Experiences from Five Years of Certification by Analysis: Anonymized Case Studies from the Aviation Industry

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Acknowledgement/Disclaimer

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• The views expressed in this presentation are those of the authors and do not necessarily reflect the view of the Agency.

• FAA research may advise regulatory decisions, however, certification approvals are based on published federal regulations and policy.
Notes

• No company proprietary data will be shown in the case studies; pictures are from research tests with similar outcomes

• The examples are from ongoing projects where additional work is needed for final approval; no unsafe designs were approved based on these activities
Background

• FAA regulations require original equipment manufacturers (OEMs) to demonstrate the safety of aircraft components
• FAA has defined a means of compliance (MOC)
• An applicant can propose alternate MOC via an Issue Paper
  – Applicant and FAA negotiate the contents of the AMOC and applicability
P/F Criteria for Aircraft Seats (Simplified)

• Aircraft seats must be designed to protect occupants from serious injury under specific conditions detailed in the Code of Federal Regulations
  – Seat must stay attached to aircraft floor
  – Occupant injury risk is below defined thresholds (multiple system response quantities)
  – A representative seat is tested to show compliance
    • Tested seat must be conformed to the design
  – Manufacture of the seats must meet design specifications
M&S Process Information

- Multiple seat manufacturers/installers have submitted Issue Papers to the FAA for approval to use M&S to reduce the number of certification tests
  - The Issue Papers reference the companies quality manuals and standard operating procedure for the creation and evaluation of models and simulations
  - The FAA reviews these documents and participates in pilot/parallel projects
Potential Demonstration of M&S Abilities

• FAA decision makers are working with applicants to define the acceptability of analysis
  – Site inspections
    • The FAA does this for testing laboratories
  – Challenge problems
    • Demonstrate ability to solve a generic problem within the specific application realm
  – Pilot projects / Parallel efforts
    • Certify by testing while showing the M&S results along the way

• Allows us to work through potential issues before authorizing widespread use
Case Study 1: Round Robin

- Company requests FAA approval of their quality manual
- 3 groups provided the manual and tasked with building a model of a specific seat
  - 1 internal to the company, 1 supplier, 1 consultant
  - Model expected to predict X within 10% during validation
- Review of simulation predictions for critical pass/fail criteria
  - Group 1: X = 1.15 Criteria
  - Group 2: X = 0.60 Criteria
  - Group 3: X = 0.85 Criteria
- FAA feedback: manual is insufficient
Case Study 2: Parallel Project

- Applicant models their design and predicts results as if the decision will be based predominately on the simulation results.
- In parallel, physical testing is conducted as official certification path and as a check on the model.
- Simulation says the seat will stay attached to aircraft floor.
Case Study 2: Seat Broke Loose
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Applicant determined that the mesh size of the floor track fitting was insufficient to predict failure

Applicant: “The process worked”
  – “The test was a fail safe and the final design is safe”

FAA: “Your process didn’t work”
  – The process the FAA was asked to approve doesn’t include a fail safe physical test, only this parallel project did
Case Study 3: Communication Issues?

• Company manual defines intermediate pass/fail criteria
  – Company defined process requires model updates when failing a criteria, no deviation specified

• Company analyst shows simulation results which do not meet criteria; modeling continues uninterrupted

• FAA asks company certification engineer if that is acceptable
Case Study 3: Communication Issues? (cont’d)

• Company certification engineer unequivocally says “No”

• FAA: “Why weren’t you consulted as the certification engineer? Why did the process proceed?”

• Cert Engineer: “Good questions. We’ll address and get back to you.”
Case Study 4: Pilot Project

• Applicant requests FAA to approve process manual
  – Applicant and FAA working together on pilot project where applicant submits simulation results prior to conducting the test [good]
  – Validation requirement is simulation value within ±10% of test result [per industry standard]

• Model predicts X = 0.95 Limit [Acceptable]
• Test X = 0.5 Limit
Case Study 4: Pilot Project (cont’d)

- Company standard operating procedure (SOP) for mesh size was used when constructing the model.
- Subsequent efforts concluded that the mesh size was insufficient.

Picture from SAE ARP 5765
Case Study 4: Pilot Project (cont’d)

• New SOP for mesh size proposed
  – New mesh size produced Sim X near Test X

• FAA concerns:
  – No convergence study was completed for either the old SOP or new SOP

• Example from industry standard
Case Study 5: Proprietary Data

- Parts supplier will not release material properties to seat designer
- Modeler uses assumed properties while awaiting results of component testing
- Model results sent to FAA prior to incorporating the component data without noting the potential issue
- FAA: the open communication during pilot projects is excellent, but questions remain about the process
Case Study 6: Conformity

• Applicant built model based on initial drawings
• Test article based on final design drawings
• [Test and sim results don’t match]
• Issues:
  – Non-conformed article used in modeling
  – Company process broke down (M&S group not notified of changes to design, timeline insufficient)
  – Process manual did not define the submission of deviations to FAA
    • Some excluded parts didn’t affect results, but still need to be documented
General Concern: Calibration

• Applicant 1: Test result = 1405 lbs, Simulation result = 1405 lbs, “Model is perfect”
  – FAA concern: what is the chance that the simulation is a true prediction knowing that test scatter is at least 100 lbs

• Applicant 2: “My simulation is within 50 lbs of the test data” [Sim = 1450 lbs, test = 1405 lbs]
  – FAA provided the data: test 1 = 1405 lbs, test 2 = 1350 lbs, test 3 = 1305 lbs
  – FAA concern: cherry picked comparator

• Applicant 3 [part of challenge problem]: “I need the test result before I start the model”
Case Study 7: Success Story

- Applicant has detailed manual with supporting evidence
  - SOPs based on good engineering practice
- Have applied the SOP to multiple seat programs (outside of certification)
- Demonstrated ability to predict failure
- Linked material database and drawing library [automated]
- M&S chain of command includes engineers with experience in certification
- Initial projects are incremental
Other Success Stories?

• FAA and industry knew this would be a work in progress and consistent progress is being made
• Communication between applicants and FAA has been extensive and productive
• Applicants have had success with small projects that were approved on a case-by-case basis
• Multiple applicants are close to having broad quality manuals approved by the FAA
Summary

• The industry is moving forward and, while there are issues, this is laying the groundwork for future (broad) acceptance
• We (FAA and applicants) are asking the tough questions early to aid the decision makers job later on
• FAA and industry are working to revise guidance material as we work through various projects and learn
Summary

• Delegation in the certification process requires the applicant to have a quality procedure that has been demonstrated to work and it needs to be followed
  • Case 1: Procedure was insufficient/not followed
  • Case 2: Procedure was insufficient
  • Case 3: Procedure not followed
  • Case 4: Procedure was insufficient
  • Case 5: Procedure not followed
  • Case 6: Procedure not followed
Conclusions

• With proper planning and coordination, analytical methods can be inserted in the certification process

• Overall, the FAA wants to know that a company has a quality procedure that has been demonstrated to work and that they follow it leading to the design of safe systems

• Approvals based on M&S should provide data that is as reliable as data generated from physical testing