



# ICAF

International Committee  
on Aeronautical Fatigue  
and Structural Integrity

## National Reviews: Airworthiness Considerations

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29 June 2023

# Airworthiness Considerations - *Outline*

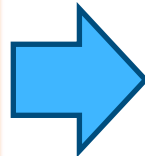
- Airworthiness Definitions
- Civil Airworthiness Perspectives and Examples
  - SHM
  - Probabilistic Methods
  - Rulemaking efforts in F&DT
  - Modeling and Simulation
  - Characterization of advanced materials
  - Etc.
- ICAF National Reviews
- Military Airworthiness Perspectives and Examples
  - Military Airworthiness Themes from ICAF 2023
  - Military Airworthiness Notable Developments

# What is Airworthiness?

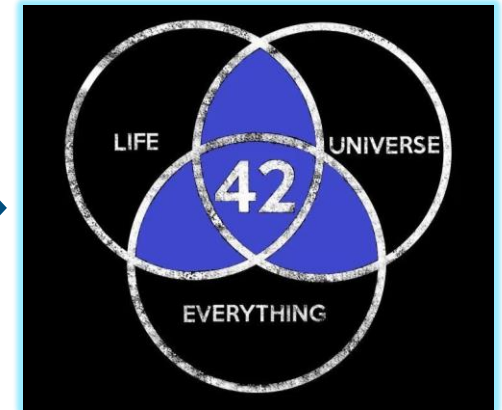
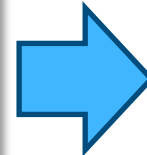
- A *very broad concept* in the context of Structural Integrity...
- Relevant concepts and definitions?
- Any difference in Civil vs. Military aviation frameworks?



- Reference: Hitchhiker's Guide to the Galaxy

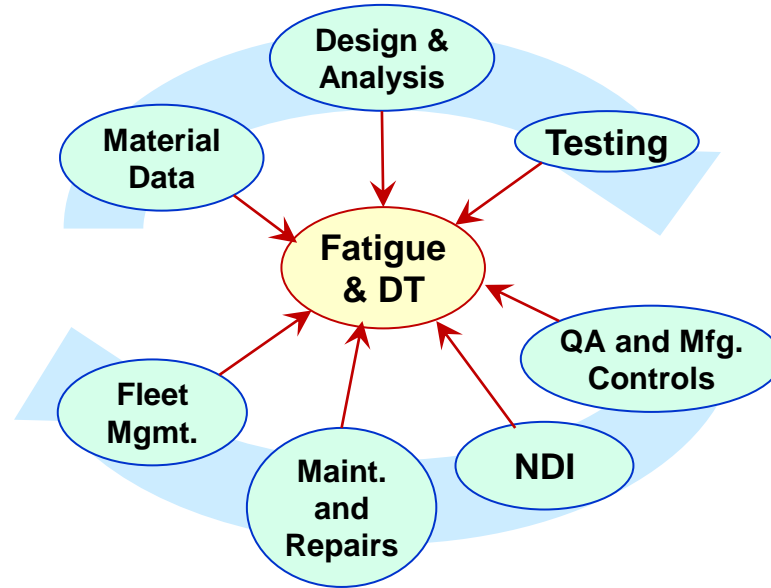


*The  
Ultimate  
Question*



- Is "42" the right answer?
- What is the question...?

# System-Level View of F&DT Discipline



All Elements Need to be Addressed to Ensure Safety (*and Airworthiness*) of Critical Aircraft Components

# Airworthiness Definitions *(Civil Aviation)*

- **Airworthiness Directives** ★
- **Continued Airworthiness**
- **Airworthiness Standards**
- **Airworthiness Certificate** ★
- **Instructions for Continued Airworthiness** ★
- **Etc...**



★ *See examples on the next slide*

# Airworthiness Definitions *(Civil Aviation)*



- **Airworthiness Directives**

Airworthiness Directives (ADs) are legally enforceable regulations issued by the FAA in accordance with 14 CFR part 39 **to correct an unsafe condition in a product.**

- Part 39 defines a product as an aircraft, engine, propeller, or appliance
- *Two types of ADs:* a) NPRM → Final Rule (AD); Emergency ADs (EAD)

- **Instructions for Continued *Airworthiness* (ICA)** – Ref: FAA Order 8110.54A

- ICA provide a way to keep products airworthy and contain documentation of **recommended methods, inspections, processes, and procedures**
- certain portions of the ICA must be approved, such as the Airworthiness Limitations Section (ALS)

- **Airworthiness Certificate (Standard vs. Special)**

- an FAA document which **grants authorization to operate an aircraft in flight**
  - a registered owner or owner's agent of an aircraft may apply for an airworthiness certificate
  - The airworthiness certificate is issued when the aircraft **meets its design requirements** and is **in condition for safe operations.**

UNITED STATES OF AMERICA DEPARTMENT OF TRANSPORTATION-FEDERAL AVIATION ADMINISTRATION <b>STANDARD AIRWORTHINESS CERTIFICATE</b>			
1 NATIONALITY AND REGISTRATION MARKS	2 MANUFACTURER AND MODEL	3 AIRCRAFT SERIAL NUMBER	4 CATEGORY
N12345	Boeing 787	43219	Transport
5 AUTHORITY AND BASIS FOR ISSUANCE This airworthiness certificate is issued pursuant to 49 U.S.C. 44734 and certifies that, as of the date of issuance, the aircraft to which issued has been inspected and found to conform to the type certificate thereto, to be in condition for safe operation, and has been shown to meet the requirements of the applicable comprehensive and detailed airworthiness code as prescribed by Annex 8 to the Convention on International Civil Aviation, except as noted herein. Exception:			
None			
6 TERMS AND CONDITIONS Unless sooner surrendered, suspended, revoked, or a termination date is otherwise established by the FAA, this airworthiness certificate is effective as long as the applicable comprehensive maintenance, and alterations are performed in accordance with Parts 21, 43, and 121 of the Federal Aviation Regulations as appropriate, and the aircraft is registered in the United States.			
DATE OF ISSUANCE	TAX REPRESENTATIVE	DESIGNATION NUMBER	
9 Jan 2015	E.R. White	NE-XX	
Any alteration, reproduction, or misuse of this certificate may be punishable by a fine not exceeding \$1,000 or imprisonment not exceeding 3 years or both. THIS CERTIFICATE MUST BE DISPLAYED IN THE AIRCRAFT IN ACCORDANCE WITH APPLICABLE FEDERAL AVIATION REGULATIONS. FAA Form 8130-2 (04-11) Supersedes Previous Edition			

# Example: Special Class *Airworthiness* Criteria for the AWPC AW609 Powered-Lift

<https://www.federalregister.gov/documents/2023/06/09/2023-12310/airworthiness-criteria-special-class-airworthiness-criteria-for-the-agustawestland-philadelphia>

- Powered-lift are type certificated as special class aircraft because the FAA has not yet established powered-lift airworthiness standards as a separate part of subchapter C of 14 CFR.
- The powered-lift has characteristics of both a rotorcraft and an airplane. Accordingly, the proposed Model AW609 certification basis contains standards from parts 23, 25, and 29, as well as other airworthiness criteria specific for a powered-lift.
- Fatigue: since the Model AW609 has a pressurized fuselage, the FAA developed Tiltrotor (TR) criteria to include the LOV requirement.

#### Reference:

Airworthiness Criteria for type certification of  
AW609 -

<https://www.regulations.gov>

(Docket No. FAA-2022-1726)



A similar development at the end of 2022: “Special Class Airworthiness Criteria for the *Joby Aero, Inc. Model JAS4-1 Powered-Lift*”



# Example: Addressing Continued Airworthiness Issue

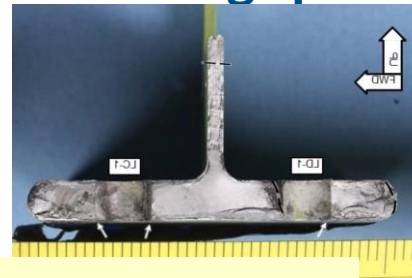


- Flight school training plane, Piper PA-28R-201 Arrow III, experienced left wing separation near the wing root while practicing touch-and-go maneuvers
- Metallurgical examination of the accident airplane's left-wing main spar lower cap found that it exhibited fracture features consistent with fatigue
- FAA AD 2020-26-16 published on 01/15/21. This AD requires calculating the factored service hours for each main wing spar to determine when an inspection is required, inspecting the lower main wing spar bolt holes for cracks, and replacing any cracked main wing spar.

## ➤ Recent Efforts

- Revision of the AD based on updated fatigue, DT, and risk analysis

<https://data.ntsb.gov/carol-rengen/aviation/ReportMain/GenerateNewestReport/96975/pdf>



# ARAC Tasking - Background

- FAA tasked Aviation Rulemaking Advisory Committee (ARAC) on January 26, 2015, to provide recommendations on damage-tolerance (DT) and fatigue evaluation requirements and associated guidance
  - Established the **Transport Airplane Metallic and Composite Structures Working Group** (TAMCSWG) to work the task under the Transport Airplane and Engine (TAE) Subcommittee
- ARAC approved the initial TAMCSWG report on September 20, 2018
  - Recommendations align with commercial industry practices
  - Link to the TAMCSWG report:
    - [https://www.faa.gov/regulations\\_policies/rulemaking/committees/documents/index.cfm/document/information/documentID/3723](https://www.faa.gov/regulations_policies/rulemaking/committees/documents/index.cfm/document/information/documentID/3723)

# ARAC Tasking Extension (20 Sept. 2018)

- FAA further tasked TAMCSWG to address:
    - **Single load path (SLP) structure**
    - **Bonding for both metals and composites**
    - **Crack interaction considerations** (*for establishing inspections programs*)
      - AC 91-82A provides evaluation considerations for establishing inspection thresholds and repeat intervals, including consideration of crack interaction, but *with no specific details on guidance*
      - Based on this, the FAA has requested information from the working group on *how to address crack interaction when establishing inspection programs*
- All the WG's tasks completed by early 2023 and reports are available in public domain

## ARAC Working Group Participants

Manufacturers	Operators	Regulators
Airbus	British Airways	Federal Aviation Administration
Boeing	Delta Air Lines	National Civil Aviation Agency of Brazil
Bombardier	FedEx	European Union Aviation Safety Agency
Dassault Aviation	United Airlines	Japan Civil Aviation Bureau
Embraer		Transport Canada Civil Aviation
Gulfstream		
Mitsubishi Aircraft		
Textron Aviation		

# Certification of SHM Systems

- Developed a generic Issue Paper (IP) in support of increasing number of applications for SHM systems certification
- The applicant should fully describe their method of compliance with §§ 25.571 and 25.1529, including, but not limited to, the following:
  - SHM system performance and **damage detection capability**
  - **Reliability and durability** considerations of SHM as a system, including how it will be evaluated
  - Applicability of the **necessary tasks for continued airworthiness** of the airplane
  - Applicability of **compliance considerations and data development** for certifying an SHM system

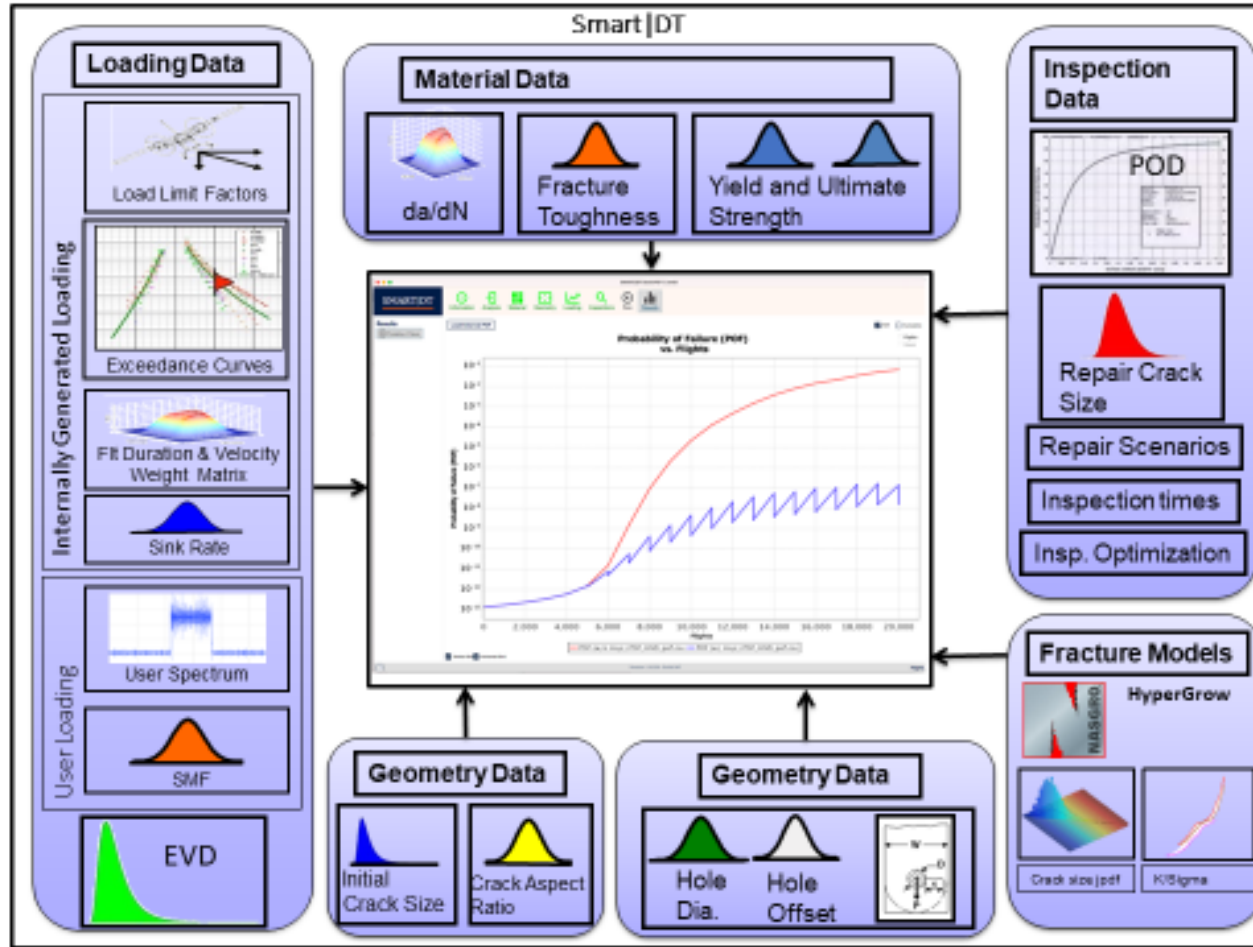
ISSUE PAPER		
PROJECT:	[Applicant] Model [make & model] Project No. [project number]	ITEM: A-# STAGE:
REG. REF.:	14 CFR § 21.50, § 25.571, §25.1529, Appendix H	DATE:
NATIONAL POLICY REF.:	AC 25.571-1D	ISSUE STATUS: Open
SUBJECT:	Qualification of a Structural Health Monitoring System for Detection of Damage in Structure	OFFICE ACTION: AIR-621, AED COMPLIANCE TARGET:
<i>Method of Compliance</i>		
STATEMENT OF ISSUE: The applicant proposes to install a Structural Health Monitoring (SHM) system on a model <Enter TCDS Model(s)> airplane. An SHM system evaluates the integrity of structure by acquiring and analyzing data from on-board sensors that interface with an electronic device (either on-board or off-board) that processes the data and provides an indication of the health of structure in terms of the existence of damage (e.g., fatigue damage). A SHM technology capable of reliably detecting		



The applicant will need to demonstrate that the damage detection capability (i.e., effectiveness) of the proposed SHM system is as good as the current FAA approved inspection program that the SHM system is replacing.

# Probabilistic Fatigue and DT Assessment for GA Aircraft

- SMART | DT and SMART | LD – *FAA-funded R&D project*



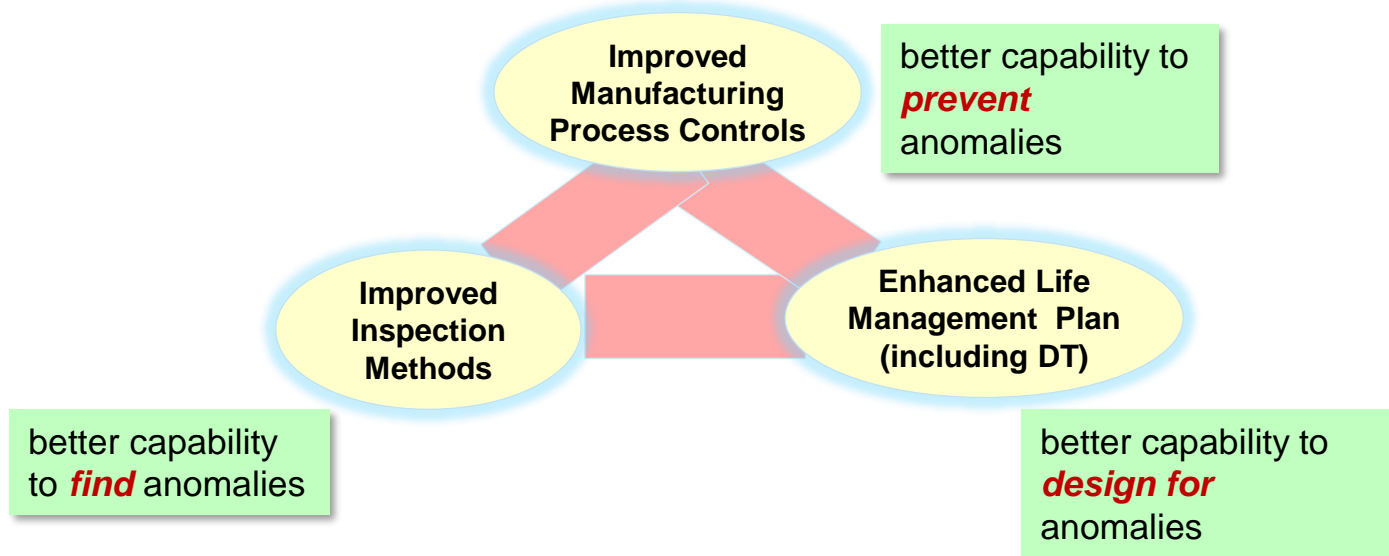
# Development of Advanced Fatigue, DT, NDI and Manufacturing Controls for Safety-Critical Turbine Engine Components

- **Key Drivers –**
  - 2016 AA Boeing 767-300ER accident (Chicago, O'Hare); uncontained 2<sup>nd</sup> stage turbine disk failure
  - 2017 Air France Airbus A380-861 accident (over Greenland); uncontained failure of fan hub
- **International industry-government collaboration (AIA RISC, JETQC, JENQC, etc.)**
- **Technical areas being addressed:**
  - Cold dwell fatigue phenomenon in certain Ti-based alloys
  - Fatigue debit due to material anomalies in certain Ni-based alloys
- ***In-line with NTSB and BEA recommendations***



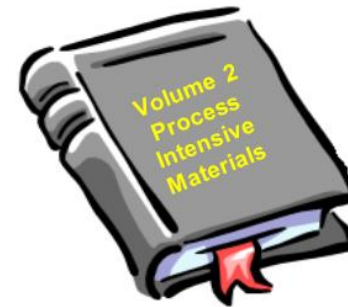
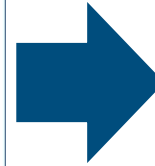
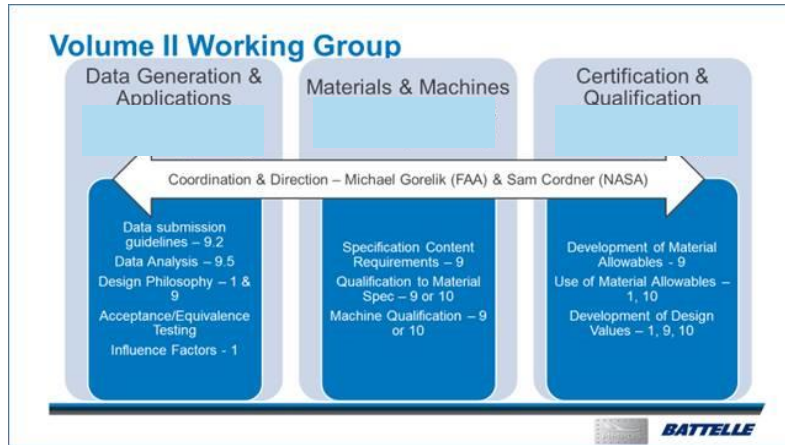
# Turbine Engines Airworthiness Experience

What worked well historically to reduce the rate of failures induced by material or manufacturing anomalies in safety-critical turbine engine components → *a three-prong approach:*



# Development of Material Allowables for AM

- **MMPDS – Development of Volume 2 Content (*new*)**
  - Process intensive materials; *initial focus on AM*



*Sample content:*

- Data submittal requirements
- Data tables
- Considerations for “further showing”

- **JMADD Program** (jointly funded by USAF and FAA)

– *Sample deliverables:*

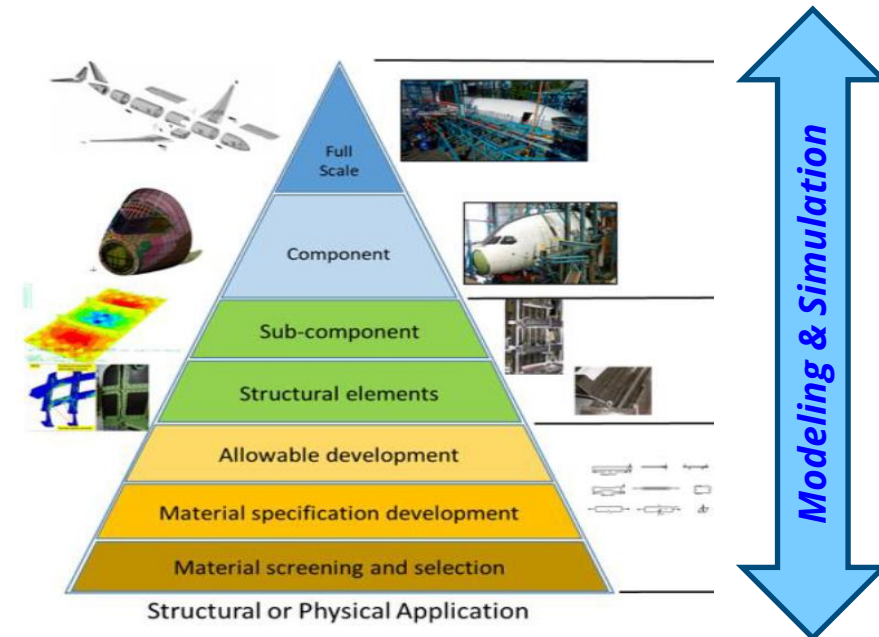
- Assess the efficacy of the existing public domain specs
- Define powder reuse strategy
- Perform testing and generate A- and B-basis allowables for LPBF Ti-6Al-4V using one or more statistical methods

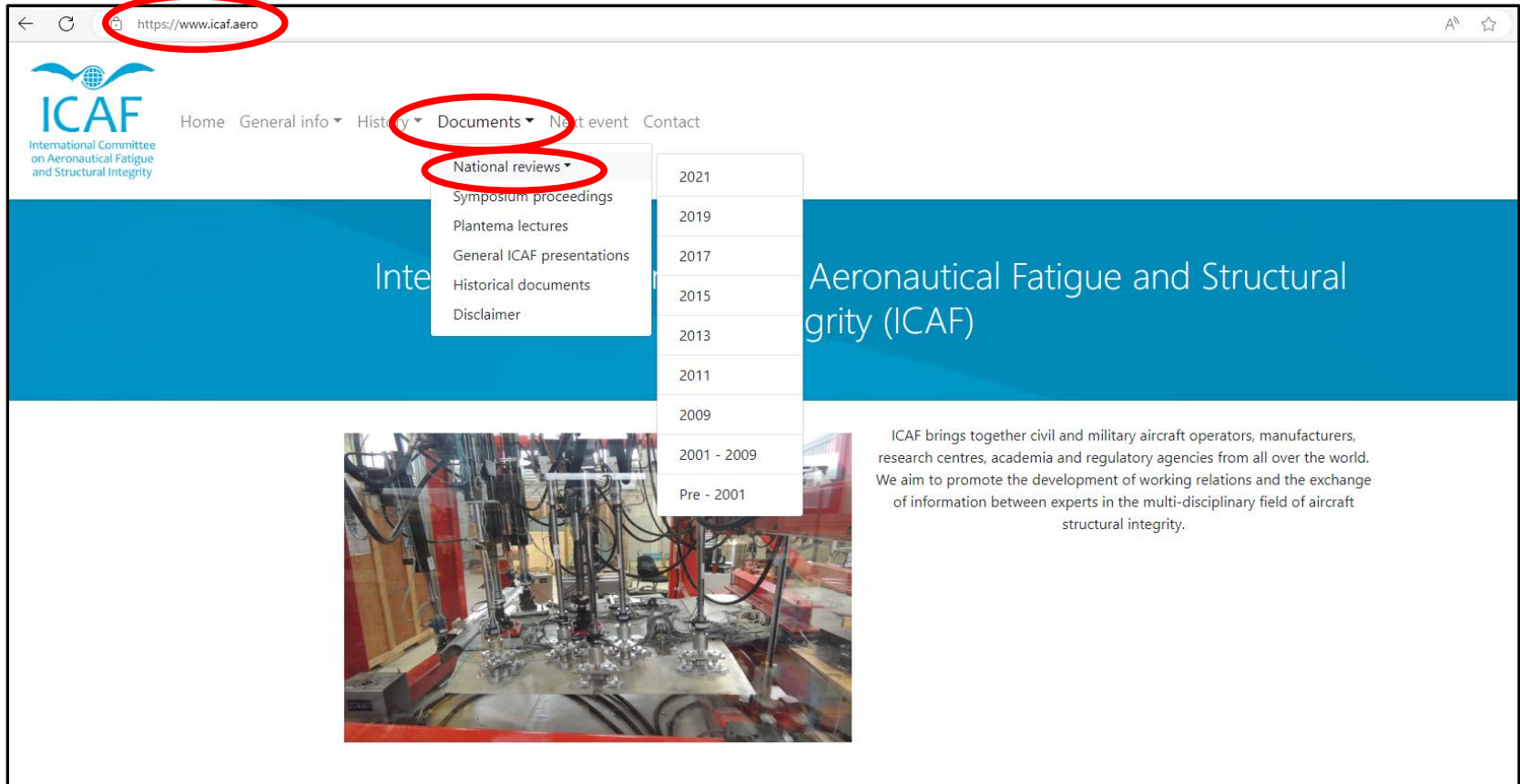
<https://www.americamakes.us/projects/5511-001-joint-metal-additive-database-definition-jmadd/>



# Increasing Use of Modeling and Simulation

- Industry – government working group morphed into a new ASME VVUQ sub-committee: **VVUQ90** “**Verification, Validation, and Uncertainty Quantification in Computational Modeling of Airframe Structures**”
- Main focus is on increasing acceptance of computational modeling methods for certification of airframe structures
- Concept of “Smarter Testing”
- Development of robust *Credibility Assurance Framework* (CAF), enabled by V&V and UQ
- *International collaboration* between industry and regulators





The screenshot shows the ICAF website interface. The browser address bar displays <https://www.icaf.aero>. The navigation menu includes 'Home', 'General info', 'History', 'Documents', 'Next event', and 'Contact'. The 'Documents' menu is expanded, showing 'National reviews' as the selected option. A secondary dropdown menu lists the following years: 2021, 2019, 2017, 2015, 2013, 2011, 2009, 2001 - 2009, and Pre - 2001. The main content area features a blue banner with the text 'Aeronautical Fatigue and Structural Integrity (ICAF)' and a photograph of an aircraft component in a testing facility.

ICAF brings together civil and military aircraft operators, manufacturers, research centres, academia and regulatory agencies from all over the world. We aim to promote the development of working relations and the exchange of information between experts in the multi-disciplinary field of aircraft structural integrity.

# Military Airworthiness - Themes from ICAF 2023

- Certification approaches for AM primary structure.
- Use of Digital Twin/Thread or Multi-Scale Structural Modelling for Rapid Certification

# Certification of Additive Manufacturing - Examples



- AM process qualification LBF (VTT)



- First AM primary structure part certification project (RUAG AG)



- Progress towards certification of first AM primary structural parts (NRC)



- Guidance on the qualification and certification of AM parts (DSTL)



- Defence Aviation Safety Authority (DASA-ADF) Additive Manufacturing Advisory Circular (AC), expected first half 2024.

# Digital Engineering backed Certification - Examples



- Plantema Lecture – Dr Claudio Dalle Donne (Airbus)



- Digital engineering for improved ASIP execution (USAF)



- Rapid fatigue testing technologies for certification (Airbus)



- Aircraft strength performance based on digital twin (AVIC Shenyang)



- Development and demonstration of digital twin technologies (NRC)

# Other 'Airworthiness Topics' from National Reviews



- Milestone Case Histories in Aircraft Structural Integrity (NLR)



- Aircraft Accident and Serious Investigation (JTSCB)



- Ageing Aircraft Regulations in the Australian Defence Force (QinetiQ)



- SHM Application to RPAS – The SAMAS Project (AFIT)

# Military Airworthiness – Notable Developments



- MIL-STD-1530E *Aircraft Structural Integrity Program* - in review with US Services, expected first half 2024.



- MIL-HDBK-516 *Airworthiness Certification Criteria* – update in work.



- AFLCMC/EZ Structures Bulletins - various
  - Convenient source: <https://daytonaero.com/usaf-structures-bulletins>



- DASA AC 005/2021 *Structural and Propulsion System Integrity Programs in the DASP*
  - [https://defence.gov.au/DASP/Docs/Manuals/Policy/ACs\\_Factsheets.htm](https://defence.gov.au/DASP/Docs/Manuals/Policy/ACs_Factsheets.htm)



- RA 5726 *Integrity Management* Issue 5 May 2023



- RA 5724 *Life Extension Programme* Issue 6 May 2023
  - <https://www.gov.uk/government/collections/5000-series-design-and-modification-engineering-regulations-dme#-5720-to-5726:-integrity-management>