[1]2014-11-25

DRAFT

Business Plan for the CEN Workshop on "Modules for Electro-Mechanical Actuators in Aircraft"

(to be approved during the Kick-off meeting on 2015-01-28)

[1] *Here the date of updating should go, updated by the last editor*

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1. Status of the Business Plan

The current status of this plan is:

☐	Review and resolution CEN/BT
☐	For feedback by interested parties
☒	For approval at Kick-Off meeting on 28-01-2015
☐	Approved at Kick-Off meeting on 28-01-2015
☐	For approval by Workshop (at Workshop meeting) on dd-mm-yy (by e-mail process)
☐	Approved by Workshop (at Workshop meeting) on dd-mm-yy (by e-mail process)

This draft document is also published on the website of ACTUATION2015 at http://www.actuation2015.eu/.

Please send us your feedback

To give your feedback on the document, or to contact ACTUATION2015 please write to: cwa@actuation2015.eu

2. Background to the Workshop

This Business Plan proposes a new CEN Workshop on standardised modules for the development of Electro-Magnetic Actuators (EMAs) for aeronautical application.

2.1. Market environment

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. Compared to hydraulic and pneumatic systems, electrical systems need to be powered only when they are used and rely on a power less subject to losses and lighter to distribute. The All-Electric Aircraft is consequently a key means at systems level to reduce fuel burn and cost as described in the ACARE 2020 Strategic Research Agenda if current technological, economical, and reliability barriers are properly addressed.
A corresponding key challenge is to make Electro Mechanical Actuators (EMAs) available in order to replace hydraulic actuators, which are costly to maintain, heavy, and high energy consuming.
In terms of market, this EMA technology is targeting as a first priority the next generation of short and medium range aircraft families, successors of the A320/B737 families. The number of such aircraft to be potentially sold in the next 30 years is very large. Up to 2010, about 4300 A320 and 6350 B737 have been built and in 2012, about 2800 A320 / A320NEO and 2300 B737/B737 MAX were still on order. Newcomers are also entering the air transport (around 100 passengers) market (e.g. Bombardier, Embraer, COMAC, Irkut).
With an estimated traffic growth of 5% per year, the future market for EMA technology represents several tens of thousands of aircraft in a period of 20 years. With a current very rough average unit cost of 55 M€ for such an aircraft, and equipment representing about a third of this price, the market represents several billion euros for the actuation part. To this main market, the other targets (helicopters, regional aircraft, long haul aircraft, and business aircraft) represent additional significant multi-billions euros markets.
The stakes are consequently enormous for the aviation industry. Standardising EMA technology will enable the aviation industry to address this market efficiently with similar products for different aircraft. The larger scale of the market for such standardized products will be an asset for equipment manufacturers, aircraft manufacturers, and operators

2.2. Legal environment

Aircraft equipped with EMA technology will have to be certified by the relevant authorities (mostly Federal Aviation Administration (FAA) in the US and the European Aviation Safety Agency (EASA) in Europe). This prerequisite will be taken into account when establishing the Workshop and developing the CWA.

2.3. Existing standards and standard related activities and documents

At present, there are no standards available for EMAs or for EMA modules. The current standardization effort shall be in line with existing standards such as general standards for actuators and Integrated Modular Avionics.

There are quite a few standards developing organizations that issue internationally coordinated and used standards in the field of aeronautics:

- ISO – The International Organization for Standardization develops International Standards. ISO has published more than 19,000 International Standards covering almost all aspects of technology and business. ISO is made of a network of national standards bodies (DIN in Germany, AFNOR in France, BSI in the UK, ANSI in USA, etc.). In the field of aeronautic equipment, ISO is active through working groups as the ISO/TC 20 dealing with aircraft and space vehicles.
- ASD-STAN – The ASD-STAN Standardization Committee is the recognized body in Europe for the preparation and promotion of European Standards (EN) for aerospace applications and is an Associated Body (ASB) to CEN, the European Committee for Standardization.
- ARINC – ARINC (Aeronautical Radio, Incorporated) is a provider of communications, engineering, and integration solutions to defence, commercial, and government customers. ARINC maintains a wide range of standards, including data bus standards, avionics equipment packaging standards, and standards for avionics equipment predominately installed on transport category aircraft. In December 2013, ARINC was acquired by Rockwell Collins.
- CEN – The European Committee for Standardization is a business facilitator in Europe, removing trade barriers for European industry and consumers. Its mission is to foster the European economy in global trading, the welfare of European citizens and the environment. Through its services, it provides a platform for the development of European Standards and other technical specifications. CEN is a major provider of European Standards and technical specifications with the exception of electro-technology (CENELEC) and telecommunication (ETSI). CEN's 33 National Members work together to develop voluntary European Standards (ENs).
- SAE – SAE International (formerly the Society of Automotive Engineers) supports the technical and professional needs of the mobility industries. SAE International is the single largest developer of globally recognized, accepted, and used aerospace standards. SAE works closely with industry, government agencies, and regulatory bodies to develop standards that meet the needs of the aerospace industry.
- EUROCAE – The European Organisation for Civil Aviation Equipment deals exclusively with aviation standardisation (airborne and ground systems and equipment) and related documents as required for use in the regulation of aviation equipment and systems.

On 6 March 2008, SAE Electro-Mechanical Actuation Committee (A-6B3)[2] initiated project "ARP5754 - Electromechanical Actuator (EMA), General Characteristics & Guidelines for Aircraft Control"[3]. The project defines general characteristics and guidelines for the design of EMAs for flight control applications or other safety critical applications. To our knowledge, there has been no activity on this project since mid-2008.

2.4. Motivation for the creation of this Workshop

The market requires a strong reduction of the life cycle costs (LCC) of EMA technologies. Investing in off-the-shelf, standardised, and scalable modules that can address various actuation applications will allow equipment manufacturers and their supply chain to address current reliability issues and exploit easier maintenance of EMAs while reducing strongly LCC thanks to a larger and sustainable market.
To achieve this standardisation objective, participants will contribute relevant technical information to the CEN Workshop, with the objective to reach consensus on a CWA.

[2] http://www.sae.org/servlets/works/committeeHome.do?comtID=TEAA6B3
[3] http://standards.sae.org/wip/arp5754/

3. Workshop proposers and Workshop participants

3.1. Workshop proposers

The Workshop is proposed by the participants of the ACTUATION 2015 project, which is funded by the European Commission under the Seventh Framework Programme (FP7/2007–2013) under grant agreement n° 284915 and especially the following participants:

Organisation	Country	Contact person
Goodrich Actuation Systems SAS, a UTC Aerospace Systems Company	France	Pascal Coron
ACQ INDUCOM	Netherlands	
AIRBUS Operations GmbH	Germany	
AIRBUS Operations LTD	United Kingdom	
AIRBUS Operations SAS	France	
ALENIA AERMACCHI SpA	Italy	
BAE Systems (Operations) LTD	United Kingdom	
CISSOID SA	Belgium	
Compania Espanola de Sistemas Aeronauticos	Spain	
CROMPTON Technology Group LTD	United Kingdom	
AIRBUS Defence and Space GmbH	Germany	
EURO HEAT PIPES SA	Belgium	
FOKKER LANDING GEAR BV	Netherlands	
Goodrich Actuation Systems Limited, a UTC Aerospace Systems Company	United Kingdom	
HARMONIC DRIVE AG	Germany	
LABINAL Power Systems SA	France	
HOTTINGER BALDWIN MESSTECHNIK GmbH	Germany	
LIEBHERR-AEROSPACE LINDENBERG GmbH	Germany	
MEGGITT (SENSOREX) SAS	France	
MESSIER-BUGATTI-DOWTY SA	France	

Organisation	Country	Contact person
MESSIER-DOWTY LTD	United Kingdom	
MICROSEMI Power Module Products SAS	France	
PIHER Sensors & Controls SA	Spain	
PARAGON SA	Greece	
PIAGGIO Aero Industries SpA	Italy	
RATIER FIGEAC	France	
ROLLVIS SA	Switzerland	
SAAB Aktiebolag	Sweden	
SAGEM Defense Securite	France	
SENER Ingenieria Y Sistemas S.A.	Spain	
SKF Aerospace France	France	
NLR	Netherlands	
Technische Universitaet Hamburg-Harburg	Germany	
THALES Avionics Electrical Motors SAS	France	
UMBRA CUSCINETTI SpA	Italy	

3.2. Workshop participants

The Workshop will be open for participation to any interested organization. The initial list of Workshop participants will be consolidated at the Kick-off meeting.

4. Workshop scope and objectives

4.1. Workshop scope

Over the last years, several industrial programmes initiated the concept of a More Electric Aircraft. The aero-equipment industry has launched several studies and developments on more electrical actuation with Electro Hydraulic Actuators (EHA) and started to introduce EMA for auxiliary equipment. This has provided incremental approaches to address hydraulic circuits issues with Fly-By-Wire technologies (A320, B777, and Falcon 7X), introduction of the 2-hydraulic/2-electric (2H/2E) flight control architecture where flight controls are powered by EHA using a local hydraulic reservoir (A380, A350XWB), and no-bleed electrical systems architecture (B787) enabling the use of smaller hydraulic components or EMAs for some systems (spoilers, brakes, and engine starters).

Several recent collaborative research and development projects[4] also started to develop the All-Electric Aircraft by moving from Fly-by-Wire to Power-by-Wire technologies. These projects have demonstrated on specific systems the superiority of electrical actuation with:

- Reduction of maintenance operations.
- Reduction of leakage-related problems.
- Health and usage monitoring system capability.
- Time effective assembly and tests.
- Improved availability and operation in aircraft.

The resulting More Electric Aircraft with Power-by-Wire actuators is an answer to limit the proliferation of hydraulic circuits. EMA systems are consequently the best candidate for the aircraft of the future (i.e. the All- Electric Aircraft) when considering they are:

- Less complex because of the absence of hydraulic system.
- Stiffer than an equivalent EHA since there is no hydraulic fluid in the load path.
- Better suited to long term storage or space applications since there is no leak potential.
- Energy saving, since contrary to hydraulic systems energy is only needed to activate EMAs when in use.

But, compared to hydraulic actuators or EHAs, economic, reliability, and technological barriers still persist for a wide adoption of EMAs, especially when considering:

- Economic issues: EMA cost targets fixed by the aircraft manufacturers are not reached in the present situation leading to a blocking situation, coming from
    - Specific costly tailored products with mono sourcing and low scale volume.
    - The lack of standard methods to design, test and qualify EMAs.

  Standardisation of components and “Design to cost” approaches are essential to make the electrical actuation cost effective. Generalisation of electrical actuation on board increases components production volumes. The definition of families among electrical and mechanical components, the standardisation of interfaces, the design of standard modules

[4] e.g. EC projects POA and MOET.

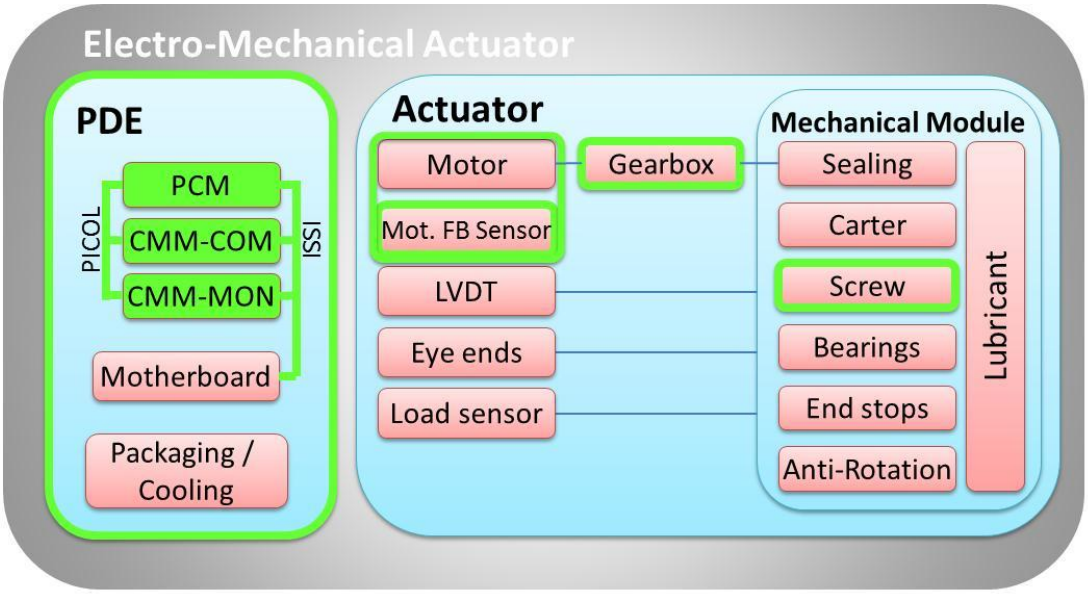
and the sharing of equipment between systems are key factors to decrease the costs like done 25 years ago for hydraulic components.

- Reliability issues: the EMA sensitivity to certain single point of failures that can lead to mechanical jams, results in a reluctance to mobilise EMA for safety critical applications as existing solutions meeting certification requirements are heavy and costly (redundancy, fail safe behaviour, etc.) and thus creates difficulties for EMA adoption and certification and again impacts on global costs. In particular, Power Drive Electronics (PDE) used to drive an EMA, Motors and Mechanics reliability in harsh environment must be improved.
- Technological issues: the current technology in use for the development of EMAs is still to be improved in terms of weight due to materials, architectures, and sensors that are not fully optimised and not using latest state-of-the-art technologies, including the use of ASIC and SiC components that are too expensive for custom made systems. Using the latest state-of-the-art technologies and optimising the systems architecture will become acceptable for standard modules based actuators when matured and made cost effective thanks to standardisation and mass production.

Consequently, to enable the production of an All-Electric Aircraft in line with ACARE 2020 objectives, the actuation industry can overcome these last barriers by developing, integrating, and validating low-cost EMA technology with:

- Standardised modules (e.g. PDE, motors, sensors, connectors, screws, etc.) and interfaces to develop cost effective and reliable EMAs, adaptable for all systems (including safety-critical systems), to all aircraft systems, and to several market segments (helicopters, business, regional and large aircraft).
- Standard design, qualification, and simulation tools with qualified processes and model library including in particular a design to cost approach.

In the ACTUATION2015 project, a proposal has been prepared for the decomposition of EMAs into modules and the decomposition of modules into components. This proposal is depicted in Figure 1 below. The potential candidates for standardization are shown with green boxes or green borders when guidelines or interfaces are considered.



PDE	Power Drive Electronics	**PCM**	Power Core Module
Mot. FB Sensor	Motor Feedback Sensor	**CMM-COM**	Control and Monitoring Module – Control
LVDT	Linear Variable Differential Transformer	**CMM-MON**	Control and Monitoring Module – Monitor
PICOL	Protocol for Inverter Control Over LVDS	**ISSI**	Internal Standardized Supply Interface

Figure 1: ACTUATION2015 definition of EMA modules and components and possible candidates for standardization (green boxes).

The level of standardization is generally module/component dependent. The Mechanical module, for example, is expected to be specific for the application of the EMA in the specific location of the aircraft. The PDE, however, is expected to have a much higher level of commonality between different EMA applications. The following items have been tentatively identified for standardization:

1. Power Drive Electronics modular architecture guidelines (PDE guidelines).
2. Power Core Module (PCM).
3. Control & Monitoring Module (CMM).
4. Internal Standardized Supply Interface (ISSI).
5. Protocol for Inverter Control Over LVDS (PICOL).
6. Motor interface including the motor position feedback sensor (Motor interface).

Descriptions of these items are provided in Annex A. Within the Workshop it will be agreed which items will be standardized and to what level.

4.2. Workshop objectives

The objective of this Workshop is to define standardised modules and interfaces for the design and manufacturing of EMAs and to provide a set of recommendations for further standardization activities to be progressed in a new or existing Technical Committee in Europe or internationally. The work will consequently focus on the following activities:

- Specify a list of standardised modules including their interface and supporting run-time and application software.
- Provide examples.
- Prepare recommendations for the standardisation process.

The Workshop will develop descriptions of standardized modules of a modular EMA. Furthermore the interfaces will be described between the modules. Although the modules are stand-alone units, the Workshop will develop an integrated CWA covering all modules, because the EMA functionality depends heavily on the integrated EMA.

With the agreement about what modules or components of modules will be standardized to what level, different Working Groups (WGs) will be established to develop agreed views on the standardized modules and components. These WGs will work within the limitations set for the complete EMA.

5. Workshop programme

The Workshop will use results of the ACTUATION2015 project as the primary input of technical information. Experts of the Workshop will generate the CWA from this and any other input made available for the Workshop. Experts will gather in meetings, will work electronically using e-mail and eCommittee in between meetings and hold teleconferences.

5.1. Languages

The CWA, as well as other documents and technical specifications, will be drafted and published in the English language. English will also be the working language of the Workshop.

5.2. Work plan

5.2.1. General process

The work plan is based on an iterative process with two iterations following the Kick-Off (KO) meeting. A plenary Workshop meeting is scheduled to validate each of these. A more detailed description is provided below:

Kick-Off Meeting (KOM)

- Establish agreement between participants about how EMAs will be decomposed into modules. Characterize the important interfaces between modules.
- Establish agreement between participants about how modules will be decomposed into components. Characterize the important interfaces between components.
- Establish agreement between participants about which modules, which components, and which interfaces are to be standardized and to what level.
- Establish WGs (and chairpersons for WGs) for modules, components, and interfaces to be standardised.
- Gather inputs for the standardization process.

After the KOM, WGs will work and communicate through eCommittee, e-mail and teleconferences. In the first two months after the KOM applicable terminology and definitions will be agreed upon.

1st progress meeting

- Review all preliminary results of WGs.
- Harmonise preliminary results to assure that interfaces between components and modules fit.

After the 1st progress meeting, WGs will work and communicate through eCommittee, e-mail and teleconferences.

2nd progress meeting

- Presentation of results of WGs.
- Harmonise preliminary results to assure that interfaces between components and modules fit.

After the 2nd progress meeting, WGs will finalise the CWA parts. Review of versions and communication will take place through eCommittee, e-mail and teleconferences.

Final Meeting

- Establish agreement about any open points that may exist in the CWA.
- Discuss the need for further standardisation activities and if needed, define actions.

If so decided during the final meeting, a Work Plan for submission of the CWA to further international standardization will be developed.

5.2.2. Work items

Work items are the modules, components, and interfaces for which standardization activities will be engaged. The following items have been tentatively identified:

1. Power Drive Electronics modular architecture guidelines (PDE guidelines).
2. Power Core Module (PCM).
3. Control & Monitoring Module (CMM).
4. Internal Standardized Supply Interface (ISSI).
5. Protocol for Inverter Control Over LVDS (PICOL).
6. Motor interface including the motor position feedback sensor (Motor interface).

Descriptions of these work items are provided in Annex A. The final list of work items will be decided by the Workshop. Each work item will develop its own CWA part in a dedicated Working Group.

5.2.3. Deliverables

The following deliverables have been identified:

1. Draft Business Plan for a CEN Workshop on modules for Electro-Mechanical Actuators in aircraft (this document).
2. Business Plan for a CEN Workshop on modules for Electro-Mechanical Actuators in aircraft (approved at KO-meeting).
3. CWA Consensus Document and Guidelines (one part for each work item).

The CWA will contain a set of recommendations for further standardization activities to be progressed in a new or existing Technical Committee (or Sub Committee) in Europe or internationally (such as the ISO Aerospace fluid systems and components technical committee (TC 20/SC 10) that is working on standardising components). In more detail, the CWA will contain:

- The list of contributors – participants from the project ACTUATION2015, but also any other interested organisation.
- A description of the purpose of the standardisation of modular EMAs.
- The proposed standards with a first description resulting from the work of the ACTUATION2015 initiated CEN Workshop.
- Recommendations for the standardisation process (next steps, especially regarding the constitution of a technical committee or sub-committee at CEN or ISO level).

As part of these activities, the participants will decide about the format to be used to describe the proposed standard modules – possibly having one document per module (e.g. PCM, CMM, etc.) or per type of module (i.e. PDE modules).

5.2.4. Time schedule

It is proposed to complete the Workshop during a period of 12 months. The provisional time schedule is as follows:

Date	**Place**	**Meeting**	**Objectives/deliverables**
KO	CEN offices, Brussels	Kick-off Meeting	Approval of the Business Plan, appointment of Chair and Secretariat
KO+3 months	TBD	1st progress meeting	1st Draft of CWA
KO+9 months	TBD	2nd progress meeting	2nd Draft of CWA approval for public comments enquiry (60 days)
KO+12 months	CEN offices, Brussels	Final meeting	Final CWA

The Kick-off (KO) is planned for 28th of January 2015.

5.3. Work already delivered

Not applicable

6. Workshop structure

6.1. Workshop Plenary

The Workshop Plenary is the highest authority of the Workshop. The Workshop Plenary consists of representatives from all Workshop members.

6.2. Workshop Chair

The Workshop Chair is responsible for running of the Workshop. His/her responsibilities include:

- To preside at Workshop Plenary meetings.
- To ensure that the Workshop delivers in line with the Business Plan.
- If deemed necessary, to initiate any required changes to the Business Plan and forward issues to the Plenary as appropriate.
- To manage the consensus building process.
- To interface with the Working Groups.
- To manage external liaisons.
- To interface with the CEN regarding strategic directions, problems arising, external relationships, etc.

NLR will perform the role of Workshop Chair.

6.3. Working Groups and Working Group Chairs

Working Groups (WGs) will be established for the development of standardization of selected modules and components. The establishment of a WG is during a plenary meeting of the Workshop. All participants are invited to contribute their experts to the WG. The Chair of the Workshop assigns one of the experts as the Chair of the WG. The Chair of the WG will be responsible for the progress of the work in the WG.

6.4. Workshop Secretariat

The role of the Secretariat is to co-ordinate the administrative duties involved in the organization and implementation of the Workshop, including:

- Business Plan for a CEN Workshop on modules for Electro-Mechanical Actuators in aircraft distribution

- Registration, documentation management, meeting organisation support for meetings described under 5.2.4 and internal process support
- To act as contact point to respond to any queries of interested parties
- CWA publication and maintenance

The Workshop Secretariat will offer the electronic platform for distribution and archiving of the Workshop documents. Between meetings, Workshop participants may also use the ACTUATION2015 collaborative platform and teleconference services to speed up the consensus building on CWA parts.

DIN will perform the role of Workshop Secretariat.

6.5. Editors

GAS-F will provide the technical input for the CWA and will coordinate the contribution of all the other ACTUATION2015 industrial participants.

ARTTIC will take care of the organisation and proof writing of documents.

7. Resource requirements

The registration and participation at this CEN Workshop is free of charge for every member of the Workshop. All costs related to the participation of interested parties in the Workshop's activities will be borne by themselves.
The cost of the Workshop Secretariat and of the CWA Editors will be supported by ACTUATION2015 funding under the work package 72 "Standardisation". In particular, a sub-contract to handle the Workshop Secretariat will be given to DIN. The sub-contract will be managed by NLR.

8. Related activities, liaisons, etc.

Not applicable

9. Contact points

Proposed Chairperson:
Mr. René Eveleens
Department Leader Aircraft Systems
National Aerospace Laboratory - NLR
Anthony Fokkerweg 2
1059 CM Amsterdam
The Netherlands
Tel: +31 88 511 3600
Fax: +31 88 511 3210
E-mail: Rene.Eveleens@nlr.nl
Website: www.nlr.nl

Proposed Secretariat
Mr. Sebastian Edelhoff
Project manager
DIN German Institute for Standardization
Am DIN-Platz
Burggrafenstrasse 6
10787 Berlin
Germany
Tel: +49 30 2601-2453
Fax: +49 30 2601-42453
E-mail: sebastian.edelhoff@din.de
Website: http://www.din.de
http://www.nl.din.de

CCMC contact
Mr. Alain Dechamps
Programme Manager - Industry, Technology & Infrastructure - Standards
CEN - European Committee for Standardization
CENELEC - European Committee for Electrotechnical Standardization
Avenue Marnix, 17
B-1000 Brussels
Belgium
Tel: +32 2 550 0867
Fax: +32 2 550 0819
E-mail: adechamps@cencenelec.eu
Website: www.cencenelec.eu

10. Annex A – Description of proposed Work Items

In the ACTUATION2015 project, a proposal has been prepared for the decomposition of EMAs into modules and the decomposition of modules into components. This proposal is depicted in Figure 2**Error! Reference source not found.**.

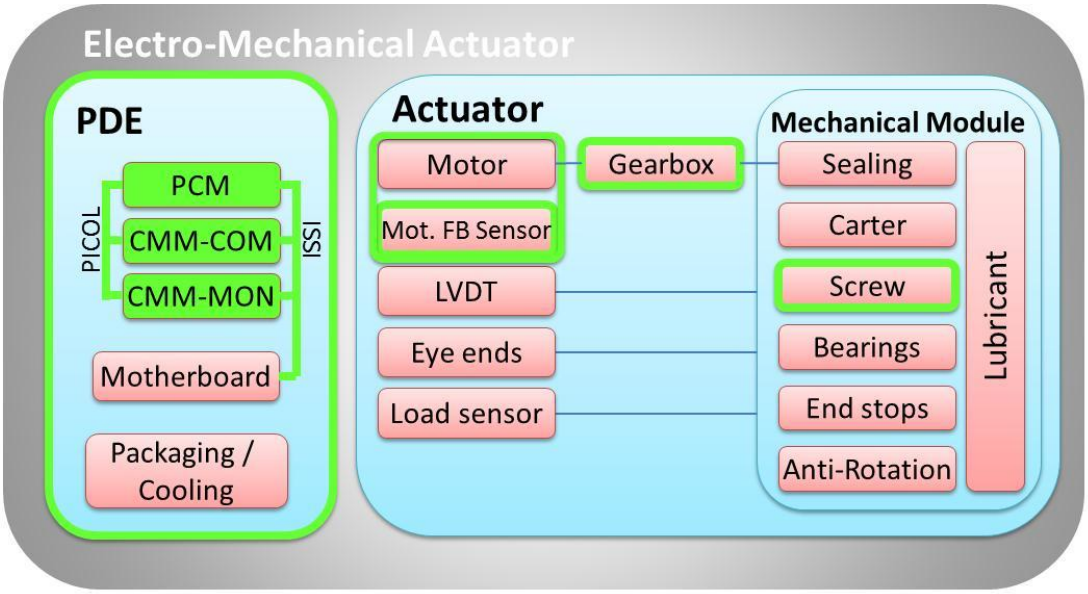


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Figure 2: ACTUATION2015 definition of EMA modules and components and possible candidates for standardization (green boxes).

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4. Internal Standardized Supply Interface (ISSI).
5. Protocol for Inverter Control Over LVDS (PICOL).
6. Motor interface including the motor position feedback sensor (Motor interface).

The following subsections provide descriptions of these items.

10.1. Power Drive Electronics modular architecture guidelines

This standard specification provides guidelines for the design of the Power Drive Electronics (PDE). It lists the reference documents applicable to the design of the PDE and describes the key PDE features including the external connectors. Those guidelines refer to the set of standard module requirements (e.g. PCM, CMM, ISSI, PICOL) to cover the aircraft application range addressed in ACTUATION2015.
A variety of other features or elements of the PDE are not covered by standard requirements to allow the tailoring of the PDE to a specific application. This includes:

- Casing.
- Thermal management.
- Mechanical support and electrical interconnects between the modules.
- Filter modules.
- Lightening and Electro-Magnetic Protection components.
- Any custom functions that are unique to a particular EMA type.

10.2. Power Core Module

Essentially the PCM standard specification consists of two parts:

- An interface control document (ICD) defining the form factor of the board, its connector and pin allocation
- A list of functional and environmental requirements

The functional description of the PCM can be summarized as follows:

- Provides Motor 3 phase and Solenoid drive power
  - Accepts duty cycle commands via the PICOL bus from CMM-COM module and generates the gate drive signals to the switches network
  - Bridge gate drivers provide isolated gate drives to the power switches
  - Power switches turn on ±270VDC to the motor and solenoid inputs according to gate drive pulse width
- Sends motor phase current, solenoid drive current, input bus voltage and motor position measurement back to CMM modules via PICOL bus
- Provides on-board temperature sensor to be read by CMM-MON
- Provides internal bias voltages from +15V input for proper component operation
- Provides the critical timing control, status acquisition, and external communication interface

10.3. Control & Monitoring Module

The CMM-COM and CMM-MON are two copies of the CMM board with different configuration and software. Essentially the CMM standard specification consists of two parts:

- An interface control document (ICD) defining the form factor of the board, its connector and pin allocation
- A list of functional and environmental requirements

The functional description of the CMM can be summarized as follows:

- Provides primary and secondary µAFDX bus communication to the flight computer system host with transformer isolation
- Address programming via 6 switched ground programming signals
- Provides internal bias voltages from +15VDC input for proper component operation
- Provides sufficient sensor interfaces to meet the need of COM or MON modules for all actuation systems considered in ACTUATION2015 programme
    - Temperature sensors (3 max): 4-wire interface to PT100 sensors
    - Load/pressure sensors (3 max): bias voltages provided to energize sensors
    - xVDT sensors (3 max): 7Vrms excitation at 2kHz provided
    - Proximity digital sensor
- Signal processing
    - Front end analogue circuitries condition sensor feedbacks for ADC conversions
    - Oversees ADC conversions, processes converted data to control actuator operation, and provides operating conditions and health status to system host
- Sends motor and solenoid control information and reads voltage, current, and position status from PCM via high speed PICOL bus
- Provides COM / MON inter-lane communication via communication bus
- Provides Actuator Non-Volatile Memory interface

10.4. Internal Standardized Supply Interface

The power supply concept of the PDE may be described as "semi-centralized":

- A first centralized stage of isolated DC/DC down converter is connected to the aircraft low-voltage bus (28VDC) and distributes a standardised regulated +15VDC power supply interface to other PDE functions
- Other boards or functions are users of the first stage and generate locally any bias voltages necessary for their operation from the +15V input.

ISSI specification defines the detailed requirements of the first +15VDC centralized stage. Its functional scope is as follows:

- Connect the PDE to aircraft low-voltage DC power bus (LVDC)
- Meet all requirements related to DC equipment
- Supply all internal PDE functions and users that are powered by LVDC
- Provide galvanic insulation between LVDC and ISSI output
- Guarantee the required hold-up/ transparency time during which LVDC voltage can go away but the +15VDC output is expected to remain operational.
- Monitor LVDC bus input voltage and output an under-voltage detection signal to ISSI users.

10.5. Protocol for Inverter Control Over LVDS

PICOL is the dedicated low-voltage differential signalling (LVDS) digital bus that is used for communications (Tx and Rx) between the Command Lane and the PCMs. The objective of PICOL digital communication system is to replace the hard-wired interface that the majority of systems use to communicate with the power inverter function. The Monitor Lane has a slave connection to PICOL that allows it to monitor data that is exchanged between the Command Lane and the PCMs.

The specification describes all PICOL features:

- Single master / multi slaves topology
- PICOL state machine that indicates the current state of the protocol
- Cyclic and deterministic exchanges between modules
- The data exchanged between the modules
- The physical layer of the network

10.6. Motor interface

All motors considered in ACTUATION2015 are three-phase star connected brushless permanent magnet synchronous motors controlled with 10kHz ±270VDC pulse-width modulation (PWM).

Some of the ACTUATION2015 applications require that the EMA motor provide an electromagnetic damping function that is proportional to velocity and permanently engaged. Other applications requiring a dual-channel architecture have a dual-winding motor controlled by two PDEs operated in an Active/Standby configuration.

The purpose of the standard motor specification is to define the technical requirements and design data applicable for the development of a motor:

- Functional requirements:
  - Provide speed and torque as commanded in continuous and short-time duty
  - Provide means to monitor rotor position
  - Provide means to monitor winding temperature
- Interface requirements
  - Single or multiple 3-phase Y-connected (star) brushless permanent magnet synchronous motor, with floating neutral
  - Supplied by a HVDC PWM source with a voltage in the range 500-650VDC (full performance) and 400-750VDC (transient)
  - Installed as part of an actuator in a non-pressurised, non-temperature controlled area
  - Motor feedback position sensor
    - Consists of 3 linear Hall-effect probes
    - Each linear Hall-effect probe is interfaced to the PCM with a 4-20mA current loop.
  - Temperature sensor of PT100 type, 4-wire interface
  - Electrical interface
  - Mechanical interface.