Certification by Analysis (CbA)
ICAS 2026 Sessions

Jeffrey Slotnick
The Boeing Company (ret.)
jeffreyslotnick@gmail.com

C. P. van Dam
University of California, Davis (ret.)

Paul Vijgen
The Boeing Company (ret.)



Monday, 14 Sept (9:55-11:25am)

Session 2.1 (Invited Presentations)

Progress in CbA

Session Chairs	**J. Slotnick, B. Aponso**
Towards Certification by Analysis: A Military Airworthiness Perspective	**A. Goerttler (Presenter)** *German Aerospace Center* *Germany*
Exploring Airworthiness CbA: A Stall Speed Case Study Based on Aero-Structural Coupled Analysis	**M. Amano** *Kawasaki Heavy Industries* *Japan*
Progress Towards Aircraft Certification by Analysis within the American Institute of Aeronautics and Astronautics	**Robert Gregg III (Presenter)** *The Boeing Company* *USA*
An Effort Toward Process Development of CbA for Flight Characteristics	**T. Ishida** *Japan Aerospace Exploration Agency* *Japan*

Wednesday, 16 Sept (3:40-5:20pm)

Session 6.8 (Invited Panel)

CbA – Accelerating Momentum and Impact

Session Chairs	**J. Slotnick, C.P. van Dam**
Panelist	**B. Aponso** *Federal Aviation Authority (FAA)* *USA*
Panelist	**D. Peterson** *Civil Aviation Safety Authority (CASA)* *Australia*
Panelist	**T. Ishida** *Japan Aerospace Exploration Agency* *Japan*
Panelist	**H. Schlickenmaier** *HS-Advanced Concepts* *USA*



Goals of CbA Sessions at ICAS 2026

- **Provide an overview, status, challenges and prospects on certification by analysis (CbA) for aerospace systems, for both commercial and military applications**
- **Discuss outstanding obstacles and hurdles preventing CbA from widespread adoption in Industry**
- **Discuss and explore pathways and opportunities to accelerate the use of CbA in Industry**



Thank you for your attention!



XHA-C26061

Certification by Analysis
- Accelerating Momentum and Impact

Takashi ISHIDA
Japan Aerospace Exploration Agency



Answer for Proposed Questions 1.

① Building Trust and Developing Qualified Personnel among Regulators, Applicants, and Analysts

- NATO AVT-407* also positions Certification by Analysis (CbA) as a **socio-technical challenge**, identifying **model assurance**, **simulation governance**, and **qualified personnel** as its key themes.
- Furthermore, discussions in the conference's personnel session emphasized the need for **"T-shaped" competencies**, combining a broad understanding of certification regulations with deep expertise in individual technical disciplines.

https://www.sto.nato.int/document/system-qualification-and-certification-by-analysis/

https://publications.sto.nato.int/publications/STO%20Meeting%20Proceedings/STO-MP-AVT-407/MP-AVT-407-IP1P.pdf

* Applied Vehicle Technology Panel of the NATO Science and Technology Organization (NATO STO)



Answer for Proposed Questions 1.

② Model Credibility and Quantification of Uncertainty

- NASA's CbA Roadmap also states that maintaining a level of safety equivalent to that achieved through flight testing requires not only accurate analysis tools, but also methods to address: V&V data, variations in uncertainty across different domains of applicability, and both **aleatory uncertainty** and **epistemic uncertainty**.
  https://ntrs.nasa.gov/api/citations/20210015404/downloads/NASA-CR-20210015404%20updated.pdf
- ASME V&V 20 likewise provides a framework for quantifying errors and uncertainties in both CFD simulations and experimental data. However, it explicitly states that interpolation or extrapolation beyond validation points must be addressed through **case-specific engineering judgment**.
  https://files.asme.org/Catalog/Codes/PrintBook/21356.pdf



Answer for Proposed Questions 1.

③ Governance of Certification Processes, Standards, Data, and Software

- NASA-STD-7009B requires, among other elements: M&S lifecycle planning, Documentation of data and software used, Defect management, Risk assessment, Capability Assessment, and Results Assessment.
- What is required for CbA is an analysis process that remains **traceable and auditable throughout the entire lifecycle**.
  https://standards.nasa.gov/sites/default/files/standards/NASA/w/CHANGE-1/1/Historical/nasa-std-7009.pdf



Answer for Proposed Questions 2.

- **Initiative**
  - Conduct an International Certification by Analysis (CbA) Demonstration Program
- **Organizational Structure**
  - Regulators, Research Organizations, Industry, Academia
- **Implementation Steps**
  - Establish publicly shareable common benchmark problems
  - Conduct validation and verification activities directly relevant to certification
- **Essential Deliverables**
  - Internationally shareable V&V standards
  - Regulatory Acceptance Framework
  - Public database
  - Collection of certification case studies



Answer for Proposed Questions 3.

- **Approach**
  - Internationally develop and maintain publicly shareable certification-grade benchmarks.
  - Apply Certification by Analysis (CbA) wherever feasible, starting with areas where implementation is practical (start small).
- **How Much Testing Is Required?**
  - It depends on the specific case.
  - Factors that determine the required extent of testing include:

    model's intended use, certification requirements being addressed, safety significance of an incorrect decision, degree of reliance on analysis, maturity of the underlying physical phenomena, distance between the validation domain and the application domain, magnitude of uncertainty, previous experience with similar geometries and operating conditions, manufacturing and operational variability, sensitivity of the results to available safety margins
  - FAA V&V guidance also explains that the accuracy of M&S should be assessed with respect to its intended use, and that accuracy becomes increasingly uncertain as conditions move farther from those that have been validated. https://faa.niar.wichita.edu/Portals/0/Model%20Validation%20Process2.pdf
  - The key consideration is not simply the number of data points, but rather the extent to which the potential input space has been covered. https://faa.niar.wichita.edu/Portals/0/Golden%20Rules%20of%20Verification%20and%20Validation%20-%20David%20Moorcroft.pdf
- **Organization Most Likely to Deliver Successful Outcomes**
  - Regulators, Research Organizations, Industry, Academia



Answer for Proposed Questions 4.

- **Key Challenge**
  - Harmonization of acceptance criteria among regulatory authorities
  - If evidence requirements differ among the FAA, EASA, national aviation authorities, and defense authorities, the same analytical results must be presented in multiple formats, diminishing the efficiency benefits of Certification by Analysis (CbA).
- **Required Actions**
  - Conduct joint demonstration programs among regulatory authorities
  - Establish common terminology
  - Develop a standardized format for model credibility reports
  - Enable mutual acceptance of V&V/UQ (Verification & Validation / Uncertainty Quantification) evidence packages
  - Develop and publish challenge problems through international working groups
  - Promote personnel exchanges for certification specialists.



Certification by Analysis (CbA)

Key Questions & Expert Insights

Ensure Safety & Effectiveness

Reduce Cost & Time-to-Market

Across All Aerospace Sectors & Domains

Global Collaboration & Harmonization

CbA Vision

Reliable, efficient, and globally accepted certification through credible analysis, strong governance, and trusted people.

Q1 What are the top three most critical challenges for CbA and why?

1 Building Trust & Developing Qualified Personnel

CbA is a socio-technical challenge. Requires "T-shaped" competencies and trust among regulators, applicants, and analysts.

2 Model Credibility & Quantification of Uncertainty

Accurate tools plus methods for V&V data, uncertainty (aleatory & epistemic), and engineering judgment beyond validation points.

3 Governance of Processes, Standards, Data & Software

Lifecycle planning, documentation, risk & capability assessment, and traceable, auditable analysis throughout the lifecycle.

Key Takeaway

Trust, credible models with quantified uncertainty, and strong governance are the pillars that enable successful CbA.

Q2 How would you structure an effort to accelerate the maturity and deployment of CbA?

Initiative

Conduct an International Certification by Analysis (CbA) Demonstration Program

Organizational Structure

Regulators | Research Organizations | Industry | Academia

Implementation Steps

1. Establish publicly shareable common benchmark problems
2. Conduct validation and verification activities directly relevant to certification
3. Engage stakeholders and iterate through demonstrations

Essential Deliverables

- Internationally shareable V&V standards
- Regulatory Acceptance Framework
- Public Database
- Collection of Certification Case Studies

Q3 How much testing is required and what approach should be taken?

Approach

Internationally develop & maintain publicly shareable certification-grade benchmarks.

Apply CbA wherever feasible, starting small in practical areas.

How Much Testing Is Required?

It depends on the specific case.

Key Factors That Determine the Extent

- Intended use of the model
- Certification requirements
- Safety significance of an incorrect decision
- Degree of reliance on analysis
- Maturity of physical phenomena
- Distance between validation & application domains
- Magnitude of uncertainty
- Experience, variability & sensitivity to safety margins

Key Principle

The key is not the number of data points, but the extent to which the potential input space has been covered.

Organization Most Likely to Deliver Success

Regulators | Research Organizations | Industry | Academia

Q4 What are the most critical regulatory issues with CbA and how should they be addressed?

Key Challenge

Harmonization of acceptance criteria among regulatory authorities.

Different evidence requirements (FAA, EASA, national & defense) cause duplicate submissions and reduce CbA efficiency benefits.

Required Actions

1. Conduct joint demonstration programs among regulatory authorities
2. Establish common terminology
3. Develop a standardized format for model credibility reports
4. Enable mutual acceptance of V&V/UQ evidence packages
5. Develop & publish challenge problems through international working groups
6. Promote personnel exchanges for certification specialists

Outcome

Globally harmonized, efficient, and trusted CbA certification.

Cross-Cutting Enablers for Successful CbA

People & Culture
Build trust, competence, and collaboration

Data & Digital Infrastructure
High-quality data, secure access, and interoperability

Standards & Best Practices
Harmonized, living standards and guidance

Continuous Learning
Feedback loops, lessons learned, and capability growth

Global Collaboration
Shared goals, transparency, and mutual benefit

Ultimate Goal

Safe, efficient, and globally accepted certification through trusted analysis.

Certification by Analysis:
Accelerating Momentum and Impact

Bimal Aponso, Office of Senior Technical Experts (AIR-20)

ICAS 2026
Sydney, Australia

Federal Aviation Administration

Challenges to using M&S

- M&S tools and techniques have expanded significantly in breadth of application and capability
  - May lead to unfounded confidence in the results
- The accuracy of a model depends, in large part, on how it is formulated – somewhat of an art-form
- Some situations where M&S-based predictions are compromised are those that:
  - Involve the confluence of engineering disciplines (aerodynamics + structures + propulsion + flight control);
  - Involve a reliance on external cues that affect a pilot's control strategy, particularly where the required pilot compensation to perform the task is high;
  - Have unsteady and separated flow (either on the aircraft surfaces, or from external disturbances from vortex shedding from nearby buildings)
  - Evaluating handling qualities, performance, controllability and maneuverability, where external cues (visual, motion, and proprioceptive) to the pilot are a critical factor

1. Top Three Challenges

"All models are wrong, but some are useful"

- Education and training on model development
  - Understand and internalize that "Garbage In = Garbage Out"
  - Domain specific
  - The value of reduced-order models
- Standardized data sets for verifying modeling methods and tools.

2. Thoughts on Improving Maturity and Deployment of CbA

- Develop consensus standards on:
  - Model verification – standardized data sets, domain extent
  - Model validation – UQ and its relation to “acceptable” levels of safety risk

- Primarily an industry/industry standards bodies activity
  - How should regulatory bodies be involved?

3. Level of Physical Testing

- Proprietary concerns preclude sharing of flight/ground test data – that is not going to change
- Potential solution is industry robust, verified, consensus tools and methods that provide a sound basis for customized models and validation methods that need individual certification requirements.

4. Critical Issues

- Understanding the risks of making a safety decision based on M&S.
  - Consequences if the decision is incorrect
- Facilitate a common conversation between regulator and stakeholder
  - Define the safety question and consequences
  - Determine the level of model credibility required for the criticality of the safety question
  - Determine the sources and quality of the validating data to achieve the desired model credibility
  - Determine the tolerance for uncertainty in the model estimate

Existing Standards/Best Practices: Using M & S for Assessing System Safety

- MIL-STD-3022 Documentation of Verification, Validation, and Accreditation (VV&A) for Models and Simulations (28 January 2008)
  - Verification, Validation, and Accreditation (VV&A) Recommended Practices Guide (RPG), Defense Modeling and Simulation Office
- NASA Technical Standard 7009B – Standard for Models and Simulations
- The American Society of Mechanical Engineers (ASME) Verification and Validation (V&V) Standards in Modeling and Simulation:
  - V&V 10–2019, Standard for Verification and Validation in Computational Solid Mechanics
  - V&V 20–2009, Standard for Verification and Validation in Computational Fluid Dynamics and Heat Transfer
  - V&V 40–2018, Assessing Credibility of Computational Modeling through Verification and Validation: Application to Medical Devices
- US Food and Drug Administration Guidance for Industry and FDA Staff – Assessing the Credibility of Computational Modeling and Simulation in Medical Device Submissions
- AIAA Recommended Practice (R-154-2021): When Flight Modeling is Used to Reduce Flight Testing Supporting Aircraft Certification
- European Union Rotorcraft Certification by Simulation Project: Preliminary Guidelines for the Rotorcraft Certification by Simulation

Relevant Terms and their Definitions (adapted from NASA-STD-7009B)

- **Validation:** The process of determining the degree to which a model or a simulation is an accurate representation of the actual or representative system from the perspective of the intended uses of the M&S.
- **Verification:** The process of determining the extent to which an M&S is compliant with its requirements and specifications as detailed in its conceptual models, mathematical models, or other constructs.
- **Domain of Validation:** The region enclosing all sets of M&S inputs for which the M&S responses compare favorably with the actual or representative system.
- **Domain of Verification:** The region enclosing all sets of M&S inputs for which the solution is determined to be correct and satisfy requirements for accuracy and precision.
- **Calibration:** The process of adjusting numerical or modeling parameters in the M&S to improve agreement with data from the actual or representative system. Note: Calibration can also be known as "tuning."



Federal Aviation Administration