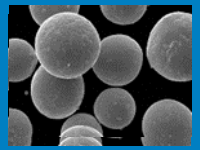
EASA
European Union Aviation Safety Agency

Additive manufacturing & DOA aspects

Wolfgang HOFFMANN
Structures Expert
CT.1.2 - Non-EU Large Transport Aeroplanes Section

Alexandru ENACHE
Section Manager
CT.6.1 Design Organisations & Policy Issues



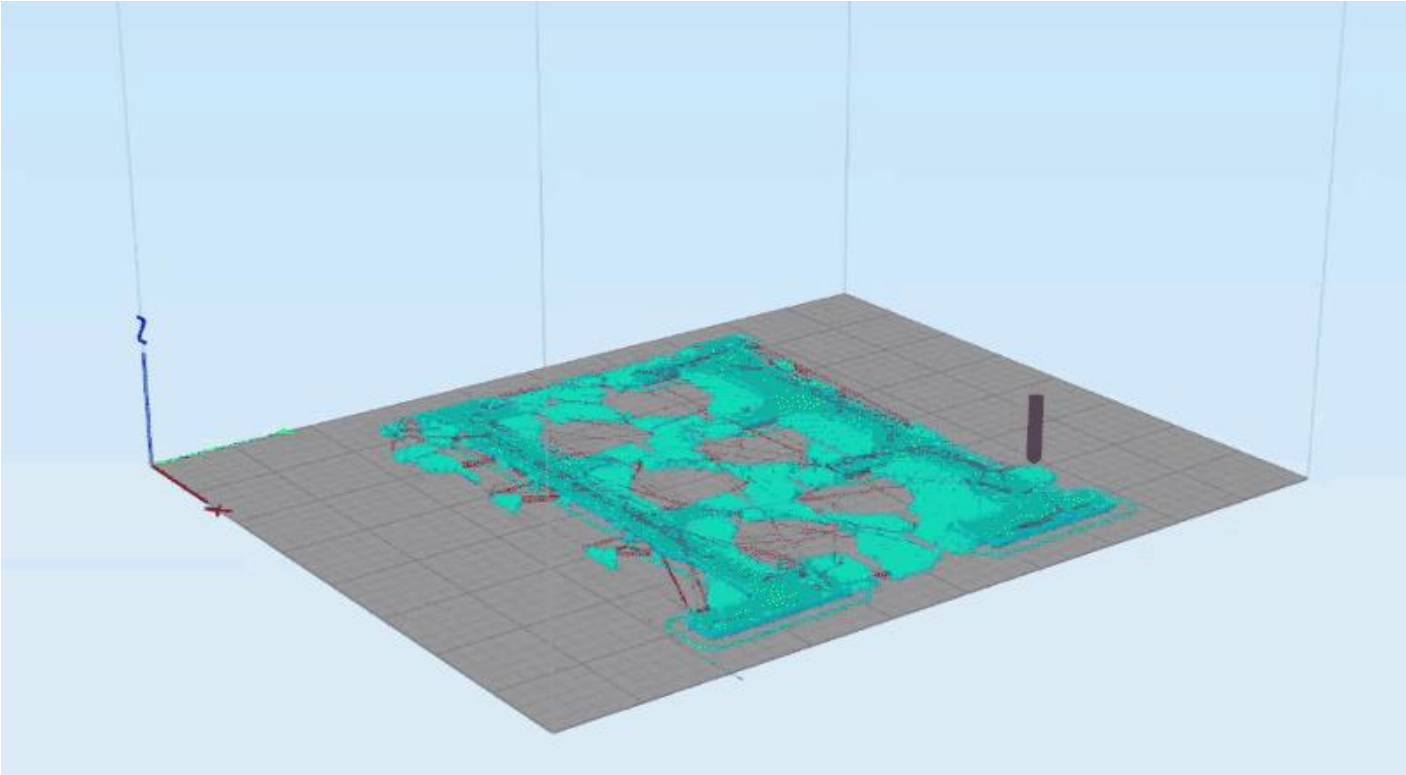
Product Certification & Design Organisation Approval Workshop

Cologne, 19 – 20 November 2019

Content

- **1st Part**
  - AM Technology and Challenges
  - EASA AM Strategy and Requirements
  - Annual AM workshops
  - SAE AM Standards Development
  - AM Guidance Material
- **2nd Part**
  - AM and DOA
  - Type Design, Material Spec, Process Spec
  - Interface DO-PO
  - Significant Change to Design Assurance System
- Closure remarks

AM Technology and Challenges / 1st Part



AM Technology and Challenges / 1st Part

Material
(metallic/plastic)

+

Process

=

Part

Uncertainties in the Input Materials

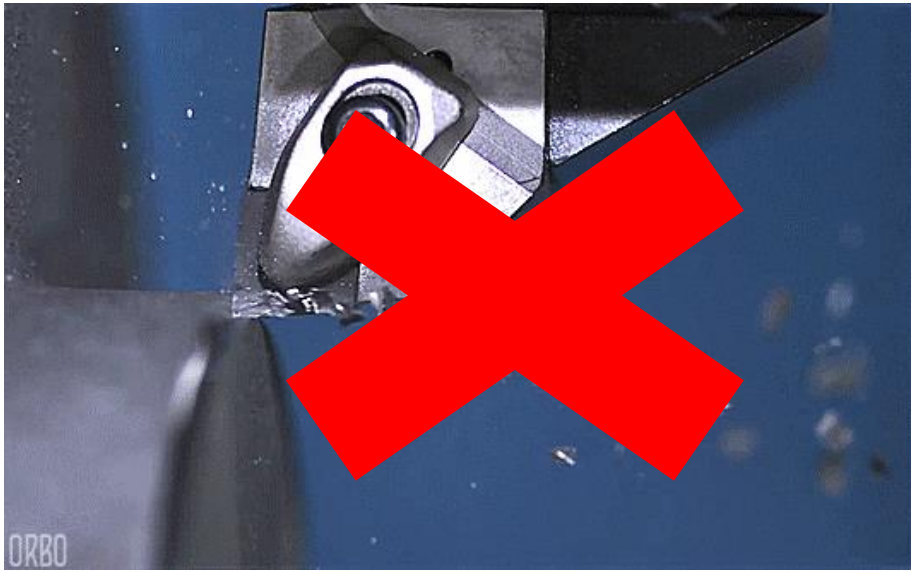
+

Uncertainties in Equipment and Process Performance

=

Uncertainties in the Final Parts

AM Technology and Challenges / 1st Part



Building objects up layer by layer, instead of traditional machining processes that cut away material can reduce material needs and costs by up to 90%

AM saves energy by eliminating production steps, substantially less material, enabling reuse of by-products, and producing lighter products

EASA AM Strategy and Requirements / 1st Part

- Understand the technology / process / product and its actual, planned or potential uses.
- Identify potential safety / environmental risks.
- Define and implement means to mitigate risks working closely with industry and NAAs (survey responsabilities for POA).
- Monitor evolution of technology / product / process and effectiveness of mitigation.
- Review and revise implementation of strategy as necessary.

EASA AM Strategy and Requirements / 1st Part

→ **Question:**

Do we need any new requirements, to cope with this new technology?

→**Answer:** currently „No“

→ **It is all about reminding how:**

- → Repairs and Design Changes
- → Impact of AM on design organizations
- → Impact of AM on production organizations
- → Impact of AM on maintenance organizations

EASA AM Strategy and Requirements / 1st Part

- governing rule is CS 2x.603:

CS 25.603: Materials (For Composite Materials see AMC 20-29*)

'The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must…..'

- be based upon experience/test
- conform to specifications (meeting design data)
- consider environmental effect (temperature, moisture etc)

*AMC 20-29 - harmonised with FAA AC 20-107B

EASA AM Strategy and Requirements / 1st Part

CS 25.605: Fabrication Methods

(a) The methods of fabrication used must produce a consistently sound structure. If a fabrication process (such as gluing, spot welding, or heat treating) requires close control to reach this objective, the process must be performed under an approved process specification.

(b) Each new aircraft fabrication method must be substantiated by a test programme

CS 25.613: Mechanical Strength Properties and Design Values Materials

(a) Material strength properties must be based on enough tests of material meeting approved specifications to establish design values on a statistical basis. *(A and B-basis)*

Annual AM workshops / 1st Part

- → **1st EASA Workshop on AM, 28th Sep. - 29th Sep. 2016, Cologne**
  - → generic
- → **2nd EASA Workshop on AM, 27th Sep. - 28th Sep. 2017, Cologne**
  - → generic
- → **3rd EASA Workshop on AM, 28th Jun. - 29th Jun. 2018 , Cologne**
  - → Machine Knowledge and Training
- → **4th FAA/EASA Workshop on AM, 21st Aug. - 23rd Aug. 2018, Wichita**
  - → Qualification and Certification of Metal Additive Manufactured Parts
- → **5th EASA/CAAS Workshop on AM, 15th Oct. – 16th Oct. 2018, Singapore**
  - → generic
- → **6th EASA/FAA Workshop on AM, 5th Nov. – 7th Nov. 2019, Cologne**
  - → Machine and Material qualification
  - → Designing for AM
  - → F&DT for AM (including NDI considerations)

for download on EASA website !

EASA

SAE AM Standards Development / 1st Part

→ Sub Groups of AM Specifications (SAE)

- → **Powder** Specifications (Feedstock Material, metall powder)
- → **Process** Specifications (EBM, LBM, Powder Bed Fusion, Wire DED)
- → **Material** Specifications (post processing)

SAE AM Standards Development / 1st Part

→ Published

- → **AMS7000** - Laser-Powder Bed Fusion (L-PBF) Produced Parts, Nickel Alloy, Corrosion and Heat-Resistant, 62Ni - 21.5Cr - 9.0Mo - 3.65Nb Stress Relieved, Hot Isostatic Pressed and Solution Annealed
- → **AMS7001** - Nickel Alloy, Corrosion and Heat-Resistant, Powder for Additive Manufacturing, 62Ni - 21.5Cr - 9.0Mo - 3.65Nb
- → **AMS7002** - Process Requirements for Production of Metal Powder Feedstock for Use in Additive Manufacturing of Aerospace Parts
- → **AMS7003** - Laser Powder Bed Fusion Process
- → **AMS7004** - Titanium Alloy Preforms from Plasma Arc Directed Energy Deposition Additive Manufacturing on Substrate Ti-6Al-4V Stress Relieved Process
- → **AMS7005** - Wire Fed Plasma Arc Directed Energy Deposition Additive Manufacturing Process
- → **AMS7008** - Nickel Alloy, Corrosion and Heat-Resistant, Powder for Additive Manufacturing, 47.5Ni - 22Cr - 1.5Co - 9.0Mo - 0.60W - 18.5Fe (Hastalloy) Powder Specifications
- → **AMS7013** - Nickel Alloy, Corrosion and Heat-Resistant, Powder for Additive Manufacturing, 60Ni - 22Cr - 2.0Mo - 14W - 0.35Al - 0.03La Process
- → **AMS7014** - Titanium Alloy, High Temperature Applications, Powder for Additive Manufacturing, Ti - 6.0Al - 2.0Sn - 4.0Zr - 2.0Mo Process

SAE AM Standards Development / 1st Part

→ Forthcoming

- → **AMS7006** - Alloy 718 Powder
- → **AMS7007** - Electron Beam Powder Bed Fusion Process
- → **AMS7009** - Additive Manufacturing of Titanium 6Al4V with Laser-Wire Deposition - Annealed and Aged
- → **AMS7010** - Laser-Wire Directed Energy Deposition Additive Manufacturing Process
- → **AMS7011** - Additive manufacturing of aerospace parts from T-6Al-4V using the Electron Beam powder bed fusion EB-PBF) process
- → **AMS7012** - 17-4PH Powder for Additive Manufacturing
- → **AMS7015** - Ti-6Al-4V, Powder For Additive Manufacturing
- → **AMS7016** - Laser-Powder Bed Fusion (L-PBF) Produced Parts, 17-4PH H1025 Alloy
- → **AMS7017** - Titanium 6-Aluminum 4-Vanadium Powder for Additive Manufacturing, ELI* Grade
- → **AMS7018** - Aluminum Alloy Powder 10.0Si - 0.35Mg (Compositions similar to UNS A03600)
- → **AMS70xx** - EBPBF Ti-6Al-4V Material Specification

* ELI: Extra Low Interstitials - referring to the purity level (O, C, N, ...)

AM Guidance Material / 1st Part

→ EASA CM–S-008 Issue 01 (published since April 2017)

→ Requirements:
CS X.571, CS X.603, CS X.605, CS X.613, CS-E 70, CS-E 100 (a), CS-P 170, CS-P 240, CS-APU 60, GM 21.A.91, 21.A.101, 21.A.133, 21.A.433, GM 21.A.435, 21.A.437, 21.A.447, 21.A.805, AMC 145.A.42(c)

→ Purpose/Scope: …provide guidance regarding regulator expectations relating to the usage of AM technologies in products (Aircraft, Rotorcraft and Propulsion) subject to EASA Type Certification

→ Update of CM on criticality approach with adaptive and straightforward guidance on statistical material properties

AM Guidance Material / 1st Part

EASA AM Guidance to POA/DOA/Maintenance because:

- possible need to increase awareness of closer relationship between design, production, continued airworthiness (CAW), more integrated than many typical metallic processes (some similarities wrt composites)

- need to increase awareness of existing rules, particularly at interfaces between design, production, and maintenance, e.g. link between non-TCH DOA, PART 145 (AMC 145.A.42 para.7), and the need for TCH data for extensive repair and ‘replacement’ (also similarities wrt composites)

2nd Part

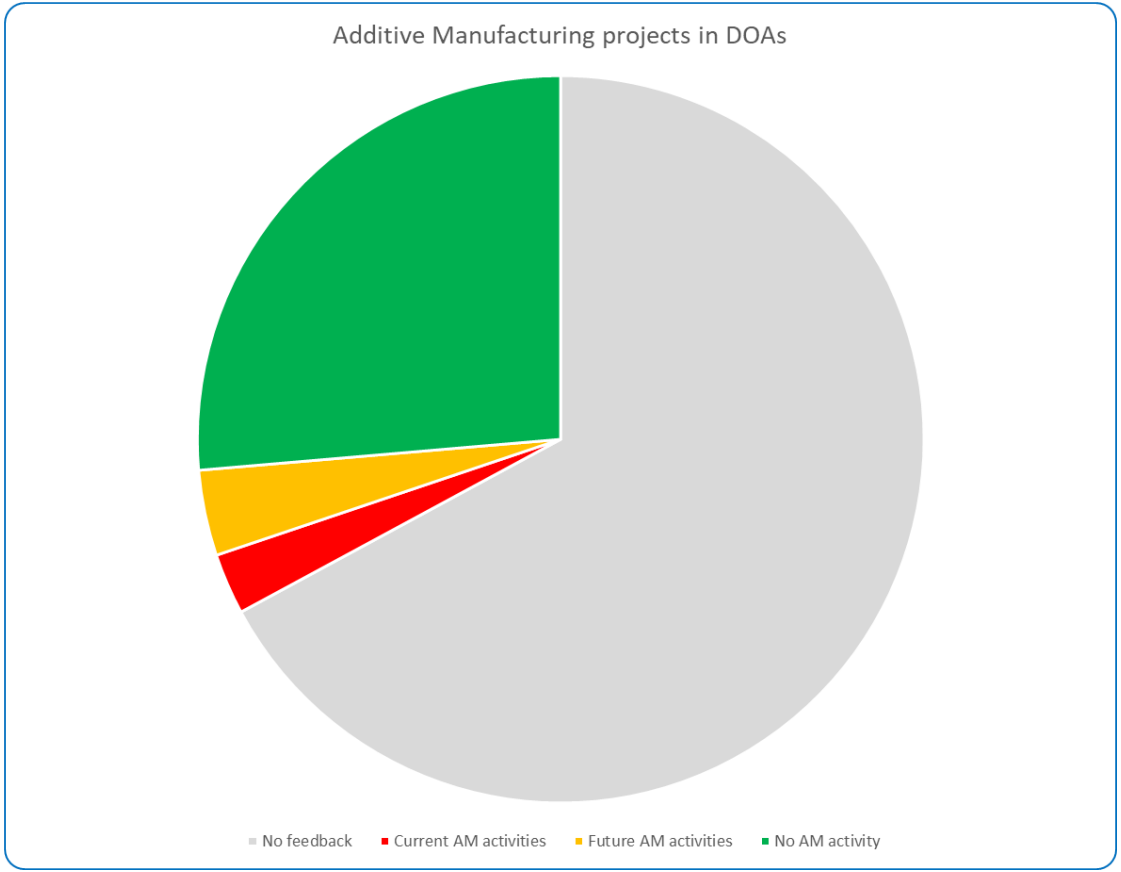
AM and DOA / 2nd Part

Some statistics

(beginning 2019)

3…4 % of the DOAs

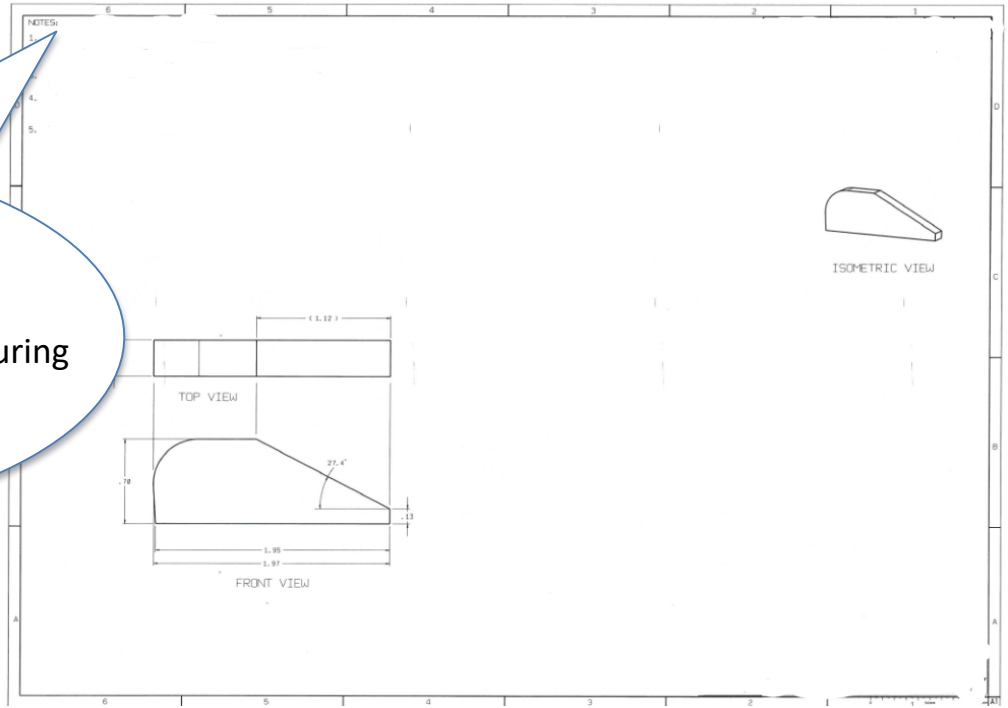
have current AM activities



AM and DOA / 2nd Part

How a DOA may start AM activities?

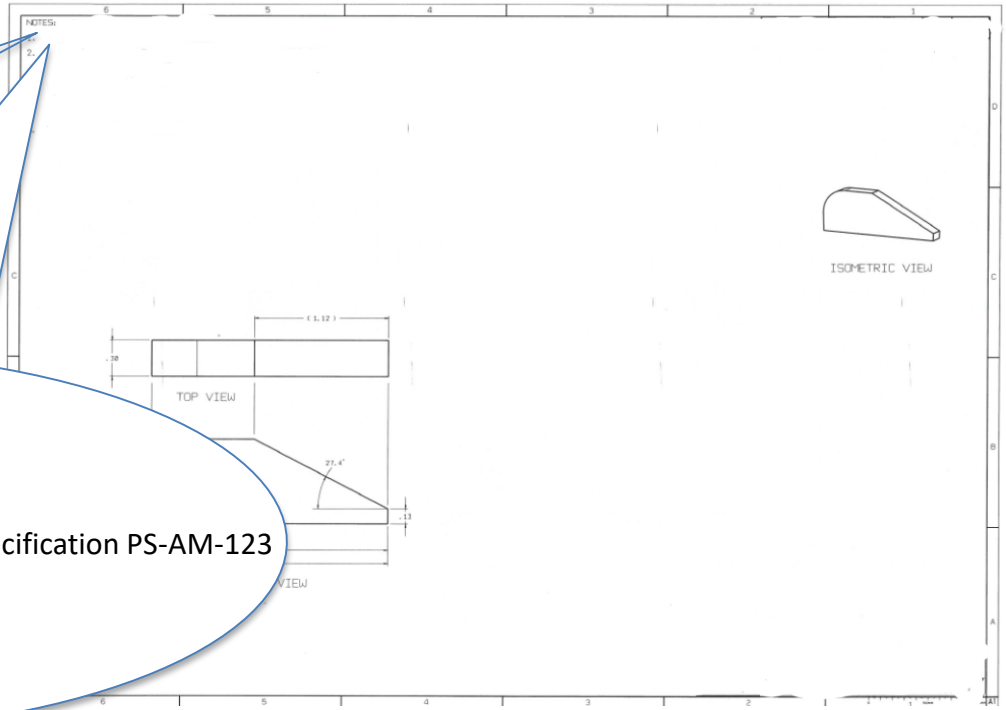
Notes
1. …
2. Part to be made by Additive Manufacturing
3. …



AM and DOA / 2nd Part

How a DOA may start AM activities?

Notes
1. …
2. Part … Manufacturing
3. …



Notes
1. …
2. Part to be made per AeroX DOA process specification PS-AM-123
3. …

Type Design, Material Spec, Process Spec/ 2nd Part

As part of a design and certification exercise, a DOA has to be able to define, qualify and control the material specifications and process specifications related to AM.

CS 25.603 Materials & CS 25.605 Fabrication methods

Approved material / process specification

21.A.31 – Type design

(a) The type design shall consist of:

1. the drawings and specifications, […]

[…]

Type Design, Material Spec, Process Spec/ 2nd Part

AM Process Specification

The AM process is dependent of a large number of factors. Depending on the particular application, the items which may need to be address in such document include: (non-exhaustive list)

- Scope (including the type of AM process)
- Applicability & Limitations (e.g. type of parts which may be manufacture according to the respective spec)
- Material (material spec, handling req., storage req.)
- Machine, equipment & tools (e.g. machine manufacturer, type/model, calibration, maintenance)
- Facilities (e.g. machine environment)
- Process description
    - Preparatory work (e.g. CAD/CAM interface);
    - Printing steps
    - Key parameters
    - Post processing
- Inspection requirements / Test requirements
- Part marking

Type Design, Material Spec, Process Spec/ 2nd Part

AM Process Specification

- The AM Process Specification may refer to existent industrial standards

- AM process should be subject of qualification

  by qualification it is demonstrated that the process complies with the defined specification and parts are manufactured in a reproducible way

- AM material / process specifications are not only part of the type design but also part of the compliance demonstration

- As part of the Type Design, the material / process specifications are subject of the TC change process

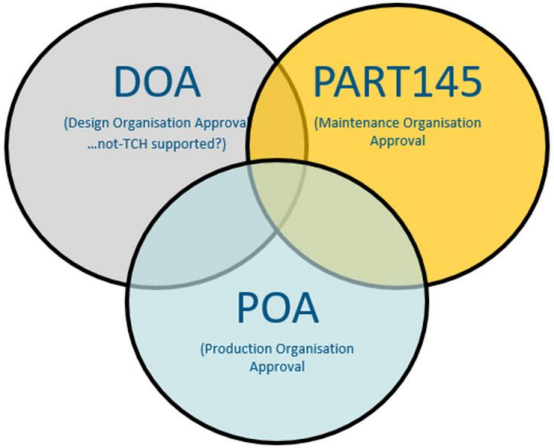
Interface DO-PO / 2nd Part

Various aspects have to be considered for this interface

→ Transfer of design data

→ Generation of manufacturing data

→ Qualification of the AM process



Additional challenges may intervene when the fabrication of AM parts is contemplated not in a production environment but in a maintenance organisation.

Significant Change to the Design Assurance System / 2nd Part

Depending on the particular application, there are quite a number of activities which a design organisation may need to undertake. These activities have to be subject of written procedures.

If a DOA has not yet implemented such procedures than we would expect that an application (EASA Form 82) for Significant Change to the Design Assurance System is submitted.

acc. 21.A.247 / GM 21.A.247

Even if procedures for definition and qualification of material / manufacture specification exist, we encourage you to discuss with your DOA Team Leader when you are considering using these procedures for introduction of AM processes

Significant Change to the Design Assurance System / 2nd Part

Either as part of the Significant Change investigation or normal surveillance, the EASA DOA Team (including the relevant EASA experts) will review several aspects, including:

Type design definition
Configuration control
Change / Repair
Classification
Certification Basis
Qualification process
Testing
Supplier control
DO-PO interfaces
Training

The investigation / surveillance review and audits might involve POA Team(s) as well

Closure remarks

→ Contact your DOA Team Leader to discuss your AM (intended) activities

→ Contact EASA AM Working Group

- Chief Expert - Airframe	R. Minter – richard.minter@easa.Europa.eu
- Structures	S. Waite (AM WG chair) – simon.waite@easa.europ.eu
	W. Hoffmann - wolfgang.hoffmann@easa.europa.eu
- Propulsion	M. Mercy - matthew.mercy@easa.europa.eu
	O. Kastanis - omiros.kastanis@easa.europa.eu
- Systems	M. Weiler - michael.weiler@easa.europa.eu
- Cabin Safety	T. Ohnimus - thomas.ohnimus@easa.europa.eu
- DOA	A. Enache - alexandru.enache@easa.europa.eu
	O. Tribout - olivier.tribout@easa.europa.eu
- POA	D. Lamothe - dominique.lamothe@easa.europa.eu
	S. Pernet - samuel.pernet@easa.europa.eu
- Maintenance	R. Tajas - rosa.tajes@easa.europa.eu

→ Follow EASA AM events (dedicated workshops, industry meetings,…)

→ Follow the EASA news on AM

EASA
European Union Aviation Safety Agency

Any questions

easa.europa.eu/connect

Your safety is our mission.

An Agency of the European Union