Certification Memorandum

Additive Manufacturing

EASA CM No.: CM–S-008 Issue 04 issued 3 September 2025

Regulatory references:
Primarily impacted product CSs:
CS2x.305, CS2x.307, CS 2X.571, CS 2X.603, CS 2X.605, CS 2X.613, CS 2X.853, CS23.2260, CS E.70, CS E.100 (a), CS P.170, CS P.240, CS APU.60, CS-ETSO (see ~~Section 2 Tables, and~~ Appendix 1 for more detailed CS listing)
Other potentially impacted references:
21.A.15, AMC 21.A.15(b), 21.A.31, GM 21.A.91, 21.A.101, 21.A.131, 21.A.133, 21.A.147, 21.A.247, 21.A.307(b), 21.A.433, GM 21.A.435(a), , 21.B.100, Part 21 Light, 145.A.42(b), CAO.A.020, M.A.603(c)

EASA Certification Memoranda clarify the European Union Aviation Safety Agency's general position on specific initial airworthiness, validation, continuing airworthiness or organisational items. They are intended to provide guidance on a particular subject and may provide complementary information for compliance demonstration, similar to AMC/GM even if not formally adopted through an ED Decision. Certification Memoranda are not intended to introduce new certification requirements or to modify existing certification requirements.

Note: Also see the Supplemental document supporting this revision to the CM

Log of issues

Issue	Issue date	Change description
01	04.04.2017	First issue.
02	03.11.2020	Issue 2 included new supporting text for the existing basic CS materials requirements and guidance regarding the use of AM in non-critical parts. Issue 2 also emphasised the importance of the appropriate transfer of knowledge and training.
03	30.04.2021	Issue 3 included all changes introduced based on the comments received during the public consultation of Issue 2 from 3rd to 24th November 2020.
04	03.09.2025	Issue 4 includes revisions following various industry - regulator AM activities, e.g. annual industry – regulator AM Events 2021/2022/2023/2024, supporting Working Group and SDO activities etc., addressing: - criticality classification - emphasis upon completing an appropriate design safety assessment - certification effort being proportionate to criticality - AM parts of no or low criticality (including examples) - reference updates - text re-organisation

Table of Content

1. Introduction

1.1. Purpose and scope

The purpose of this Certification Memorandum is to provide guidance regarding EASA certification effort expectations of industry associated with the introduction and use of Additive Manufacturing (AM) technologies (metallic and non-metallic) across a broad range of Products, Parts, and Appliances subject to showing compliance with CS-22, CS-VLA, CS-23, CS-25, CS-VLR, CS-27, CS-29, CS-E, CS-P, CS-APU, CS-ETSO, including other emerging product Certification Specifications (CSs) and Special Conditions (SCs), e.g. those addressing VCA etc.

This CM has been developed in conjunction with tasks, priorities, and objectives identified in various industry-regulator AM related activities, e.g EAAMIRG Actions.

EAAMIRG Action Item 1: Part Classification and Authority Engagement
EAAMIRG Action Item 2: Standardisation: understanding and use of 'standards'

Issue 3 of this CM was raised following rapid development in the planned use of AM since the initial release of the CM and also following considerable dialogue between industry and the regulators (in accordance with the intent of this CM at issue 1). Issue 3 included new guidance intended to support the existing certification specifications (see Appendix 1 of this CM), some of which have been superseded by revision to AMC 25.603, 605, and 613, for CS25 at amdt.27 (intended to address materials, processes, and fabrication methods, including Advanced Manufacturing methods, such as AM). Issue 3 also included some guidance associated with the use of AM in non-critical applications and emphasised the importance of appropriate knowledge transfer and training.

Issue 4 builds upon subsequent industry-regulator AM activities, including the annual industry – regulator AM Event 2021, 2022, 2023 and 2024 Working Group activities, and progress made in other various Working Groups, e.g. EAAMIRG, AIA, MMPDS, and other Standards Development Organisations (SDOs). Issue 4 content has also been developed in response to industry questions to EASA. Amendments include reference to standardisation of understanding and awareness of criticality and new emphasis upon the importance of developing appropriate thorough design safety assessment processes, e.g. FHAs, FMECAs, ~~RASs~~ etc., particularly for non-Type Certificate Holder (TCH) organisations repairing or altering baseline structures and systems. Issue 4 also develops the intent for initial demonstration of certification effort to be proportionate to novelty, criticality, and complexity, and provides further guidance regarding the use of AM in no or low-criticality applications, including the addition of a new Appendix 5 'Examples'.

At the time of this CM revision, AM has been used for new parts or parts produced for the purpose of 'repair by replacement'. Therefore, **the scope for this CM Policy revision (Section 3) is limited to new parts or 'repair by replacement' for parts of no and low criticality**. Further revision to this CM will be required for repairs involving material build up on baseline structure damaged (and prepared) surfaces.

Note: ~~AM is a term used to cover a broad range of new and emerging manufacturing processes (also known as 3D printing) that involve sequential-layer material addition (metallic and/or non-metallic) throughout a 3D work envelope (i.e. 'build space', 'build volume') under automated control.~~ This CM does not address established and approved methods which may demonstrate similarities with the evolving definitions of AM, e.g. repetitive weld build-up repair processes accepted prior to the issue of this CM.

Note: This CM does not attempt to catalogue the use of, or repeat detail from, the many evolving industry guidance documents related to AM materials, processes, fabrication methods, or applications. The use of such guidance, e.g. as developed by standardisation bodies, industry-regulator groups etc., may be accepted based upon demonstration of appropriate applicability and substantiation, as agreed with the competent authority.

IMPORTANT REMINDER: AM is a rapidly developing technology supported by many developing industry guideline documents, but lacking regulatory guidance in any detail. Therefore, this CM revision process attempts to periodically document and share progress relative to EASA regulatory expectations and does not represent a complete or final EASA position. EASA is of the opinion that this approach is preferable, i.e preferable to not doing so, for the purposes of visibility and for progressing safe development and use of AM in certified parts.

Section 2 content ONLY provides background and context for the developing Policy, NOT Policy~~, unless specifically directly referenced from Section 3.~~ .

Section 3 content provides Policy. This revision addresses early engagement with EASA regarding AM and also applications of no or low criticality (Class~~ifications~~ C and D).

NOTE: This CM revision is supported by a Supplemental document intended to record supporting discussion necessary to provide context for this revision content, and also for potential future CM revision evolutions. Such supplemental documents are considered to be appropriate in the absence of complete and published reference documentation existing elsewhere, as may be typical for new and developing technologies and applications, whilst maintaining a more acceptable and manageable format for the main CM document.

1.2. References

It is intended that the following reference materials be used in conjunction with this Certification Memorandum:

Note: Although it is not common to include reference to other draft guidance documents in regulatory guidance, EASA considers that the context of this CM development justifies such referencing in Section 2 for the purposes of discussion because it addresses rapidly developing new technology applications, particularly also noting the broader intent of a CM (see cover page text). However, in the case of any perceived conflict of information, existing established regulatory guidance, including this CM, takes precedent and/or EASA may be consulted for clarification.

Reference	Title	Code	Issue	Date
AIA	AIA Recommended Guidance for Certification of AM Components			February 2020
ASTM F3572-22	'Standard Practices for Additive Manufacturing – General Principles – Part Classifications for Additive Manufactured Parts Used in Aviation'			2022
DO160	'Environmental Conditions and Test Procedures for Airborne Equipment'			2010
EASA CM 21.A-K-001	Installation of new parts and appliances without an EASA Form 1 https://www.easa.europa.eu/en/document-library/product-certification-consultations/easa-cm-21a-k-001-certification-memorandum		Issue 2	June 2023
EASA CM-S-002	'Application of CS 25.561(c)(2) 1.33 'Wear and Tear' Factor – Frequent Removal of Interior Structures' https://www.easa.europa.eu/en/document-library/product-certification-consultations/easa-cm-s-002		Issue 1	June 2014

Reference	Title	Code	Issue	Date
Supplement to EASA CM-S-008	Additive Manufacturing (supplemental document)			2025
FAA AC 33.15-3	Powder Bed Fusion Additive Manufacturing Process for Aircraft Engine Parts			2023
FAA AC 43-18	Fabrication of Aircraft Parts by Maintenance Personnel		Chg 2	Feb. 2008
FAA memo	Applicant Specific Guidance Memorandum for Additive Manufactured (ASGM) Parts for Transport Airplanes' (outline as delivered by FAA at the EASA FAA AM Event 2021): https://www.easa.europa.eu/newsroom-and-events/events/easa-faa-industry-regulator-am-event-0			2021
~~FAA RAS~~	~~Risk Analysis Specification (RAS) – https://my.faa.gov/sites/my.faa.gov/files/org/linebusiness/avs/offices/air/sms/cos/RiskAnalysisSpec.pdf~~			~~October 2006~~
ISO/ASTM DIS 52927:2022	'Additive manufacturing – General principles – Main characteristics and corresponding test methods'			2022

1.3. Abbreviations and Definitions

1.3.1 Abbreviations:

ADOA	Alternative Procedures to Design Organisation Approval
AIA	Aerospace Industry Association
AM	Additive Manufacturing
AMC	Acceptable Means of Compliance
AMPs	Advanced Materials and Processes
ASGM	Applicant Specific Guidance Memorandum (FAA)
ASTM	American Society for Testing and Materials
BC	Boundary Conditions
CACRC	Commercial Aircraft Composite Repair Committee
CDI	Compliance Demonstration Item
CM	Certification ~~Memoranda~~Memorandum

CMH-17	Composite Materials Handbook – 17
CRI	Certification Review Item
CS	Certification Specification
DDP	Declaration of Design and Performance
DEV	Deviation
DO	Design Organisation
DOA	Design Organisation Approval
EAAMIRG	European Aviation Additive Manufacturing Industry Regulator Group
EASA	European Union Aviation Safety Agency ("the Agency")
EB-PBF	Electron Beam Powder Bed Fusion
ECS	Environmental Control System
ESF	Equivalent Safety Finding
ETSO	European Technical Standard Order
FAA	Federal Aviation Administration
FDM	Fused Deposition Modeling
FE	Finite Element
FHA	Functional Hazard Assessment
FMEA	Failure Mode and Effects Analysis
FMECA	Failure Mode, Effects, and Criticality Analysis
FPI	Flourescent Penetrant Inspection
GA	General Aviation
GM	Guidance Material
KC	Key Characteristic
KPP	Key Process Parameter
LoI	Level of Involvement (EASA Point 21.B.100)
LL	Limit Load
L-PBF	Laser Powder Bed Fusion
M&P	Materials and Processes

MMPDS	Metallic Materials Properties Development and Standardisation
MoC	Means of Compliance
NDI	Non Destructive Inspection
OQ	(Machine) Operational Qualification
PCD	Process Control Document
PDA	Part Departing Aircraft
PFMEA	Process Failure Mode and Effects Analysis
POA	Production Organisation Approval
PQ	(Process) Performance Qualification
PSE	Principal Structural Element
~~RAS~~	~~Risk Analysis Specification (FAA)~~
REACH	Registration Evaluation, Authorisation and Restriction of Chemicals
SAE	Society of Automotive Engineers
SC	Special Condition
SDO	Standards Development Organisation
SPC	Statistical Process Control
STC	Supplemental Type Certificate
STCH	Supplemental Type Certificate Holder
TC	Type Certificate
TCH	Type Certificate Holder
UL	Ultimate Load
VCA	VTOL Capable Aircraft

1.3.2 Definitions:

The following list attempts to use existing definitions from other regulatory and guidelines documents in order to minimise divergence in guidance. Furthermore, some new definitions are added, as necessary.
Note: Applicants are reminded that inconsistencies exist in literature and throughout industry regarding some definitions and terminology, e.g. definitions of anomalies, flaws, and defects. Therefore, applicants are advised to clearly define intended meanings in certification processes.

Allowable (AMC 20-29): Material values that are determined from test data on a probability basis (e.g., A or B basis values, with 99% probability and 95% confidence, or 90% probability and 95% confidence, respectively). The amount of data required to derive these values is governed by the statistical significance (or basis) needed.

Anomaly (for the purposes of this CM, proposed by FAA, until any further standardisation occurs): Flaw or defect that deviates from what is expected or an abnormality that cannot be explained for a specific material type.

A-Basis (MMPDS): The lower value of either the statistically calculated number T99, or the specification minimum (S-basis). The statistically calculated number indicates that at least 99 percent of the population is expected to equal or exceed the statistically calculated mechanical property value with a confidence of 95 percent. This statistical calculated number is computed using MMPDS (Vol.1) procedures, or similar, e.g. CMH-17

B-Basis (MMPDS): This designation indicates that at least 90 percent of the population of values is expected to equal or exceed the statistically calculated mechanical property value, with a confidence of 95 percent. This statistical calculated number is computed using MMPDS (Vol.1) procedures, or similar, e.g. CMH-17

Criticality: See Section 2 subpart 'Design certification 'Criticality' and proportionate certification effort demonstration'

C-Basis (MMPDS): The lower of either a statistically calculated number, or the specification minimum (S-basis). The statistically calculated number indicates that at least 99 percent of the population of values is expected to equal or exceed the C-basis material allowable, with a confidence of 95 percent. This statistically calculated number is computed using the procedures specified in MMPDS Volume II, Section 9.5. Use of these values to demonstrate compliance with static strength requirements requires further showing; see MMPDS Volume II, Chapter 10

Declaration of Design and Performance (DDP) (Regulation (EU) No 748/2012 21.A.608): The central summary document containing the definition and all relevant references of an article. Its informational content could be compared to the one of a Type Certificate Data Sheet for products. In the DDP the applicant is required to state that the article is designed, tested and manufactured in compliance with the applicable sections of Part 21 and CS-ETSO.

Defect (ASTM E1316-23a): One or more flaws whose aggregate size, shape, orientation, location, or properties do not meet specified acceptance criteria and are rejectable.

Design Safety Assessment (for the purpose of this CM): Terminology used in this CM to encompass all appropriate 'top down' and 'bottom up' assessments, e.g. Safety Assessments, FHA, FMECA~~, RAS~~ etc.

Design Value (AMC 20-29): Material, structural elements, and structural detail properties that have been determined from test data and chosen to assure a high degree of confidence in the integrity of the completed structure. These values are most often based on allowables adjusted to account for actual structural conditions, and used in analysis to compute margins-of-safety.

D-Basis (MMPDS): At least 90 percent of the population of values is expected to equal or exceed the D-Basis material allowable, with a confidence of 95 percent. This statistically calculated number is computed using the procedures specified in MMPDS Volume II, Section 9.5. Use of these values to demonstrate compliance with static strength requirements requires further showing; see MMPDS Volume II, Chapter 10.

'End to end' (for the purposes of this CM): Terminology used to indicate consideration throughout design, production, and in-service, including raw material suppliers, AM machine manufacturers and suppliers, and other stakeholders.

Flaw (ASTM E1316-23a): An imperfection or discontinuity that may be detectable by nondestructive testing and is not necessarily rejectable.

Flaw characterization (ASTM E1316-23a) : The process of quantifying the size, shape, orientation, location, growth, or other properties, of a flaw based on NDT [non-destructive testing] response.

Full MoC: (for the purposes of this CM): Complete MoC, as would be used for a 'conventional ' safety critical part, e.g. complete A or B-Basis testing, testing of all appropriate load cases at various levels in the test and analysis test pyramid, full instrumentation etc

Machine Operational Qualification (OQ) (AIA Recommended Guidance for Certification of AM Components 2020)**:** OQ is to be performed under sufficient process control to maintain stable material performance. Machine OQ occurs when the machine is qualified to a given material specification. OQ has been completed when it has been demonstrated that the material specification requirements can be met by the machine with statistical relevance over multiple builds.

Point Design (AMC 20-29): An element or detail of a specific design which is not considered generically applicable to other structure for the purposes of substantiation, e.g., lugs and major joints. Such a design element or detail can be qualified by test or by a combination of test and analysis.

Process Performance Qualification (PQ) (AIA Recommended Guidance for Certification of AM Components 2020)**:** PQ has occurred when it has been demonstrated that all product requirements are met, under process control, and can be produced with statistical relevance over multiple builds in a production environment.

Simplified MoC (for the purposes of this CM): Reduced and/or selective MoC, as might be used in proportion to lower criticality applications, e.g. use of reduced test item numbers for B-Basis (e.g. using factors associated with normal distribution), reduced load case and/or 'Point Design' testing (as might be used for a part/detail with a dominant load case), reduced instrumentation, use of higher design factors, demonstration of applicability and equivalence with respect to an established and accepted database etc.

S-Basis (MMPDS): At least 99 percent of the populations of values are excepted to equal or exceed the S-Basis material allowable, with a confidence of 95 percent. This statistically calculated number is computed using the procedures specified in MMPDS Section 9.2.4.1, or similar. Use of these values to demonstrate compliance with static strength requirements may require further showing.
Note : Also see ESDU 00932 MMDH (Metallic Materials Data Handbook)

Threat Assessment (AMC 20-29): Determination of possible locations, types, and sizes of damage considering fatigue, environmental effects, intrinsic flaws, and foreign object impact or other accidental damage (including discrete source) that may occur during manufacturing, operation or maintenance

2. Background – increasing development of AM use in aviation and the EASA regulations

~~**IMPORTANT REMINDER:**~~

~~**Section 2 content ONLY provides background and context for the developing of Policy, NOT Policy, unless specifically directly referenced from Section 3.**~~

~~**Section 3 content provides Policy. This revision addresses early engagement with EASA regarding AM and applications of no or low criticality (Classifications C and D).**~~

Additive Manufacturing (AM), also known as 3-D printing, refers to a range of manufacturing methods where the as-purchased feedstock material (i.e. powder, wire, filament etc.) is consolidated by a machine into a near-finished part. For example, for metallic materials, typically the as-purchased material is deposited in the machine by various methods and fused using lasers, electron beams, plasma or electrical arc into a near final shape component or surface, whilst non-metallic materials may be heated and extruded through a moving nozzle to create a final part. Consequently, these methods can produce complex parts with 'engineering properties' which are highly material, process, and configuration dependent and which may generate significant variability if production is not governed by strict process control documentation. Therefore, design and production of parts using AM on certified products will rely upon close communication between design organisations, production organisations, equipment manufacturers (and/or equipment suppliers) and material manufacturers and/or suppliers.

Background - Design certification regulations:

EASA review (within the EASA AM Working Group, see Appendix 6 'contacts' list) indicates that no CS level change is required to specifically address the use of AM. However, some broader revisions to CS25.603, 25.605, and 25.613 AMC were completed in 2021 (see CS25 amdt.27) in order to update the texts and to better reflect recent and emerging materials, processes, and fabrication methods (often referred to as 'Advanced Materials and Processes' (AMPs) or 'Advanced Manufacturing'). Although the CSs have not been changed specifically for AM, these AMC amendments are also intended to better support certification of products including AM technology, e.g. by placing explicit emphasis upon the need to determine representative design values which may be defined during material consolidation in the near-finished complex part configuration and which may impact addressing CS2x.305 and CS2x.307, including appropriate test and analysis pyramid definitions (to be defined by the DO with appropriate understanding and support from the PO regarding production processes and related stakeholder inputs). Furthermore, these revisions to the AMC have been made to better align with the regulatory move towards the use of 'Performance Based Regulation*' (being more safety outcome driven, less prescriptive driven) and also the expectations for certification effort to initially be demonstrated to be proportionate to 'criticality', aligned with Level of Involvement (LoI) regulatory guidance, ref. AMC 21.B.100(a).

*https://www.easa.europa.eu/sites/default/files/dfu/Report%20A%20Harmonised%20European%20Approach%20to%20a%20Performance%20Based%20Environment.pdf

Note: CS25 amdt.27 AMC revisions address~~es~~ 'Large Aeroplane' products. However, they have been written to also be broadly applicable for consideration when showing compliance with other product CSs. EASA plans to amend and further align the other product CS and AMC texts accordingly and/or produce a generic AMC 20-XX document 'Advanced Manufacturing'.

Note: The 'novelty' of AM applications in aviation limits potential use of existing experience based quantitative data (e.g. to assess frequency of relevant events) necessary to develop complete Risk Assessments in conjunction with criticality classifications in support of existing EASA LoI strategies, e.g. EASA Point 21.B.100 and AMC (LoI). Therefore, 'engineering judgement' will be important for the development of an initial 'step by step' strategy supporting the use of AM relative to criticality.

Note: Work addressing other developing technologies is in progress to support 'similar' processes (largely from a qualitative perspective), e.g. SAE ARP7520 'Aircraft Modifications Involving Composite~~ Aircraft Structures~~' (draft), being developed by SAE CACRC, as tasked by FAA.

Note: EASA recognises that much of the content in this CM, particularly that associated with applications of no or low criticality, is adequately generic to be more broadly applicable to materials, processes, and fabrication methods other than AM. Therefore, the scope of applicability of this CM content could potentially be developed accordingly. However, this would require further work beyond the scope of this CM.

3. EASA Certification Policy and Guidance for DOA, ADOA and POA Holders*

*see Appendix 1 for associated regulations

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~~Section 2 content ONLY provides background and context for the developing Policy, NOT Policy, unless specifically directly referenced from Section 3.~~

~~Section 3 content provides Policy. This revision addresses early engagement with EASA regarding AM and applications of no or low criticality (Classifications C and D).~~

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All aviation products, parts and appliances are required to meet the relevant certification specifications or other means agreed or prescribed by EASA, e.g. DEV, ESF, SCs etc., respectively, including the ETSO minimum performance standards, according to the type certification basis, e.g. regarding strength, durability, flammability etc.., regardless of the material, process, or fabrication methods used to generate the engineering properties. Therefore, the significance of using additive manufacturing should be considered when establishing the certification programme (including details supporting MoCs) in accordance with points 21.A.15, 21.A.93, 21.A.432C, 21.A.605, or the compliance demonstration plan in accordance with points 21L.A.24 and 21L.A.43.

Note: Applicants are reminded that, typically being of novel material and process, the introduction of AM requires that particular attention be given to satisfying the intent of CS2x.605 for any products.

3.1. Design Certification

EASA expects applicants to adopt a 'step by step' strategy for the increasing design and use of AM in certified products relative to criticality. Therefore, existing policy is limited to the consideration of 'early engagement with EASA' and applications of 'no and low criticality', as follows:

Note: Further guidance regarding criticality classification may be found in Appendices 2 and 3.

3.1.1 Early engagement with EASA:

Individuals or organisations responsible for the design and certification of AM parts (or any repair activities using AM) should pay special attention to the many important considerations, including those below, in the development of AM parts or repairs, ideally before initiating discussion with EASA:

- identify, and demonstrate, understanding of, the part criticality ~~of the application~~ (inclusively accounting for potential new damage and failure modes introduced by AM ~~etc., see Section 2~~) supported by an appropriate Threat Assessment and design safety assessments, e.g. FHA, FMECA~~,~~ ~~RAS~~ etc., including both 'top down' and 'bottom up' assessments.
  Note: EASA's initial expectations of an applicant's effort to demonstrate meeting the requirements will likely be proportionate to the part criticality, novelty, and complexity. **However, this does not alleviate the need for industry from having to complete all necessary work to meet all appropriate safety requirements and this expectation may be tested by the regulators exercising the right to request further information supporting criticality classification and/or substantiation of MoCs.**
- use of appropriate Material & Process specifications, supported by appropriate PCDs
- identification of the Key Variables and Key Process Parameters, including demonstration of understanding of the sensitivity of the 'engineering properties' important to the safety of the final parts and products to the KPPs.
  Note: Associated definitions and practices are yet to be standardised by industry.

- representative development work in support of a first application for any new material and/or process. The extent of initial work is likely to be beyond that expected for a similar application of no or low, criticality using 'conventional' technologies until use of the novel AM material and/or process (novel to the industry and/or applicant and/or regulator) has been successfully established.
- statistical coverage of engineering properties important to safety (noting the potential for many influencing parameters, variability, and different competing damage and failure modes). When certification is predominantly by analysis, it is essential that design values account for variables introduced throughout the AM process used to fabricate production parts, including consideration of the variables associated with the constituent materials (e.g. powder or wire) and post processing.

Note: The statistical management of complex part design value development by 'Point Design' or 'Detail' testing is yet to be standardised.
Note: the use of small datasets should follow acceptable statistical practices, yet to be standardised.

- appropriate and substantiated use of standards
- appropriate transfer of knowledge and control between stakeholders, as necessary to ensure the development of complete and achievable specifications which allow consistent production of safe certified parts.

Note: Applications to EASA may also be supported by applicable information included in response to the recently introduced FAA Applicant Specific Guidance Memorandum (ASGM) intended to encourage early project preparation and engagement with FAA for AM projects, as presented by FAA at the EASA FAA AM Event 2021.

3.1.2 AM parts of 'no or low criticality' (Class C and D only):

Further to para. 3.1.1, for parts of no or low criticality (see Appendices 2 and 3), i.e. being of no, or minimal, safety concern, either at aircraft or passenger level, the applicant will be required to demonstrate emphaisis upon the following:

- **thorough and conservative determination of no or low criticality classification, including both 'top down' and 'bottom up' safety assessments, such that it may be easily demonstrated to EASA that the AM part does not adversely impact safety, e.g. relative to conventional technologies used for similar applications, allowing for all likely defect, damage and failure modes including consideration of potential non-conformities, and impact upon structural an system functions etc.**
  Note: This is essential if EASA is to accept applications of no and low criticality, and supporting MoC being proportionate to criticality.
- appropriate scope and capability regarding the AM technology to be used (including appropriate stakeholder and supply chain management).
- representative development work, see Appendix 5
- conservative design practices have been used, including consideration of attachments to surrounding structure etc..
  Note: Although inclusion of redundant attachment points may be beneficial, e.g. in order to help ensure that part separation does not occur, care will also be necessary to ensure that the baseline structure or product is not adversely affected, e.g. due to 'wear and tear', fretting, galvanic incompatibility, contamination, misalignment, access for inspection, system function interference, etc.(as intended by the relevant CS's).
- use of appropriate PCDs supported by appropriate Material & Process specifications
- an appropriate use of standards, e.g. SDO standards, or in-house specifications etc. Subject to clear demonstration of no or low criticality classification (Class D only), appropriate use of some test standards not specific to aviation could be demonstrated to support the certification process, e.g. ISO/ASTM DIS 52927:2022.
- S-basis data per MMPDS or CMH-17 values may be used to support proportionate MoCs for Class C and D, noting that such data is coupon based and would require consideration of additional influencing factors in order to provide design values representative of a more complex configuration.
- direct part testing (e.g. certification by 'Point Design' and/or 'Detail' testing supporting CS2x.305, CS2x.307, or testing of other 'engineering properties') in addition to, or in place of, coupon testing may be more appropriate in order to determine unique failure characteristics, particularly for complex parts, which could be supported by appropriate use of further conservative factors in design. However, such an approach may be challenging for many reasons, including the definition of representative load cases (and Boundary Conditions), e.g. testing may be difficult due to practical limitations regarding representative load transfer into small complex parts etc.. A standardised approach is yet to be developed and agreement with a competent authority will be necessary until such standards are developed.
- for parts for which strength properties are important to maintaining fit, form, and function, e.g. maintaining shape, supporting its own weight or negligible/low loads, that a minimal set of representative coupon test data is presented showing that the material properties can be produced

which consistently meet the application design requirements , e.g. in tension, shear, and compression, as applicable. Altrenatively, 'Point Design' and/or 'Detail' testing may be considered.

- appropriate performance when subjected to vibration loads, which may result in failure modes, extents, and variabilities significantly different to those resulting from static loads. Although certification effort expectations are likely to be minimal for C and D classified parts, some justification regarding performance in a vibratory environment would be expected (and/or including reference to previous similar experience), e.g. demonstration of durability, testing in accordance with DO-160 etc. For Class D parts, by definition, any failure should be demonstrated to be of no safety consequence. Therefore, no specific vibratory testing of the part may be necessary. However, in order to support confidence in the reliability of the part, and it's classification, whilst also minimising any potential risk from excessive numbers of repeated failures, the applicant should provide any supporting evidence regarding behaviour in vibratory environments, if available. EASA is of the opinion that such consideration is likely to have formed part of any commercially driven material and process selection decision, so should also (at least) be available to the regulators as part of any safety related assessment.

  Note: For products intended for both civil and military use, inconsistencies may exist between civil and military standards addressing vibration and fatigue. Any differences should be identified and addressed accordingly.
- flammability requirements are potentially the first regulatory requirements challenging many parts which would otherwise be considered to be of no and low criticality, e.g. some smaller interiors parts. However, the need for AM specific actions for flammability considerations has not been agreed or standardised and some variation in practices have been noted. A material supplier Certficate of Conformatity alone is unlikely to be acceptable, see CM Supplemental document. Therefore, flammability MoCs should be agreed with the regulator on a 'case by case' basis until such standardisation is completed.
- agreement to use the approach described above with the regulatory authority on a 'case by case' basis, unless the repair or replacement application can be readily shown to fall within the scope of this CM guidance and previous regulatory agreement, in which case such data would need to be available to the regulatory authority in accordance with established regulatory authority practices, e.g. during audits, upon request etc., as required by the scope of the applicants approval.

Note: Appendix 5 includes examples of early AM applications in certified parts of no and low criticality, including reference to supporting development work considered necessary to do so.

~~3.1.~~3.2. Design Certification - Certification Programmes and MoCs

As required by standard EASA certification processes, e.g. for TC or a major type change, EASA typically expects applicants to submit a certification plan, referenced to the appropriate CSs and other means prescribed or required by EASA in the certification basis, supported by MoCs identifying how the applicant intends to demonstrate compliance with the certification basis.

Regulations already include some guidance supporting MoC expectations for some parts and products (particularly those of higher criticality), e.g. , CS 27.602 and CS 29.602 for rotorcraft Critical Parts require~~s~~ a critical parts plan whilst CS-E, e.g. CS-E-515 for Critical Engine Parts, requires an Engineering Plan, a Manufacturing Plan, and a Service Management Plan. These are considered to be useful means of communicating and standardising delivery of 'end to end' data (design, production, and in-service) to the regulatory authority for integrated technologies, such as AM. Therefore, EASA encourages applicants using AM to consider developing project documentation content using these concepts, e.g. Engineering, Manufacturing, and Service Management Plans, if an established means of communication with the regulatory authority does not already exist. The content and extent of data included can be adapted to be proportionate to criticality for broader use beyond critical engine applications, e.g. for other product parts of no or low criticality.

Applicants engaged with post TC activities are also reminded that Instructions for Continued Airworthiness are required to ensure that the product, and changes to it, can be maintained in an airworthy condition.

~~3.2.~~3.3. Design Certification - Changes and Repairs

In accordance with the Guidance Material contained in Appendix A to GM 21.A.91, the use of AM in Changes and Repairs to Type Certificates and Supplemental Type Certificates is considered to be a change to the material, process, and method of manufacture and should be evaluated as such when classifying changes and repairs. For repair, and repair design, the guidance contained in this CM (including relevant guidance under Appendix 1 of this CM) should also be considered when evaluating the use of AM, including consideration of the impact of AM upon the original baseline structure materials and engineering properties when appropriate. The use of AM in repairs and design changes may be classified Major based upon the level of substantiation required, ref. GM 21.A.435(a), being also a function of criticality, novelty (i.e. novel to the applicant and/or industry and/or regulator), and complexity. Design Organisations are advised to consult the Agency when introducing AM in repairs, including cases where they hold a privilege for repair design approval.

~~3.3.~~3.4. Impact of AM on design organisations

Design Organisation Approval Holders as well as Design Organisations using ADOA are advised to involve the Agency at the earliest opportunity during the development and implementation of AM. It is envisaged that the use of AM will initially lead to a higher level of involvement of EASA in compliance verification. In addition, specific audits may be scheduled to examine the introduction and use of AM within the scope of the design organisation audit cycle. These audits may take place concurrently with the review of AM applications rather than post approval.

Note: The introduction of additive manufacturing may, depending upon circumstances, represent a significant change to the Design Assurance System of the DOA Holder according to point 21.A.247.

~~3.4.~~3.5. Impact of AM on production organisations

Production Organisation Approval holders are advised to inform their respective competent authorities at the earliest opportunity before the implementation of AM processes.

Implementation of an AM process by a POA holder is controlled through the applicable design data identified and transferred to the POA holder under the responsibility of the design approval applicant or holder. The design approval applicant or holder is also responsible for showing that the applicable design data complies with the requirements of point 21.A.31. The POA holder shall ensure conformity to the applicable design data of the items it produces under its POA.

Implementation of an AM process that is new for the POA holder is a change to the approved production organisation typically identified as a significant change in accordance with point 21.A.147. ~~However, depending on circumstances, such a change may not necessarily be a significant change.~~

It is ultimately the responsibility of the design approval holder to ensure that the production methods (e.g. processes, fabrication technologies etc.), or any changes, are appropriately addressed. Therefore, a robust communication process between the POA holder and the DOA holder should be demonstrated, supported by appropriate DO-PO agreements (21.A.133), which include appropriate engagement with the material supplier and other impacted subcontractors. Production Organisations are therefore reminded of the published design data requirements in point 21.A.~~1~~31.

To ensure that such a change to the approved production organisation does not result in any non-compliance with Part 21 Section A Subpart G, it is in the interest of both the competent authority, point 21.1, and the POA holder, to establish a relationship and exchange information that will permit the necessary evaluation work to be conducted before the implementation of the change. In case of such a change, the competent authority is recommended to inform EASA, and, as usual, these parties are also recommended to cooperate closely. It is recommended that the use of AM will be subject to specific oversight by the competent authority, either in the frame of significant change(s) according to point 21.A.147 (when applicable) and/or continued surveillance of the POA holder.

~~3.5.~~3.6. Transfer of knowledge and training:

In support of existing regulations, applicants are required to demonstrate that staff have appropriate levels of competence throughout design, manufacture, and in service activities in accordance with Safety Management System (SMS) principles, e.g. point 21.A.145(d)(1), point 21.A.239(c)(5)(i) etc. This also applies to the regulatory authorities, ref. PART 21.B.25(a)(3) and GM*.

*Note: In order to improve certification efficiency, it is important for industry to familiarise competent authorities with new technology applications because this should improve the potential to quickly agree upon appropriate means of showing compliance with the requirements.

4. Whom this Certification Memorandum affects

This Certification Memorandum is applicable to individuals and organisations introducing AM during certification of Products, Parts and Appliances, Design Changes to Products, Parts and Repairs to Products in compliance with the material, process, and fabrication related specifications, including those in CS-22, CS-VLA, CS-23, CS-25, CS-VLR, CS-27, CS-29, CS-E, CS-P, CS-APU, CS-ETSO's etc., and other emerging product Certification Specifications (CSs) and Special Conditions (SCs), e.g. those addressing VTOL Capable Aircraft (VCA) etc.. It is also relevant to DOA and POA Applicants/Holders and their competent authorities, as well as other organisations declaring their capabilities under Part 21L and Part 21F organisations.

Note: The content of this CM may also be of relevance to Part 145, Part CAO, and Part M Subpart F organisations for awareness purposes. These organisations, and supporting DOAs not directly supported by TCHs, wishing to fabricate parts per Point145.A.42(b)(iii) , CAO.A.20(c) or M.A. 603(c) are reminded of the associated criteria requiring the use of appropriately approved data, design support, and approval.

5. Remarks

1. For any question concerning the technical content of this EASA Certification Memorandum, please contact the appropriate EASA focal point as identified in Appendix 6.

Appendix 1: Applicable regulations and guidance

All aviation parts and products are required to meet the relevant certification specifications and other means prescribed or required by EASA as part of the type certification basis, e.g. regarding strength, durability, flammability etc., regardless of the material and process combination used to generate the engineering properties. However, those CSs likely to require particular attention associated with the introduction of AM include:

- CS 2X.305 Strength and d~~D~~eformation
- CS 2X.307 Proof of s~~S~~tructure
- CS 2 X.561 Emergency Landing Conditions - General
- CS 2X.562 Emergency l~~L~~anding d~~D~~ynamic c~~C~~onditions
- CS 2X.571 Damage tolerance and ~~F~~fatigue evaluation of structure~~& Damage Tolerance~~
- CS 2X.601 Design and Construction - General
- CS 2X.603 Materials
- CS 2X.605 Fabrication m~~M~~ethods
- CS 27/29.602 Critical ~~P~~parts
- CS 2X.613 Material s~~S~~trength p~~P~~roperties and m~~M~~aterial design v~~V~~alues
- CS 2X.853 Compartment i~~I~~nteriors
- CS 2x.855 Cargo or b~~B~~aggage ~~C~~compartments
- CS 2X.901c Powerplant – General - Installation
- CS 2X.903c Powerplant – General - Engines (control of engine rotation)
- CS 2X.1191 Powerplant Fire Protection - Firewalls
- CS 2X.1309 Equipment, systems and installations
- CS 2X.1435 Hydraulic Systems
- CS 23.2240 Structural d~~D~~urability
- CS 23.2260 Materials and processes
- CS 23.2325 Fire p~~P~~rotection
- CS~~-~~APU 60 Materials
- CS~~-~~APU 130 Mount Strength
- CS~~-~~APU 150 Critical Parts
- CS~~-~~APU 210 Safety Analysis
- CS~~-~~APU 300 Vibration
- CS~~-~~E 70 Materials and Manufacturing Methods
- CS~~-~~E 90 Prevention of Corrosion and Deterioration
- CS~~-~~E 100(a) Strength~~ (a)~~
- CS~~-~~E 170~~-~~ Engine Systems and Component Verification
- CS~~-~~E 510 Safety Analysis (turbine engines)
- CS~~-~~E 515 Engine Critical Parts (turbine engines)
- CS~~-~~E 520 Strength (turbine engines)
- CS~~-~~E 650 Vibratory Survey (turbine engines)
- CS-P 150 Propeller Safety Analysis
- CS-P 160 Propeller Critical Parts Integrity
- CS~~-~~P 170 Materials and Manufacturing Methods
- ~~CS-P 150 Propeller Safety Analysis~~
- ~~CS-P 160 Propeller Critical Parts Integrity~~
- CS~~-~~P 240 Strength

Reminder: CS23 at amendment 5, or later amendments, do not carry the same CS numbering as CS-23 Amdt 4, or other CS's.

Note: The need to specifically include CS2x.619 (Special factors)* in the highlighted list above has been discussed between industry and regulators on several occasions. However, the current consensus is that the material, process, fabrication requirements, and other specifications listed above, should be more appropriate to address the material, process, and fabrication, aspects of Cx.619, as has generally been the case for the use of composite materials and processes. However, the need to consider the other aspects of

CS2x.619, and the other specifications listed in CS2x.619, should be considered independently based upon the part configuration and the relationship between test and analysis, noting that the need for additional factors should also become evident via representative testing of the complex AM part (and/or details) as defined in an appropriate test and analysis pyramid.

*CS 23.2265 for CS-23 at Amdt 5 or later

Note: The potential to adapt some aspects of CS 25.621 'Casting f~~F~~actors' for use with some AM technologies and applications is yet to be established.

Further to the CSs above, the showing of compliance with the following Part~~ART ~~-21, Part-145, Part-CAO and Part-M ~~regulations ~~requirements, and the application of some associated guidance material, may be impacted by the introduction of AM into aviation products:

- Point 21.A.15 Application
- AMC 21.A.15(b) Content of the Certification Programme
- Point 21.A.31 Type Design
- GM 21.A.91 Classification of c~~C~~hanges to a type ~~design ~~certificate
- Point 21.A.93 Application
- Point 21.A.101 Type-certification basis, operational suitability data certification basis and environmental protection requirements for a major change to a type-certificate~~Designation of applicable certification specifications and environmental protection requirements~~
- Point 21.A.131 Scope – Applicable Design Data
- Point 21.A.133 Eligibility
- Point 21.A.139 ~~Quality System~~Production management system
- Point 21.A.145 ~~Approval Requirements~~Resources
- Point 21.A.147 Changes in the production management system
- Point 21.A.163 Privileges
- Point 21.A.247 Changes in the design ~~assurance ~~management system
- Point 21.A.307 The eligibility of parts and appliances for installation
- Point 21.A.432C Application for a repair design approval
- Point 21.A.433 Requirements for approval of a repair design
- Point 21.A.435 Classification and approval of repair designs
- GM 21.A.435 (a) Classification of r~~R~~epairs
- Point 21.A.605 Data r~~R~~equirements
- Point 21.A.608 Declaration of Design and Performance
- Point 21.A.805 Identification of c~~C~~ritical Parts
- Point 21.A.807 identification of ETSO articles
- Point 21.B.100 Level of i~~I~~nvolvement
- Point 145.A.42(b) Components, standard parts and materials for installation
- Point CAO.A.020 Terms of approval
- Point M.A.603(c)- Extent of Approval

Note: See also Part~~-ART ~~21 Light ~~– Making Design & Manufacturing Easier~~for aircraft intended primarily for sports and recreational use and related products and parts.

Appendix 2: Design Certification - further background discussion:

In support of Section 2 'Background' for this rapidly developing technology, the following text documents evolving context within which this issue of the CM content was developed.

Although this CM does not intend to either repeat existing broader EASA requirements and guidance, or repeat detail from evolving AM guidance documentation, e.g. AIA Recommended Guidance for Certification of AM Components 2020, FAA AC 33 15-3 etc., EASA continues to emphasise the importance of the points below relating to certification of safe AM parts throughout the 'end to end' process:

Note: These themes are expanded in this CM-S-008 revision Supplemental document.

- materials, facilities, and stakeholder
- representative testing
- production considerations and Design Values
- anomalies, flaws, and defects
- variability
- specifications and Standards
- flammability
- knowledge transfer and training

Design certification 'Criticality' and proportionate certification effort demonstration:

Regulators and industry recognize that design and certification efforts vary based on the criticality of a design's safety impact. This has been formalized in recent LoI requirements, which prioritize EASA expectations of industry to initially demonstrate appropriate Means of Compliance (MoCs), including supporting work, relative to criticality, novelty (to the industry and/or applicant and/or regulator), and complexity. While established databases can support this process, applicants must complete all necessary work to meet safety requirements. In accordance with established practices, regulators may request additional supporting information, such as evidence for criticality classification, which informs the extent of required compliance work for certification.

Criticality: The word '**criticality**' is used extensively throughout the regulations and in industry in various contexts which may impact product and/or passenger safety, e.g. part criticality, manufacturing criticality, and procedural/administrative criticality. For the purposes of this CM, **part criticality** is a measure of the significance of a part to the overall safety of a product or its occupants.

Manufacturing criticality is a measure of the sensitivity of AM properties to M&P and manufacturing method process variability. This may, or may not, have safety implications, depending upon the part criticality.

Procedural/administrative criticality may also impact product and/or passenger safety, e.g. inappropriate use of certification processes, such as LoI, may adversely impact effective and safe certification.

Although part criticality should not be affected by material and fabrication processes, the potential for poorly understood processes impacting part criticality may exist for new technology applications. This CM explicitly emphasises that applicants developing no or low criticality applications should consider the risks of a poor process resulting in non-conformity. This may help an applicant to define a broader threat envelop in the part criticality assessment than may have been considered for a more conventional design and M&P application. **This does not allow an excuse for poor process, but should support an additional margin in conservative assessment of no or low part criticality, i.e. ensuring that a C or D Classification is appropriate. Note that regulation of other highly sensitive M&P in existing designs include further mitigations intended to support safety, but which also explicitly do not allow such mitigations to permit poor process. This is of particular importance for configurations which could result in defects which may be challenging to detect by inspection. For example, bonded structures require 'backup features' intended to meet specific residual load capability requirements if bond failure occurs upon rare occasions ('weak bonds' not being readily detectable). However, this does not permit poor process. Certification requires that process design and**

production control will maintain regulatory load capability, e.g. UL, supported by appropriate maintenance practices, for a product lifetime (aligned with the intent of EU Basic Regulations).

Some product CS's include specific content which is applicable to subsets of parts, structures, or systems, which are considered to be more critical to maintaining safety than others. For example, parts the failure of which could contribute to a catastrophic failure such as Critical Parts, PSEs, etc..

Note that the part 'criticality' terminology associated with parts, structure, and systems, is sometimes inconsistent across the range of products and CSs, although broadly addressing similar intents. This CM does not attempt to address these inconsistencies. Furthermore, this CM does not supercede any established criticality classification practices, e.g. part identification and management associated with 'Critical Parts', ref. PART 21, but attempts to start to standardise some aspects of these practices relative to initially demonstrating certification effort being proportionate to criticality.

Noting that AM is relatively new to many in aviation, it will be a particular challenge to develop appropriate knowledge and a body of data to certify AM parts of higher criticality (e.g. Classification A and B etc) in the near future. However, some simple applications can readily be determined to be of no or low criticality, i.e. being of no, or minimal, safety concern., provided that such determination is supported by an appropriate threat assessment and design safety assessments, e.g. some small interiors items, some minor systems-structures such as multiple redundant brackets supporting non-safety critical systems, etc., see Appendices 3 and 5.

Industry - regulator work continues regarding the definition and management of criticality, e.g. ASTM published standard F3572-22, and related work with EAAMIRG attempts to identify commonalities in part criticality across a range of products and applications to help better standardise and simplify industry certification approaches in a manner proportionate to the criticality. The table below identifies criteria defining commonality of classifications of criticality across products, the first 3 columns being developed from ASTM F3572-22 (Table 1):

ASTM F3572-22 Classification	Consequence of Failure	General Description	Application for engine products (CS-E 510), propellers (CS-P 150) and APU (CS-APU 210)	Application for aircraft products (CS-25.1309, CS-23, CS-27, CS-29, CS-22, CS-VLA)
A	High	Part whose failure can directly affect continued safe flight and landing Part whose failure can result in serious or fatal injury to passengers or cabin crews or maintenance personnel Part whose failure can result in excessive workload of flight crew	**HAZ** engine/propeller/APU Effects	**CAT/HAZ** aircraft effects
B	Medium	Part whose failure can indirectly affect continued safe flight and landing Part whose failure can result in minor injury to passengers or cabin crews or maintenance personnel Part whose failure can result in significant increase in workload of flight crew	**MAJ** engine/propeller/APU Effects	**MAJ** aircraft effects
C	Low	Part whose failure has no effect on continued safe flight and landing Part whose failure has no effect on passenger or cabin crew or maintenance personnel safety Part whose failure can result in slight reduction in operational/functional capabilities Part whose failure can result in slight increase in workload of flight crew	**MIN** engine/propeller/APU Effects	**MIN** aircraft effects
D	Negligible or No Effect	Part not covered above Part whose failure would pose no risk of damage to other equipment or personnel Parts not affecting operational/functional capabilities	No effect	No effect

Table 1: AM PART CRITICALITY CLASSIFICATION – STANDARDISATION ACROSS PRODUCTS

Certification effort proportionality to part criticality: See Appendix 4

Appendix 3~~2~~: Design Certification for AM parts of no or low criticality classification (Class C and D only) – further guidance:

Existing potential no and low criticality classification regulatory references:

~~For parts of no or low criticality (criticality classifications C and D ONLY, see also ASTM 3572-22 Table 1), i.e. being of no, or minimal, safety concern, either at aircraft or passenger level, and considering 'Certification Effort Proportionality to Part Criticality' tables and 'footnotes', see Section 2 in this CM, the applicant will be required to demonstrate, at least:~~

- ~~appropriate scope and capability regarding the AM technology to be used (including appropriate stakeholder and supply chain management).~~
- ~~representative development work in support of a first application for any new material and/or process. The extent of initial work is likely to be beyond that expected for a similar application of no or low, criticality using 'conventional' technologies until use of the novel AM material and/or process (novel to the industry and/or applicant) has been successfully established, also see comments in Appendix 4 'Examples' introduction text.~~
- ~~that criticality has been correctly assessed, supported by an appropriate design safety assessment including both 'top down' and 'bottom up' processes, see Appendix 3, such that it may be easily demonstrated that the AM part does not adversely impact safety, e.g. relative to conventional technologies used for similar applications, allowing for all likely defect, damage and failure modes including consideration of potential non-conformities. etc.~~
  ~~Note: This approach is intended to reinforce the indetification of conservative determination of no and low criticality, not allow poor process.~~
- ~~conservative design practices have been used, including consideration of attachments to surrounding structure etc..~~
- ~~Note: Although inclusion of redundant attachment points may be beneficial, e.g. in order to help ensure that part separation does not occur, care will also be necessary to ensure that the baseline structure or product is not adversely affected, e.g. due to 'wear and tear', fretting, galvanic incompatibility, contamination, misalignment, access for inspection etc.(as intended by the relevant CS's).~~
- ~~an appropriate use of standards, e.g. SDO standards, or in-house specifications etc.. Subject to clear demonstration of no or low criticality classification, appropriate use of some test standards not specific to aviation could support the certification process, e.g. ISO/ASTM DIS 52927:2022.~~
- ~~for parts for which strength properties are important to maintaining fit, form, and function, e.g. maintaining shape, supporting its own weight or limited low loads (see note below), that a minimal set of representative coupon test data is presented showing that the material properties can be produced which consistently meet the application design requirements , e.g. in tension, shear, and compression, as applicable, e.g. S-basis~~
- ~~S-basis data per MMPDS or CMH-17 values may be used to support proportionate MoCs for Class C and D, noting that such data is coupon based and would require consideration of additional influencing factors in order to provide design values representative of a more complex configuration.~~
- ~~direct part testing (certification by 'Point Design' or 'Detail' testing supporting CS2x.305 etc.) in addition to, or in place of, coupon testing may be more appropriate in order to determine unique failure characteristics, particularly for complex parts, which could be supported by appropriate use of further conservative factors in design. However, such an approach may be challenging for many reasons, including the definition of representative load cases (and boundary conditions), and because testing may be difficult, e.g. due to practical limitations regarding representative load transfer into small complex parts etc.. A standardised approach is yet to be developed and agreement with a competent authority will be necessary until such standards are developed.~~
- ~~Note: The need to address vibration loads and potential related degradation relative to the identification and assessment of parts of no or low criticality is yet to be established and standardised. However, although certification effort expectations are likely to be minimal for C and D classified parts, some justification regarding performance in a vibratory environment would be~~

~~expected (and/or including reference to previous similar experience), e.g. demonstration of durability, testing in accordance with DO-160 etc.etc.. EASA is of the opinion that such consideration is likely to have formed part of any commercially driven material and process selection decision, so should also (at least) form part of any potentially safety related assessment.~~

~~Note: For products intended for both civil and military use, inconsistencies may exist between civil and military standards addressing vibration and fatigue. Any differences should be identified and addressed accordingly.~~

- ~~flammability requirements are potentially the first regulatory requirements challenging many parts which would otherwise be considered to be of no and low criticality, e.g. some smaller interiors parts. However, the need for AM specific actions for flammability considerations has not been agreed or standardised, although some variation in practices has been noted, also see Section 2 and 3. Therefore, flammability MoCs should be agreed with the regulator on a 'case by case' basis until such standardisation is completed.~~
- ~~agreement to use the approach described in this Appendix with the regulatory authority on a 'case by case' basis, unless the repair or replacement application can be readily shown to fall within the scope of this CM guidance and previous regulatory agreement, in which case such data would need to be available to the regulatory authority in accordance with established regulatory authority practices, e.g. during audits, upon request etc., as required by the scope of the applicants approval.~~
- ~~the use of small datasets should follow acceptable statistical practices, yet to be standardised.~~

~~No and low criticality classification – further EASA comments:~~In order to ~~help~~ further support identification of parts which might be considered as being potential candidates for consideration as being of no or low criticality, without intending to be exhaustive, EASA makes the following references~~....~~:

PART 21, point 21.A.307 'The eligibility of parts and appliances for installation'~~Parts without Form 1'~~: ~~PART~~ GM1 21.A.307(b)(3) and (b)(4) provides some guidance regarding the identification of 'parts with negligible safety effect' for which release **does not require an EASA Form 1**, per point 21.A.307(b), i.e. refer to: https://www.easa.europa.eu/en/document-library/easy-access-rules/online-publications/easy-access-rules-airworthiness-and?page=1&kw=307:

'(a) for ELA1 and ELA2 aircraft, at worst:
(1) slightly reduces the operational or functional certified capabilities of the aircraft or its safety margins;
(2) causes some physical discomfort to its occupants; and
(3) slightly increases the workload of the flight crew; and

(b) for any other aircraft:
(1) has no effect on the operational or functional certified capabilities of the aircraft, or on its safety margins;
(2) causes no physical discomfort to the occupants; and
(3) has no effect on the flight crew.'

EASA CM 21.A-K-001 'Installation of new parts and appliances without an EASA Form 1': This provides further guidance regarding the determination of appropriate part classification for parts potentially not requiring a Form 1. This emphasises the importance of an appropriate assessment, including consideration of the significance of the impact of a non-conformances upon safety outcomes.

EASA CM-S-002 'Frequent removal of interior structures': Furthermore, interior parts which might be considered as being candidates for no or low criticality classification could include those below the mass thresholds , as adapted from EASA CM-S-002 Note 1:

'Interior items of mass < 0,45 kg (1lb) (or < 0,15 kg (1/3lb) if attached to a seat, ref. AC 25.562-1). However, this low criticality candidate threshold will not be considered for any safety equipment mountings (PBE, Fire Extinguishers, Oxygen Bottles, etc.. Such critical applications will require full certification MoC consideration).'

Items addressed by ETSO will be expected to demonstrate similar considerations.

Reminder: Aligned with the intent of CMs (see cover sheet), this CM is not intended to 'introduce new certification requirements, or to modify existing certification requirements~~ and do not constitute any legal obligation~~'. However, for the purposes of pursuing proportionate regulation effort relative to criticality, the intent is for parts manufactured using AM considered to be of no or low criticality (in accordance with the guidance above) to be addressed under a minor change approval, even upon initial use of AM for "D" parts, provided all other aspects of the change meet the requirements for minor classification in accordance with established EASA processes based upon the amount of work required for approval (as indicated in PART 21). Design organisations (including holders of, or applicants for, ETSO authorization(s)) are expected to inform EASA, and POA Holders are expected to inform their respective Competent Authority, of intent to use AM (and the intended applications, criticalities, etc..) and to provide an impact assessment for the introduction of AM process based on a gap analysis, although EASA/the respective POA Competent Authority retains the right to change the assessment in accordance with established EASA/respective POA Competent Authority processes.

Note: For smaller and less complex GA aircraft, see also PART 21 Light – Making Design & Manufacturing Easier
Note: Design organisations are reminded of their responsibilities regarding engagement with POA Holders and other stakeholders in the supply chain, including AM machine manufacturers and suppliers.

Note: For the purposes of certification efficiency, particularly for parts of no or low criticality, being of no, or minimal, safety concern either at aircraft or passenger level, and in order to help to provide a 'level playing field', EASA is of the opinion that industry may benefit from:

- developing common standards supporting expectations for compliance data, e.g. statistics, testing etc..,
- developing simple common data presentation protocols for the purposes of supporting certification

These actions may aid the efficiency of certification and regulatory authority audit processes.

Such tasks could be addressed through use of an appropriate standardisation organisation, or other industry/regulatory authority groups, and should not compromise the classification and criticality assessment of the product as agreed between applicants and the regulatory authorities through normal product certification processes.

~~Appendix 3: Design safety assessment for AM parts of no or low criticality (Class C and D)~~

Design safety assessment supporting no and low criticality classification:

~~Note: At the time of this CM revision, the majority of AM applications of no or low criticality being proposed for, or having already been accepted in, certified parts are either new parts or parts produced for the purpose of 'repair by replacement'. Therefore, the following text addresses such applications. However, as the use of AM expands to more broadly address repairs, e.g. repairs involving material build-up on baseline structure damaged (and prepared) surfaces, further amendments may be required in future revisions.~~

~~Aviation products are subject to safety assessments, e.g. FHA, FMECA, RAS etc., as required by the appropriate CS requirements accordingly. These requirements are to be considered by all stakeholders, e.g. TCHs, STCHs, DOAs supporting MROs, ETSOs etc.. However, r~~Recognising that many stakeholders do not have direct access to the TCH, STCH, or other original DOA design safety assessments, e.g. some DOAs supporting MROs, ETSOs etc., it is important that the design and manufacture of any AM parts conservatively address the potential impact of part failure upon safety, including the baseline product, relative to all potentially impacted disciplines beyond the direct functionality of the part, e.g. airframe, systems, propulsion, interiors (including seats) etc.. This should include consideration of the potential for non-compliance (note: a consideration not intended to allow poor process) and any new failure modes and/or new debris forms which could potentially change the outcome of an original configuration design safety assessment relative to more conventional materials and processes, e.g. the AM part may introduce new debris threats, resulting in potential impact, system ingestion, system jamming, fire threats, or the potential to introduce sharp edges for interior parts (either as a completed part or in its likely damaged states). Such a review is of particular importance at interfaces between disciplines, e.g. propulsion-structure, system-structure applications etc., due to the increased potential for unintended consequences resulting from incomplete knowledge of the product and/or the TCH's design safety assessments.

Noting that many design safety assessments involve some element of 'engineering judgement', it is important that applications which have been assessed to be of no criticality (Class D) are also adequately controlled, at least, by commercial specifications to ensure that multiple and repeated failures are not to be expected because quantitative data typically does not yet exist to support meaningful risk assessments for such new technologies and applications. Such an approach may be important when failure could result in loose debris, or release of some energy due to existing load in the part.

If the potential benefit from certification effort being proportionate to criticality is to be realised by an applicant, and accepted by the regulator, it is essential that applicants can demonstrate that the points above have been considered in this assessment in order to ensure a safe criticality classification. If the applicant does not have direct access to the TCH design safety assessment or direct TCH support, then the simple figure below is included to encourage this thought process in order to support a no or low criticality classification, i.e. both 'top down' and' bottom up' design safety assessment approaches should have been considered in order to support any demonstration of a no or low criticality classification as being appropriate.

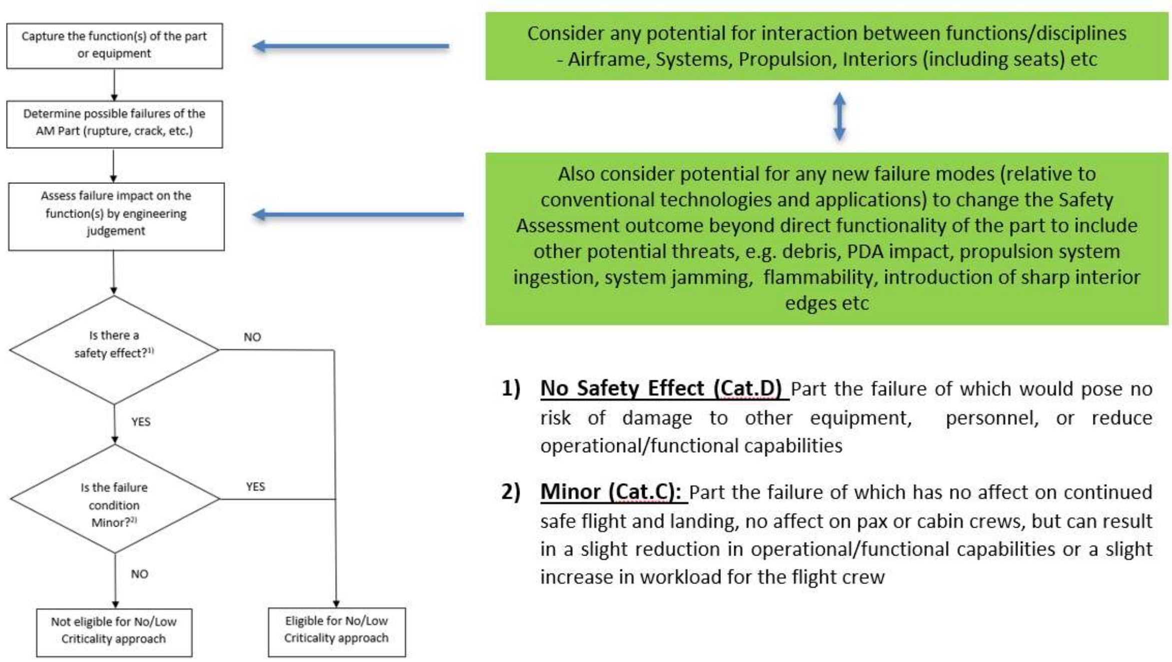

Fig.1: Design safety assessment for AM parts of no or low criticality

Appendix 4: Certification effort proportionality to part criticality - discussion:

Recent efforts to better formalise and prioritise regulatory expectations of industry demonstrating appropriate MoCs (including supporting test and analysis work), when meeting CSs and AMC needs in proportion to part criticality, has resulted in draft tables (and supporting discussions) referenced in the Supplemental document supporting this CM. This content has been included for awareness and visibility purposes in this revison and **does not represent policy.**

Appendix 5: Early AM applications in certified parts of no or low criticality:

In order to increase awareness, knowledge, and standardisation of AM throughout industry (and regulators), whilst following the intended 'step by step' approach relative to criticality of application, industry shared working examples of already certified, or close to being certified, applications of no or low criticality, as documented in the Supplemental document to this CM revision. This process informed some of the policy content added to this revision of the CM supporting no and low criticality applications and supported development of an industry 'level playing field'.

Appendix 6: EASA AM contacts

Please use the following initial EASA contacts for the product or discipline of interest:

Materials	S. Waite	simon.waite@easa.europa.eu
Aircraft Structures	W. Hoffmann	wolfgang.hoffmann@easa.europa.eu
Propulsion (Engines, Propellers & APU)	O. Kastanis M. Mercy*	omiros.kastanis@easa.europa.eu matthew.mercy@easa.europa.eu
Cabin Safety	T. Ohnimus F. Negri	thomas.ohnimus@easa.europa.eu fabrizio.negri@easa.europa.eu
Systems	M. Weiler	michael.weiler@easa.europa.eu
Design Organisation Approvals	C. Caruso A. Enache*	claudio.caruso@easa.europa.eu alexandru.enache@easa.europa.eu
Production Organisation Approvals	A. Duranec	ana-marija.duranec@easa.europa.eu
Maintenance Organisation Approvals	R. Tajes	rosa.tajes@easa.europa.eu

*original EASA contact addressing theme