recorded up to this level.

#### 2.2.24.2.4 Functional Upset Testing (Multiple Stroke/Burst)

The equipment shall pass the tests defined in ABD0100.1.2 “Lightning multiple pulse/stroke upset testing”.

The test shall be conducted using the setup and protocol described below:  TBD

Pass/Fail criteria: TBD

### 2.2.24.3 Radio Frequency Susceptibility

The test procedure and set-up shall be in accordance with ED-14/D0160, section 20 "radio frequency susceptibility"

The supplier shall determine the necessary time to detect any malfunction or upset of the equipment under test. The dwell time used for the test shall be selected in accordance with this time.

In any case, the test application shall guarantee that

- below 100kHz: a minimum of 10 test frequencies per decade with a minimum dwell time of 2s per test frequency are applied;
- above 100kHz: a minimum of 100 test frequencies per decade with a minimum dwell time of 2s per test frequency are applied;

#### 2.2.24.3.1 Radio Frequency Conducted Susceptibility (10kHz to 400MHz)

The equipment shall pass the tests defined in ABD0100.1.2, chapter 3.3.2. “Radio Frequency Conducted Susceptibility (10 kHz to 400 MHz)”.

The test procedure and test set-up shall be in accordance with EUROCAE ED14 E/ RTCA DO 160E section 20:

The modulation defined by the EUROCAE ED14 E/ RTCA DO160E section 20 shall be used

The frequency sweep rate shall be compatible with the time needed to detect any equipment malfunction or upset. The default sweep rate to be used is 3 minutes per decade.

The following table gives the test level of the current to be injected on each group of wires following ABD0100.1.2 procedure.

| **CONDUCTED susceptibility environment** | | |
|---|---|---|
| ***EQUIPMENT CATEGORY*** | ***GROUP OF WIRE LOCATION*** | ***TEST LEVELS (mA)*** |
| ***Category A Critical equipment FCS and ECS*** | Power supply : All<br>Exposed Area : Wing | *150 mA* |

Defined levels are RMS levels of the calibrated current; below 500 kHz, the specified test level must follow a 20 dB/decade decreasing slope.

During the test, when necessary, adjust and control the forward power to limit the induced current on the bundle to no more than 3.3 times the specified level.

For conducted susceptibility testing, the shield of any shielded cable of the bundle shall be disconnected from ground and any other point.

Where several cable bundles connect to equipment under test, simultaneous injection on all bundles is the normal practice. If this is not practicable, then with the agreement of the Purchaser (shall be defined in the Control Plan), successive injection on each bundle in turn will be accepted with the provision that an additional injection test on the entire interconnection bundling is carried out at the highest level required in the specification.

**Pass/Fail criteria:** To define this behaviour the rules defined in the following shall be followed around neutral position:

| ***PASS / FAIL CRITERIA FOR HIRF*** | |
|---|---|
| ***EQUIPMENT CATEGORY*** | ***APPLICABLE CRITERIA*** |
| **Category A**<br>**Critical equipment**<br>**FCS and ECS** | Corresponding equipment function shall not be affected during and after the test and actuator movement shall be less than +/-**TBD**°. |

In case of a functional failure is detected before the maximum test levels are reached and that this failure is considered acceptable (within the requirement pass/fail criteria), the test shall be completed up to the maximum level and the behaviour of the equipment recorded up to this level.

#### 2.2.24.3.2 Radio Frequency Conducted Susceptibility (10kHz to 400MHz)

The equipment shall pass the tests defined in ABD0100.1.2 "RF Conducted Susceptibility in the 10 kHz-400MHz band"

For µAFDX interface: **TBD**

**Pass/Fail criteria:** No message loss shall be observed during the test.

#### 2.2.24.3.3 Radio Frequency Radiated Susceptibility (100MHz to 18GHz)

The equipment shall pass the tests defined in ABD0100.1.2, chapter 3.3.3. “Radio Frequency Radiated Susceptibility (100 MHz to 18 GHz)”.

The test procedure and test set-up shall be in accordance with EUROCAE ED14 E/ RTCA DO 160E section 20:

The modulation defined by the EUROCAE ED14 E/ RTCA DO160E section 20 shall be used.

The frequency sweep rate shall be compatible with the time needed to detect any equipment malfunction or upset. The default sweep rate to be used is 3 minutes per decade.

The following tables give respectively the Average test level and the Pulse test level of the electric field to be radiated on the equipment following ABD0100.1.2 procedure.

| ***RADIATED SUSCEPTIBILITY ENVIRONMENT (AVERAGE)*** | | |
|---|---|---|
| ***EQUIPMENT CATEGORY*** | ***EQUIPMENT LOCATION*** | ***TEST LEVELS (V/m)*** |
| ***Category A Critical equipment FCS and ECS*** | Exposed Area : Wing | *100 MHz - 1GHz:* ***100***<br>*1 GHz - 18 GHz:* ***300*** |

| ***RADIATED SUSCEPTIBILITY ENVIRONMENT (PULSE)*** | | |
|---|---|---|
| ***EQUIPMENT CATEGORY*** | ***EQUIPMENT LOCATION*** | ***TEST LEVELS (V/m)*** |
| ***Category A Critical equipment FCS and ECS*** | Exposed Area : Wing | *400 MHz - 1 GHz:* ***700***<br>*1 GHz - 18 GHz:* ***3000*** |

**Pass/Fail criteria:** corresponding function shall not be adversely affected during and after the test and actuator movement shall be less than +/- **TBD**° around neutral position.

In the case a functional failure is detected before the maximum test levels are reached and that this failure is considered acceptable (within the requirement pass/fail criteria), the test shall be completed up to the maximum level and the behaviour of the equipment recorded up to this level.

#### 2.2.24.3.4 Radio Frequency Radiated Susceptibility in the 300MHz to 6GHz band (Internal Transmitter Environment)

N/A

### 2.2.24.4 On Board System Electromagnetic Environment

Regarding on board system electromagnetic environment, dedicated 28 VDC power supply shall be considered as a signal line.

#### 2.2.24.4.1 Magnetic Effect

The Supplier shall demonstrate compliance with the Equipment test specification defined in ABD0100 1.2 chapter 3.4.1 "Magnetic effects".

The applicable test category shall be Category A according to D0 160 section 15.

#### 2.2.24.4.2 Power Supply Voltage Spike

The Supplier shall demonstrate compliance with the Equipment test specification defined in ABD0100 1.8.1. "Equipment specific requirements chapter" or specific requirement on 540 VDC network.

#### 2.2.24.4.3 Power Supply Audio Frequency Conducted Susceptibility

The Supplier shall demonstrate compliance with the Equipment test specification defined in ABD100 1.2 chapter 3.4.3 "Power Supply Audio Frequency Conducted Susceptibility".

The applicable test category is R according to D0 160 chapter 18.

#### 2.2.24.4.4 Induced Signal Susceptibility

The Supplier shall demonstrate compliance with the Equipment test specification defined in ABD100 1.2 chapter 3.4.4 "Induced Signal Susceptibility".

The applicable category shall be Category ZC according to D0 160 chapter 19.

#### 2.2.24.4.5 Emission of Radio Frequency Energy (150kHz – 6GHz)

The supplier shall demonstrate compliance with the Equipment specification defined in ABD100 1.2 chapter 3.4.5 "Emission of Radio Frequency energy".

The applicable test category shall be Category H according to ED14E/DO160E Section 21.

This requirement shall be extended up to 200 MHz with the same level than the level defined at 30 MHz.

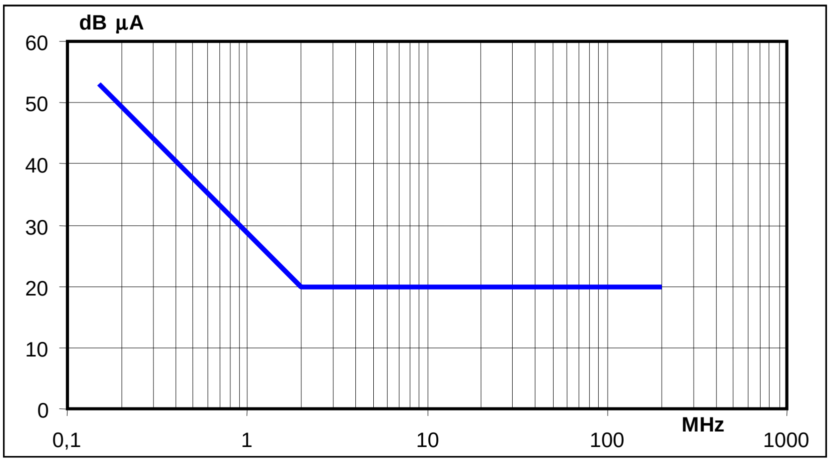
RF emissions test shall be performed at maximum power consumption of the equipment.

#### 2.2.24.4.5.1 Radio Frequency Radiated Emission

The Supplier shall demonstrate compliance with ED14E/DO160E Section 21 Radiated Emissions. The equipment category is Category H.

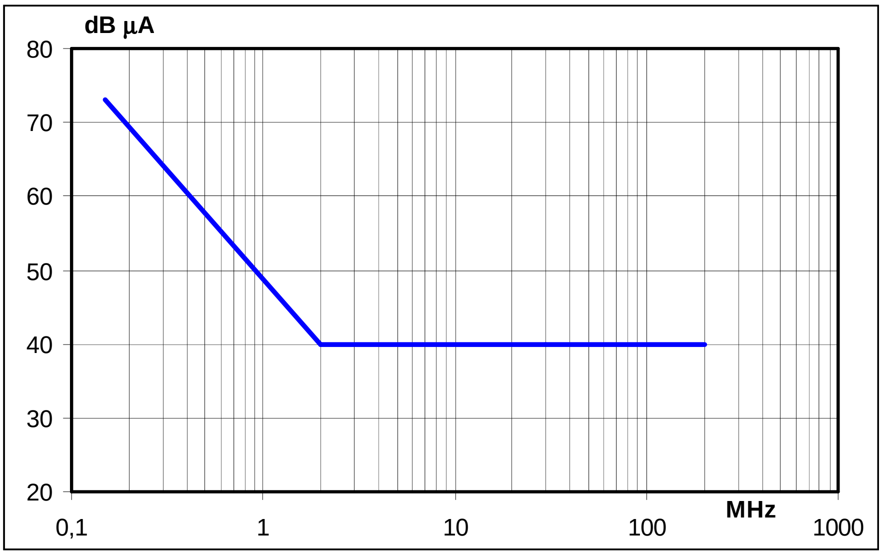
#### 2.2.24.4.5.2 Radio Frequency Conducted Emission on power supply

The Supplier shall demonstrate compliance with ED14E/DO160E Section 21 Conducted Emissions on Power Lines. The equipment category is Category H. This Conducted Emission requirement shall be extended up to 200 MHz with the same level than the level defined at 30 MHz (see next figure).




#### 2.2.24.4.5.3 Radio Frequency Conducted Emission on interconnecting cable

The Supplier shall demonstrate compliance with ED14E/DO160E Section 21 Conducted Emissions on Interconnecting Cables. The equipment category is Category H. This Conducted Emission requirement shall be extended up to 200 MHz with the same level as at 30 MHz (see next figure).




#### 2.2.24.4.6 Common mode ground reference fluctuation

This test is applicable only if optional grounding wire voltage reference is used.

The test shall be run in accordance with **TBD**.

## 2.2.25 Electrostatic discharge (ESD)

The Supplier shall demonstrate compliance with the Equipment test specification defined in ABD 100 1.2 chapter 3.5 “Electrostatic Discharge Susceptibility”.

The test is applicable for all electronic equipment, which are accessible to any person during operation or maintenance of the aircraft.

The applicable test category shall be Category B.

## 2.2.26 Single Event Upset (SEU)/Multiple Bit Upset (MBU)

The ABD0100.1.2 §4 and ABD0100.1.9 chapters shall be applicable.

### 2.2.26.1 Protection Objectives

The Equipment shall comply with the SEU/MBU requirements of the ABD0100.1.9 §2.4

The impact of SEU/MBU on the occurrence of the S/R unexpected events given listed in PTS paragraph 3.2.2.25 "S/R unexpected events" as well as the impact of MTBUR shall be assessed taking into account that the aircraft is exposed to an Atmospheric Neutron Flux in the range of 1 Mev to 800 Mev of 8600 n/cm2/h. For that purpose, the component failure conditions that could be triggered by this particle environment shall be identified and their consequences on the equipment behaviour analysed.

If the SEU/MBU rate is too high for demonstrating either safety objectives or reliability objectives without specific design precautions, the Hardware and Software implementation shall be tolerant to SEU/MBU.

For that purpose, refer to the next paragraph that gives some design recommendations.

#### 2.2.26.2 Design recommendations

Based on the current technology status, the recommended design points for SEU/MBU rate limitation are:

- Limit the use of RAM,
- Where possible, the use of EPROM is preferred,
- Assess the risk of the use of RAM,
- Assess the risk to the register part of microcircuits (microprocessors, programmable circuits, ...),
- Analyse the technologies of components to determine their SEU/MBU sensitivity,
- Avoid unnecessary control,
- Ensure that the integrated circuit packaging cannot be a source of high-energy particles when exposed to the neutron flux.

#### 2.2.26.3 SEU/MBU Risk Analysis

The equipment supplier shall provide a specific document giving the SEU/MBU risk analysis as required in ABD0100.1.9 §2.4.

If necessary (defined at the "verification method" of the SEU/MBU document), the equipment supplier shall include into the qualification plan and qualification test reports specific sections dealing with the efficiency and integrity demonstration of the protection mechanisms linked to SEU/MBU protection.

### 2.2.27 Intrinsic safety

Where aircraft electrical equipment operates in a flammable atmosphere or is connected to equipment in a flammable atmosphere then the intrinsic safety requirements of ABD0100.1.3 shall apply.

The supplier shall provide an intrinsic safety report analysing the system design.

#### 2.2.28 Other test requirements

**TBD**

## 2.3 Equipment Specific Hardware requirements

The Hardware (electrical, mechanical, electromechanical) Design Assurance Process shall comply with the ABD0100.2.5.

The Equipment design assurance shall comply with ABD0100.2.7.

The Electronic Hardware Design Assurance Process shall comply with the ABD0100.2.11.

The development and management of the hardware of the electronic module shall be in accordance with RTCA/EUROCAE DO-254/ED-80.

### 2.3.1 Electronic Hardware Design Assurance Level Definition

The electronic hardware design assurance level, as identified by the System Safety Process, is Level A according to the categorisation of failure conditions of EUROCAE ED-80 / RTCA DO-254.

### 2.3.2 Dissimilarity

Note: Dissimilar software shall only be developed for Hardware Level A if requested by the safety process.

The objectives of RTCA/DO-254 shall be considered.

### 2.3.3 Development Methodologies

The development of electronic hardware shall be done according to the mandatory guidelines of EUROCAE ED-80 / RTCA DO-254, ABD0100.1.9, ABD0100.2.11 and applicable CRIs.

#### 2.3.3.1 Particular requirements regarding Electronic Hardware Design

Regarding their documentation all items shall be treated as “complex” until Airbus agrees to the evidence that an item can be rated as “simple”.

The documentation shall be started immediately in the planning phase with all necessary documents in reference to EUROCAE ED-80 / RTCA DO-254 and ABD0100.2.11.

In the conceptual design data and in the detailed design data, block diagrams shall be provided and the function and complexity of each block shall be explained.

Traceability in both directions between high level blocks, lower level blocks and to the respective code shall be established.

Single Event Upsets shall be taken into account according to the design assurance level.

At power-up a self-test shall assess and confirm the device's functionality. After self-test the device shall enter operational mode from a certain initial condition.

#### 2.3.3.2 HDL Language and Synthesizer Considerations

Programming language:

- A high-level Hardware Description Language like VHDL or Verilog shall be preferred,
- RAM Based FPGA shall be forbidden.

### 2.3.4 Tool Specification

Assessment and qualification of electronic hardware development tools shall be in accordance with EUROCAE ED-80 / RTCA DO-254 section 11.4.

Tools for supporting verification/validation activities (including timing analysis, behavioural simulation, gate level simulation...) – refer to EUROCAE ED-80 / RTCA DO-254 section 6.

Test tools as listed below shall be mandatory:

- HDL-Code checker,
- Static Timing Analyser,
- Simulator (behavioural),
- Simulator (gate level),
- Simulator (back-annotation).

A configuration management tool (concurrent version system) shall be used to control design artefacts as for example design files and life cycle data documents.

### 2.3.5 Electronic Hardware re-use

The re-use of electronic hardware components shall be in compliance with EUROCAE ED-80 / RTCA DO-254 section 11.1 and applicable CRIs.

### 2.3.6 Commercial Off The Shelf (COTS) Components Usage

Usage of COTS components shall be in accordance with EUROCAE ED-80 / RTCA DO-254 section 11.2 and 11.3.

Usage of complex COTS (including usage of IP-cores) shall be stated in the Plan for Hardware Aspects of Certification and shall satisfy EUROCAE ED-80 / RTCA DO-254 according to the design assurance level.

Dissimilarity of Complex COTS shall be respected between COM and MON computation units.

### 2.3.7 Initialisation of FPGAs

Non-volatile FPGA configuration/programming shall be confirmed by appropriate check-methods.

### 2.3.8 User Modifiable Hardware

There shall be no user modifiable hardware.

### 2.3.9 Field Loading of Modifiable Electronic Hardware Functionality

**TBD**

## 2.4 Equipment Specific Software Requirements

The software product shall comply with ABD100.1.10

The software level, as identified by the System Safety Process, is level A according to DO178 classification.

The development and management of the software shall be in accordance with RTCA/EUROCAE DO-178/ED-12 Level A.

A watchdog compliant with ABD100.1.9 and ABD100.1.10 shall be implemented on each lane (COM and MON).

Watchdog consequence shall be discussed with the purchaser.

In case of abnormal results (div by zero, overflow, underflow), the affected lane (COM or MON) shall indicate the failure on µAFDX bus using BFSYS status bit.

### 2.4.1 Software Level Definition

The software level, as identified by the System Safety Process, is Level A according to RTCA/DO-178 classification. Activities, as specified in RTCA/EUROCAE D0178/ED-12, appropriate to this level shall be completed.

Reduction of the software level by applying special design techniques (e.g. partitioning, dissimilarity) must only be achieved with agreement of the certification authorities.

If the software level, initially determined by safety objectives, shall be increased for commercial reasons, the requirements in section **TBD** shall be considered.

### 2.4.2 Partitioning/Segregation

The objectives of ABD0100.1.10 section 7, RTCA/DO-178 section 2.3.1 and the explanation provided in RTCA/DO-248 section 4.14 shall be considered.

Software partitioning is required for the following functions: **TBD**.

The rationale for selecting the above data for partitioning and the required software development level, if different to that previously identified, is as follows: **TBD**.

In addition the following data has been identified as requiring frequent modification and therefore the software design must be such that this data may be changed efficiently: **TBD**.

### 2.4.3 Dissimilarity

Note: Dissimilar software shall only be developed for Software Level A if requested by the safety process.

The objectives of RTCA/DO-178 section 12.3.3 shall be considered.

### 2.4.4 Software Development Specific Features

#### 2.4.4.1 Development Methodologies

The production of software shall be done according to the mandatory guidelines of RTCA/DO-178, ABD0100.1.10, ABD0100.2.4 and applicable CRIs.

The policy for the intended use of IEEE floating point computation shall be described in the Plan for Software Aspects of Certification (PSAC) and detailed in Software Design and code Standards. It shall cover:

- Selected options of the standard,
- Operands relative precision problems.

Use of an automatic code generator is to be encouraged.

#### 2.4.4.2 Languages

Programming language:

- The software development shall be carried out using structured languages, like C ANSI or ADA 83,
- Usage of object orientated programming languages (e.g. C++ or JAVA) shall be evaluated against security objectives and shall be mutually agreed between purchaser and applicant. When object-oriented programming languages are used, a safe subset of object-orientated features shall be defined and an increased verification effort shall be considered,
- Features with dynamic run-time behaviour shall be avoided. No dynamic objects shall be created or destroyed during run-time,
- Usage of pointers shall be limited to compiler-internal mechanisms. If there is reason to introduce further pointer programming techniques, the chosen mechanisms shall be discussed with and agreed by the purchaser during the project's planning phase,
- Usage of assembler language shall be limited to reasonable cases for time critical modules.

Compiler Considerations:

- Usage of special software dependent resources (e.g. usage of CPU-registers for special purposes or cache memory) shall be justified and mentioned within the Software Accomplishment Summary.

### 2.4.4.3 Tool Specification

Assessment and qualification of software development tools shall be in accordance with RTCA/DO-178 section 12.2.

For the proposed software development the following tools will be used, under the headings as stated below:

- Requirements and Design tools:
    - If the software requirements are developed with a tool using a formalized language, the requirements contained in applicable CRIs shall be taken into account.
- Code generation tools:
    - If code generators are used, the requirements contained in applicable CRIs shall be taken into account.
- Verification tools:
    - Use of a Code Checker tool shall be mandatory,
    - Use of Test Tools shall be mandatory.
- Tools for supporting integral processes:
    - Integral processes like configuration management, change management and problem reporting shall be handled with appropriate tools.

### 2.4.4.4 Specification of Commercial Off The Shelf (COTS)

COTS software parts and development data shall be provided in accordance with the requirements of RTCA/DO-178 section 2.4. The applicable software level shall be determined through the software part that uses the COTS component.

COTS software parts shall be identified in the Plan for Software Aspects of Certification, the Software Accomplishment Summary and the Software Configuration Index Document.

### 2.4.4.5 Special Software Parts (Instrumented Software Insertion)

If “instrumented” code will be inserted for test purposes (capturing data for the „structural coverage analysis“, monitoring dynamical memory utilisation, run-time metrics measurement) the following procedure shall be applied:

The instrumented code shall only be used for demonstration of structural coverage, timing behaviour, etc. Subsequently, the target executable object code shall be compiled and linked from the non-instrumented source code. Requirements-based testing shall be repeated on the same testing-level and documented for the non-instrumented software package to demonstrate equivalence of functional and runtime-behaviour for both instrumented and non-instrumented code.

The detailed methodology shall be described in the project specific software plans and shall be noted within the Software Accomplishment Summary.

### 2.4.5 Software Re-use

If the qualification of reused software components is not based on RTCA/DO-178, or in the case of software level upgrade, the equipment and software must be re-qualified according to RTCA/DO-178 with respect to the actual software level.

### 2.4.6 Software Re-usability

N/A

### 2.4.7 Software Loading

LRI software loading due to reconfiguration or installation shall be done within 15 minutes for 32 Mb. For retrofit and update, LRI software loading time of a single system shall be considered according to the system and the periodicity of the update.

Taking account the difference between the conditions of data loading on Aircraft and in shop, the software shall be consistent enough and can be, for example, broken down in blocks, which can be loaded independently.

### 2.4.8 User Modifiable Software

#### 2.4.8.1 UMS – Airborne

N/A

#### 2.4.8.2 UMS – Ground Support Equipment

N/A

### 2.4.9 User of Real Time Monitors

In case that the implementation of a Real Time Monitor is necessary for monitoring a (safety critical) function of equipment, the following requirement shall be taken into account:

- The Real Time Monitor shall be clearly identifiable in all phases of requirements, analysis and design.

In case that the implementation of a Real Time Monitor is necessary for monitoring a (safety critical) function of equipment, the following requirements shall be taken into account:

- The Real Time Monitor shall be assigned the highest priority in the scheduling cycle,
- The timing requirements that apply for the monitored function shall determine the minimum scheduling frequency of the Real Time Monitor.

### 2.4.10 Real Time Operating System Software

Specific embedded or loadable testing S/W shall be developed for testing purposes.

For every equipments :

- A real time scheduling mechanism shall control the operational software tasks. ABD0100.1.10 section 2 shall be considered for the selection of the appropriate mechanism,
- If the mechanism has no strictly predictable time behaviour, as e.g. main loops applying polling mechanism, additional design precautions and verification measures shall be taken to fulfil the real time requirements of the system,
- If the real time scheduler is COTS software, section 2.4.4.4 of this specification shall be applied.

## 2.5 Safety and Reliability

The general safety and reliability requirements are contained in:

- The "Equipment - Design -General Requirements for Suppliers - Safety and Reliability Requirements" (ABD0100.1.3),
- If applicable, in the "Requirements and Guidelines for System Designer - Safety and Reliability Requirements" (ABD0200.1.3 if applicable).

If not otherwise stated, all definitions are in accordance with CSDD (Common Support Data Dictionary) and ABD0100.1.3.

The failure behaviour shall be analysed in respect to the FMEA or Fault tree analysis.

### 2.5.1 Quantitative Safety/Reliability Requirements

#### 2.5.1.1 Quantitative Safety Requirements

The following failure conditions of the item of equipment have been identified as significant for safety. The requirements have been defined taking into account the certification bases and eventual customers/airlines specific requirements as well as Purchaser specific design requirements.

The EMAs shall be capable of meeting the following safety objectives throughout their total declared service life when operated in the environmental conditions defined in this specification.

Additional failure conditions and their associated safety objectives can be possibly defined during the development. Also severisation to safety objectives are possible during the development.

All failures or combination of failures that can affect the safety shall be stated including their Failure Probabilities.

The values hereafter shall be considered as maximum values to satisfy the requirements.

The following safety objectives, established as a mean probability per flight hour (or per cycle, if necessary), shall be met.

Based on the FMEA, the supplier will sum individual failure rate of single failure under the following minimum scenario list. Individual failure shall be used only one time :

The following safety objectives, established as a mean probability per flight hour (or per cycle, if necessary), shall be met:

| | |
|---|---|
| Actuator disconnection | $3.10^{-8}/_{Fh}$ |
| Actuator jamming | $1.10^{-7}/_{Fh}$ |
| Actuator runaway | $5.10^{-7}/_{Fh}$ |
| Actuator uncommanded oscillatory motion | $5.10^{-7}/_{Fh}$ |

| | |
|---|---|
| Actuator loss of control (no more answer to FCC orders) | $5.10^{-5}/_{Fh}$ |
| Impossible switch from active to anti-extension mode | $1.10^{-7}/_{Fh}$ |
| Impossible switch from anti-extension to active mode | $1.10^{-6}/_{Fh}$ |
| Uncommanded switch from anti-extension to active mode | $1.10^{-7}/_{Fh}$ |
| Uncommanded switch from active to anti-extension | $3.10^{-6}/_{Fh}$ |
| Erroneous valid mode information | $1.10^{-7}/_{Fh}$ |
| Erroneous invalid mode information | $1.10^{-6}/_{Fh}$ |
| Erroneous valid mechanical output position information | $1.10^{-6}/_{Fh}$ |
| Erroneous invalid mechanical output position information | $1.10^{-6}/_{Fh}$ |
| Erroneous valid motor position information | $1.10^{-6}/_{Fh}$ |
| Erroneous invalid motor position information | $1.10^{-6}/_{Fh}$ |
| Erroneous valid actuator torque information | $1.10^{-6}/_{Fh}$ |
| Erroneous invalid actuator torque information | $5.10^{-6}/_{Fh}$ |
| Erroneous valid temperature information (for each temperature information) | $1.10^{-6}/_{Fh}$ |
| Erroneous invalid temperature information (for each temperature information) | $1.10^{-6}/_{Fh}$ |
| Loss of torque limitation (in active, anti-extension and recentring mode(*)) | $5.10^{-8}/_{Fh}$ |
| Loss of minimum dynamic stiffness performances in active mode | $2.10^{-6}/_{Fh}$ |
| Loss temperature information(for each temperature information) | $1,5.10^{-6}/_{Fh}$ |

*(*) For the A320 demonstrator only*,

NOTE: The unit is considered jammed if deenergized, an external torque up to 50% of the maximum torque specified in § 2.1.6.1.1 – *Torque and Deflection Rate Performances* is needed to move its mechanical output shaft. The jamming safety requirement ($1.10^{-8}/_{FH}$) is specific to this research project and according to A320 safety analysis. It could be stronger for a future application ($10^{-9}/_{FH}$). Jamming prediction must be particularly analyzed in the frame of the health monitoring because it may make the actuator more reliable against jamming occurrence (detect and potentially repair/replace actuator some flights before jamming).

### 2.5.1.2 Quantitative Reliability Requirements

To comply with reliability objectives, solutions based on equipment component intrinsic reliability/maintainability improvement (i.e. increase of MTBF, accessibility or improvement of removal procedure, etc.) will be preferred, compared with a solution leading to an increase in equipment architecture complexity (i.e. redundancy, etc.). If the last case is envisaged, it shall be discussed during an equipment review before approval.

#### 2.5.1.2.1 Operational Data

The turn-around time between two flights (with 540VDC ON and 28VDC ON) is 90 minutes.

#### 2.5.1.2.2 Service and Useful Life

The objective for service and useful life shall be the NSA aircraft service life.

For each sizing criteria of the actuator (e.g. fatigue, endurance…), Design Service Goals and useful life shall be the most severe of the following A/C lives.

The life of the actuator in active mode with specified duty cycles in §2.1.6.4 – *Duty Cycles* shall be the earlier between

- 30 years,
- Or 100 000 flights / 150 000 flight hours (flight duration is 1.5 hour).

The life of the actuator in anti-extension mode with specified duty cycles in §2.1.6.4 - *Duty Cycles* shall be:

- 20 000 flights / 30 000 flight hours (TBC) (flight duration is 1.5 hour).

#### 2.5.1.2.3 Design/Reliability Objectives

The failure cases of the items of equipments have been identified as significant for reliability. The requirements have been defined taking into account the eventual customers/airlines specific requirements as well as Purchaser specific design requirements.

The EMAs shall be capable of meeting the following design/reliability objectives throughout their total declared service life when operated in the environmental conditions defined in this specification.

Additional failure conditions and their associated design/reliability objectives are possible during the development. Also alterations to objectives are possible during the development.

The values hereafter shall be considered as maximum values to satisfy the requirements.

The design/reliability objectives defined in § 2.5.1.1 – *Quantitative Safety Requirements* established as a mean probability per flight hour, shall be achieved.

If it is evident that the Supplier's equipment constitute a significant influence on the Aircraft Operational Reliability (OR) defined at ATA level, the Supplier shall identify the key factors which influence Aircraft OR, and shall contribute proactively toward ensuring that their design, test, and manufacturing processes are consistent with the achievement of an acceptable level of OR.

#### 2.5.1.2.4 MTBF

The MTBF/MTBUR ratio will be defined in paragraph 2.6.4 – *MTBUR Objectives.*

The equipment MTBF shall be **TBA** FH (objective > 150 000 FH).

MTBF is an output of the parametric model and has to be challenged according to each input parameter.

The Supplier shall identify, justify and commit to meet the specified reliability value MTBF as required by the verification program (Refer to ABD0100.1.3).

If appropriate, "Mean Cycles Between Failure" (MCBF) can be used instead of MTBF.

#### 2.5.1.3 Qualitative Safety Requirements

Reliability, maintainability, safety (RMS) analysis shall be performed to cover the following particular scenarios:

- Actuator disconnection
- Actuator mechanical jamming
- Actuator runaway
- Actuator uncommanded oscillations
- Failures leading to loss of active mode
- Degradation of performance
- Loss of control
- Loss of torque limitation
- Risk of fire.

Failure modes to be considered shall be agreed between the Purchaser and the Supplier.

Failure consequence shall be demonstrated either by evidence or by test.

No single failure shall result in generating a torque greater than 1.5 times the limit torque.

The list of single failures undetectable (whatever the effect) in active or other operating mode or during maintenance tests (see § 2.5.7 – Safety/Reliability Tests) shall be listed in the Safety Analysis (FMEA). (objective: none).

The risk of fire due to an internal cause shall be self-contained within the unit (i.e. skin temperature shall not exceed 100℃, no external spark…).

The EMAs shall send the temperature sensors information to the flight control computer. They may use these information to switch OFF the electrical power supply.

The supplier will categorize and recommend disposition of these failures either as safety significant requiring a scheduled inspection, or a non-safety significant when the analysis supports that the failure can tolerate dormancy for the life of the aircraft.

The safety relevant items/functions shall be adequately isolated; i.e. failure of one component/sub-function shall not cause a failure of another one.

Possible common mode faults (e.g. design errors, quality issues, signal distortion, requirement errors and environmental factors) shall be analysed in the Common Mode Analysis.

A qualitative analysis (reliability block diagram) is required for the following failure conditions:

- Actuator mechanical jamming
- Actuator runaway

- Actuator disconnection

The analysis shall consider failure sequences of the scenarios (e.g. failures occur prior or during flight).

All dormant failures have to be indicated.
All possible means of detection have to be indicated.

Incorrect assembly and adjustment that could result in a malfunction shall not be possible.

Safety relevant failures which are dormant shall be avoided.

The supplier shall participate together with the purchaser to the definition of all relevant means of reducing dormancy time as far as possible (the objective is to minimize CMR (Certification Maintenance Requirement) and automatic tests,…).

The list of CMR is: **TBD**

All failures or combination of failures which can affect the safety shall be stated including their Failure Probabilities.

The supplier shall participate together with the purchaser to the definition of the MMEL directives.

The Master Minimum Equipment List (MMEL) and Common Deviation List shall maximize the ability to dispatch the aircraft with failed equipment or functions within the design capability and safety analysis.

#### 2.5.1.4 Qualitative Reliability Requirements

A failure of BITE (Built In Test Equipment) systems shall not affect the operation of the components being monitored.

The possibility of common mode faults that significantly reduce the reliability shall be avoided.

The use of failure rates of similar or already certified item of equipment presumes that the rates are adapted to the possible changed operational and environmental conditions. These adaptations have to be documented for each failure rate.

In addition to Safety/Reliability Activities during In-Service Phase defined in ABD0100 1.3, the Supplier has to maintain a continuous program for the determination of the In-Service OR behaviour.

### 2.5.2 Reused Equipment

In case of reused Equipment, Supplier shall analyse impact of changed operational/environmental conditions on the equipment (Impact on quantitative and qualitative S/R requirements) and provide the result to Airbus for approval.

### 2.5.3 Development Assurance Level Requirements

The Development Assurance Level(s) relevant for the item of equipments is level A.

### 2.5.4 Software Safety/Reliability Requirements

The development and management of software shall be in accordance with RTCA/EUROCAE DO-178/ED-12.

The rules of "defensive programming" shall be taken into account, i.e.

- Used codes shall assure that no undesired or unscheduled events can be generated by the software itself,
- Neither run-time error nor non-deterministic construct, whose consequence include processor halt, data corruption and security breaches, shall remain in the software (use of a static analysis tool could be a means to help demonstrating these topics),
- Hardware failures shall not result in software executing hazardous or irregular operations.

The software design shall not compromise the hardware failure tolerance.

It shall be analysed how far software errors are involved in the safety and reliability relevant failure conditions, i.e. they shall be indicated qualitative in the block diagrams/fault trees and/or the FMEA.

### 2.5.5 Specific ETOPS Requirements

N/A

### 2.5.6 Safety/Reliability Activities during Development

The required safety/reliability activities and document shall be in accordance with the ABD0100.1.3.

FMEA & FMES description: table **TBD**

Update of documents has to be issued on request of Purchaser to answer Airworthiness Authorities requests.

In the FMEA parts or component failure modes resulting in sparks, overheating or fire shall be explicitly mentioned, if they are any.

The FMES shall list the FMEA failure modes causing sparks, overheating and fire as separate failure modes.

### 2.5.7 Safety/Reliability Tests

In order to achieve the safety and reliability objectives, the Supplier shall define and implement tests in the unit. These tests shall satisfy the requirements of ABD0100.1.4 paragraph 4. An approval of the purchaser is necessary.

The Supplier shall provide a justification of their efficiency, in particular an exhaustive list of failures that are detected and associated functions.

The Supplier shall establish a procedure to report failures that occurred during the tests and to launch corrective actions. A report containing the occurred failures and a description of the design improvements shall be provided to the Purchaser.

#### 2.5.7.1 Reliability Tests

Refer to paragraph 2.7.1.1 - *Robustness Tests* .

#### 2.5.7.2 Safety Tests

Supplier shall comply with ABD100.1.4

Automatic test:

An auto-diagnostic test shall be performed (Provision: before each flight, at power-ON), performing:

- Electronic components integrity test: Processor, FPGA, ASIC, PLDs...: components integrity shall be checked during initialization (Power On). Memories shall be checked during initialization or during functional mode in case of background tasks.
  This test shall be submitted to the purchaser for approval.
- Actuator functions test: **TBA** (objective: none).

The aim is to make this test as complete as possible without reducing significantly the equipment MTBF.

Manual checks:

- manual pre-flight check consisting in max speed full deflection, actuators in active mode
- Additional tests will be performed from the cockpit every **TBD** flights and shall enable to check actuator functions **TBA** (objective: none)..

Dormant failure in normal active configuration

All dormant failures involved in loss of a function shall be detectable by specific maintenance tests.

### 2.5.8 Safety/Reliability Activities during In-Service

N/A for Research Project.

### 2.5.9 Disposal Instructions

If, by design, the equipments contain some sensitive components (impact on environment or personal) which need a dedicated procedure for recycling, end life storage, end life destruction, and other situations relative to the end life of the equipment, the supplier shall identify those components and shall propose an adequate procedure. The manufacturer shall agree to the selection of such components and shall review the proposed procedure.

## 2.6 Maintainability

### 2.6.1 General

The EMAs shall be subjected to detailed maintainability aspects and reliability analyses in order to meet customer expectations and shall comply with the general maintainability requirements defined in ABD 100 1.4, ABD0100.1.5, ABD0100.1.15.

Equipment designs shall take benefit of lessons learnt from supplier previous programs.

The impact analysis of options on the aircraft supportability performances (operational reliability, maintainability, testability, maintenance program...) shall be provided and approved by the Purchaser.

Concepts featuring new technology shall be subjected to rigorous evaluation against reliability, maintainability, reparability and supportability criteria before final concept selection.

#### 2.6.1.1 Maintainability and Maintenance Evaluation

Supplier shall feed with details the “Maintainability & Maintenance Evaluation” document, ref. X00FM0500302 to be presented as the initial supplier proposal and the final version shall be delivered and validated at the CDR.

#### 2.6.1.2 Latched Failures

The following failures shall be latched until the end of the flight: **TBA** (Objective: none).

For definition of failures being latched refer to ABD 100.1.4 “Normal Mode Definition”.

### 2.6.2 Maintenance Concept

The EMAs maintenance program concept should be a flexible concept, i.e. “scheduled maintenance between A/C operation” instead of “operation between schedules maintenance”.

Fault tolerance principles or component intrinsic reliability shall be adopted when appropriate to achieve operational reliability targets and minimize line maintenance work.

To reduce number of Flight Deck Effects and to reduce unscheduled maintenance tasks, it shall be possible to reconfigure LRIs, automatically or manually in flight or on the ground, that are held as cold spares.

A failure, which has no operational consequence for the current and next flight, shall not be visible to the flight crew.

In order to reduce the number of unjustified LRI removals due to design bugs leading to software failures, the supplier shall issue specific procedures enabling the operator to maintain the LRM/LRI onboard the aircraft, any safety impact being addressed. A customer/supplier/manufacturer specific procedure shall be issued to track and to fix software faults.

The need for specialized labour skills, compared to those used on existing AIRBUS aircraft shall be avoided for maintenance tasks.

Hard Time limited components in equipment design shall be avoided. If their use cannot be avoided, a justification shall be provided to the Purchaser for agreement.

As a requirement, no Preventative Maintenance shall be required between Flights on the same day.

To support a 15-day deferred maintenance policy there should be design intent to ensure that a large majority of MMEL entries are C (10 days) or D (120 days) rectification categories.

### 2.6.3 Fatigue Life Limits

Fatigue life limited parts shall be avoided as specified in ABD 100 1.4.

Any life limit identified and proposed by the equipment Supplier must be fully justified by relevant data and accepted by the aircraft Manufacturer. The equipment itself and the hardware item shall be appropriately and individually identified to ensure traceability and to allow monitoring of life status. The relevant documentation (e.g.: CMM Component Maintenance Manual) shall include all data to allow monitoring of life status as well as replacement of the affected hardware item(s).

### 2.6.4 MTBUR Objectives

#### 2.6.4.1 MTBUR

As per the ABD 100.1.3, the MTBUR (Mean Time Between Unscheduled Removal) is obtained by dividing the total number of flight hours logged by a population of an item of equipment over a certain period of time by the total number of unscheduled removals during that same period.

#### 2.6.4.2 MTBUR/MTBF Ratio

The MTBUR/MTBF shall be at least equal to **TBA** FH / **TBA** FH.

To achieve the Operational Reliability and DMC targets, the NFF rate shall be lower than 15% for avionic/electronic parts (ECU, ...) and lower than 10% for electrical/mechanical parts (EMA without LRI). (Ref ABD100.1.4E for 15%).

#### 2.6.4.3 Guaranteed MTBUR

The supplier shall provide the purchaser with a guaranteed MTBUR value.

#### 2.6.4.4 Operational Reliability

N/A

### 2.6.5 Direct Maintenance Cost

The supplier shall provide the purchaser guaranteed direct maintenance cost values on component level and shipset level.

### 2.6.6 Scheduled Maintenance

#### 2.6.6.1 Maintenance Plan

The maintenance plan requirements are defined in the ABD0100.1.15.

The HMV (Heavy Maintenance Visit) Interval is **TBD** Years.

Means shall be provided on A/C to verify operations of redundancies/back-up systems, protective devices, fail-safe mechanisms and dual load path items.

Scheduled maintenance tasks at frequencies below the HMV, shall be of a line maintenance type: No specific GSE (in case of simple GSE need, approval shall be provided by the Purchaser), No highly skilled personnel, No specific Aircraft condition. No need for A/C in a controlled environment (like hangar).

The design shall support scheduled maintenance tasks and their corrective actions to be performed within 4 Hours (maximum stop on Long range Operation).

The EMAs minimum Scheduled Maintenance interval shall be **TBA** FH (objective: no maintenance).

Manual checks from the cockpit shall be possible.

The requirements for specialised tools and equipment for line, base and workshop maintenance shall be kept to a practicable minimum (paragraph 2.6.8 – *Tools, Tests and Ground Support Requirements*) and submitted to Purchaser approval.

If any special tools for maintenance tasks are needed, the supplier shall demonstrate their performance.

The checks and maintenance operations required to meet life requirements shall be as follows: **TBA**

Each Scheduled Maintenance interval shall be justified by qualification tests or safety or reliability analysis.

EMAs target of Schedule Maintenance man-hours compared to the HMV is **TBD** M/H.

#### 2.6.6.2 In Service Limits

The supplier shall provide a list of components that are subjected to degradation through wear, loss of consumable or loss of performance, and the limits in between these components are still serviceable.

The unit shall not incorporate any component for which life is lower than the specified service life and shall not be subjected to any Time Between Overhauls (TBO).

#### 2.6.6.3 Maintenance Task Data

This section is covered by the following document: “Maintainability & Maintenance Evaluation”, ref. X00FM0500302.

### 2.6.7 Design for Maintainability

The splitting into LRI shall minimize the mean time between removals of the structural or heavy components of the equipment.

The following component shall be designed as Line Replaceable Items :

- Electronic Control Unit (ECU)

The following components shall be replaceable:

- The tailstock spherical bearing,
- The rod end spherical roller bearing.

Safety cables shall not be used on LRI.

The supplier shall propose LRI replacement times excluding time for A/C accessibility.

The suggested format is the following one:

| LRU/LRI Component | Component Replacement | |
|---|---|---|
| | Total Elapsed Time (Min) | No of Men |
| Actuator (LRU) | **TBA (Objective < 30 min)** | **1** |
| ECU (LRI) | **TBA (Objective < 15min)** | **1** |

#### 2.6.7.1 Accessibility

Access will be provided from below, for actuator installation/removal and for LRI's removal.

A component should be installed so that it is possible to use common tools listed on the attaching parts and connections.

The Supplier shall fully support the Purchaser to reach the following objectives:

- Cable assemblies shall be routed to avoid part access restrictions.
- Grease fitting location shall allow the use of standard grease guns through access panel.
- The supplier shall provide a maintainability 3D digital model including the maintainability volume for the Removal/Installation of each LRI with tools.
- The maintainability 3D digital models shall be provided at the initial supplier proposal stage and shall be updated after each design modification.
- The final version of the maintainability 3D digital models shall be delivered and validated at the CDR.
- The supplier shall participate to the demonstration with this 3D digital model easy and quick access to the LRI attachments and connections.
- The results of accessibility studies performed on 3D digital model shall help to fill the MME “Maintainability & Maintenance Evaluation”.
- All joints, terminals, connections, etc, shall be positioned to allow easy access with standard tools without risk of damage adjacent components, structure or cables.
- A failed component shall not prevent access to itself.
- In general, easy and quick accessibility shall be required for those items which are required (for economical and safety reasons) for the flight.
- In addition to the influence on the equipment design, the specified installation position shall be checked for allowing good access.
- A bonding test point should be accessible at any time without removal of aircraft part.

#### 2.6.7.2 Installation

Shop and On-aircraft maintenance activities shall be performed using standard tools list ref V00RP0602539.

Maintenance and test device operating force shall not be higher than 15daN.

Tightening torque required for the installation or adjustment of the complete unit shall be minimized and submitted to the Purchaser approval. The installation of the complete unit shall not require application of tightening torque higher than 5 mdaN.

All LRIs of the unit must be replaceable without the removal of other equipment.

LRI design shall ensure that units are physically interchangeable only when they are functionally interchangeable. Mechanical keying may be used.

LRIs shall be fixed by non-losable fasteners means.

Deviations for LRU removal shall be submitted to the Purchaser for agreement.

Hinge pins and attachment bolts shall be locked. The choice of the locking devices shall be submitted to the Purchaser for agreement.

Where wire locking of a component or assembly is required, wire lock pigtails should be protected to avoid injury of pilots or maintenance crew.

Electrical connectors shall be orientated towards fixed structure side.

To prevent fluids from entering, no plugs or receptacles shall be installed vertically.
Electrical connectors to interface with A/C shall be arranged so that ingress of water into the plug connections be avoided (e.g. drip loops) and installed where they cannot be damaged by the hydraulic fluid.

All adjustment points, rigging marks shall be permanently identifiable and easily accessible:

When vertically installed, bolts should be fitted with their head uppermost and when this is not possible additional locking features shall be considered.

Adjustment devices shall be locked so that the adjustment point cannot unintentionally be altered.

Adjustment devices shall be provided with markings or indicators which show the extent and type of adjustment.

As maintenance procedure recommendations are not always followed, the occurrence of equipment removal with "power on" sometimes happens (considered as Human Factors). As a consequence, the supplier shall take this bad practice into account in the design in order to prevent reliability impact and to protect personal health.

### 2.6.7.3 Inspection/Test

The Supplier shall propose to A/C manufacturer suitable inspection and test procedures to permit cost-effective verification of correct installation and functionality of the equipment (through the MME, “Maintainability & Maintenance Evaluation ”).

Adjustment, calibration of a component after replacement shall be avoided.

There shall be no flight test requirements for safety reasons, after any components have been changed or reinstalled.

As far as practical, LRI and component functions, including redundancies, shall be testable in situ (on A/C).

The incorrect repositioning of any equipment/parts after maintenance tasks shall be detected before flight.
If not possible, the Supplier shall ensure that :

- the item will automatically recover its normal working functionality after maintenance tasks are performed,
- the criticality of the item will be known by maintenance crew,
- for critical and essential items (in compliance with system Safety/Reliability requirements), a double maintenance inspection task should be foreseen if necessary.

#### 2.6.7.4 Fault Diagnosis

Fault diagnosis of the EMAs shall be performed thanks to the Health Monitoring function.

#### 2.6.7.5 Electronics Equipment Maintainability

N/A

#### 2.6.7.6 Servicing/Lubrication/Handling

All wiring shall be coded, as necessary, for ease of identification during in-service maintenance

Connectors shall be fitted with all the pins specified in the standard. Pins must be crimped and not soldered, except if necessary and to be submitted to the purchaser.

All lubricated components shall be lubricated for the whole aircraft service life.

In general, all ground servicing points shall be compatible with ground servicing equipment available at major airports.

Handling interfaces, agreed between the supplier and the Purchaser, shall be provided on the unit at adequate place to lift and carry the unit.
Hoisting provisions shall be furnished for components weighing 25 kg or more, and hoisting provisions should be considered on a case by case basis where components of 15 kg or more require a lift to be performed at arm's length.

<u>Standardized components</u>

In general, all ground servicing points shall be compatible with ground servicing equipment available at major airports and shall comply with « ISO » and/or other standards that are indicated in the corresponding Aircraft Standard Specification.

#### 2.6.7.7 Reparability

Components shall be designed with maximum reparability features. For electronics components, special requirements are made in ABD0100.1.4.

The Supplier shall supply the Purchaser with the repair data detailing the time to repair and the cost of the spare parts (through the MME, “Maintainability & Maintenance Evaluation ”).

All "No Go" and "Go If" LRI shall have, as a general objective, a removal/installation time (excluding data loading) less than 0.25hr or, alternatively, have a realistic way to restore the function within the minimum turn-around time.

Deactivation of an LRI under the MMEL following a failure detected during a standard pre-flight and start up procedure shall take less than five minutes.

LRU shall be repairable in shop by LRI replacement.

### 2.6.7.8 Avoidance of Maintenance Errors

Aircraft design (structure, equipment, systems, component and items) shall eliminate (when possible) or minimize all potential hazards and risks for maintainers.

If it is technically impossible to eliminate Health & Safety risks by design, an appropriate combination of the following requirements shall be provided to minimize the risk to maintainers.

- Means of protection against hazards and risks (collective protections shall be favoured above individual protections);
- Provide sufficient information to identify, avoid or protect against hazards and risks;
- Provide an appropriate training for Health & Safety related procedures;

Note: Placards and markings alone shall not be considered as satisfactory Health & Safety solution.

The design of any equipment, components, and items on the aircraft shall take into account maintenance tasks that will be performed on them and the real conditions under which the tasks are performed: environmental, operational and climatic conditions.

All equipment, components, or items and their orientation, location, routing, and order shall be designed to ensure that all associated maintenance tasks are easy, intuitive, self-evident, and unambiguous to identify and to perform.

Special care shall be taken to protect the equipment against the effects of mishandling, miss-operation or human errors during maintenance operations (through the MME, “Maintainability & Maintenance Evaluation”).

The equipment shall be designed wherever possible such that incorrect assembly, transposed connections and installations are impossible by means such as symmetry of attachments, locating spigots, different end spigots, different end fitting to be utilized.

Connections shall be arranged so that cross connection or wrong connection is impossible (e.g. by segregation or differing cable lengths/sizes).The control of cable length by clipping is not considered to be an adequate safe guard against cross connection.

It shall be impossible to install any equipment, component, or item in the wrong orientation, in the incorrect location, using improper routing, or in the wrong order.

Screws which are not lock wired shall not include a lockwire hole.

All rigging pins/locking devices shall be provided with warning flags that can be seen from the ground when device is installed.

The Supplier shall provide all means and assistance required to the purchaser during development phases, to guarantee that any maintenance tool cannot be kept fitted on the equipment in flight configuration (visual warning means are not considered sufficient).

All components which could be used as a step or handle shall be protected or withstand such inadvertent use of the component.

#### 2.6.7.9 Other requirements

Technological evolution shall be managed without having non mixable LRIs.

### 2.6.8 Tools, Tests and Ground Support Requirements

N/A

### 2.6.9 Support Requirements

#### 2.6.9.1 Support Data

The Supplier shall supply maintainability data in the form identified by ABD0100.1.4 and "General Conditions of Purchase".

#### 2.6.9.2 Maintenance Demonstration

At the request of the purchaser the supplier shall assist the purchaser to establish documentation for maintainability demonstrations carried out by the airframe manufacturer for aircraft customers. The information or demonstrations will prove that any maintenance tasks found to be necessary can be completed correctly, in a reasonable time and at a reasonable material and man-power cost. One of the means to demonstrate maintenance of the equipment is the 3D maintainability volume required in § 2.6.7.1 – *Accessibility.*

The following shall be demonstrated:

- Lubricant filling or draining (using standard tools, draining 100%).
- Clearance for the use of wrenches or other maintenance tools to perform removal/ installation tasks.

#### 2.6.9.3 Equipment Rework

List of repair procedures: **TBA**

### 2.6.10 Guaranteed Shop Processing Time (SPT)

N/A

## 2.7 Off Aircraft Tests and Testability Requirements

Tests are part of the verification process.

Verification is the responsibility of the Supplier.

The equipment shall comply with Off-aircraft tests and testability requirements specified in ABD0100.1.5.

The validation/verification activities intended to be performed by the Supplier shall be identified at software level, equipment level, and also to cover Dual / multi LRI configuration of the equipment.

The supplier shall warranty and demonstrate 100% coverage of agreed standard defined in PTS before each Purchaser Integration Test Centre delivery.

The supplier shall perform, before Purchaser Integration Test Centre delivery:

- A complete integration at software level of automatic (if any) and manual code.
- A complete integration at equipment level of the LRI.

The Supplier shall provide all means and assistance required to the purchaser to analyse Ground tests & Flight test data (for development and serial phases).

In case of anomaly encountered during purchaser integration test, the Supplier shall be requested and bring assistance within a given delay (to be defined during the PTS workshop).

### 2.7.1 Hardware Tests for Verification of Design

The design verification tests shall comply with the ABD0100.1.5 §1.1 and §1.2, and ABD0100.2.7 §2.2.

#### 2.7.1.1 Robustness Tests

The Supplier shall perform the robustness tests according to the ABD0100.1.5 §1.3 during the design phase, to know the operational margin and the destructive margin (functional and environmental) of the equipment and also the weak points of the design to allow its improvement.

In this case, the levels of the test constraint are slowly increased above the nominal or qualification level to reach the equipment limits.

An accelerated reliability testing technique, like Highly Accelerated Life Tests shall be applied as early as possible in the component design process. Such tests shall be performed by the Supplier based on the specification TN-EAD 460/12/00 of the Purchaser.

The supplier shall describe how he wants to perform Limit or Destructive Test during development of the concerned components. The applied technique shall expose the tested components to stresses such as random vibration (6 degrees of freedom), rapid temperature transitions, voltage margining, frequency margining, and any other stresses that are appropriate to find the weak areas in the design.
The Supplier shall take into account that the standard sequence of signals/data coming from the outside can be not compliant. In this case, the equipment shall not enter in a wrong state and shall not give a wrong status outside.

The Supplier shall choose a set of representative combination of signals/data to apply to its equipment and then demonstrate its robustness.

The RG Aero00029 shall be used as a guideline to perform these activities.

The supplier shall propose robustness test plan which shall include at least:

- Fatigue tests continued up to rupture of the unit, with an increased severity if necessary and in such a way that its results could be used to predict the fatigue life of the unit under a modified duty cycle,
- Endurance tests continued up to rupture of the unit,
- Limit or Destructive Test / Stress Screening Test (random vibration, rapid temperature transitions,…) before the CDR,
- Engineering electrical test to be performed before the delivery of the Iron Bird Unit:
  - Inrush current test,
  - Voltage spike due to equipment torque switching,
  - Voltage transient (Transparency time…).
- Other risk mitigation tests.

During the whole test, the components shall be operated under torque conditions and shall be fully monitored.

#### 2.7.1.2 Risk Management

The minimum identified risk areas shall be addressed as follows during the development phase:

Risk item 1: **TBA**
Purpose of this risk: **TBA**
Mitigation plan: **TBA**
Back-up Plan: **TBA**
Target completion date: **TBA**

### 2.7.2 Hardware Verification Tests of Product in Production

#### 2.7.2.1 Enhanced Stress Screening (ESS)

The guidance on Screening Test requirements are the following ones.

The Supplier shall propose a test like Highly Accelerated Stress Screening that is to apply during the manufacturing of each component or a representative sample to reveal manufacturing flaws.

The objectives of these tests are to ensure that no weak point (latent defects, early failures) is existing in the product manufacturing process due to undetected changes or modifications (parts, processes…).

The test conditions shall be derived from the operating and destruct limits observed during the design accelerated reliability tests above.

The Supplier shall comply with the ESS requirements of the ABD0100.1.5 §2.1.

#### 2.7.2.2 Manufacturing tests

The purpose of the Manufacturing Tests is to define the requirements for all production tests and inspections to perform on each LRI and on the sub-assembly (SRU), for approval before delivery of item of equipment. The Manufacturing Tests shall comply with ABD0100.1.5 §2.2.

The dielectric test and the insulation resistance test shall be carried out only once in the life of an equipment, before delivery (see ABD0100.1.5§3).

#### 2.7.2.3 Acceptance Test Specification (ATS)

The purpose of the Acceptance Test is to guarantee that the equipment meets the technical specification and its Definition Dossier. The supplier shall comply with ABD0100.1.5 §2.3 Acceptance Test Specification.

The supplier shall make the demonstration that the acceptance limit definition, applicable to new equipment in laboratory conditions, satisfactorily covers the specified limits taking into account ageing effect, environmental conditions, acceptance test means discrepancies and manufacturing dispersions.

Each equipment and LRI shall be submitted to an acceptance procedure including inspection test, of which the purpose is to demonstrate that the item of equipment complies with the definition dossier of the units submitted to the qualification process.

The acceptance test shall include the verification of the operation and characteristics of 100% of the functional components.

The inspections, acceptance test procedure, acceptance test report format, allowable limits and their proposed evolutions shall be submitted to the purchaser approval.

Every subcomponents ATP shall be provided.

### 2.7.3 Hardware Verification of Equipment after Maintenance (Return to Service)

Requirements for Automatic test capabilities e.g. ATE are identified in ABD0100.1.5.

The use of Automatic Test Equipment (ATE) shall be maximized for avionics shop test.

The Supplier shall deliver a Return To Service (RTS) test specification as requested in ABD0100.1.5 §4.1.1 and §2.4.

The Supplier shall comply with the Electric/Electronic Testability Requirements as requested in the ABD0100.1.5 §4.

### 2.7.4 Verification of Equipment during its Life Cycle

Dedicated qualification tests will be performed on each new equipment standard. The supplier is responsible for any corrective action in case of deviation compared to EIS standard qualification, which is reference for non-regression.

### 2.7.5 Mixed Operation Tests

If two or more standards of equipment are used on a given aircraft, they shall be interchangeable and mixable.

### 2.7.6 Electronic Tests

Requirements for automatic tests capabilities are identified in ABD0100 1.5 § 4.1.

“GO / NO GO” testing shall not necessitate the opening of the LRI.

Shop test of a given LRI shall not require involvement of other LRI(s).

For testing purpose, design shall take into account the need to quickly load a test program without erasing any LRI resident software and data.

If a LRI has to be data-loaded with a test program for workshop testing, the loading shall be fast and shall not erase the LRI program and memory. For partial test of a LRI (one chapter), a data-loaded procedure shall not exceed 3 minutes. For a complete test of an LRI, a data-loaded procedure of 10 minutes is allowed.

Automatic test programs provided in the CMM shall be available at the same time as each new LRI hardware and software standard and shall be in accordance with Arinc 625-1.

Automatic test programs provided in the CMM shall be a subset of the Acceptance Test Procedure (see ABD0100.1.5 §2.4). The definition of such a subset shall take into account the following rules:

- The qualification tests (example: Insulation test, tests at the limit of the power supply), the aspect tests (example: test the presence of all components), the software tests integrity (only the checksum should be tested) should not be part of the Maintenance Testing Simulator (MTS),
- The execution of the complete tests including installation of the test program should not exceed 2.5 hours,
- Some tolerances may be adapted to components ageing.

The automatic test programs shall be able to identify the faulty SRU and it shall be possible to test separately any SRU: it shall be possible to perform a loop test on one dedicated SRU without opening the LRI.

Any additional requirements for internal capabilities of the equipment shall be identified by the Supplier and submitted to the Purchaser's acceptance.

### 2.7.7 Testing of Fault and Health Monitoring

For equipment with Fault and Health Monitoring functions a test procedure shall be agreed with the Purchaser and performed by the Supplier.

For each monitoring function the Supplier shall provide a test procedure with corresponding test result.

The test result shall contain for each fault symptom the level on which the fault or abnormal condition is indicated:

- Transmission to FCC,
- NVM memorization,
- Others.

### 2.7.8 BITE Verification

N/A

### 2.7.9 Data Loading Verification

N/A

## 2.8 Product Support

All maintenance/servicing/repair documentation will be supplied in accordance with the requirements specified in the GRESS modules 1and 6.

The Supplier shall maintain an example of each standard of equipment that is in Airline use, to enable queries originating from Airlines to be investigated.

## 2.9 Packaging, Storage and Handling

### 2.9.1 Disposal Instructions

If, by design, the equipment contains some sensitive components (impact on environment or personal) which need a dedicated procedure for recycling, end life storage, end life destruction, and other situations relative to the end life of the equipment, the Supplier shall identify those components and shall propose an adequate procedure. The manufacturer shall agree to the selection of such components and shall review the proposed procedure.

### 2.9.2 Equipment Transportation Requirements

None

### 2.9.3 Packaging Storage and Handling Requirements

The Supplier shall ensure that when packaging and/or storage devices (e.g. dust covers, protective covers, blanking caps, etc) are fitted they comply with one or more of the following requirements:

- The equipment/item cannot be installed.
- That such devices are temporarily fitted with means to ensure that the installer removes them before installation, e.g. a red flag.
- That they are designed so that no damage or malfunction occurs if the equipment is operated.

The supplier shall also ensure that no parts, e.g. seals, can be inadvertently left on the equipment/item when the packing/storage devices are removed.

The Supplier shall minimize the cost of storage and handling.

The unit shall be delivered in neutral position.

The electrical connectors shall be equipped with protective caps.

The moving parts shall be secured.

The storage conditions are as follows:

- The unit shall be capable of being stored up to 5 years in its original packaging without retest prior to use.
- The grease fitting shall be located at the specified position.

# 3 Design Process Requirements

## 3.1 Purchaser – Supplier relations requirements

The Supplier/Purchaser responsibilities are defined in ABD0100.2.1.

## 3.2 Supplier Organisation Requirements

The Supplier design organisation requirements are defined in ABD0100.2.2

The Supplier shall have a written procedure for reporting to the Purchaser all events coming from in service, production or design that may jeopardize the safety of Airbus certified Aircraft (see ABD0100.2.2 §1.5).

The supplier shall also assure the design processes of its sub-contractors according to ABD0100.2.6.

## 3.3 Supplier/Sub-contractor Requirements

The supplier shall assure the design processes of its sub-contractors according to ABD0100.2.6.

## 3.4 Equipment Design Assurance Process Requirements

The Supplier shall comply with ABD0100.2.3 - Equipment Assurance.

The Electronic Hardware Design Assurance Process shall comply with the ABD0100.2.11.

The software Design Assurance Process shall comply with the ABD01002.4.

The Supplier shall comply with GRESS module 1.15 - Product / Process Assurance.

## 3.5 Project Management Processes

These requirements are placed on the Supplier in order to achieve a high confidence factor that the developing product is in line with that required, and to meet the Purchasers responsibility in respect of certification.

The supplier shall comply with GRESS Module 1 - Project Management. The applicable deliverable documentation summary is shown in the documentation requirement list, table 4.4.2-1.

The formal review meetings shall be organized by the Supplier and conducted by the Purchaser.

The required relevant Supplier documents shall be delivered to the Purchaser two weeks before the review meetings.

The review meeting actions shall be co-signed by the Supplier and the Purchaser.

### 3.5.1 Development Plans

The Supplier shall provide an Equipment Development Plan giving description of the activities planned in terms of Development, Validation and Verification, Safety, Design, …, as well as resources, organization and means, as required and defined by ABD0100.2.3 §3.1. This plan may consist of one or more documents covering items listed in sub-chapter 3.5.2 - *Documentation* and ABD0100.2.1/2.2/2.3/2.6/2.7/2.8/2.9/2.10/2.11.

### 3.5.2 Documentation

Documentation deliverables are identified in sub-chapter Documentation of this PTS and in GRESS module 7.

The Supplier shall control the documentation as requested in ABD0100.2.2 §1.2.

#### 3.5.2.1 Routing of Documentation

The Supplier addresses and responsible persons shall be identified (see ABD0100.2.9 §8.1.2).

#### 3.5.2.2 Documentation Media

All the documents shall be provided on paper format for official delivery (associated to the program milestones) plus electronic distribution in the dedicated i-share or on CD.

### 3.5.3 Technical Data and Documentation Processes

The Supplier Technical Data and Documentation Process shall comply with ABD0100.2.9 §6.2.

### 3.5.4 Post Certification Development

The Supplier shall provide the Purchaser with fault reports for each item of equipment rejected for repair, fault investigation or upgrade for the service life of the equipment and perform a continuous improvement program (Ref ABD0100.2.1 §2.3 and in compliance with GRESS module 5).

### 3.5.5 Technical Correspondence

The Supplier Technical Correspondence shall comply with the ABD0100.2.1 §2.5.

Performance indicators shall be defined by the Supplier and agreed by the Purchaser. They shall be assessed for each progress meeting (see GRESS 1.12.4) and/or for each delivery of a major standard.

### 3.5.6 Meetings

All meetings shall be planned according to AIRBUS research task manager.

### 3.5.7 Project Management Tools

The Supplier and Purchaser project management shall agree common program tools where possible.

### 3.5.8 General Project Timescales and Milestones

The key events of the project, review meetings, unit deliveries and qualification activities are shown in Appendix 7 *Appendix 7 – Planning and Milestones*

### 3.5.9 Management of open problems

For software open problems, the supplier shall comply with ABD0100.2.4 §10 and ABD0100.2.9 §8.3.

For hardware open problems, the supplier shall comply with ABD0100.2.11 §1.5.7 and ABD0100.2.9 §8.3.

For equipment open problems, the supplier shall comply with ABD0100.2.3 §3.11 and ABD0100.2.9 §8.3.

## 3.6 Validation/Verification Process and Review Requirements

The Supplier shall make the demonstration that the unit complies with this specification and provide to the Purchaser the documents required (see §5.6 - *Appendix 6 – Documentation Requirement List*) to demonstrate that the system meets the applicable CS 25 ad FAR 25 regulation and the specific requirements which might be defined by the certification authorities until the certification date.

### 3.6.1 Validation/Verification Process Requirements

The validation process is the determination that:

- The requirements of each specification level cover, in terms of completeness and correctness, the upper requirements;
- The derived requirements of each specification level are completely and correctly defined.

The verification process is the evaluation of an implementation of requirements to determine that they have been met.

The validation/verification activities of the Supplier shall meet the objectives of the validation/verification process of ABD0100.2.7.

The validation/verification activities shall be identified at equipment level, hardware level and software levels.

The supplier shall warranty and demonstrate 100% coverage of agreed standard defined in PTS before each delivery to the Purchaser Integration Test Centre.

Qualification unit shall be full production standard.

The Supplier shall achieve the qualification tests, and provide a validation and qualification dossier, for the unit and all major components, covering all the unit functions.

The Supplier shall provide all means and assistance required to the purchaser to analyse Ground tests & Flight test data.

During assistance, the supplier shall provide all necessary data monitoring instrumentation.
The data monitoring instrumentation services shall not disturb functional exchanges of the monitored system and its environment.

#### 3.6.1.1 Validation Activities

The PTS requirements can be split in two categories: the product requirements and the process requirements. They shall be managed by the supplier as follows :

- The product requirements shall be covered by Supplier product documentation for the design, the safety, the maintenance, the qualification, the production…
- The process requirements shall be covered by supplier plans and procedures.

In any case, traceability data shall be provided to insure that all the PTS requirements (product and process) are covered.

#### 3.6.1.2 Verification Activities

The verification activities are described in the ABD0100.2.7.

### 3.6.2 Reviews

#### 3.6.2.1 Equipment Level Reviews

The development process starts with a Kick-off meeting and is punctuated with several reviews that are listed in Table below. The aim of these reviews is to allow, or deny, transition between the development phases according to the quality of the documentation delivered by the Supplier to the Purchaser i.e. to the quantity and criticality of the actions opened during a given review.

Following table gives guidance on equipment review selection.

| EQUIPMENT REVIEWS | Standard Reference |
|---|---|
| **Plans Reviews (PR):** | |
| Equipment / Hardware PR | ABD0100.2.7 §7.5<br>GRESS module 1§1.12.2.2 |
| Software Planning Process Review (PPR) | ABD0100.2.4 |
| | |
| **Preliminary Design Review (PDR):** | |
| Equipment / Hardware PDR | ABD0100.2.7 §7.6<br>GRESS module 1§1.12.2.2 |
| Software Requirements Review (SRR) | ABD0100.2.4 |
| Safety Preliminary Design Review (SPDR) | ABD0100.2.7§3.4 |
| Maintainability Preliminary Design Review (MPDR) | ABD0100.2.7§3.4 |
| | |
| **Detailed Design Review (DDR):** | |
| Equipment / Hardware DDR | ABD0100.2.7 §7.7<br>GRESS module 1§1.12.2.2 |
| | |
| **Critical Design Review (CDR)** | |
| Equipment / Hardware CDR | ABD0100.2.7 §7.8 |
| Software Critical Design Review (SCDR) | ABD0100.2.4 |
| | |
| **First Laboratory Unit Acceptance Review (LUAR):** | |
| Equipment / Hardware LUAR | ABD0100.2.7 §7.9<br>GRESS module 1§1.12.2.2 |
| Software First Delivery Review (FDR) | ABD0100.2.4 |
| Software Tool Acceptance Review (TAR) | ABD0100.2.4 |

| EQUIPMENT REVIEWS | Standard Reference |
|---|---|
| | |
| **First Flight Article Review (FFAR):** | |
| Equipment FFAR | ABD0100.2.7 §7.10<br>GRESS module 1§1.12.2.2 |
| Software First Flight Review (FFR) | ABD0100.2.4 |
| Final Safety Review (FSR) | ABD0100.2.7 §3.7 |
| Final Maintainability Review (FMR) | ABD0100.2.7 §3.7 |
| | |
| **Certification Flight Article Review (CFAR): (*)** | |
| Equipment / Hardware CFAR | ABD0100.2.7 §7.11<br>GRESS module 1§1.12.2.2 |
| Software Compliance Review First Flight Certification (CRC) | ABD0100.2.4 |
| Software Compliance Review for tool Qualification (CRQ) | ABD0100.2.4 |
| | |
| **End of project:** | |
| Final Review (FR) | GRESS module 1 §1.17 |

*(*) Not applicable for the A320 demonstrator*

The Supplier shall be compliant with the objectives of the reviews defined in the ABD0100.2.7 §7.

The Equipment Reviews (PR, PDR, CRD) and the Software Reviews (PPR, SRR, SDR) may be conducted at different times allowing both the Supplier and the Purchaser to concentrate on a smaller amount of documentation, lessening the number of comments and subsequently facilitating the discussions during the reviews.

The documentation required prior to each review as defined in the DRL shall be issued under the form of an electronic distribution in the dedicated i-share or on CD-ROM and/or paper form and shall be delivered at least 15 days prior the review.

The Supplier shall be compliant with the objectives of the reviews defined in the ABD0100.2.7 §7.

- **Kick Off Meeting (KOM)**

The aim of the KOM is to present to the different teams all the project’s participants, the task of each one and the main aspects of the project (planning, purchaser specification, contract and analysis of the development risks).

- **Plan Review (PR)**

At the early stage of the project, the aim of the PR is to present the unit supplier teams, methods, means and plans, check their adequacy towards the objectives to be achieved and point out the potential difficulties.

- **Preliminary Design Review (PDR)**

The aim of the PDR is to validate that the equipment definition, the supplier internal design directives and standards and the Supplier subcomponent specifications complies with the requirements of the present technical specification.
The main lines of the equipment design, the test programs of the equipment and the selected technological options shall be identified. The new technologies to be validated shall be identified and presented with a risk analysis.
A full scale sectional drawing substantiated by appropriate performance, stress analysis…shall be issued.

- **Detailed Design Review (DDR)**

The aim of the DDR is to validate the detail design of the equipment against the specification, the Supplier internal directives and standards, the specification of subcomponents and the industrial realization and to supply the necessary justification.
The complete set of the detail drawings shall be available.

- **Critical Design Review (CDR)**

The aim of the CDR is to validate the design and to validate the definition of the first item of the equipment intended for qualification tests.
The acceptance of the CDR shall correspond to the start of the formal qualification tests.

- **First Laboratory Unit Acceptance Review (LUAR)**

The aim of the LUAR is :

- to validate that the units produced for system integration laboratory tests, perform the specified functions,
- to ensure that the delivered units have been produced according to the industrial process defined and validated at CDR,
- to ensure that the delivered units satisfy the industrial dossier (definition, manufacturing, inspection, tests…)

- **First Flight Article Review (FFAR)**

The aim of the FFAR is:

- to validate that the equipment intended for first flight has been produced on industrial processes and means defined and validated at CDR and satisfy the industrial dossier of definition, manufacturing, inspection, tests),
- to pronounce on the acceptation of the equipment standard for 1st flight.

During this review a randomly selected unit will be submitted to an ATP and fully stripped down.

- **Certification First Article Review (CFAR): (*)**

The aim of the CFAR is to validate that the elements necessary to pass successfully the certification are met.

*(*) Not applicable for the A320 demonstrator*

- **Final review (FR):**

The aim of the FR is to formally close the Development Phase of that project. This indicates that the contractual requirement have now been met in terms of maturity of the equipment (performances, schedule, quality and cost).
In some cases the Equipment Reviews (PR, PDR, CRD) and the Software Reviews (PPR, SRR, SW-CDR) may be conducted at different times allowing both the Supplier and the Purchaser to concentrate on a smaller amount of documentation, lessening the number of comments and subsequently facilitating the discussions during the reviews.

### 3.6.3 Test Mean Review

The entry into service of the test mean shall be submitted to the purchaser acceptance. This acceptance shall be performed before CDR.

On purchaser request, the supplier shall invite the purchaser to participate in its tests on its lab facilities and shall present the available test results.

The acceptance test rig shall be designed as a "GO / NO GO" device to check unit attachments dimensions.
The supplier shall demonstrate that the procedure, test bench, etc… allow to guarantee the results of the acceptance test procedure.

The supplier test mean shall be representative of the following aspects of the A/C installation:

- Attitude of the unit
- Installation of the unit
- Surface Inertia
- Attachment stiffness
- Attachment components and tightening torque.

The tests that require servo-loop performance measurements shall be carried out using a servo-loop equipment representative of the aircraft.

## 3.7 Adaptation of the Software Design Assurance Process

### 3.7.1 General

Adaptation of the Software Design Assurance Process applies for level E software, and modified requirements of ABD0100.2.4 are detailed in section 3.4 – *Equipment Design Assurance Process requirements* of this specification.

### 3.7.2 Airborne Software

**TBD**

### 3.7.3 Tool Software

**TBD**

### 3.7.4 Airborne Electronic Hardware

No adaptation of the design assurance process for airborne electronic hardware is foreseen.

## 3.8 Qualification and Certification

For definition and objectives of the qualification process see ABD0100.2.8.

### 3.8.1 Qualification

#### 3.8.1.1 Equipment Classification

The actuators are classified in certification Category Critical (DAL A) according to ABD100.

All technical steps of the qualification program shall be discussed and agreed by the Airworthiness Authorities. All justification documents, including test schedules and programs shall be available to the Airworthiness Authorities in advance for review and agreement.

The Airworthiness Authorities may ask to witness any test in the Supplier premises, in particular as part of category 1 qualification follow up. In this case, the Supplier shall authorize Airworthiness Authorities to access its premises during qualification phases.

#### 3.8.1.2 Qualification Documentation

The qualification documents shall comply with ABD0100.2.8 Formal qualification and Purchaser acceptance process (see ABD0100.2.8§1.5 Documentation for qualification).

The qualification dossier shall include at minimum the following items:

- A development plan identifying the task on the critical path,
- A qualification time schedule covering the production of the documentation below and the detail of the testing activities,
- A requirement verification program which defines the type of compliance demonstration proposed for each specified requirement (eg. test, analysis, description....),
- A description of the unit including the schematics required for understanding its operation and the features of the main components,
- A full scale sectional drawing including all the views required for understanding the construction and operation of the unit,
- A part list giving the materials, treatments and protection against galvanic effect,
- The specification of all the subassemblies and/or LRIs
    - Electric Motor
    - ECU
    - Sensors
    - Actuator NVM,
    - Harnesses (if applicable).

- A detailed weight breakdown,
- A performance analysis including in particular :
    - The static and dynamic study of the servoloop regarding the gain and filter determination,
    - An assessment of the effect of temperature variation and manufacturing tolerances.
- Electrical models (SABER format is required) file.
- A thermal model (MATLAB format is required) file.
- A stress analysis covering the static and fatigue cases,
- A fatigue life justification analysis covering the successive evolutions of the duty cycle data,
- A failure analysis including a failure mode and effect analysis giving the effect and probabilities of all possible single failures and the fault trees of certain failures conditions. Further downgrading of failure probabilities will be submitted to the approval of the Purchaser,
- A Limit or Destructive Test and Screening Test justification dossier (plan, procedure, test report, design reliability verification report) for the following list of components considered as a minimum list:
    - Thermal cycling on electrical sub-components with as minimum : motor brake if applicable, Position and load sensors, NVM
    - Endurance on complete actuators
    - Electronic parts: ECU, Drivers of the memory device

The supplier shall also state the reasons for not applying the test philosophies defined in § 2.7 – *Off Aircraft Tests and Testability Requirements* for any components, which he considers inappropriate for these tests.

A Design Reliability Verification report shall give full details of all failures that have occurred during the test period. This report is to be forwarded to the A/C manufacturer, and shall include comments on implications for the reliability data listed in § 2.5 - *Safety and Reliability.*

The report shall include a list of modifications performed following the Limit or Destructive Test process, and justifications for the omission of modifications to correct certain failure modes:
- A built standard document describing the changes to the unit definition,
- A qualification test procedure, with associated specification and test coverage and demonstration of the test rig capability, with associated Reproducibility & Repetitivity plan,
- A qualification test report,
- The analyses, that may have been agreed as acceptable qualification means,
- A production acceptance test procedure, with associated specification and test coverage and demonstration of the test rig capability, with associated Reproducibility & Repetitively plan,
- A declaration of design and performance,
- Lessons learnt document based on the Supplier experience.

They shall be updated to cover any evolution of the unit. Refer to DRL (Appendix 6) for delivery date.

### 3.8.1.3 Achievements of Qualification

The equipment shall meet the requirement defined in the ABD0100.2.8.

The qualification of the unit is under the responsibility of the Supplier but has to be agreed by the Purchaser and the Airworthiness Authorities.

Qualification activities to be performed and completed within the following time scale:

Before the delivery of the first laboratory unit :
- Acceptance test,
- Enhanced Stress screening test for the ECU

Before the delivery of the next laboratory units and iron bird units:
- Performance tests,
- Endurance tests covering 250 FH minimum.
- Thermal test demonstration
- Fire protection demonstration
- Limit or Destructive Test / Screening Test.
- Power supply tests including Voltage spikes.

Before the first flight :
- Shocks
- Constant Acceleration
- Waterproofness
- High and low temperature performance tests,
- Strength tests to limit loads,
- Endurance tests covering 1000 FH minimum,
- Mechanical vibrations in all functioning mode .
- Explosion proofness
- Lightning damage testing
- Radio frequency susceptibility (conducted and radiated)
- Emission of Radio Frequency Energy
- Lightning Multiple Pulses/Strokes
- Icing
- Lightning Direct Effect

Before the aircraft certification :
- Strength tests to the ultimate loads.
- Fatigue tests to cover the specified life under the specified duty cycle. A scatter coefficient of 6, 5.2 or 4.5 shall be used if respectively 1, 2 or 3 units are subjected to the test. The test shall then be continued to rupture of the unit, with an increased severity if necessary and in such a way that its results could be used to predict the fatigue life of the unit under a modified duty cycle. Bearing friction shall be represented. Possible repair methods that may impact life (e.g. chrome plating) shall be justified by test.
- Endurance test to cover 33 % of the specified life of the unit and all its components. 100% of the specified endurance life shall be covered 3 years after A/C certification. The test shall then be continued to performance degradation (excessive wear, etc…) and limited to 200% of the specified endurance life. The test shall be conducted with associated maintenance task (e.g. bearing re-lubrication) with a representative interval multiply by two (*2) in comparison with these defined in the maintenance plan (§ 2.6.6.1 – *Maintenance Plan).*
- Environment test on the basis of DO 160 document.
- Failure tests possibly required to support the failure analysis and all certification issues
- Production unit installation cycle test

Equipment supplier shall provide the purchaser with qualification evidence as requested in ABD0100.2.8 paragraph 1.4.4.1: Qualification Activities to be performed before the first delivery and before the first flight test.

#### 3.8.1.4 Witnessing of Tests

Purchaser may ask to witness any test in the supplier premises.

### 3.8.2 Certification

#### 3.8.2.1 Airworthiness Requirements

The Supplier shall comply with any mandatory additional requirements (CRI : Certification Revue Item ) that are issued by the authorities during the design and certification processes (EASA, FAA and other authorities).

#### 3.8.2.2 Certification Liaison Process

The Supplier shall provide any further assistance that may be needed during the certification process.

## 3.9 Configuration Management

Configuration Management rules shall be discussed and jointly agreed between the equipment Supplier and the Purchaser.

Configuration management shall comply with ABD0100.2.9.

## 3.10 Quality

This PTS and the applicable ABD100 modules fully cover design quality requirements, as per ABD100.2.10.
Engineering for manufacturing and quality of deliveries requirements are defined in GRESS, modules 3 and 5.
Quality System and Aerospace Approvals Requirements are defined in GRESS module 0.

### 3.10.1 Requirements

The Supplier shall establish and maintain a Quality Assurance System in compliance with the quality requirements of the Purchaser. This Quality Assurance System shall enable the purchaser to evaluate the quality of the unit development process and to check, by appropriate test means, that the quality of serial production units is maintained.

This system must be described in the Quality Assurance Manual, a copy of which shall be provided in the Supplier's proposal.

### 3.10.2 Quality Assurance

For each item of equipment, Quality Assurance is based on establishment by the Supplier of Quality Assurance rules, practices and procedures throughout the life cycle of the equipment. These quality assurance rules, practices and procedures shall enable the Purchaser to evaluate the quality of the unit development (design and industrialization) and to check that the quality of the serial production units will be secured.

#### 3.10.2.1 Design Quality Assurance

For the design phase, the quality assurance aspects are considered as fully covered by the tasks and the data/documents requested by this PTS and the Documentation Requirement List (DRL) referring to AP1013 requirements.

The Supplier shall define the means to meet the requirements of this PTS in the design /or development plan(s).

#### 3.10.2.2 Engineering for Manufacturing

For the industrialization of the item of equipment, the quality requirements are defined into AP1013.

The Supplier shall define the means to meet the requirements of AP1013 (GRESS) into Equipment Industrial Quality Dossier related to this item of equipment.

#### 3.10.2.3 Production

For the production of the equipments, the quality requirements are defined into AP1013 (GRESS).

#### 3.10.3 Duplicate Inspection

Refer to IQ DA 09-26

### 3.11 Methods and Tools

#### 3.11.1 Purchaser Specification Methods and Tools

The Purchaser will use the following tools to produce the application detailed specification:

- CAD Data,
- SABER,
- MATLAB/SIMULINK,
- SCADE tool: "Safety Critical Application Development Environment" and a symbol library that enables input logic and processing logic and control laws to be described.
- To be completed.

#### 3.11.2 CAD Data

Refer to paragraph 4.2 – *Deliverable CAD data.*

#### 3.11.3 SABER for Electrical Network Simulations

Software format requested is SABER (Version **TBD**).

A data exchange convention will be jointly agreed and signed between the equipment Supplier and the Purchaser.

Model description and delivery conditions are provided in § 5.2 – *Appendix 2 – SABER Model Requirements.*

#### 3.11.4 Matlab Simulink for Performance and Thermal Simulations

Software format requested is MATLAB (Version **TBD**). A data exchange convention will be jointly agreed and signed between the equipment Supplier and the Purchaser.

#### 3.11.5 Requirements Placed on the Supplier due to Purchaser Tool

The Supplier is requested either to have the same tool or to interface with the Purchaser's tool.

The breakdown of the software shall be the same as the one used by the Purchaser to produce the application detailed specification. To achieve this objective a procedure shall be mutually defined so that the Purchaser specification integrates the Supplier's wishes.

The identification and the meaning of various symbols shall be the same for the Supplier and the Purchaser.

The signal identifications shall be the same (those of the Signals data base for external signals, those of the application software specification for internal signal).

The internal signals shall be accessible. The Supplier shall provide a table giving the corresponding data addresses.

Where digital mock-ups are used by the Purchaser and required to be used by the Supplier, a Data Exchange Convention between the Purchaser and the Supplier shall be agreed before the first model delivery.

# 4 Deliverables

## 4.1 Equipment

For the NSA aircraft (2E architecture), the Supplier shall provide the Purchaser with :

| ***Designation*** | ***Quantity (Units)*** |
|---|---|
| Physical EMA Mock-Up | *1* |
| Purchaser test rig EMA (instrumented) | *1* |
| Iron Bird (not instrumented) | *10* |
| Static Cell Tests (instrumented) | *10* |
| Flight Tests – 4 A/C (instrumented) | *40* |
| Spares (instrumented) | *4* |

*(*) For the A320 Demonstrator, the Supplier shall provide the Purchaser with :*

| ***Designation*** | ***Quantity (Units)*** |
|---|---|
| *Physical EMA Mock-Up* | *1* |
| *Purchaser test rig EMA (instrumented)* | *1* |
| *Flight tests – 1 A/C (instrumented)* | *1* |
| *Spares (instrumented)* | *1* |

The standards of the delivered units shall be at a certification level. These standards shall be discussed with the purchaser and approved by the purchaser.

The test units shall be maintained to the latest standard in order to guarantee, at any time, validity and effectiveness of laboratory tests. Therefore, the test units shall be retrofitted (or replaced if necessary) by the Supplier (following a planning to be agreed by the Purchaser) in order to embody on them all the modifications agreed according to the modification procedures.

The Supplier shall provide all necessary Consumable Materials to operate and maintain the units.

The supplier shall be able to replace, on purchaser request, a set of equipments by a set of updated equipments for Integration tests performed by the purchaser in case of S/W or H/W evolution.

For First delivery, First flight and intermediate standards, the supplier shall comply with ABD0100.2.4 §9.8.

### 4.1.1 Laboratory/Rig Units

The software implemented shall be complete and without anomalies.

The units to be fitted to the Purchaser test rigs shall be equipped with devices to permit installation of temperature sensors. Location to be defined in agreement with the Purchaser. This interface shall be defined during the DDR phase.

Some units to be fitted to flight test aircraft shall be equipped with devices to permit installation of strain gauges for the measurement of the air torques and devices to permit installation of temperature sensors. This instrumentation will be installed and calibrated by the purchaser.

The location of the strain gauges and the possible modification of the unit to get the required bonding interface and stress level shall be agreed with the Purchaser to get the required accuracy. The stress associated to the maximum load of the unit shall be of about 20 hbars for steel and 7 hbars for light alloy.

The modification, if any, shall be performed by the Supplier.

The life of the possibly modified components shall not be lower than 1000 flights (**TBC)**

### 4.1.2 Physical Mock-Up

Refer to ABD 0100.1.7.

The Supplier shall provide one Spoiler actuator mock-up to the Purchaser.

It shall be possible to manually position the output position of the actuators to any position within their stop to stop ranges.

For the use of stereo lithographic mock up, the supplier shall deliver a spare in case of rupture during aircraft mock up process.

## 4.2 Deliverable CAD Data

The Supplier shall provide a 3D model (Digital space allocation and interface mock-up) of the actuators designed in accordance with the Airbus method and process defined for equipment modelling: AM2257 (CAD software format requested is CATIA-V5 R16).

The Supplier shall also provide the Space Allocation Volume and Mechanical Interface Drawing and the Detailed Assembly Drawing (Full Scale Sectional Drawing) on the form of a CAD file in accordance with the Airbus method and process for equipment modelling: AM2257.

A data exchange convention will be jointly agreed and signed between the equipment Supplier and the Purchaser. This document describes the data exchange process (via direct computer data link or other means) in accordance with Airbus method and process defined for Supplier digital mock-up exchange: AM2226.

The data exchange convention will be signed at the same time as the PTS signature.

Drawings, digital mock-up and all CAD data shall be systematically updated to cover any equipment design evolutions, in agreement with Airbus method and process defined for equipment modelling: AM2226.

The metric system shall be used for all the delivered drawings and C.A.D Data and system related dimensions, including those of components from ISO-inch standards.

The Supplier's outline drawing/CAD file shall be kept fully representative of the external geometry of the unit and no change can be made to it without the prior approval of the Purchaser.

## 4.3 Drawings

The Supplier shall provide on the form of CAD files (including subcontracted parts):

- A “Space allocation volume[s] and mechanical interface drawing[s]”,
- Detailed assembly drawing[s] (full scale sectional drawing[s]),
- And any other drawing[s] on request, included subcontracted parts on the form of CAD files.

Texts on drawings shall be worded in English language.

The drawings shall be representative of the unit as used on aircraft (protection caps removed, …).

### 4.3.1 Space Allocation Volume and Mechanical Interface Drawing

The Supplier equipment allocation volume and mechanical interface drawing shall comprise, at the minimum:

- All the views required for showing the overall dimensions including details such as screw heads,
- The full nameplate and other markings on the unit (Refer to ABD 100 2.9) showing actual direction of letters or other signs,
- The space required to remove all the LRI's by using Standard Tools to be agreed by the Purchaser,
- The wiring diagram,
- The tightening torques and locking devices applicable to the LRI fasteners, adjustment devices, connecting elements,
- All the interface dimensions and geometrical tolerances or dimensional standards :

- Mechanical interfaces (definition of flanges, fool-proofing devices, brackets when existing, …)
- Manual interfaces (manual override characteristics, location of venting screws, locking devices, …
- Visual interfaces (location of indication, …)
- Electrical interfaces (definition of electrical connectors, pins allocation, grounding and bonding points, …)
- Centre of gravity, weight indication.

The detailed design of that interface shall be agreed between the supplier and the purchaser.

List of agreed Standard tools for LRI removal ("Tool Box") will be provided by the purchaser to the supplier in CATIA V5.
The Space Envelope and Mechanical Interface drawing shall become part of the Acceptance Test Procedure (ATP) and may be used to update the space envelope and interface drawing of the specification.

The Space Envelope and Mechanical Interface drawing shall be kept fully representative of the external geometry and interfaces of the unit and no change can be made to it without the prior acceptance of the Purchaser.

### 4.3.2 Detailed Assembly Drawing (Full Scale sectional Drawing)

The Detailed Assembly Drawing (Full Scale Sectional Drawing) shall include all the views required for understanding the construction, operation and failure modes of the unit. Some sections shall be added to provide visibility on the internal geometry of the equipment.

### 4.3.3 Other Drawings

If requested by the Purchaser, the supplier shall provide the Purchaser with the elements of the manufacturing drawings (including semi-finished products), production processes, component or material specification required for solving any technical problem that might occur.

## 4.4 Tools

The supplier shall provide to the purchaser, as enabling product, the data loading tool to upload its loadable elements and if necessary additional specific tools.

### 4.4.1 Development Tools

Specific test means specifications shall be available at PDR in preliminary issue and DDR in final issue.

The developments tools shall be configuration managed by the Supplier. It shall be possible during the design life cycle to :

- identify the version of the tools used to develop any item
- to reuse development tools at a given version.

### 4.4.2 Software Development Facilities

Assessment and qualification of software development tools shall be in accordance with RTCA/DO-178B section 12.2

### 4.4.3 Hardware Development Facilities

The Supplier shall comply with ABD0100.2.11 §4.13 - Tool Assessment and Qualification.

### 4.4.4 Support Requirement

The Supplier shall provide on request any hardware, software or system test equipment necessary to perform a Production Acceptance Test on the equipment at the Airframe.

## 4.5 Digital Models for Simulation

The supplier shall provide following digital model to be integrated to the Purchaser global model:

- Matlab Simulink model for performance analysis purpose (it will be included in the performance dossier).
- Matlab Simulink model for thermal analysis purpose.
- Saber for electrical network simulation

## 4.6 Documentation

The metric system only shall be used in all the delivered documentation.

### 4.6.1 Supplier Equipment Specifications

The Supplier Development Plan and SES are required to be submitted to the Purchaser in accordance with ABD0100 Chapter 3 and Sub chapter 1.5 of this PTS.

A Supplier Equipment Specification (SES) document shall be a top-level specification giving details of the Suppliers proposal in response to the PTS product requirements part.

Lower level documents shall be created from this SES.

The requirements of this PTS and any referenced or applicable documents listed in paragraph 3.1.4 have precedence over the Supplier documents (SES and lower level documents).

The Supplier's technical proposal shall include:

- a description of the units including the schematics required for understanding their operation and the features of their main components,
- an outline drawing which may be used to update the space envelope and interface drawing of the specification; this drawing shall comprise:
    - all views required for showing the overall dimensions including details
    - all the interface dimensions or standards
    - the labels and marking on the unit;

  This drawing is to be distributed within the Airbus partner organizations on charge of the definition on the installation of the unit.
- a 3D CAD (Computer Aided Design) file, giving the equipment envelope and interface definition, CAD file data transfer via direct computer data link, CD or other means shall be proposed,
- a full scale sectional drawings including all the views required for understanding the construction, operation and failure modes of the units,
- part lists giving the materials, treatments and protections against galvanic corrosion
- a description of the in service experience of the main components / technologies
- performance analyses showing that the proposed designs fulfill the performance requirements,
- stress analyses including the static and fatigue (for fatigue loaded parts) analyses of the main components as well as the definition of the methods to cover future evolutions of the duty cycle data,
- wear life analyses of components subject to wear (friction elements, bearings…),
- detailed weight breakdowns,
- a failure analysis giving the effect and probabilities (to be substantiated) of the possible single failures and the MTBF assessments.
- the data mentioned as To Be Answered (**TBA**) in the specification and the relevant substantiation,
- the identification of the cost and weight effective specification requirements and the description of the possible alternative designs that might be proposed and their quantified advantage in terms of weight, cost....
- key parameters with associated variation laws, in order to support PTS subsequent changes and proposed by the Supplier (see Appendix 16)
- a lessons learnt document
- the risk mitigation plan including the proposed tests and the definition of the involved demonstrators
- the validation and verification plans based on tests. It shall describe the number of units and the description of the test rigs required, the test laboratories involved. Acceptance Test Procedure and Qualification Test Procedure proposals, including failure tests, shall be provided,
- the detailed time schedules covering risk mitigation, design, development, industrialization and qualification activities, including the demonstration that either the final product will be

achieved on time or that specific definitions/manufacturing techniques (eg. machining instead of casting) have to be implemented to meet the program requirements,
- a compliance matrix
- a specification, ATP and QTP coverage analysis
- HALT HASS plan: the supplier shall describe how he wants to perform Highly Accelerated Life Testing during development and Highly Accelerated Stress Screening during production of the concerned components.

All these documents shall be provided by email or in the dedicated e-room.

The Space envelope and interface drawings / models shall comply with the requirements of paragraphs §2.1.9.1 – *Installation and Kinematic*, §2.1.9.2 – *Mechanical Interface* and §4.2 – *Deliverable CAD data.*

### 4.6.2 Documentation

The Supplier shall provide all deliverables identified in Appendix 6 Documentation Requirement List

**Acceptance:** with or without acceptance of a document by the Purchaser, the Supplier remains fully responsible of the content of its documents, and of the compliance of their content with the Purchaser's requirements.

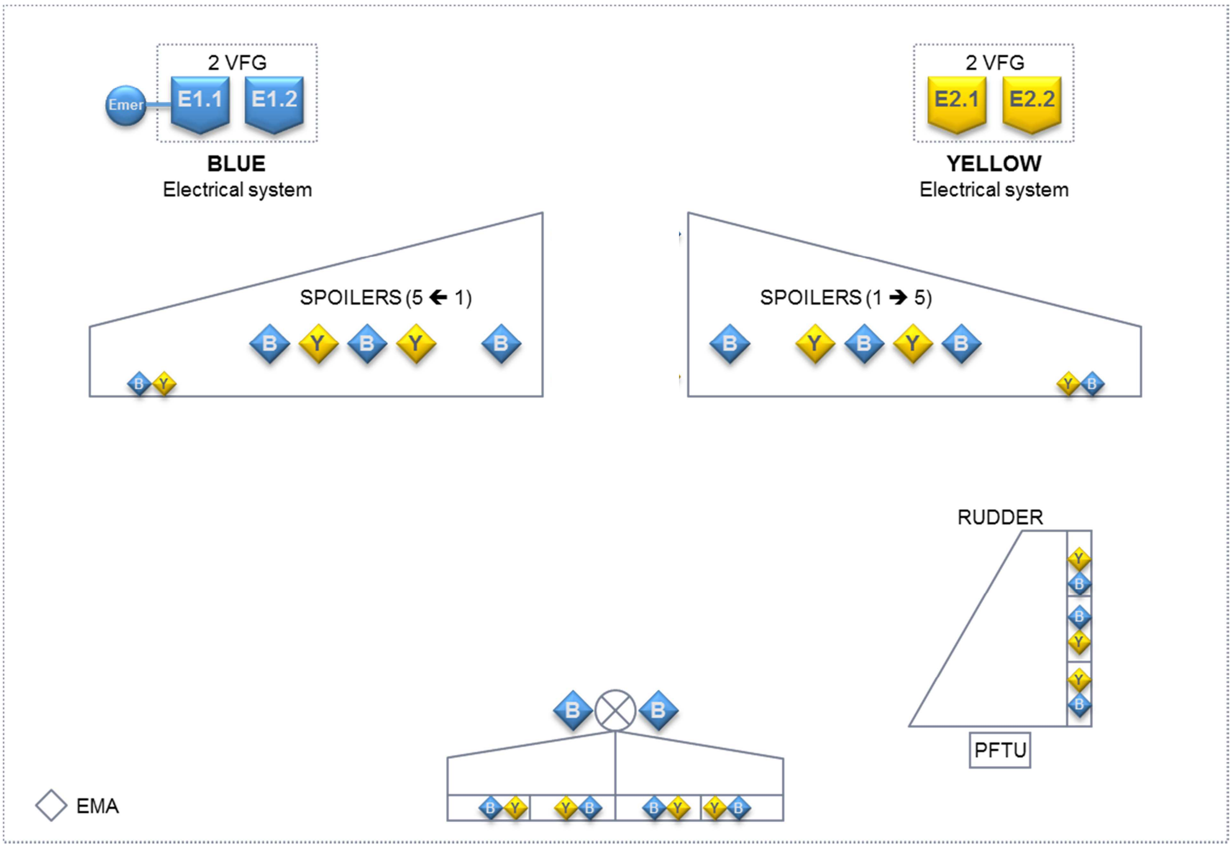
The organization of data or documentation is only a suggestion. The Supplier may have a different proposal.

The documents shall be delivered two weeks before the mentioned review under heading "Due Dates". If several meetings are mentioned, the first delivered versions of the document are intended to be initial (but complete) versions, which are to be finalized along the different reviews, up to the final version, which is to be delivered for the last mentioned review.

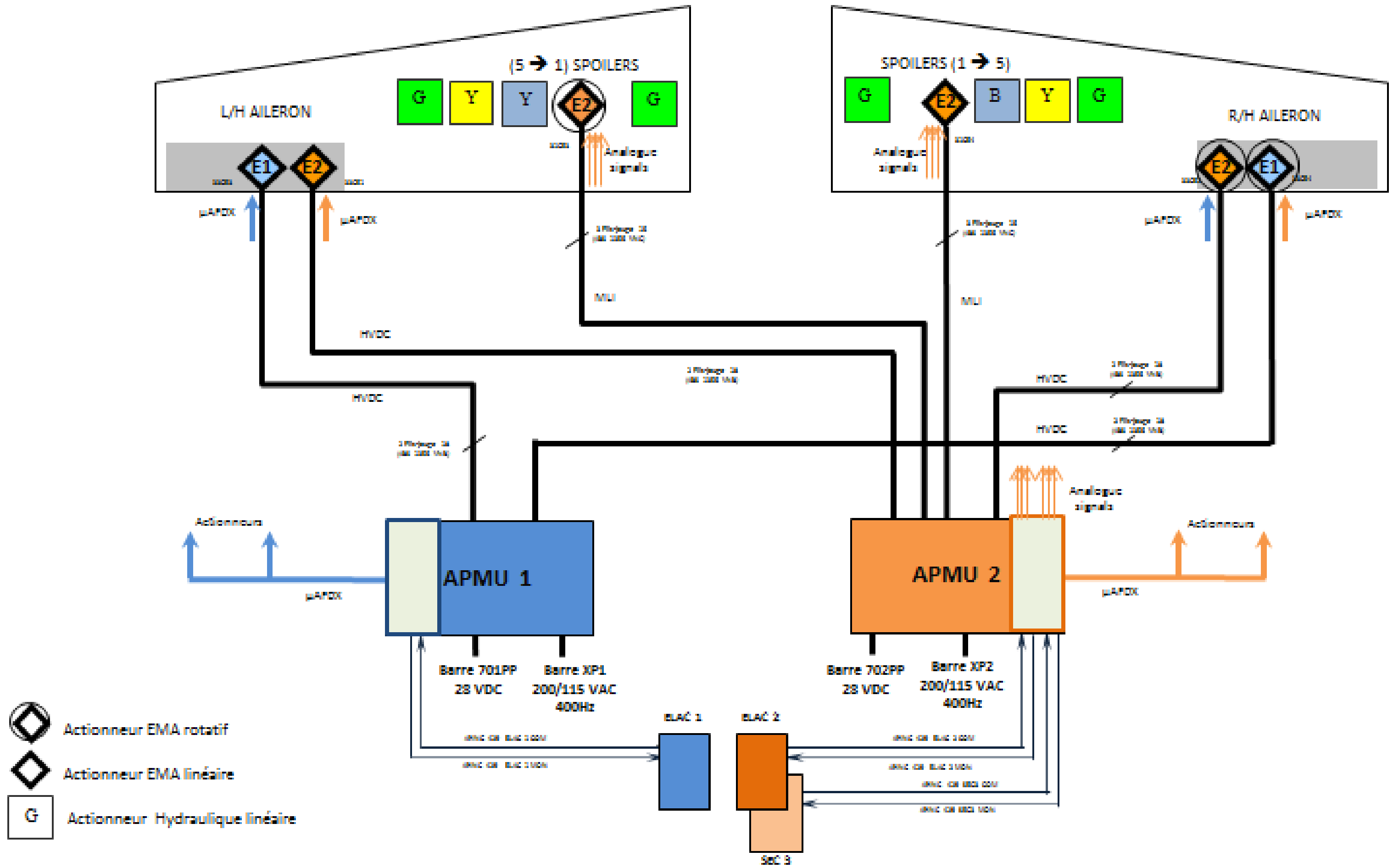
# 5 Appendixes

## 5.1 Appendix 1 : NSA and A320 Flight Test Platform FCS Architecture synoptics

NSA Primary Flight Control System Architecture synoptic:



A320 Flight Test Platform – Primary Flight Control System Architecture synoptic:




Note : The APMU 1 and 2 shall be interchangeable

## 5.2 Appendix 2 : SABER Model Requirements

Objectives:

This appendix contains the requirements that supplier shall take into account to perform an actuator SABER model. This model shall be delivered to the purchaser in order to perform following studies:

- Sizing of the NSA A/C electrical network by coupling actuator SABER models with NSA electrical network SABER model and flight control computer SABER models,
- Verification of the compliance with electrical directives provided in document "electrical System Virtual Prototyping NSA SABER models requirements" ref. V24RP0607448 issue2,
- Electrical validation and verification of flight conditions in particular cases not tested on Iron-Bird.

Only behavioural model is required.

Model Description:

The actuator model shall be based on the main functions that allow the evaluation of its electrical behaviour as described here above.
Therefore, an adequate level of detail shall be used for each part identified on the following schematic. **TBA**

The supplier shall propose Inputs and Outputs parameters judged relevant.
The parametric model shall include the scaling laws and the major formula linking the input and the output parameters associated to a dedicated EMA architecture.
SI units shall be used inside the model and for inputs and outputs.
The EMA SABER model shall be split in two main type of function modelling:

- From HVDC to motor:

  This part of the model will be directly connected to the A/C electrical network SABER model and shall be built using electronic simplified component of the library (ideal rectifier diode, ideal brake chopper or soft start switch…).
  This electrical "first stage" shall be representative of the currents absorbed and the voltages available in term of waveforms and amplitudes.

- From motor to mechanical device (gear, …) :

  This part of the model shall be built using system block diagram representation (simulink like) based on simplified model of each main function. This block diagram model shall be representative of the power demanded (equivalent DC current absorbed) to the electrical part taking into account efficiency of the main components. The temperature effect on efficiency (viscous friction, …) shall be taken into account but no thermal model is required for this SABER model.

Delivery conditions:

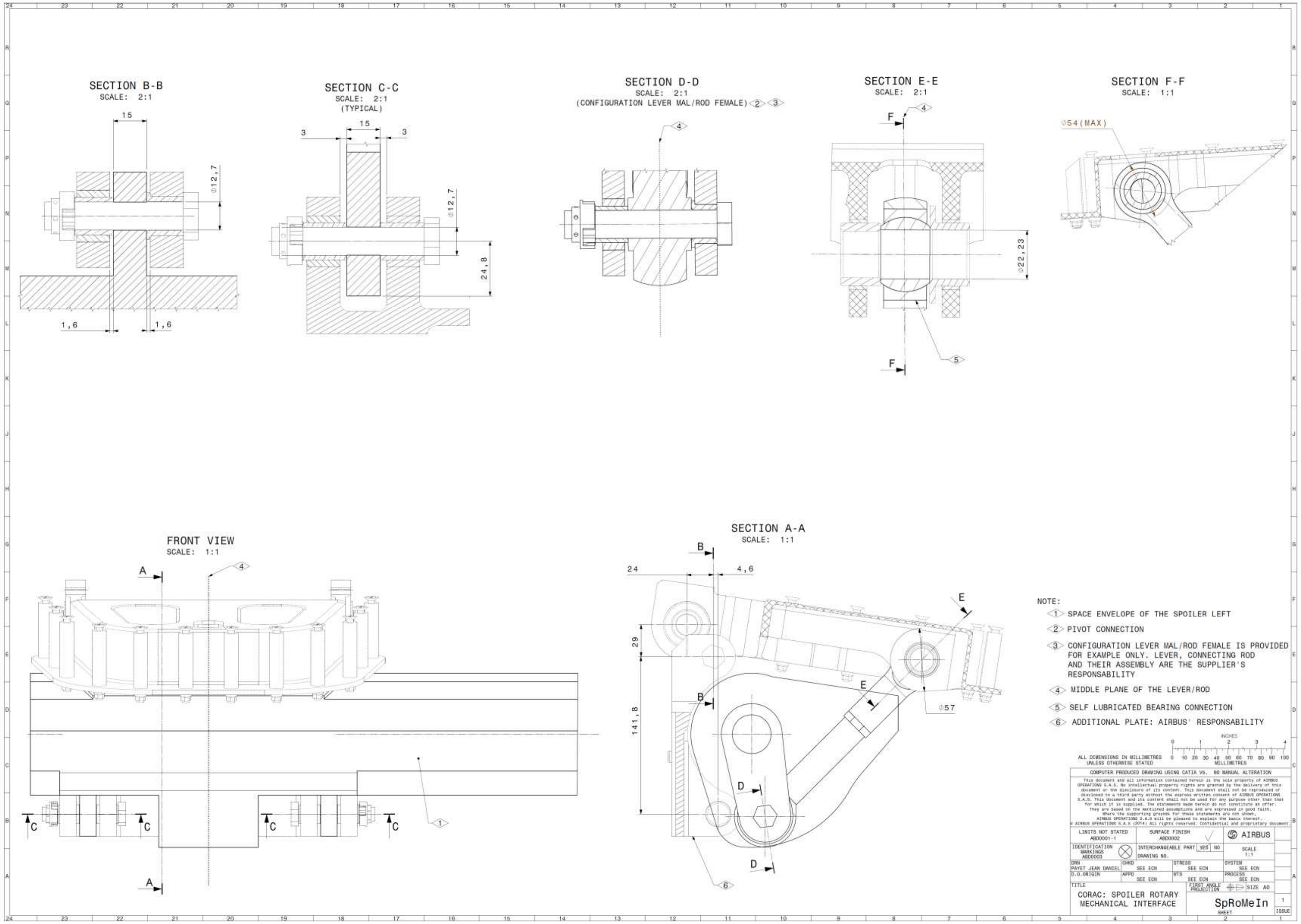
Different milestones with a different level of validation have to be considered for model deliveries:

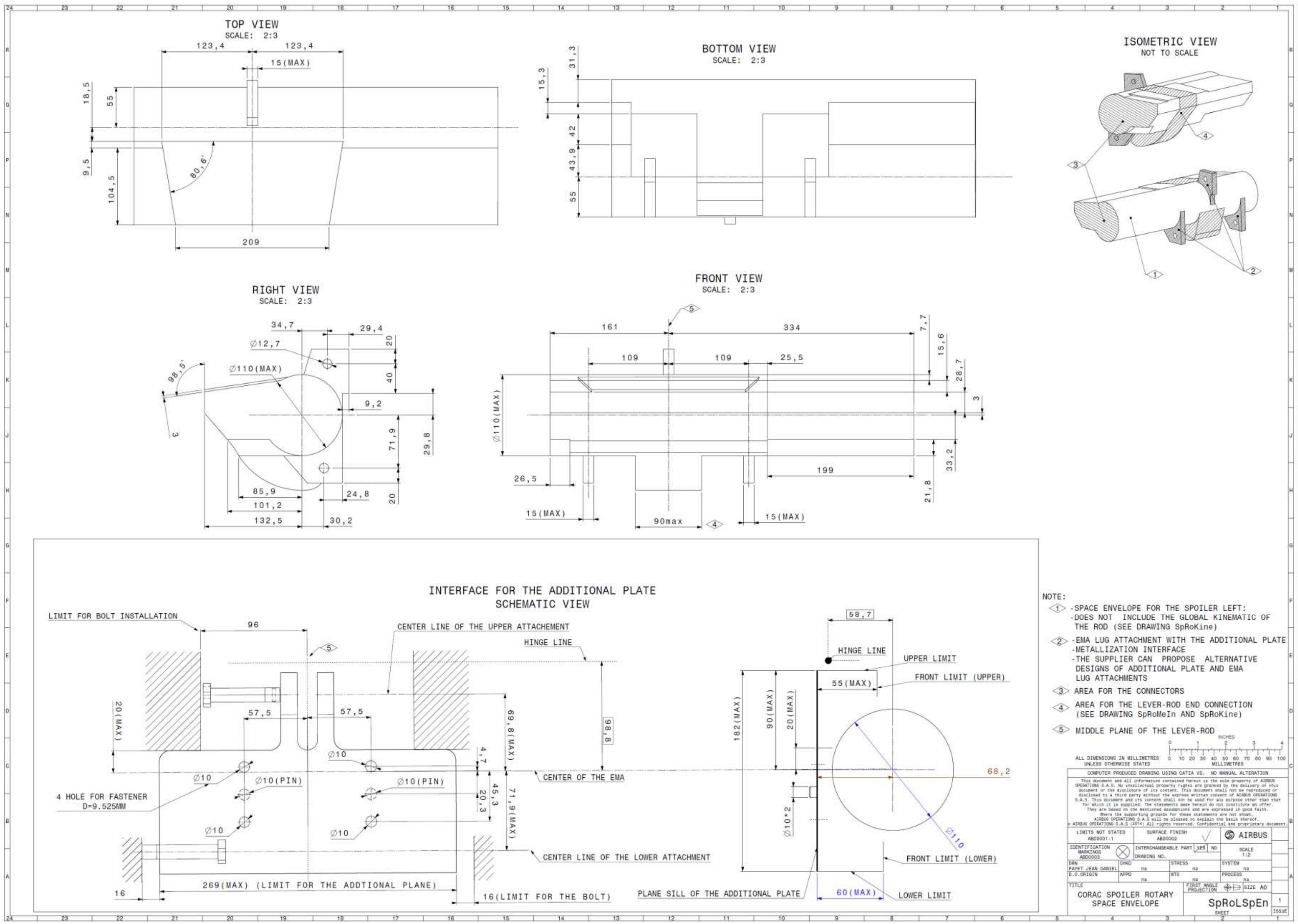
- 1/ A preliminary model delivery shall be done one month before PDR. This model shall be validated by theoretical studies and simulation cases.
- 2/ An advanced model delivery shall be done at DDR after complementary validation based on test performed on existing similar devices and/or sub-assemblies.
- 3/ A consolidated model delivery shall be done at CDR after consolidated validation based on tests performed on existing similar devices and/or sub-assemblies.
- 4/ A validated model delivery shall be done one month before LUAR after temperature and electrical tests.
- 5/ If during qualification tests, major changes are decided, an update of the model shall be delivered.

For each model delivery, associated documentation including test bench cases as described in V24RP0607448 issue2 and validation results shall be provided.

## 5.3 Appendix 3 : Mechanical Interfaces and Space Allocation

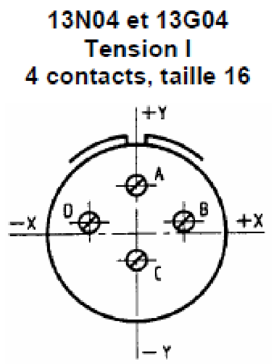
Mechanical Interfaces (drawing ref. SpRoMeIn issue 1) and Space Allocation (drawing ref. SpRoLSpEn issue 1) are provided in both following pages.


SECTION B-B
SCALE: 2:1
SECTION C-C
SCALE: 2:1
(TYPICAL)
SECTION D-D
SCALE: 2:1
(CONFIGURATION LEVER MAL/ROD FEMALE) 2 3
SECTION E-E
SCALE: 2:1
SECTION F-F
SCALE: 1:1
Ø54 (MAX)
FRONT VIEW
SCALE: 1:1
SECTION A-A
SCALE: 1:1
Ø57
NOTE:
1 SPACE ENVELOPE OF THE SPOILER LEFT
2 PIVOT CONNECTION
3 CONFIGURATION LEVER MAL/ROD FEMALE IS PROVIDED FOR EXAMPLE ONLY. LEVER, CONNECTING ROD AND THEIR ASSEMBLY ARE THE SUPPLIER'S RESPONSABILITY
4 MIDDLE PLANE OF THE LEVER/ROD
5 SELF LUBRICATED BEARING CONNECTION
6 ADDITIONAL PLATE: AIRBUS' RESPONSABILITY
ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED
INCHES
MILLIMETRES
COMPUTER PRODUCED DRAWING USING CATIA V5. NO MANUAL ALTERATION
LIMITS NOT STATED ABD0001-1
SURFACE FINISH ABD0002
AIRBUS
IDENTIFICATION MARKINGS ABD0003
INTERCHANGEABLE PART YES NO
DRAWING NO.
SCALE 1:1
DRN PAYET JEAN DANIEL
CHKD SEE ECN
STRESS SEE ECN
SYSTEM SEE ECN
D.O.ORIGIN
APPD SEE ECN
WTS SEE ECN
PROCESS SEE ECN
TITLE
CORAC: SPOILER ROTARY MECHANICAL INTERFACE
FIRST ANGLE PROJECTION
SIZE A0
SpRoMeIn
SHEET
1
ISSUE


TOP VIEW
SCALE: 2:3
BOTTOM VIEW
SCALE: 2:3
ISOMETRIC VIEW
NOT TO SCALE
RIGHT VIEW
SCALE: 2:3
FRONT VIEW
SCALE: 2:3
INTERFACE FOR THE ADDITIONAL PLATE
SCHEMATIC VIEW
LIMIT FOR BOLT INSTALLATION
CENTER LINE OF THE UPPER ATTACHEMENT
HINGE LINE
CENTER OF THE EMA
4 HOLE FOR FASTENER
D=9.525MM
CENTER LINE OF THE LOWER ATTACHMENT
269(MAX) (LIMIT FOR THE ADDTIONAL PLANE)
16(LIMIT FOR THE BOLT)
PLANE SILL OF THE ADDITIONAL PLATE
UPPER LIMIT
FRONT LIMIT (UPPER)
FRONT LIMIT (LOWER)
LOWER LIMIT
NOTE:
1 -SPACE ENVELOPE FOR THE SPOILER LEFT:
-DOES NOT INCLUDE THE GLOBAL KINEMATIC OF THE ROD (SEE DRAWING SpRoKine)
2 -EMA LUG ATTACHMENT WITH THE ADDITIONAL PLATE
-METALLIZATION INTERFACE
-THE SUPPLIER CAN PROPOSE ALTERNATIVE DESIGNS OF ADDITIONAL PLATE AND EMA LUG ATTACHMENTS
3 AREA FOR THE CONNECTORS
4 AREA FOR THE LEVER-ROD END CONNECTION (SEE DRAWING SpRoMeIn AND SpRoKine)
5 MIDDLE PLANE OF THE LEVER-ROD
ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED
COMPUTER PRODUCED DRAWING USING CATIA V5. NO MANUAL ALTERATION
AIRBUS
CORAC SPOILER ROTARY SPACE ENVELOPE
SpRoLSpEn

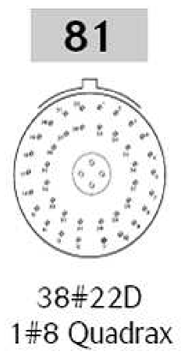
## 5.4 Appendix 4 : Electrical Connections

**Connector A** : (High Power): stainless steel hermetic connector EN364513N04MA.




A - Bonding
B - +HVDC (+270VDC)
C - Spare
D - -HVDC (-270VDC)

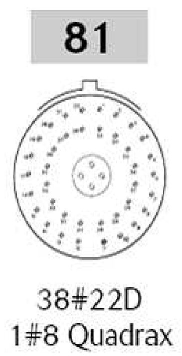
**Connector B** (COM): Stainless steel hermetic connector (polarized Quadrax)




| | |
|---|---|
| 1 – PP0GND | 11 – PP5GND |
| 2 – PP0 | 12 – PP5 |
| 3 – PP1 | 13 – PP6GND |
| 4 – PP1GND | 14 – PP6 |
| 5 – PP2 | |
| 6 – PP2GND | |
| 7 – PP3GND | |
| 8 – PP3 | |
| 9 – PP4GND | |
| 10 – PP4 | |

1 – µAFDX A Tx+
2 – µAFDX A Rx+
3 – µAFDX A Tx-
4 – µAFDX A Rx-
5 – µAFDX shielding

**Connector C** (MON): Stainless steel hermetic connector (polarized Quadrax)

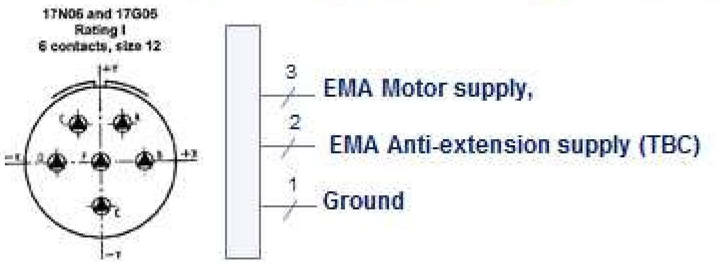



| | |
|---|---|
| 1 – PP7GND | 19 – Volt. Ref. |
| 2 – PP7 | 20 – 28VDC High |
| 3 – PP8 | 21 – 28VDC Low |
| 4 – PP8GND | 22 – RVDT VA High |
| 5 – PP9 | 23 – RVDT VA Low |
| 6 – PP9GND | 24 – RVDT VB High |
| 7 – PP10GND | 25 – RVDT VB Low |
| 8 – PP10 | 26 – RVDT supply High |
| 9 – PP11GND | 27 – RVDT supply Low |
| 10 – PP11 | |
| 11 – PP12GND | |
| 12 – PP12 | |
| 13 – PP13GND | |
| 14 – PP13 | |

1 – µAFDX B Tx+
2 – µAFDX B Rx+
3 – µAFDX B Tx-
4 – µAFDX B Rx-
5 – µAFDX shielding

*(*) For the A320 demonstrator, The electrical connections requirements are provided below:*

Connector A (high Power): ref. EN364517N06




Connector B (COM): Stainless Steel Hermetic Connector ref. EN364513N35


13N35

Connector C (MON): Stainless Steel Hermetic Connector ref. EN364513N35

## 5.5 Appendix 5 : Duty Cycles

These duty cycles are provided to the supplier for evaluation. The real time simulated data, named F(t) and including the variation of the surface deflection and of the hinge moment in function of time are the contractual data.

### 5.5.1 Function of Time F(t) Delivery

The F(t) data are supplied as Matlab files describing real time simulated flights.

These files are Matlab structure arrays with fields:

- Time (second);
- Deflection order (deg);
- Hinge moment (Nm) at surface level,
- Weighting Factor ("“coefficient for F(t)”),
- Altitude (feet) for thermal duty cycles only,

One (1) F(t) is a simulation of one (1) complete flight which contains all flight phases: TAXI OUT, TAKE OFF, CLIMB, CRUISE, DESCENT, APPROACH and LANDING, TAXI IN.

Note: These F(t) do not take into account additional cycles that shall be also considered. (see § *2.1.6.4 – Duty Cycles*)

Sign Conventions are described below:

- 0° to + 50° → Upper Spoiler Functional Stroke,
- 0° to - 12° → Lower Spoiler Functional Stroke,
- Hinge moment > 0 → hinge moment driving the surface downwards
- Hinge moment < 0 → hinge moment driving the surface upwards,
- Δ deflection order (e.g. αi – αj) > 0 → Surface is driving downwards
- Δ deflection order (e.g. αi – αj) < 0 → Surface is driving upwards

### 5.5.2 Endurance / Fatigue Duty cycles

Endurance / Fatigue Duty cycles are provided in GENOME i-share.

F(t) data are supplied as Matlab files named:

- F_t_Spoiler_NSA_90min_flight1;
- F_t_Spoiler_NSA_90min_flight2;

For fatigue and endurance sizing, both duty cycles shall be considered with associated weighting factor.

### 5.5.3 Thermal Duty cycles

Thermal duty cycles are provided in GENOME i-share.

F(t) data are supplied as Matlab file named:

- F_t_Spoiler_NSA_90min_thermal flight1,
- F_t_Spoiler_NSA_90min_thermal flight2,

For thermal sizing, among both duty cycles, only the most severe duty cycle shall be considered (i.e. weighting factor is set to 1)

The external air temperature shall be determined by supplier with both the altitude provided in F(t) and ISA+35℃ profile.

### 5.5.4 Airbus Methodology for F(t) Damage Estimation

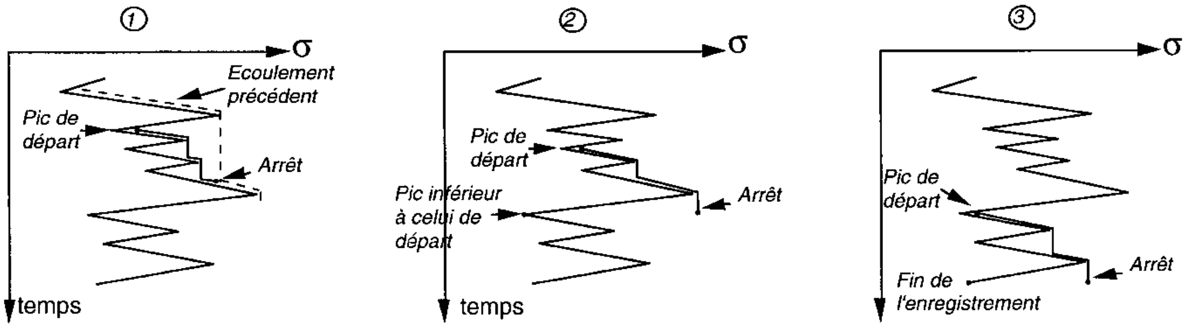
Note: For fatigue and endurance analysis, the Supplier shall define its own criteria which shall be reviewed and agreed by the purchaser.

#### 5.5.4.1 Methodology for Fatigue damage estimation:

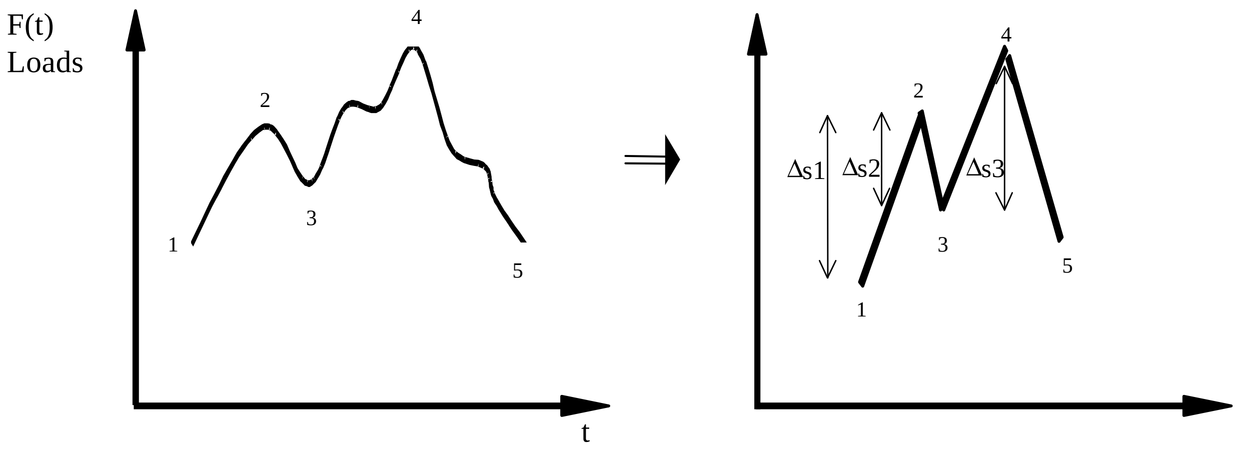
1 - Rainflow Method

The « Rainflow » method from norm AFNOR A03-406 is used in order to divide the hinge moment spectrum of time history (F(t)) in elementary cycles with equivalent fatigue severity.

The Rainflow method can be assimilated to a drop of water, which flows along the spectrum, as shown below:



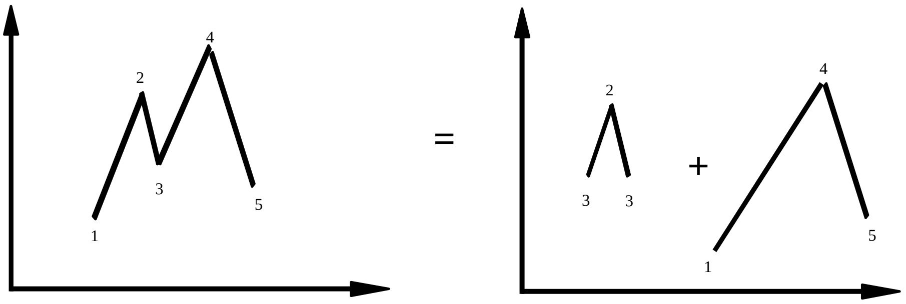

The extreme points of the F(t) load spectrum are identified.



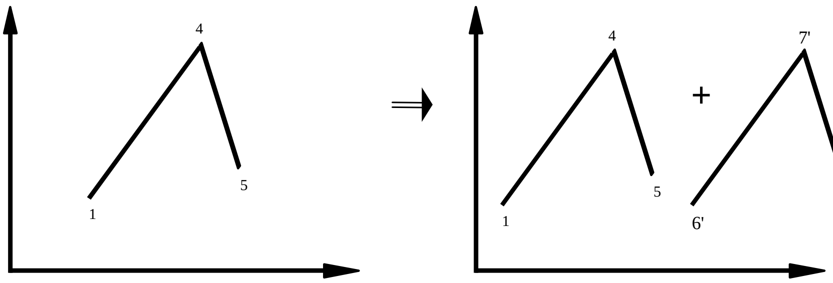

The principle of the loads extrema extraction is defined as follows:

1. We use 4 successive points 1, 2, 3, 4.
2. We compare the lengths ΔS1, ΔS2, ΔS3 where
    - ΔS1 = length between the points 1 and 2
    - ΔS2 = length between the points 2 and 3
    - ΔS3 = length between the points 3 and 4

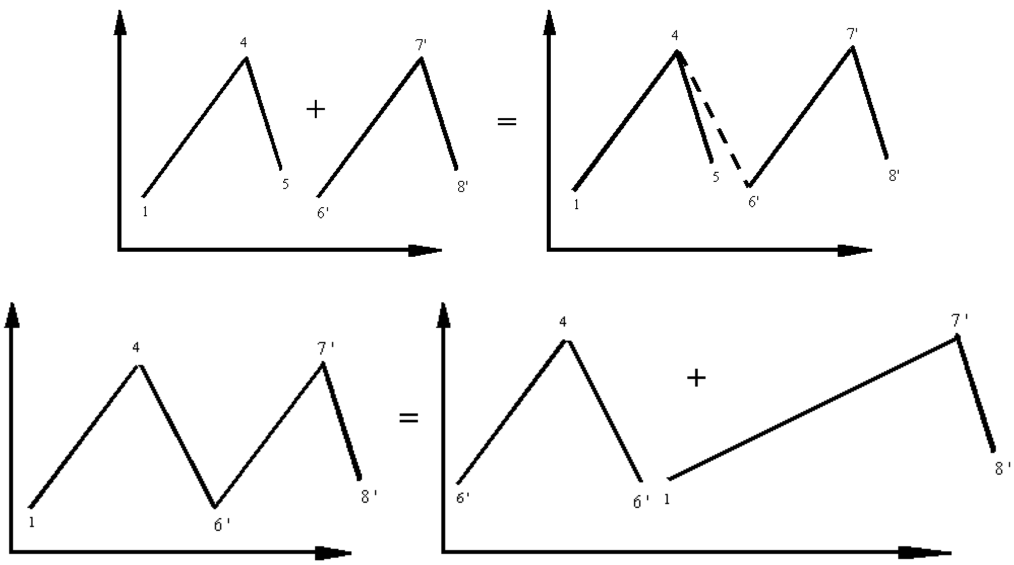
- If $\Delta S2 \leq \Delta S1$ and $\Delta S2 \leq \Delta S3$, the cycle represented by the extrema 2 and 3 is extracted from the spectrum. And points 1 and 4 are linked.
- Otherwise, the counting is continued with the 4 following points




3. We repeat this operation until the end of the spectrum. At the end, we have the remainder (1,4,5). In order to divide completely the spectrum, we add to the existing remainder the same remainder (1,4,5 → 1,4,5 and 6',7',8').




4. We repeat steps 1 and 2. At the end, we have exactly the remainder (1, 7', 8').
The signal is completely decomposed, remainder included.
For this example, we have extracted from initial cycle (1,2,3,4,5) two elementary cycles (6',4,6' and remainder 1, 7', 8').



After Rainflow counting, Airbus obtains several elementary cycles with different load min and load max values.

2 – Fatigue Severity Calculation

a/ Calculation of the $F_i(R=0.1)$ of each extracted cycle i for each flight:

**If $-10 \leq F_{min}(R)/ F_{max}(R) \leq 1 \Rightarrow$** $R = F_{min}(R)/ F_{max}(R)$ and $F_i\ (R=0.1) = |\ F_{max}(R)|((1-R)/0.9)^{0.6}$ ($[F_{min}(R)\ F_{max}(R)]$ alternated loads or $[F_{min}(R)\ F_{max}(R)]$ pure tension loads):

**If $F_{min}(R)/ F_{max}(R) < -10$ or $F_{min}(R)/ F_{max}(R) > 1 \Rightarrow$**
$R = F_{max}(R)\ /\ F_{min}(R)$ and $F_i\ (R=0.1) = |\ F_{min}(R)|((1-R)/0.9)^{0.6}$
(compression load $F_{min}(R)$ >> tension load $F_{max}(R)$ or $[F_{min}(R)\ F_{max}(R)]$ pure compression loads):

Note1: this is a conservative approach. Assumption is pure compression loads [Fmin; Fmax < 0] induce the same damage in term of fatigue than pure traction loads [Fmin; Fmax > 0].

Note2: in order to be in accordance with note1, the lower bound R=-10 is a necessary bound. Actually, we consider that |Fmin|>>|Fmax| so that the cycle [Fmin, Fmax] can be assimilated to a pure compression one. If there were no lower bound, there will be a big difference in term of fatigue between a cycle [-1000, 2] and a cycle [-1000, -2] whereas those cycles are similar for the equipment.

b/ Search of the flight case representative cycle [$F_i$min, $F_i$max] associated with**:**

$$\mathbf{F_{max}(R=0.1) =} \mathrm{Max}[F_i(R=0.1)]$$

c/ Calculation of the fatigue severity of each extracted cycle:

$$\mathbf{S_i = F_i\ (R=0.1)^{\gamma}};$$

With: γ is 4.5 for light alloys or 6.4 for titanium alloy and steel.

d/ Calculation of the representative number of cycles associated with the representative cycle. The representative number of cycles Nb_rep is then multiplied by the “coefficient for F(t)” Cp:

$$\mathbf{Nb\_rep = Cp \times \Sigma[F_i\ (R=0.1)^{\gamma}]\ /\ (F_{max}(R=0.1)^{\gamma})}$$

e/ Calculation of the fatigue severity of the whole flight : $\mathbf{S = Nb\_rep \times [F_{max}(R=0.1)]^{\gamma}}$

### 5.5.4.2 Methodology for Endurance damage estimation:

Stroke assessment for each flight case:

- The maximum and the minimum surface deflection orders are extracted
- The total stroke of the flight is calculated by summing the change in position between each sampled point:

$$\mathbf{Stroke = \Sigma[deflection(j) - deflection\ (i)]}$$

- Calculation of the representative number of movements:

$$\mathbf{Stroke = nb\_mvts\_rep \times 2 \times [Max(deflection)\text{-}Min(deflection)]}$$
$$\mathbf{\Rightarrow nb\_mvts\_rep = Stroke\ /\ (2 \times [Max(deflection)\text{-}Min(deflection)])}$$

Number of small movements assessment for each flight case:

Based on the rod axial position y:

Number of small movements (n) defined by: 0.1mm ≤ |Δy| ≤ 1mm
Extracted if n ≥ 3 consecutive small movements
One movement is defined by one back and forth stroke of the rod

Number of direction reversal:

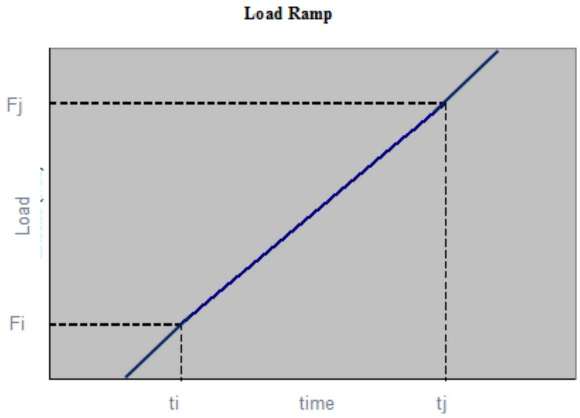
Number of direction reversals per flight are calculated,

Number of starts and stops:

Number of starts and stop per flight are calculated,

Equivalent Load:

- The evolution of the load on each ramp (between 2 sampled points: i , j) is characterized by an equivalent load, called Framp which is calculated with the Power Mean Load Derivation formula.




Calculation of Load Ramp between sampled points i and j of F(t)

$$F_{ramp(i,j)} = \left[ \frac{F_i^{p+1} - F_j^{p+1}}{(p+1)(F_i - F_j)} \right]^{(1/p)}$$

With:

- p exponent depending of rolling elements (ex: 3 for balls)
- F: load (daN),
- i,j: 2 sampled successive points.

- The equivalent load of whole flight (i.e. F(t)) is the p root of the sum of all Ramp Loads powered by p with assumption of steady speed.

$$F_{equivalent} = \left( \frac{\sum \Delta\alpha_{i,j} * F^{p}_{ramp(i,j)}}{\sum \Delta\alpha_{i,j}} \right)^{(1/p)}$$

With:

- p exponent depending of rolling elements (ex: 3 for balls)
- $F_{ramp}$: equivalent load calculated between each sampled F(t) point (daN) (see above),
- Δαi,j = |αi- αj| : Stroke between points i and j.

Rolling wear assessment:

Wear of the rolling components is estimated per flight as follow:

$$Severity_{endurance} = \sum (\Delta\alpha_{i,j} * F^{p}_{ramp(i,j)})$$

With:

- p exponent depending of rolling elements (ex: 3 for balls)
- $F_{ramp(i,j)}$: equivalent load calculated between i and j sampled points (daN),
- $\Delta\alpha i,j = |\alpha i - \alpha j|$ : Stroke between points i and j.

## 5.6 Appendix 6 : Documentation Requirement List (DRL)

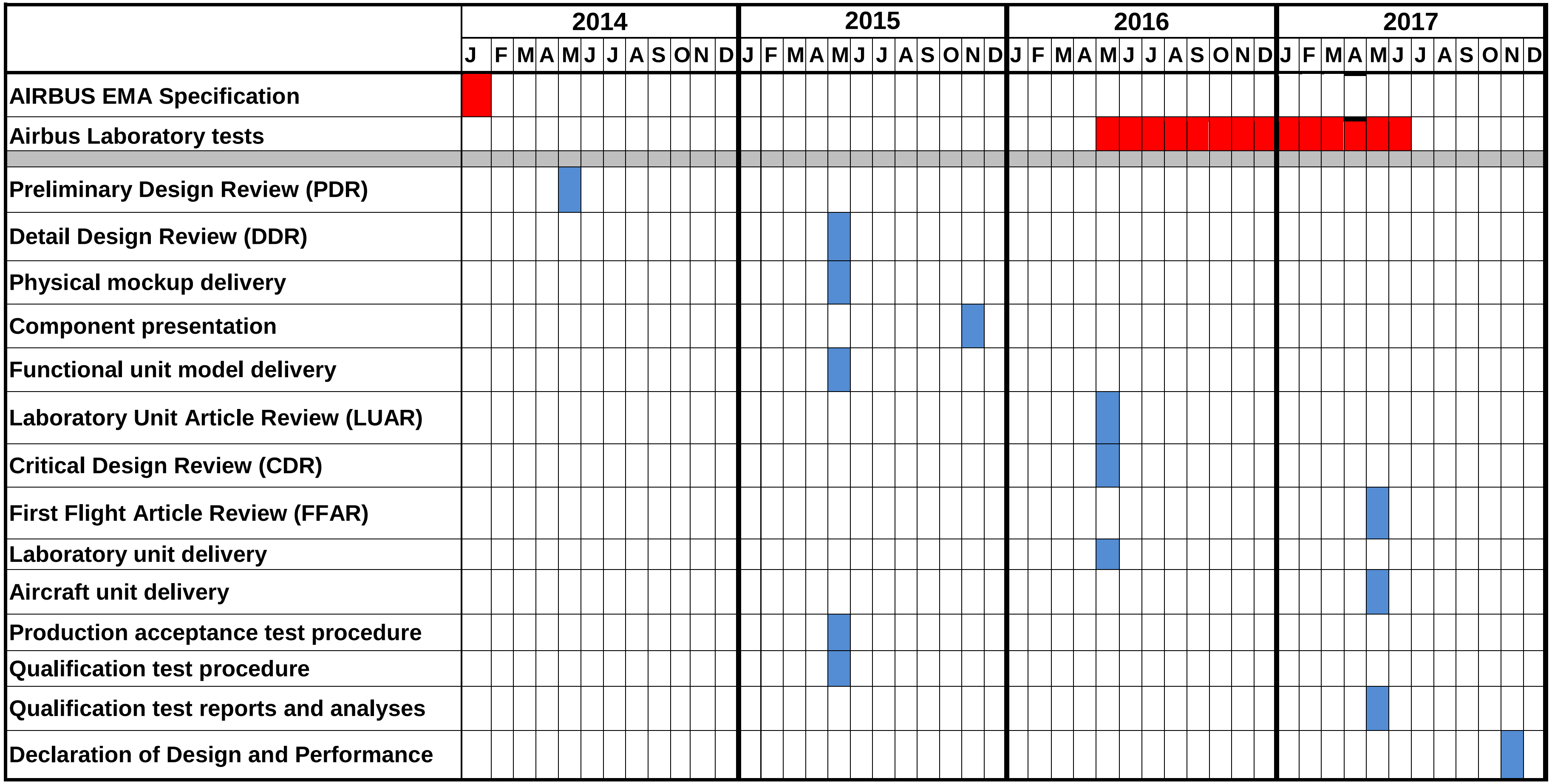
The applicable document list is provided below:

1/ The Documentation Requirement List (DRL) consists, as a minimum, in the following list:

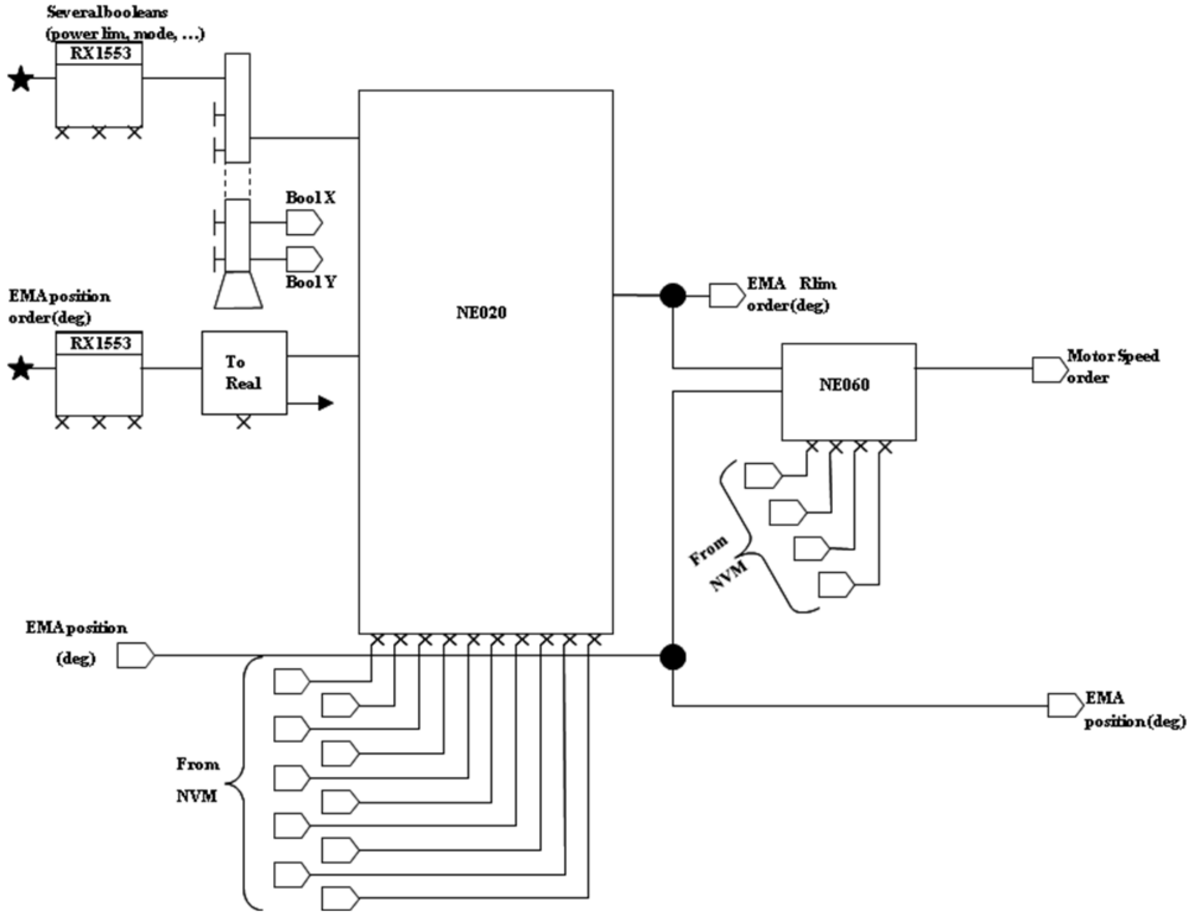
| Designation | Reference | Milestones | Updated target Date | Edition | Approbation Airbus | Comments ( last issue) |
|---|---|---|---|---|---|---|
| General Documents | | | | | | |
| DEVELOPMENT PLAN | | PR | | | | |
| DOCUMENT REQUIREMENT LIST | | PR | | | | |
| CONFIGURATION MANAGEMENT PLAN | | PR | | | | ABD100 2.3 & 2.9 |
| VALIDATION AND VERIFICATION PLAN | | PR | | | | ABD100 2.7 |
| EMC/HIRF/LIGHTNING CONTROL PLAN | | PR | | | | ABD100 1.2 |
| QUALIFICATION PLAN | | PR | | | | ABD100 2.8 |
| RISKS MANAGEMENT | | PR | | | | PTS |
| PARAMETRIC MODEL | | PR | | | | PTS |
| Definition dossier | | | | | | |
| SUPPLIER EQUIPMENT SPECIFICATION | | PDR | | | | ABD100 2.3 |
| DESIGN JUSTIFICATION DOSSIER ( DJD) | | PDR | | | | |
| INTERFACE CONTROL DATA | | PDR | | | | ABD100 1.1 |
| COMPONENT DESIGN DOSSIER | | PDR | | | | |

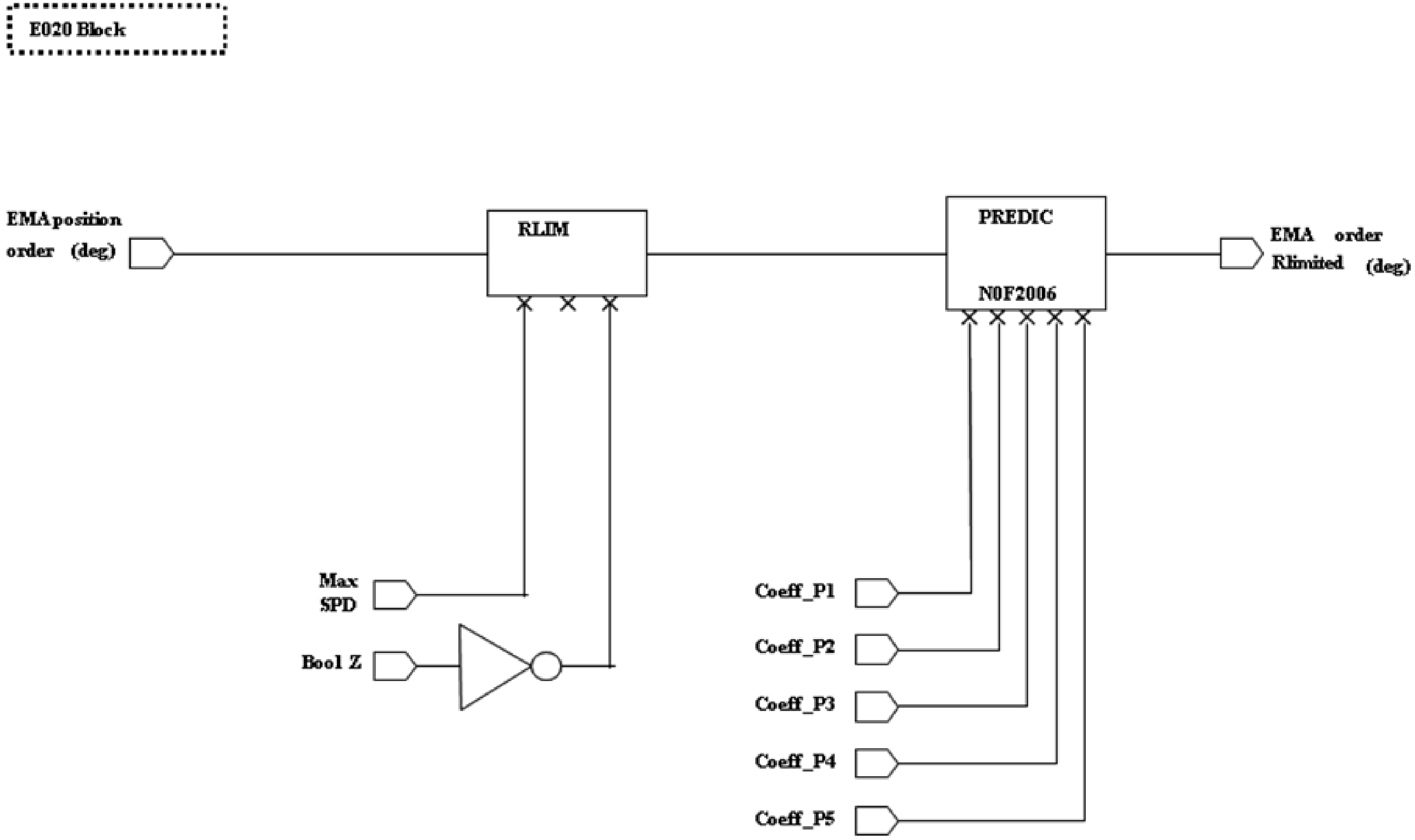
| | | | | | | |
|---|---|---|---|---|---|---|
| **STRENGH AND LIFE ANALYSIS DATA** | | **DDR** | | | | **ABD100 1.7 & 2.5** |
| **THERMAL ANALYSIS DATA** | | **DDR** | | | | **ABD100 1.7 & 2.5** |
| **CAD DATA** | | **DDR** | | | | **ABD100 1.7** |
| **SPACE ENVELOPE AND MECHANICAL INTERFACE DRAWING** | | **PDR** | | | | **ABD100 1.7** |
| **FULL SCALE SECTIONAL DRAWING** | | **PDR** | | | | **ABD100 1.7** |
| **DETAIL DRAWING** | | **DDR** | | | | |
| **DESCRIPTION OF THE UNIT** | | **PDR** | | | | **PTS** |
| **HEALTH MONITORING DOCUMENT** | | **DDR** | | | | |
| **SAFETY & REABILITY ANALYSIS (FMEA,….)** | | **PDR** | | | | **ABD100 1.3** |
| **ACCEPTANCE TEST PROCEDURE** | | **PDR (First issue)** | | | | **ABD100 1.5** |
| **QUALIFICATION TEST PROCEDURE(QTP)** | | **PDR (First issue)** | | | | **ABD100 2.8** |
| **QUALIFICATION TEST REPORT (QTR)** | | **FFAR** | | | | **ABD100 2.8** |
| **DECLARATION OF DESIGN AND PERFORMANCE (DDP)** | | **FFAR** | | | | **ABD100 2.8** |
| **MAINTENABILITY DOSSIER (CMM,…)** | | **CDR** | | | | |
| **Lessons learnt document** | | **FFAR** | | | | **PTS** |
| | | | | | | |

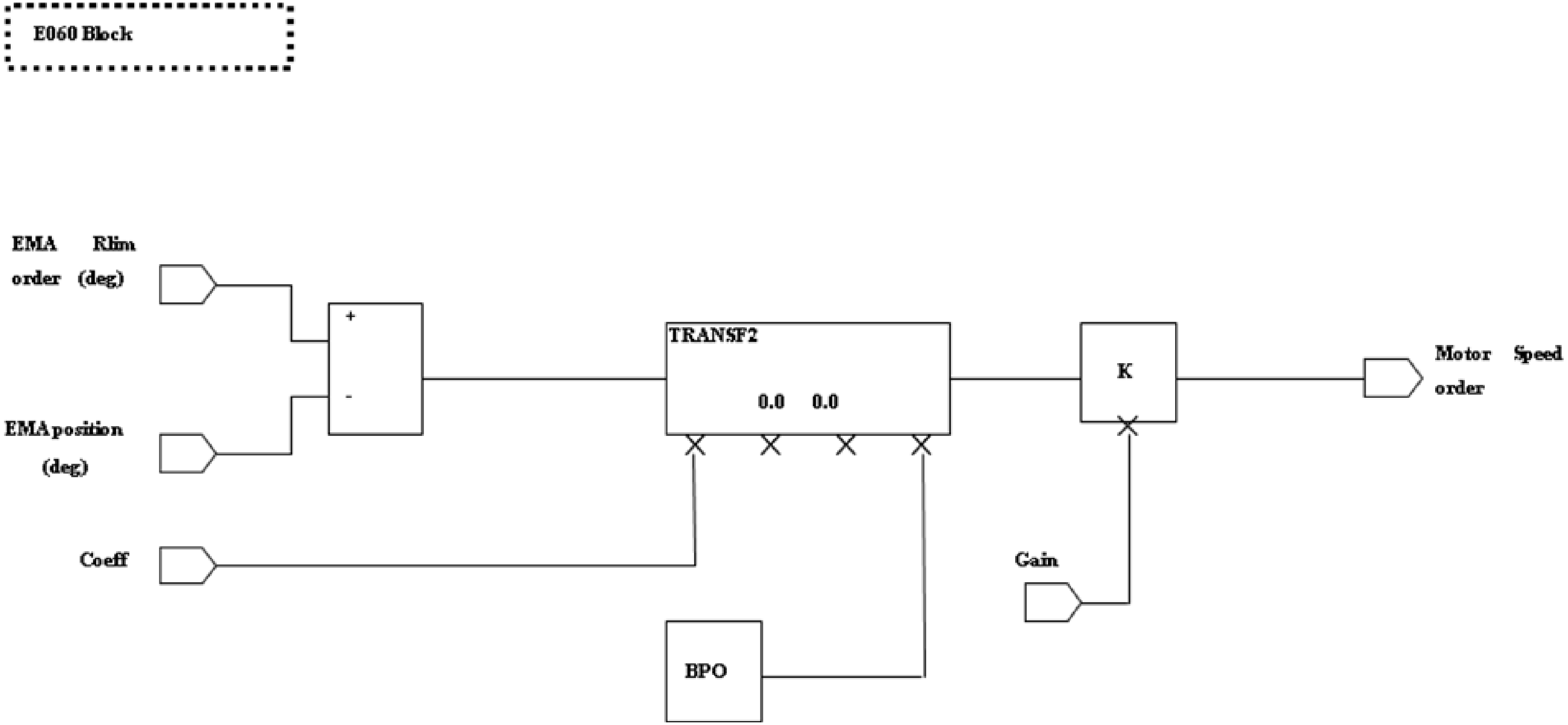
## 5.7 Appendix 7 : Planning and Milestones



## 5.8 Appendix 8 : SCADE sheet examples



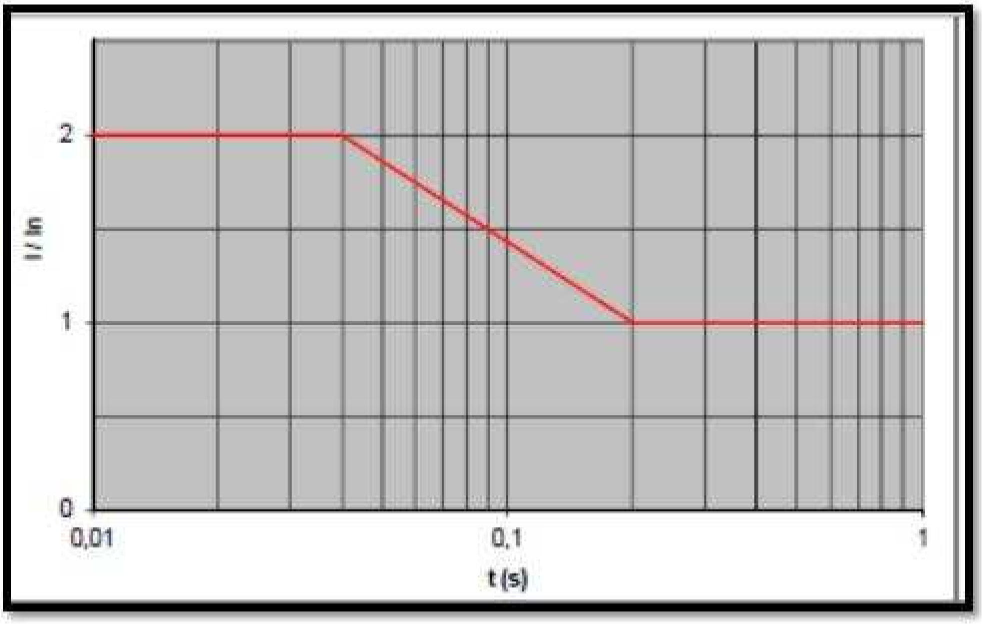

E020 Block
EMA position order (deg)
RLIM
PREDIC
N0F2006
EMA order Rlimited (deg)
Max SPD
Bool Z
Coeff_P1
Coeff_P2
Coeff_P3
Coeff_P4
Coeff_P5


E060 Block
EMA Rlim
order (deg)
+
-
EMA position
(deg)
TRANSF2
0.0 0.0
K
Motor Speed
order
Coeff
Gain
BPO

## 5.9 Appendix 9 : Circuit Breaker Tripping Characteristics

- **HVDC Circuit Breaker (SSPC):**

The disjunction characteristics of the 540VDC Circuit Breaker shall be in accordance with the figure provided hereafter with $I_n$=.5 A.




The average value shall be computed over a 5 ms timeframe.

| Duration (ms) | Current (p.u) |
|---|---|
| 0 – 10 | 2 |
| 40 | 2 |
| 200 | 1 |

Note 1: Inrush current requirement applies not only to power-on and power-cut conditions, but also to any transient operation o HVDC equipment in normal conditions. Thus, HVDC load equipment shall meet this requirement shall meet this requirement for all related voltage conditions.

Note 2: Modification of inrush current amplitude and duration requirements may be proposed if agreed with Airframer.

Note 3: For each AC /DC power output, a failsafe $I^2t$ protection device must be included.
This backup must be independent, simple and robust, as far as practicable.

Differential-mode current unbalance (leakage current):

For each DC power outputs, during normal operation in steady-state conditions, current unbalance between +270 V and –270 V shall not exceed 2A.

- **<u>LVDC Circuit Breaker:</u>**

The disjunction characteristics of the 28VDC Circuit Breaker shall be in accordance with following table and graph with $I_n$ = 3 A:

| | | Overload (in % of $I_n$) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 200 | | 500 | | 1 000 | |
| | | 3 poles | 1 pole | 3 poles | 1 pole | 3 poles | 1 pole |
| **Ambient temperatures** °C | **Ratings** A | **Trip time** s | | | | | |
| 23 ± 5 | All | 2 to 20 | 2 to 22 | 0,15 to 4,00 | 0,15 to 5,20 | 0,05 to 1,00 | 0,06 to 1,30 |
| − 55 ± 5 | | ≤ 60 | ≤ 110 | | | | |
| 90 ± 5 | | ≥ 1,5 | ≥ 1,5 | | | | |

NOTE 1 When 3 poles are loaded, they will be connected in series.

NOTE 2 When 1 pole is loaded, the two other poles are not loaded.

Schéma de principe et de câblage

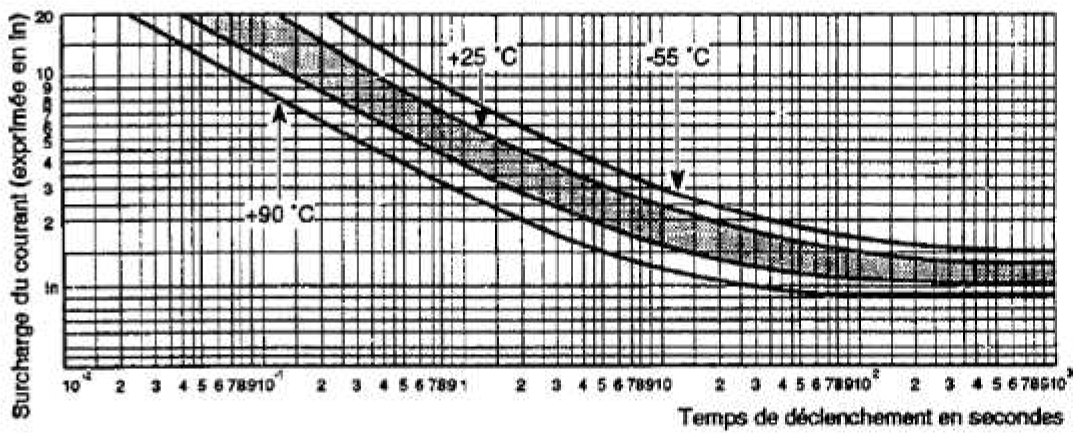



Figure 2 - Courbe de déclenchement

## 5.10 Appendix 10 : Sensors and associated treatment performances

| Sensor | SCADE name | Report Unit | Measurement Range | Coding Range | Static Accuracy | | Resolution (LSB) | Noise | Bandwidth | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | at application software input | | on µAFDX bus (at FCC input) | |
| | | | | | at zero | at full range | | | attenuation | phase | attenuation | phase |
| **Mechanical Output Position** | POS | EMA Degree (°) | -31,48 to 100,48 | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** |
| **Surface Position (*)** | PSURF | Surface Degree (°) | -13,54 to 51,68 | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** |
| **Motor Position** | MPOS | Motor Degree (°) | +/- 180 | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** |
| **Motor Current** | MCURx (x:number of sensor) | Ampere (A) | +/- **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** |
| **Torque** | LOAD | Newton.meter (N.m) | +/- **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** |
| **ECU Temperature measurement** | ECUTEMP | Degree Celsius (°C) | -55 to 150 | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** |
| **Motor Temperature measurement** | MTRTEMP | Degree Celsius (°C) | -55 to 150 | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** | **TBA** |