Aircraft Certification by Simulation

Paul Bolds-Moorehead
Dave Shikany
Boeing Commercial Airplanes

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Agenda

- Where are we today?
- Where do we want to go in the future?
- Why do we think we can get there?
- What are the challenges ahead?
Current State

- For new airplane models (First-of-Model) handling qualities (HQ) compliance almost exclusively demonstrated with flight test
  - Limited Cert by Simulation (failures)

- For derivative airplane models HQ compliance predominantly demonstrated with flight test
  - Some Cert by Simulation for areas of minimal change
  - Take advantage of flight updated parent airplane simulation
Future State

- Goal of expanding the use of Cert by Simulation for First-of-Model to reduce HQ certification flight testing
- Goal of eliminating HQ certification flight testing for a derivative airplane model
- A shift in flight testing from demonstrating compliance to validating a simulation
HQ Flight Testing

- Pre-Certification
  - Envelope expansion
  - Configuration/control law development/validation
  - Database development/validation
  - Certification practice

- Certification
  - Demonstrate compliance to the certifying authority

- Current focus on moving certification flight testing to cert by simulation

- Likely future pressure on pre-certification testing
Handling Qualities Certification Source Data

- The source of data to support handling qualities certification varies throughout the life cycle of an airplane program

- Sources
  - Certification flight test (retained or delegated)
  - Piloted simulator session
  - Desktop simulation analysis
  - Parent airplane (similarity)
  - Wind tunnel or CFD (Post ATC – antennas)
Sources of Handling Qualities Certification Data
First-of-Model

Current:
- Flight Test (majority)
- Piloted Sim Cab
- Desktop Sim
- Other

Future:
- Flight Test (majority)
- Piloted Sim Cab
- Desktop Sim
- Other
Sources of Handling Qualities Certification Data

Derivative Model

Current

- Flight Test
- Piloted Sim Cab
- Desktop Sim
- Other

Future

- Flight Test
- Piloted Sim Cab
- Desktop Sim
- Other
Why Do We Think We Can Get There?

- The harmonized regulations state that: “Each requirement … must be met … by tests upon an airplane of the type for which certification is requested, or by calculations based on, and equal in accuracy to, the results of testing.” (§25.21(a)(1))

- Predictive methods, particularly for derivative airplanes, have demonstrated the ability to match flight test data with a pre-flight simulation model.

- For derivative airplanes the industry has already been using Cert by Simulation for a portion of the regulations – This can be expanded and we can now look toward taking advantage of the simulation for the First-of-Model as well.

- Any Cert by Simulation efforts will utilize a simulation updated with early flight test results. For derivative airplanes the simulation will incorporate the Level D update of the parent airplane.
Why Do We Think We Can Get There?
Pre-flight Simulation Model Fidelity Assessment of Derivative Airplanes

- Four airplane models were chosen since they represent typical derivatives in a family of airplanes

- Matches were generated with pre-flight aerodynamic models and graded using Level D/Type VII tolerances

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<thead>
<tr>
<th>Color</th>
<th>Description</th>
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<tbody>
<tr>
<td>Green</td>
<td>All required parameters are within tolerance</td>
</tr>
<tr>
<td>Yellow</td>
<td>Required parameter slightly or briefly exceeds tolerance</td>
</tr>
<tr>
<td>Red</td>
<td>Required parameters significantly exceed tolerance</td>
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Summary of Pre-flight Simulation Model Fidelity Assessment

219 Matches Assessed…75% Matched within Tolerance
Challenges in Moving Forward

- Acceptance of the simulation being as accurate as flight test per regulation §25.21

- How “good” does the simulation need to be?
  - Are the Part 60/ CS-FSTD / ICAO 9625 tolerances good enough?
  - Do new criteria need to be defined?
Regulatory Acceptance
Challenges in Moving Forward

- Industry activity is spinning up

- **AIAA Community of Interest**
  - Objective is to develop a “Recommended Practices” (RP) document to streamline the acceptance of CQbA by Regulatory Agencies
  - Col kick-off scheduled for June 2018 in Atlanta, GA (AIAA Aviation)
  - White Paper has been completed, and notional outline of RP document is in work

- Boeing has engaged the Industry and Regulatory Authorities on possible research activity related to Certification by Simulation or Certification by Analysis
How good does the simulation need to be?
Challenges in Moving Forward

- **Part 25**
  - Ensure the airplane exceeds a minimum requirement

- **Part 60**
  - Ensure the simulator represents the airplane by matching flight test data within a tolerance
Part 60 Tolerances
Challenges in Moving Forward – How good is good enough?

- **Pros**
  - Well understood industry standard

- **Cons**
  - Possible to be within tolerance yet not meet Part 25 requirements
One-sided Part 60 Tolerances
Challenges in Moving Forward – How good is good enough?

- **Pros**
  - Addresses conditions that may be marginal from Part 25 perspective

- **Cons**
  - Too restrictive for cases where there is adequate margin

![Diagram showing Fs and Vc with a shaded area indicating fail and a line indicating minimum stick force gradient.](image)
Margin on Part 25 Criteria
Challenges in Moving Forward – How good is good enough?

- **Pros**
  - Could compliment fidelity requirements

- **Cons**
  - Conservative approach if simulation provides adequate fidelity
How good does the simulation need to be?
Challenges in Moving Forward

- Different options to address regulatory requirement that Cert by Simulation be “equal in accuracy to the results of testing”

- Careful consideration will be needed to ensure simulation fidelity requirements drive needed accuracy without being overly conservative

- Could be a combination of concepts explored on previous slides

- Fidelity requirements will likely change for the different airplane certification requirements
Summary

- Regulatory material allows for the use of Cert by Simulation and current practice does this to a limited extent

- Shift the focus of flight testing from demonstrating compliance to updating/validating the simulation

- The fidelity of Boeing simulation is sufficient to support the expanded use of Cert by Simulation – particularly for derivative airplanes

- Flight simulator fidelity requirements have been driven by training needs – to expand the use of simulation as an analysis tool may require additional/new fidelity requirements