The Digital Thread for Aerospace and Defense:

What are we certifying with regulators using Model Based Definition?

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PLM Roadmap 2017

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Abstract

Aerospace and Defense companies that make product for the commercial aviation industry have all certified at least one aircraft configuration with regulators using the latest technologies in model based definition. Interestingly, regulators continue to be anchored in paper based paradigms of engineering design and are cognizant of the need to advance model based definition in the digital enterprise. The PLM A&D Action Group has taken positive steps to examine the digital thread and explore the art of the possible for certifying commercial aircraft designs in an industry consistent manner. Examine with us the elements of the digital thread and our thoughts on a consistent approach to certification relevant data.

Agenda

1. Introduction
   - A&D PLM Action Group
2. Compliance & Certification
   - Evolution of the Certification Process
3. MBD & The Digital Enterprise
   - Issue & Proposition
4. Current Status
   - Next Steps

Aerospace & Defense PLM Action Group

Founded in February 2014

AIRBUS | BOEING | BOMBARDIER l'évolution de la mobilité | DASSAULT AVIATION | EMBRAER

GE Aviation | Gulfstream A GENERAL DYNAMICS COMPANY | Pratt & Whitney A United Technologies Company | Rolls-Royce | SAFRAN

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Aerospace & Defense PLM Action Group

Mission

An association of aerospace & defense companies within CIMdata's globally recognized PLM Community Program, which functions as a ***PLM advocacy group*** to:

- Set the direction for the aerospace & defense industry on PLM-related topics that matter to members
- Promote common industry PLM processes and practices
- Define requirements for common interest PLM-related capabilities
- Communicate with a unified voice to PLM solution providers
- Sponsor collaborative PLM research on member-prioritized industry and technology topics

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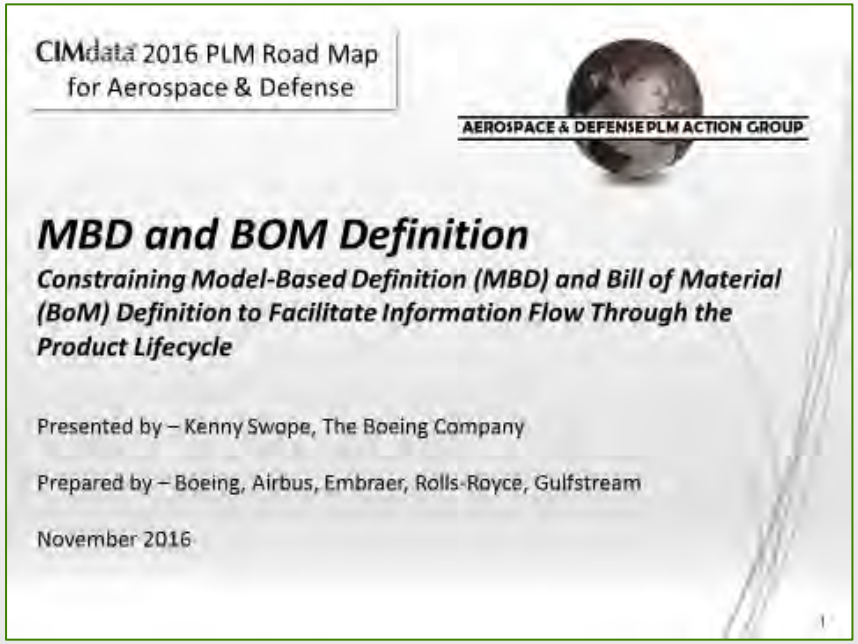
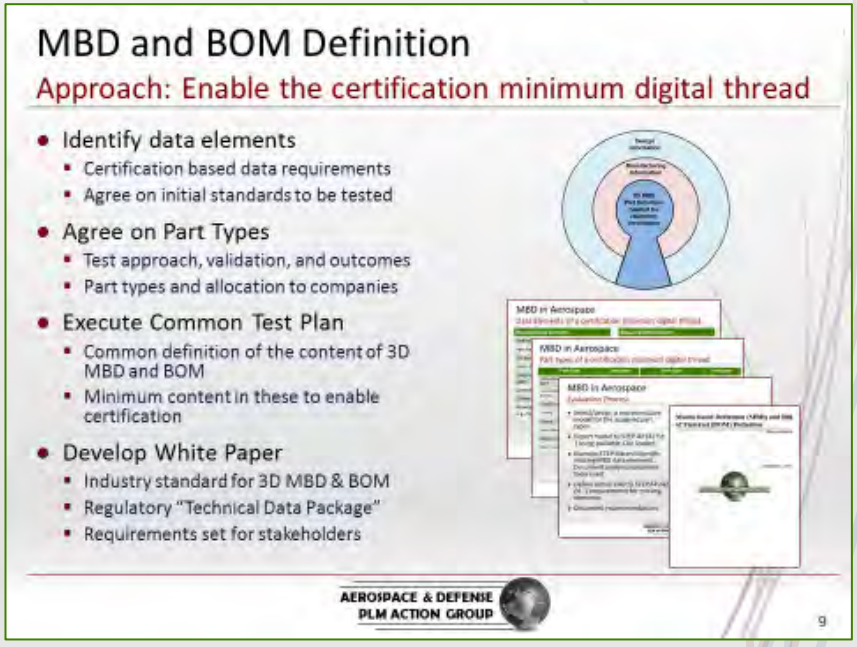
History





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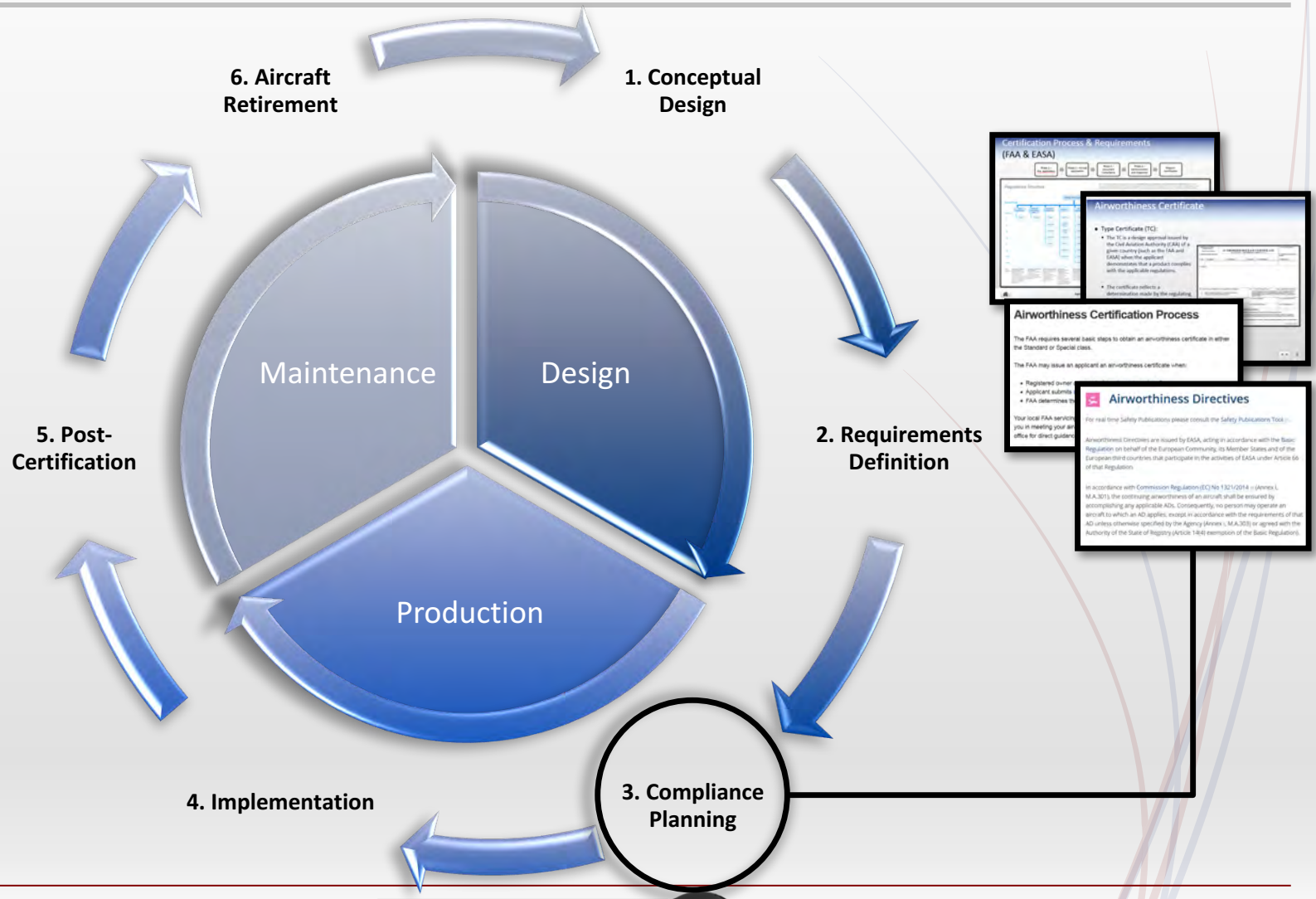
Compliance and Certification: EASA & FAA



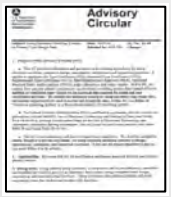
Excerpts courtesy of www.easa.europa.eu and www.faa.gov/

Evolution of the Certification Process

100 Years of History

Legacy Drawing Based Certification

FAA Order 8000.79



AC21-48

- 2D Layouts
- 2D Drawings
- EBOM
- MBOM

2D Hand-Drawn Designs

2D CAD Designs

- 2D CAD Layouts
- 2D CAD Drawings
- 2D Hardcopy
- EBOM
- MBOM

- 3D Solid Model
- 2D CAD Drawing
- EBOM
- MBOM

3D CAD + 2D CAD Designs

New MBD Based Certification

- 3D Solid Model
- 2D CAD Drawing
- EBOM
- MBOM

3D Designs

Standardized Certification by Drawings

Individual Agreements

Standard Process

1920's to 2010 | 2010 to Today | Tomorrow

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MBD and the Digital Enterprise

- **"Model Based Definition (MBD)** is a mechanical engineering initiative where a 3D model with Product Manufacturing Information, PMI [GD&T, surface finish, etc], augments or replaces a 2D engineering drawing as design documentation."

- In the **digital enterprise** MBD is the **single source of engineering truth** and enables the **digital thread.**

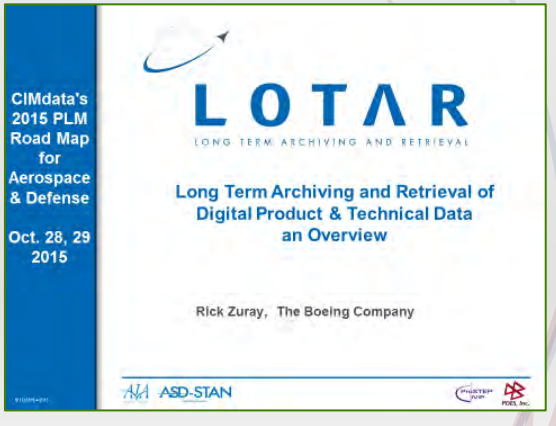
- Existing certification relies on **drawings** which do not exist in the **MBD** world.

§ 21.31 Type design.

The type design consists of—

(a) The drawings and specifications, and a listing of those drawings and specifications, necessary to define the configuration and the design features of the product shown to comply with the requirements of that part of this subchapter applicable to the product;

(b) Information on dimensions, materials, and processes necessary to define the structural strength of the product;



Can we define a standardized common approach to use MBD for certification?

Proposal:

- Determine the industry minimum MBD content for certification
- Ensure technical package proposal facilitates and associated tools/systems support interoperability
- Share industry analysis results for the technical data package content and format to FAA & EASA
- Align priorities across industry groups solving for the technical problem

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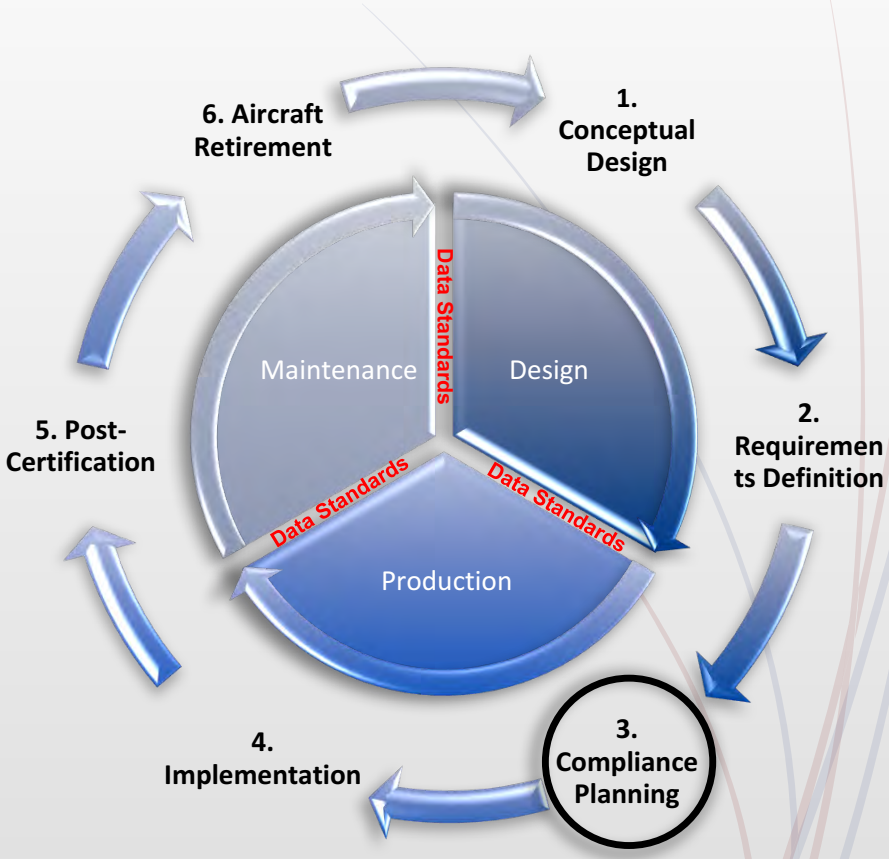
Project Activities

- What is the **minimum MBD** content to support the **digital thread** for the industry?
  - Design
  - Manufacture
  - Certification
- Interoperability based on **industry data standards** is a key to the **digital thread**.
- **AP242** is the recognized majority direction for enabling this **interoperability.**



Evaluating Standard Support for the Minimum MBD Digital Thread (Design + Manufacture + Certification)

- Multiple part types were analyzed for **minimum MBD digital thread required data elements.**
- Each element was evaluated based on both the support by the standard **and** translation tool.

Part Type	Data Element Support Score
Common MBD Elements	Partially Covered
Composite - Detail - Core Stiffened Bond and Co-Cured	Mostly Covered
Casting/Forging	Partially Covered
Forging	Partially Covered
Sheet Metal	Partially Covered
Machined	Not Well Covered
Tube Assembly - Flexible & Ridged	Partially Covered
Wire Harness	Not Well Covered
Installation	N/A
Standard Part - Electrical (Connector, Back Shell, etc.)	Not Well Covered
Under Evaluation for Revision 2 of this Paper	
Ducting - Metallic - Mechanically Fastened	
Standard Part - Mechanical	
Supplied Part - Mechanical Systems (Pump, Actuator, etc.)	
Supplied Part - E/E Systems (Battery, LRU, etc.)	

Category	Description	Associated Score
	Not Supported	0%
	Not Well Support	1-29%
	Partially Supported	30-85%
	Mostly Supported	86-99%
	Fully Supported	100%

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Detailed Examples

Machined

The following machined product design elements are required for MBD part models in addition to the common data elements listed above in Table 3. Table 7 documents specific data element support in AP242.

Minimum Data Element	Evaluation Comments	Score:
Assembly & BOM Structure Management	Multiple child/parent body errors in translation	
Part Attribute Data	Annotation supported; no semantic linkage	
URL Data	URL feature attribute data did not translate	
Security/Classification Attributes	Annotation supported; no semantic linkage	
Symbolic Thread Representation	Thread representation did not translate	
Drilling Features	Defined in STEP AP242 but not implemented	
Milling Features	Defined in STEP AP242 but not implemented	
Turning Features	Defined in STEP AP242 but not implemented	
Pattern Feature Attributes	Multi-instanced feature PMI did not translate to multiple faces	
Tabular Data	NX limitation; PMI based table not available	
Lightweight Cross Section Views	Resulted in multiple additional geometry bodies originated from component part and translated into an assembly part file	
Key Product Characteristics	Annotation supported; no semantic linkage	
Wave Linked Body	Linked bodies did not translate	

Table 7—Machined Part MBD Elements and Their Support Level

Wire Harness

Electrical wire harnesses are not explicitly supported in Edition 1 of AP242. The geometric representation of the physical layout of the harness is supported. Significant work has been done in Edition 2 to support the definition of the components of a harness assembly (connectors, splices, sleeves, etc.) as well as the connectivity and signal model. See "STEP AP 242 Electrical Harness XML Tutorial" from LOTAR International for details on support in Edition 2 for wire harnesses.

Minimum Data Element	Comments	Score:
Local Axis System	Well supported	
Wireframe Geometry	Well supported	
Solid Definition	Well supported	
Neutral Fiber of Harness Segment	Well supported	
Harness Segment	Not supported	
Harness Node	Not supported	
Connectivity	Not supported	
Harness Segment Protection	Not supported	
Thickness of the Protection	Not supported	
Protection Type (laving, tape, rigid...)	Not supported	
Outer Diameter	Not supported	
Inner Diameter	Not supported	
Bended Radius	Not well supported	
Wire	Not supported	
Cable	Not supported	
Signal	Not supported	
Length	Not supported	
Forced Length	Not supported	
Cut Length	Not supported	
Marking Label	Not supported	
Identification Label	Not supported	
Localization Label	Not supported	
Segregation Code	Not supported	
Manufacturing Tolerances (bending, length)	Not supported	
Electrical Device	Not supported	
Reference Designator	Not supported	
Terminal	Not supported	
Support/Fixing	Not supported	

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Detailed Examples

Standard Part

The properties of Standard Parts are specific to the family of standard part being reviewed, i.e. the mechanical standard part family properties vary from the tubing standard part family's. This paper recognizes the complexity of the standard part topic and acknowledges the below definitions only represent an analysis of a subset of the families. Future versions of this paper will add analysis of further families as well as additional detailed analysis (existing and new).

Mechanical Standard Part Family

The design and translation of standard part definitions are represented through similar requirements to machined parts with similar constraints.

Tubing Standard Part Family

The design and translation of standard part definitions are represented through similar requirements to machined parts with similar constraints.

Data Element	Comments	Score:
Local Axis System	Well supported	
Wireframe Geometry	Well supported	
Solid Definition	Well supported	
Dimensions	Well supported	
Tolerances	Not supported	
Mass	Not supported	
Angle	Not supported	
Fire Resistance	Not supported	
Material Code	Not supported	
Marking	Not supported	
Surface Treatment	Not supported	
Serial Number	Not supported	
Class	Not supported	
Identification	Not supported	
Connectivity	Not supported	
End Point / Port	Not supported	
Type of Fluid	Not supported	
Pressure (nominal, max)	Not supported	
Flow	Not supported	
Function	Not supported	

Table 9—Tube Standard Part MBD Elements and Their Support Level

Electrical Standard Part Family

Mechanical (physical) properties of a standardized electrical wiring components are considered equivalent to mechanical standards parts from a data content view. Additionally, the electrical properties define in the context of the Wire Harness assembly they are used in. Reference both of these sections for the full definition of standard part – electrical.

Data Element	Comments	Score:
Local Axis System	Well supported	
Wireframe Geometry	Well supported	
Solid Definition	Well supported	
Dimensions	Well supported	
Tolerance	Not supported	
Mass	Not supported	
Angle	Not supported	
Fire Resistance	Not supported	
Material Code	Not supported	
Marking	Not supported	
Surface Treatment	Not supported	
Serial Number	Not supported	
Identification	Not supported	
Termination	Not supported	

Table 10—Electrical Standard Part MBD Elements and Their Support Level

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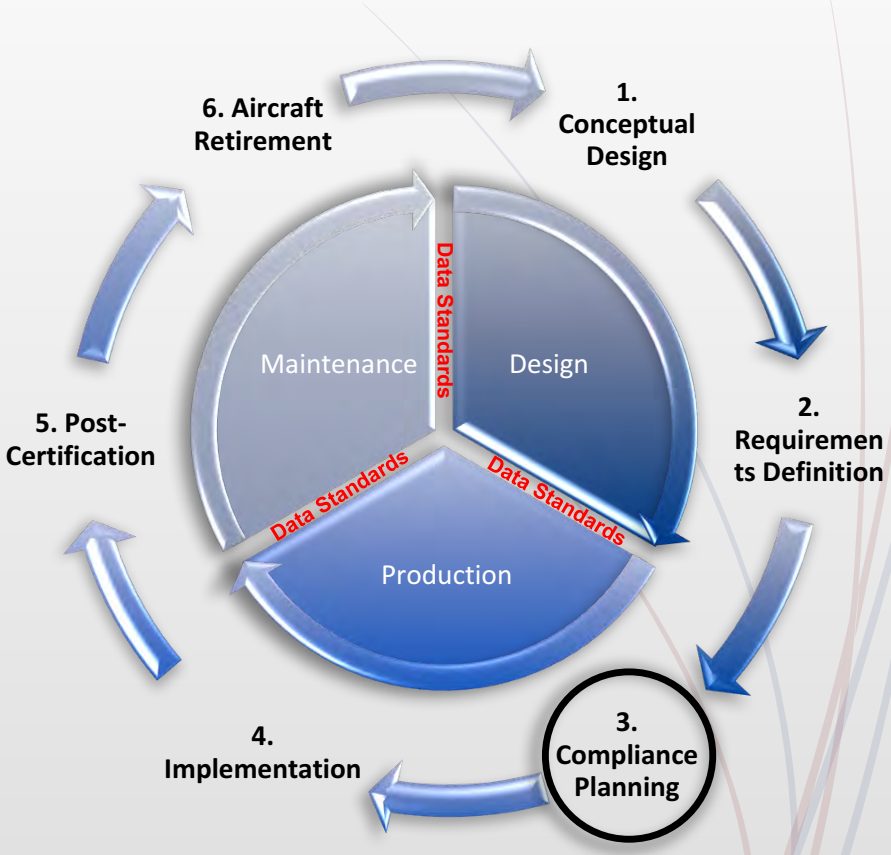
Status

Develop the common definition for A&D of Model-Based Definition and Bill of Material with a recommendation on the minimum content necessary to satisfy certification requirements.

Proposal:

- ☑ Determine the industry minimum MBD content for certification
- ◆ Ensure technical package proposal facilitates and associated tools/systems support interoperability
- Share industry analysis results for the technical data package content and format to FAA & EASA
- Align priorities across industry groups solving for the technical problem



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Next Steps

- Nov 2017: Publish Minimum MBD Digital Thread White Paper
- Q1 2018: Publish Minimum MBD **Certification** Digital Thread White Paper
- Engage with PLM and Translator Vendors to increase coverage of AP242 and validate interoperability
- Share industry analysis results for the technical data package content and format with FAA & EASA
- Get Involved! The A&D Industry faces emerging risk by not coming together to solve this critical technical challenge.

Thank You!

AEROSPACE & DEFENSE PLM ACTION GROUP

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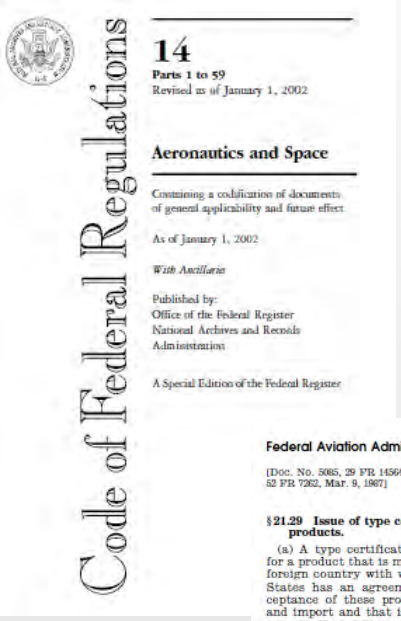
Regulatory Timeline



Code of Federal Regulations

14
Parts 1 to 59
Revised as of January 1, 2002

Aeronautics and Space

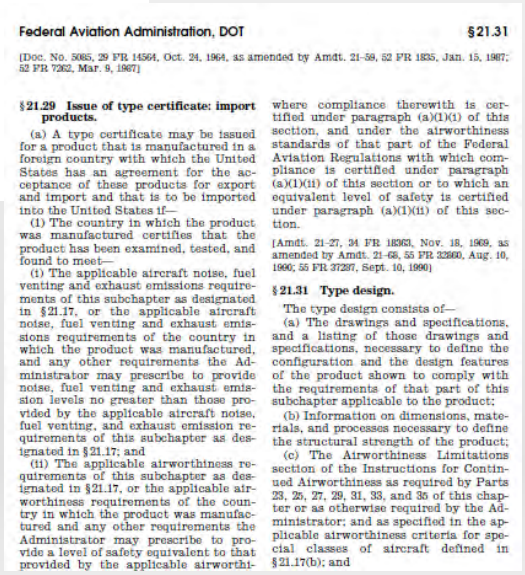
Containing a codification of documents of general applicability and future effect

As of January 1, 2002

With Ancillaries

Published by:
Office of the Federal Register
National Archives and Records Administration

A Special Edition of the Federal Register



Federal Aviation Administration, DOT §21.31

[Doc. No. 5085, 29 FR 14564, Oct. 24, 1964, as amended by Amdt. 21-59, 52 FR 1835, Jan. 15, 1987; 52 FR 7262, Mar. 9, 1987]

§21.29 Issue of type certificate: import products.

(a) A type certificate may be issued for a product that is manufactured in a foreign country with which the United States has an agreement for the acceptance of these products for export and import and that is to be imported into the United States if—

(1) The country in which the product was manufactured certifies that the product has been examined, tested, and found to meet—

(i) The applicable aircraft noise, fuel venting and exhaust emissions requirements of this subchapter as designated in §21.17, or the applicable aircraft noise, fuel venting and exhaust emissions requirements of the country in which the product was manufactured, and any other requirements the Administrator may prescribe to provide noise, fuel venting and exhaust emission levels no greater than those provided by the applicable aircraft noise, fuel venting, and exhaust emission requirements of this subchapter as designated in §21.17; and

(ii) The applicable airworthiness requirements of this subchapter as designated in §21.17, or the applicable airworthiness requirements of the country in which the product was manufactured and any other requirements the Administrator may prescribe to provide a level of safety equivalent to that provided by the applicable airworthiness where compliance therewith is certified under paragraph (a)(1)(i) of this section, and under the airworthiness standards of that part of the Federal Aviation Regulations with which compliance is certified under paragraph (a)(1)(ii) of this section or to which an equivalent level of safety is certified under paragraph (a)(1)(ii) of this section.

[Amdt. 21-27, 34 FR 18363, Nov. 18, 1969, as amended by Amdt. 21-68, 55 FR 32960, Aug. 10, 1990; 55 FR 37297, Sept. 10, 1990]

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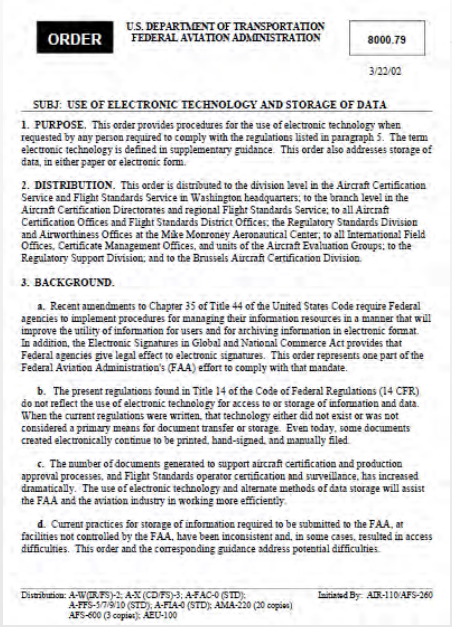
(b) Information on dimensions, materials, and processes necessary to define the structural strength of the product;

(c) The Airworthiness Limitations section of the Instructions for Continued Airworthiness as required by Parts 23, 25, 27, 29, 31, 33, and 35 of this chapter or as otherwise required by the Administrator; and as specified in the applicable airworthiness criteria for special classes of aircraft defined in §21.17(b); and



ORDER

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

8000.79

3/22/02

SUBJ: USE OF ELECTRONIC TECHNOLOGY AND STORAGE OF DATA

1. **PURPOSE.** This order provides procedures for the use of electronic technology when requested by any person required to comply with the regulations listed in paragraph 5. The term electronic technology is defined in supplementary guidance. This order also addresses storage of data, in either paper or electronic form.

2. **DISTRIBUTION.** This order is distributed to the division level in the Aircraft Certification Service and Flight Standards Service in Washington headquarters; to the branch level in the Aircraft Certification Directorates and regional Flight Standards Service; to all Aircraft Certification Offices and Flight Standards District Offices; the Regulatory Standards Division and Airworthiness Offices at the Mike Monroney Aeronautical Center; to all International Field Offices, Certificate Management Offices, and units of the Aircraft Evaluation Groups; to the Regulatory Support Division; and to the Brussels Aircraft Certification Division.

3. **BACKGROUND.**

a. Recent amendments to Chapter 35 of Title 44 of the United States Code require Federal agencies to implement procedures for managing their information resources in a manner that will improve the utility of information for users and for archiving information in electronic format. In addition, the Electronic Signatures in Global and National Commerce Act provides that Federal agencies give legal effect to electronic signatures. This order represents one part of the Federal Aviation Administration's (FAA) effort to comply with that mandate.

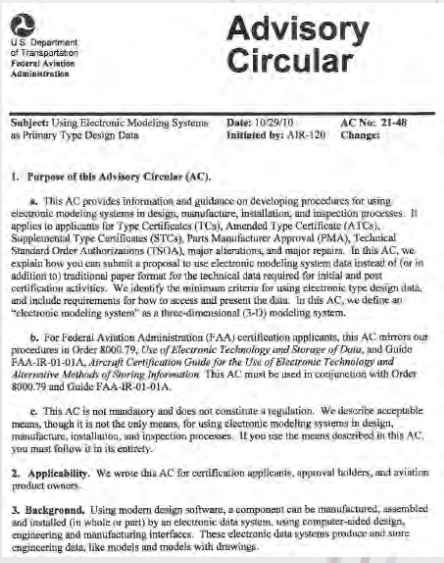
b. The present regulations found in Title 14 of the Code of Federal Regulations (14 CFR) do not reflect the use of electronic technology for access to or storage of information and data. When the current regulations were written, that technology either did not exist or was not considered a primary means for document transfer or storage. Even today, some documents created electronically continue to be printed, hand-signed, and manually filed.

c. The number of documents generated to support aircraft certification and production approval processes, and Flight Standards operator certification and surveillance, has increased dramatically. The use of electronic technology and alternate methods of data storage will assist the FAA and the aviation industry in working more efficiently.

d. Current practices for storage of information required to be submitted to the FAA, at facilities not controlled by the FAA, have been inconsistent and, in some cases, resulted in access difficulties. This order and the corresponding guidance address potential difficulties.

Distribution: A-W(RJFS)-2; A-X (CD/FS)-3; A-FAC-0 (STD); A-FFS-5/7/9/10 (STD); A-FIA-0 (STD); AMA-220 (20 copies) AFS-600 (3 copies); AEU-100

Initiated By: AIR-110/AFS-260



U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Using Electronic Modeling Systems as Primary Type Design Data

Date: 10/29/10 **AC No:** 21-48
Initiated by: AIR-120 **Change:**

1. **Purpose of this Advisory Circular (AC).**

a. This AC provides information and guidance on developing procedures for using electronic modeling systems in design, manufacture, installation, and inspection processes. It applies to applicants for Type Certificates (TCs), Amended Type Certificate (ATCs), Supplemental Type Certificates (STCs), Parts Manufacturer Approval (PMA), Technical Standard Order Authorizations (TSOA), major alterations, and major repairs. In this AC, we explain how you can submit a proposal to use electronic modeling system data instead of (or in addition to) traditional paper format for the technical data required for initial and post certification activities. We identify the minimum criteria for using electronic type design data, and include requirements for how to access and present the data. In this AC, we define an "electronic modeling system" as a three-dimensional (3-D) modeling system.

b. For Federal Aviation Administration (FAA) certification applicants, this AC mirrors our procedures in Order 8000.79, *Use of Electronic Technology and Storage of Data*, and Guide FAA-IR-01-01A, *Aircraft Certification Guide for the Use of Electronic Technology and Alternative Methods of Storing Information*. This AC must be used in conjunction with Order 8000.79 and Guide FAA-IR-01-01A.

c. This AC is not mandatory and does not constitute a regulation. We describe acceptable means, though it is not the only means, for using electronic modeling systems in design, manufacture, installation, and inspection processes. If you use the means described in this AC, you must follow it in its entirety.

2. **Applicability.** We wrote this AC for certification applicants, approval holders, and aviation product owners.

3. **Background.** Using modern design software, a component can be manufactured, assembled and installed (in whole or part) by an electronic data system, using computer-aided design, engineering and manufacturing interfaces. These electronic data systems produce and store engineering data, like models and models with drawings.

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Airworthiness Certificate

- Type Certificate (TC):
  - The TC is a design approval issued by the Civil Aviation Authority (CAA) of a given country (such as the FAA and EASA) when the applicant demonstrates that a product complies with the applicable regulations.
  - The certificate reflects a determination made by the regulating body that the aircraft is manufactured according to an approved design, and that the design ensures compliance with airworthiness requirements.

1. Approving Civil Aviation Authority/Country: FAA/United States	2. AUTHORIZED RELEASE CERTIFICATE FAA Form 8130–3, AIRWORTHINESS APPROVAL TAG				3. Form Tracking Number:
4. Organization Name and Address:					5. Work Order/Contract/Invoice Number:
6. Item:	7. Description:	8. Part Number:	9. Quantity:	10. Serial Number:	11. Status/Work:
12. Remarks:					
13a. Certifies the items identified above were manufactured in conformity to: ☐ Approved design data and are in a condition for safe operation. ☐ Non-approved design data specified in Block 12.			14a. ☐ 14 CFR 43.9 Return to Service ☐ Other regulation specified in Block 12 Certifies that unless otherwise specified in Block 12, the work identified in Block 11 and described in Block 12 was accomplished in accordance with Title 14, Code of Federal Regulations, part 43 and in respect to that work, the items are approved for return to service.		
13b. Authorized Signature:	13c. Approval/Authorization No.:		14b. Authorized Signature:		14c. Approval/Certificate No.:
13d. Name (Typed or Printed):	13e. Date (dd/mmm/yyyy):		14d. Name (Typed or Printed):		14e. Date (dd/mmm/yyyy):
User/Installer Responsibilities					
It is important to understand that the existence of this document alone does not automatically constitute authority to install the aircraft engine/propeller/article. Where the user/installer performs work in accordance with the national regulations of an airworthiness authority different than the airworthiness authority of the country specified in Block 1, it is essential that the user/installer ensures that his/her airworthiness authority accepts aircraft engine(s)/propeller(s)/article(s) from the airworthiness authority of the country specified in Block 1. Statements in Blocks 13a and 14a do not constitute installation certification. In all cases, aircraft maintenance records must contain an installation certification issued in accordance with the national regulations by the user/installer before the aircraft may be flown.					
FAA Form 8130–3 (02–14)					NSN: 0052-00-012-9005

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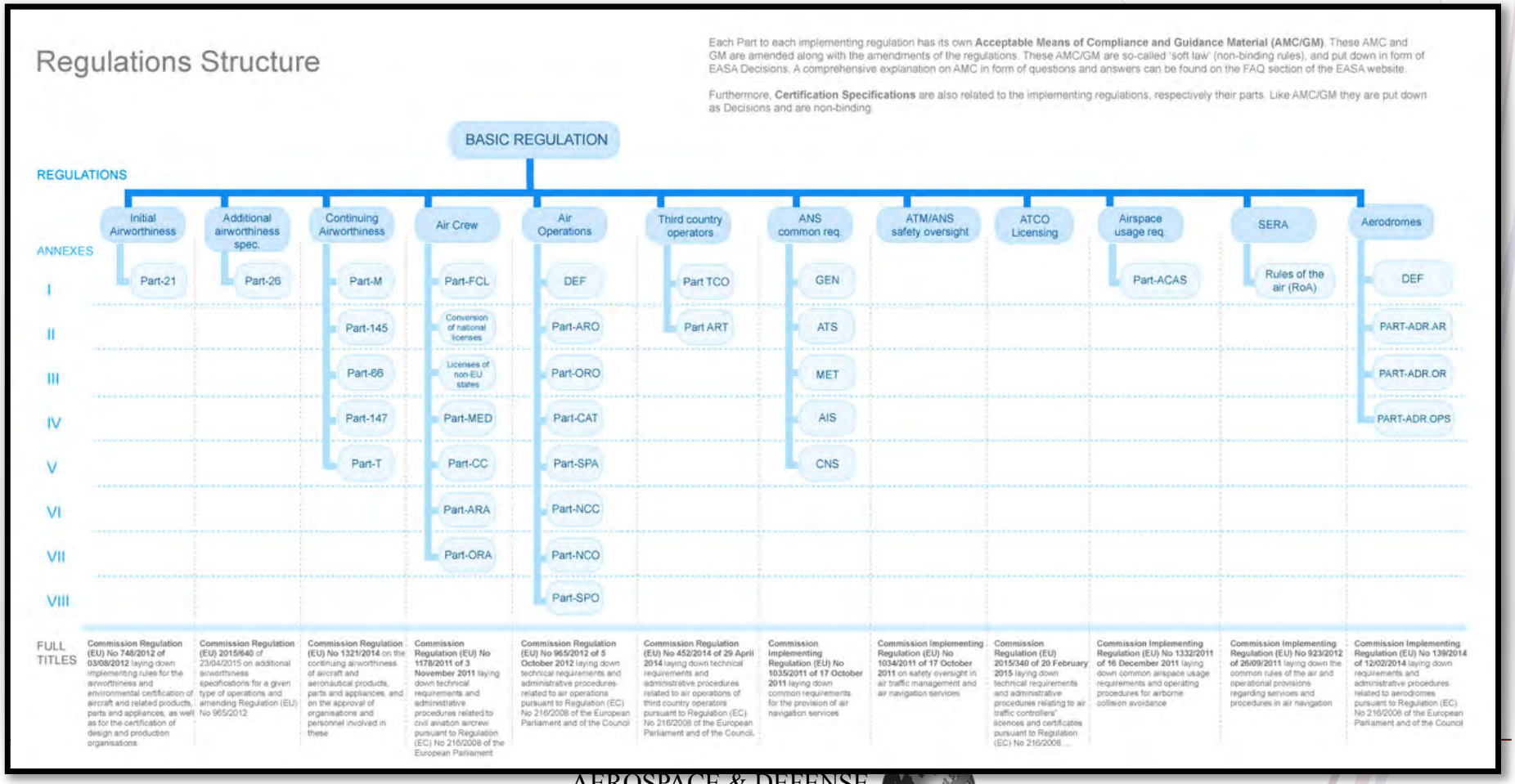
Certification Process & Requirements (FAA & EASA)

Phase 1 – Pre_Application → Phase 2 – Formal Application → Phase 3 – Document Compliance → Phase 4 – Demonstration and Inspection → Phase 5 - Certification



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Certification Requirements

Federal Aviation Administration, DOT **§21.31**

[Doc. No. 5085, 29 FR 14564, Oct. 24, 1964, as amended by Amdt. 21–59, 52 FR 1835, Jan. 15, 1987; 52 FR 7262, Mar. 9, 1987]

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CIMdata's 2015 PLM Road Map for Aerospace & Defense

Oct. 28, 29 2015

LOTAR

LONG TERM ARCHIVING AND RETRIEVAL

Long Term Archiving and Retrieval of Digital Product & Technical Data an Overview

Rick Zuray, The Boeing Company