



Progress Towards Aircraft Certification by Analysis within the American Institute of Aeronautics and Astronautics

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Outline

- What is Certification by Analysis (CbA)?
- Introducing the AIAA CbA Community of Interest
- Past accomplishments of the CbA CoI
- Current focus: the CbA Challenge Problem
- Outlook for 2027 and beyond

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Certification by Analysis

What is Certification by Analysis (CbA)?

- CbA is a broad term that describes the process by which engineering analysis tools are used to supplement flight testing to demonstrate compliance with regulatory requirements
- For each requirement that is to be met through this process, the analysis tools must be sufficiently accurate to ensure that an equivalent level of safety is obtained as if the aircraft to be certified had been flight tested for the requirement

Key Element: Successful CbA requires the establishment of trust in the predictive models that help reduce or replace flight test



Establishing Trust in Models

Trust in models can broadly be categorized into three main components

Solving Equations Correctly	Solving the Correct Equations	Understanding and Mitigating Risk
Verification	Validation *	Uncertainty Quantification

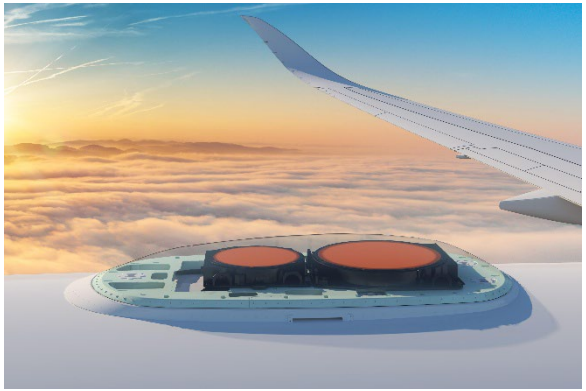
V&V and UQ lead to Trust → Trust enables CbA

* Including pre-test predictions compared post-test physical data

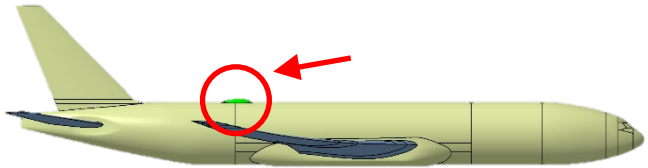


Introducing the AIAA CbA Community of Interest

- Formed in ~2017, the AIAA CbA CoI is responsible for a variety of CbA documents
  - AIAA Recommended Practice R-154-2021: When Flight Modelling Is Used to Reduce Flight Testing Supporting Aircraft Certification
  - UQ Position Paper that identified categories of V&V and UQ impediments for CbA
  - CbA community Challenge Problem definition
- Organizing team makeup:
  - Includes Boeing, DLR, Airbus, and NASA representatives
  - Members have backgrounds in aerodynamics, structures, ground test, flight test, certification processes, and V&V and UQ



Notional antenna radome design

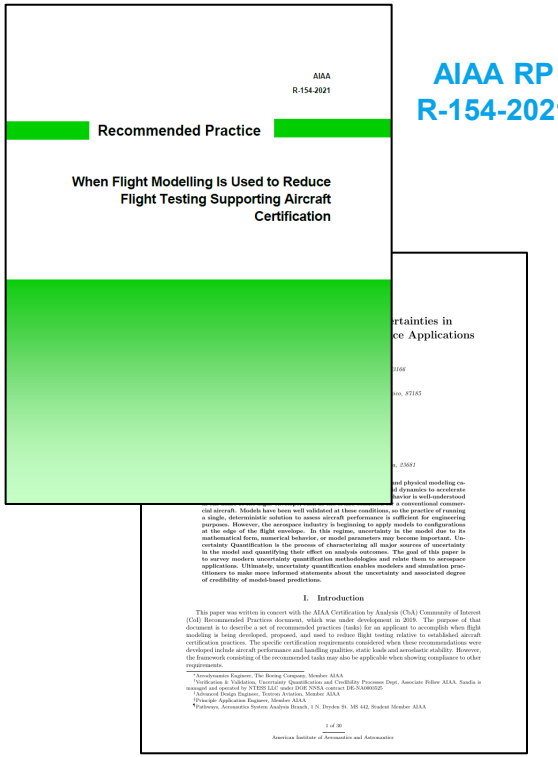


NASA CRM with antenna radome added to upper fuselage



AIAA Recommended Practice and UQ Companion Paper

- The CbA Recommended Practice defined **6 steps** for an applicant to accomplish when flight modeling is used to reduce certification flight testing:
  1. Configuration & process management
  2. Verification of the models
  3. Verification that the models were applied correctly
  4. Validation of the models
  5. Justification of analysis adequacy in recognition of potential modeling error and/or uncertainty
  6. A summary assessment of applicability for showing compliance
- A UQ Companion Paper was written to further expand upon steps 4 and 5, including examples



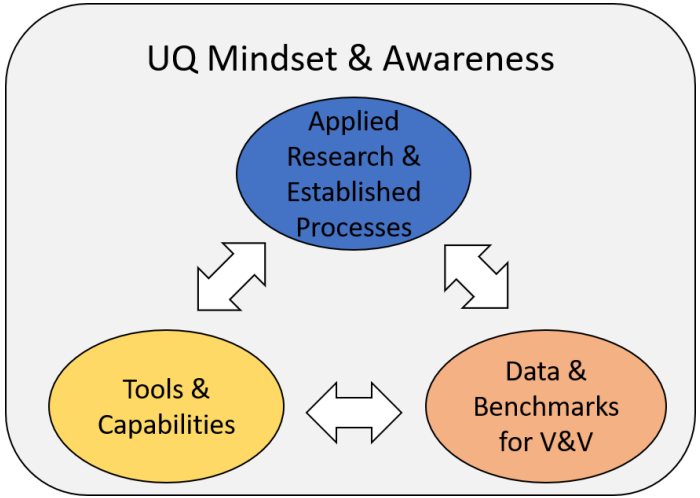
AIAA RP R-154-2021

AIAA Paper 2020-1520



CbA UQ Position Paper

- Community interest was growing, but AIAA progress towards CbA was slow…
  → Hence the CbA UQ Position Paper!
- Paper describes technological shortcomings and programmatic impediments that must be overcome to enable CbA goals
- Challenges are sorted into four categories:
  - UQ Mindset & Awareness
  - Tools & Capabilities
  - Data & Benchmarks for V&V
  - Applied Research & Established Processes



AIAA Paper 2024-2532 articulates many details surrounding these issues

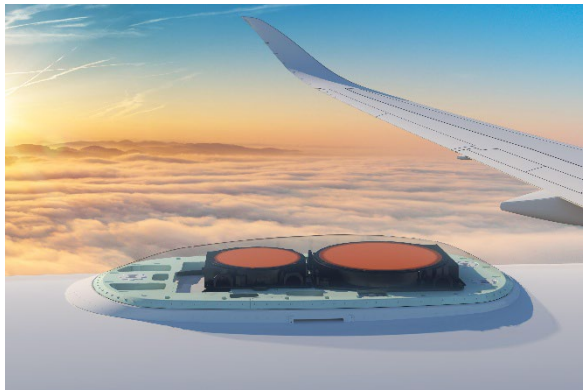
Feedback from associated CbA panel session: Community is ready to stop *talking* and start *doing*

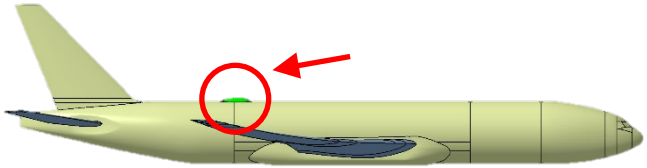


AIAA CbA Challenge Problem Overview

Introducing the AIAA CbA Challenge Problem

- A generic antenna shape has been derived based on existing fairings
- How could CFD, structural analysis, verification, validation, and uncertainty quantification be used to show that the addition of a radome on the fuselage of a previously certified airplane would not affect the original compliance demonstration?





NASA CRM including VTP + antenna fairing



Challenge Problem Goals

The goal of the Challenge Problem is for the aerospace community to develop V&V and UQ frameworks applicable to CbA and to demonstrate them on a relevant test case

See AIAA Paper 2025-3107 for full details of the problem

- This involves an understanding of:
  - Multi-disciplinary sources of uncertainty
  - How to categorize and quantify sources
  - How to propagate heterogeneous sources of uncertainty
  - How to determine the impact and relevance of uncertainties w.r.t. certification regulations
- The proposed Challenge Problem serves as a testbed to achieve the goals
  - It should be neither seen as a pure simulation exercise nor as a full certification of an actual aircraft alteration
  - It serves as an industrial-relevant case to develop V&V and UQ frameworks for CbA



Challenge Problem Deliverables

Sampling of FAA regulations relevant to the addition of an antenna radome:

Part	Subpart	Paragraph(s)	Description
25	B	25.251(b)(d)	Vibration and buffeting
25	B	25 25.253	High-speed characteristics
25	C	25.301(a)(b)	Loads (cover paragraph for validated aircraft model)
25	C	25.305(a)(e)	Strength and deformation (buffeting Loads)

Participants are expected to provide:

1. **An assessment of structural margin** for the antenna radome mounting structure computed for a range of operational conditions and relevant structural failure criteria, and including an estimate of total uncertainty based on several sources of uncertainty
2. **A detailed description of the V&V and UQ framework** that was employed to facilitate the calculations required for the item above, including all assumptions, advantages, and identified limitations of the framework for all steps involved



Challenge Problem Participation

Community response to the Challenge Problem has been excellent

- 14 abstracts have been submitted by teams from North America, South America, Europe, and Asia
- 5 abstracts result from multi-organization partnerships
- 6 industrial, 5 university, and 6 government research institutions plan to participate

What happens next?

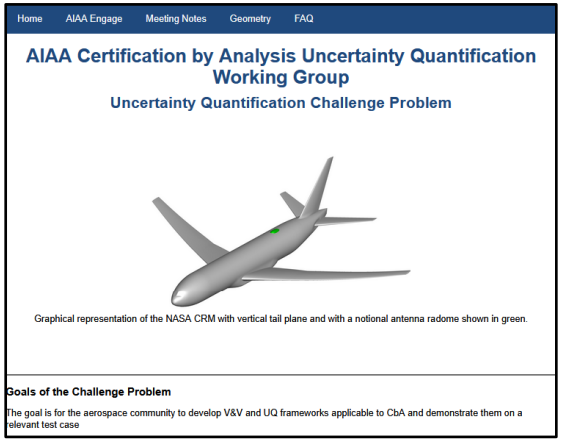
- The AIAA CFD2030, Applied Aerodynamics, and UQ Technical Committees are jointly hosting three special sessions at the AIAA SciTech Forum in Orlando, FL, January 2027
- Challenge Problem participants will present their results, and their technical papers will become available in the conference proceedings
- Following the sessions, the CbA CoI will host an evening meeting to discuss community feedback, collective results, and next steps for the CoI

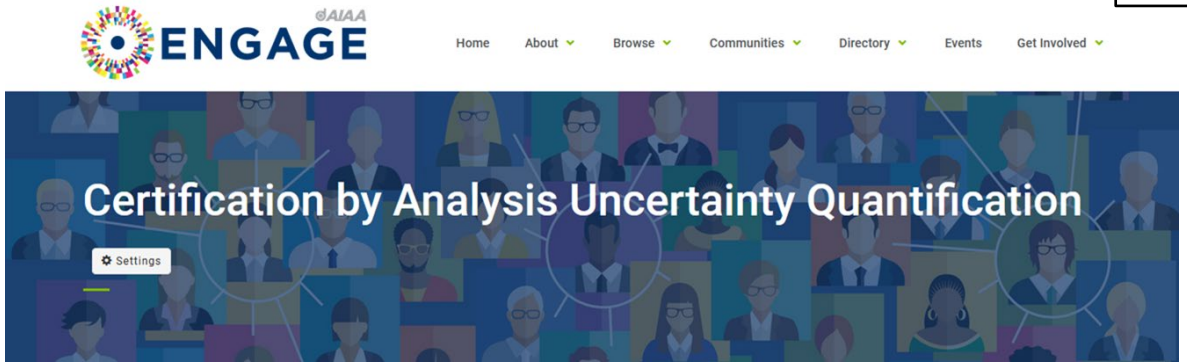


Community Resources: AIAA Engage and CbA UQ Website

How to follow along?

- Join our AIAA Engage community to receive meeting notifications, participate in discussion forums, watch recordings of past meetings, and share files
- Visit the Challenge Problem website for geometry downloads, FEM files, FAQ, and more: https://www.aiaa-uq4cba.org/







https://engage.aiaa.org/communities/community-home?CommunityKey=277d7888-91e3-4e77-8f61-0190026a4c84

Outlook for 2027+

The AIAA SciTech Special Sessions are not the end

- The CbA CoI Organizing Team plans to submit a summary paper of Challenge Problem results to the AIAA Aviation 2027 conference (June 2027, San Diego, CA)
- A panel session is also planned at Aviation 2027 to discuss lessons learned and potential next steps
- A survey will be distributed to the community in Q1 2027 to solicit feedback on the Challenge Problem, suggested new research directions, etc.
- The Organizing Team will continue to engage with regulator guest speakers and begin pursuing avenues for regulators to provide feedback / guidance on community activities
- Additional potential for cross-organizational collaborations with groups pursuing CbA and V&V topics (e.g., AIAA, NATO, Certification DX, ASME VV40, ASME VV90)

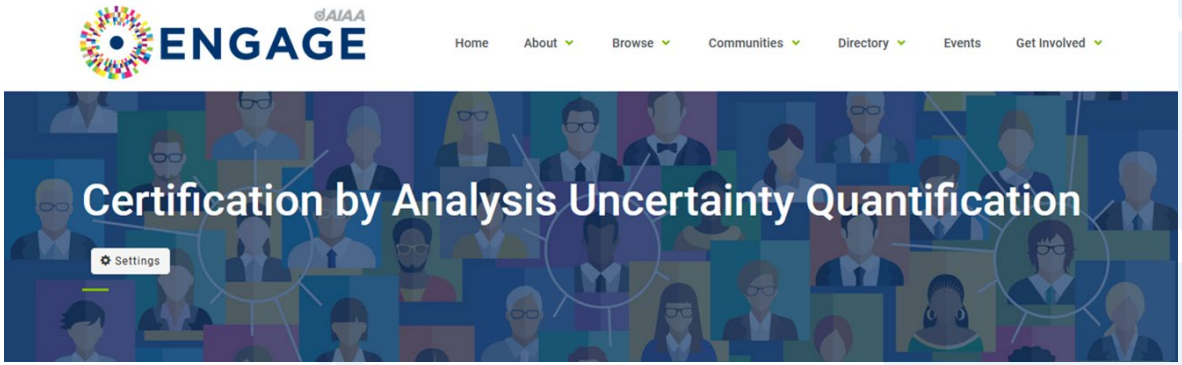


Conclusions

- Verification, Validation, & Uncertainty Quantification are key to establishing trust in models, a necessary component for successful CbA
- The AIAA CbA Community has been active for approximately 8 years!
  - Primary focus has been on commercial aircraft CbA
  - CbA challenges and opportunities have been articulated in multiple documents
  - An enthusiastic group of international collaborators is working towards submissions to a CbA Challenge Problem
- Collaboration with other groups outside of AIAA will help advance CbA
  - Pursue further engagement and feedback from regulators
  - Potential for cross-organizational discussion or collaboration on CbA and V&V topics

Please reach out to join an active community to achieve our common goals for accurate analysis models that enable safe & effective Certification by Analysis!




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