How OEMs support compliance with CS-FSTD(A) Issue 2 specifications - Boeing

EASA Information Session CS-FSTD(A) Issue 2
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Agenda

- Boeing Data Updates Overview
  - Airplane Models with Extended Envelope Training (EET) Updates
  - Airplane Models without EET Updates
  - Key Components of EET Data/Information
- Details on Specific Topics
  - Aerodynamic Model Enhancements (Stall)
  - Buffet (Stall)
  - Elevator Feel Shift (Stall)
  - Subject Matter Expert (SME) Pilot Assessment (Stall)
  - V-n Diagram (UPRT)
  - Icing
  - Severe Engine Icing

Boeing Data Updates Overview

- Data package updates driven by Part 60 Change 2
  - To support Extended Envelope Training (EET) requirements
- Data Package covers EASA, FAA, and ICAO requirements
- Boeing EET updates:
  1. Existing data packages: Supplement documents
  2. New data packages: Data embedded in the core model documents and binary
     - No specific “CS-FSTD(A) Issue 2” supplements
     - Revising EET data
       - EASA updates
       - Information and clarifications based on recent FAA qualification experiences
       - Estimated completion – Q1 2019

Airplane Models with EET Updates

Airplane models with extended envelope training (EET) updates

- 737-700, 737-700W, 737-800, 737-800W, 737-800WSFP, 737-900ERW, 737-8*
- 747-400/400F, 747-8I/8F
- 757-200
- 767-300ER/300F/400ER
- 777-200/200ER, 777-300ER
- 777-200LR/777F
- 787-8*, 787-9*
- 717
- MD80/MD90
- MD-11

Most EET updates contained in a single supplemental document to the basic data package
** 787, 737MAX and future airplanes will contain required information in basic package*

All of the above have been qualified under Part 60 Change 2

Airplane Models without EET Updates

Airplane Models without EET updates

- 727
- 737-200/200ADV, 737-300, 737-400 and 737-500
- 737-900
- 747-100/200/300
- 767-200
- 777-300
- DC-10
- DC-9s

Existing data/models can in many cases still support:

- Upset Recovery,
- Some icing tasks

Key Components of EET Data Updates

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- MODEL DESCRIPTION
  - Aerodynamic Model Updates .....(supports SOC)
  - Source Data .....(supports SOC)
  - Alpha/Beta Envelope ..... (supports SOC, supports IOS training envelope)
  - V-n Diagram ..... …….(supports SOC, supports IOS training envelope)
  - Initial Buffet/Buffet Onset
  - Stall Roll-off
  - SME Pilot Subjective Assessment .....(supports SOC)
- CHECKOUT DATA
  - Stalls - Roll-Off Model
- VALIDATION DATA
  - Validation Data Roadmap Matrix Supplement (VDR)
  - Stick Pusher System Force Calibration .....(Validation data, g.2 & 2.a.10)
    - Elevator Feel Shift (EFS) engineering sim ground case (737NG, 737MAX, 747-8, 767-400ER)
    - Pusher (767-300ER, 717, MD-80, MD-90)
  - Stall Characteristics .....(Validation data, 2.c.8a and 2.c.8b)
    - High altitude & turning stall matches
    - Relevant information stall ID & Stall warning system
  - Engine and Airframe Icing Effects Demonstration .....(Validation data, 2.i.1)
    - Icing demonstration data, Stall data Ice on and off
    - Relevant Information on aero Ice modeling and Ice weight effects
  - Stall Buffet ..... (Validation data, 3.g.5)

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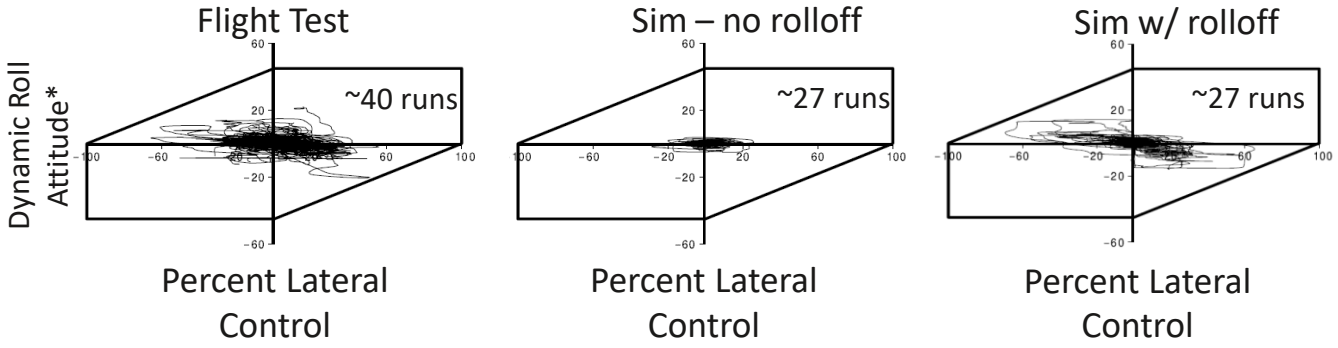
Aerodynamic Model Enhancements for Full Stall

- Minimal code changes – mostly updates of existing data tables
  - Table changes typically occur above stick shaker angle of attack
- Table updates
  - Based on analysis of flight test stalls
  - Extensions to tables as required
- Addition of stall roll-off model
  - Introduces random rolling moment near stall angle of attack
  - Based on flight data with test pilot tuning



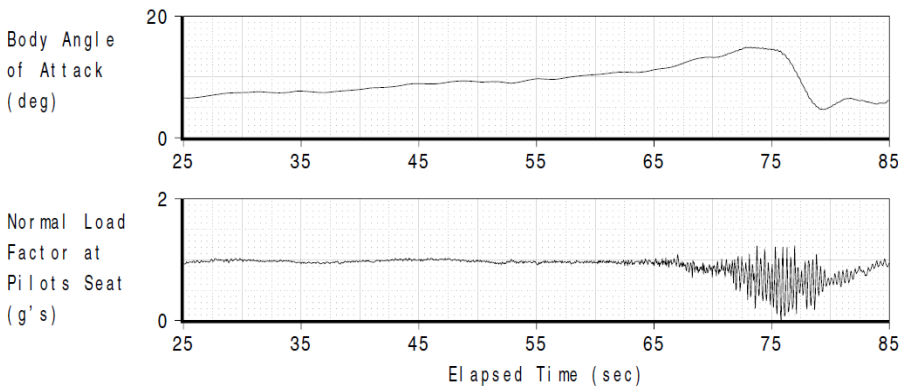
- Buffet re-index based on flight test data / new criteria
- Improved stall hysteresis model

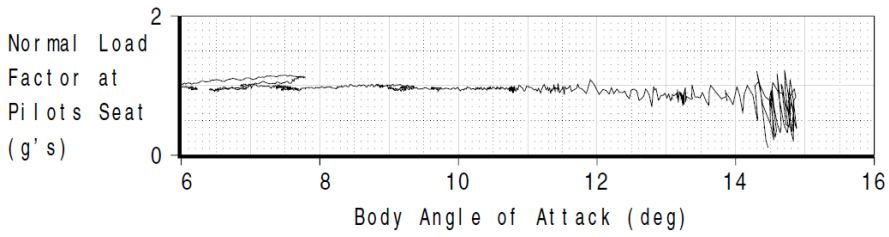
Stall Buffet

- Boeing provides
  - Stall buffet flight test data for model development and validation
  - Buffet Onset and Initial Buffet Thresholds
- Training Device Manufacturers develop buffet models

Important to be aware of buffet characteristics for a given airplane

- For Example, Flaps UP stall identification is often based on deterrent buffet
  - One characteristic of deterrent buffet is the inability to read cockpit instruments





Elevator Feel Shift (EFS) Validation (g.2, 2.a.10) Global Services

- General Requirement g.2 and 2.a.10 require a Stick Pusher validation test
  - EET data packages - Stick pusher only on 767-300ER, 717, MD-80, MD-90

- Issue 2, General Requirement g.2 expanded, relative to Part 60 Change 2
  - Stick pusher system force calibration test to equivalent longitudinal control feel systems
  - g.2 can be interpreted to cover the Elevator Feel Shift (EFS) functionality
  - Not the intent of EASA to introduce any requirements above and beyond the FAA

- Elevator Feel Shift system enhances stall identification
  - Roughly doubles column forces at or beyond Clmax to aid in the airplane certification Stall ID characteristic of nose down pitch not readily arrestable
  - Airplanes with EFS - 737NG, 737MAX, 767-400ER, 747-8

- Boeing is adding EFS system force calibration data
  - Supports “test required” comment in General Requirement g.2 and related 2.a.10 requirements
  - Engineering simulation time history validation test
  - Validates EFS system operation including activation and de-activation logic.

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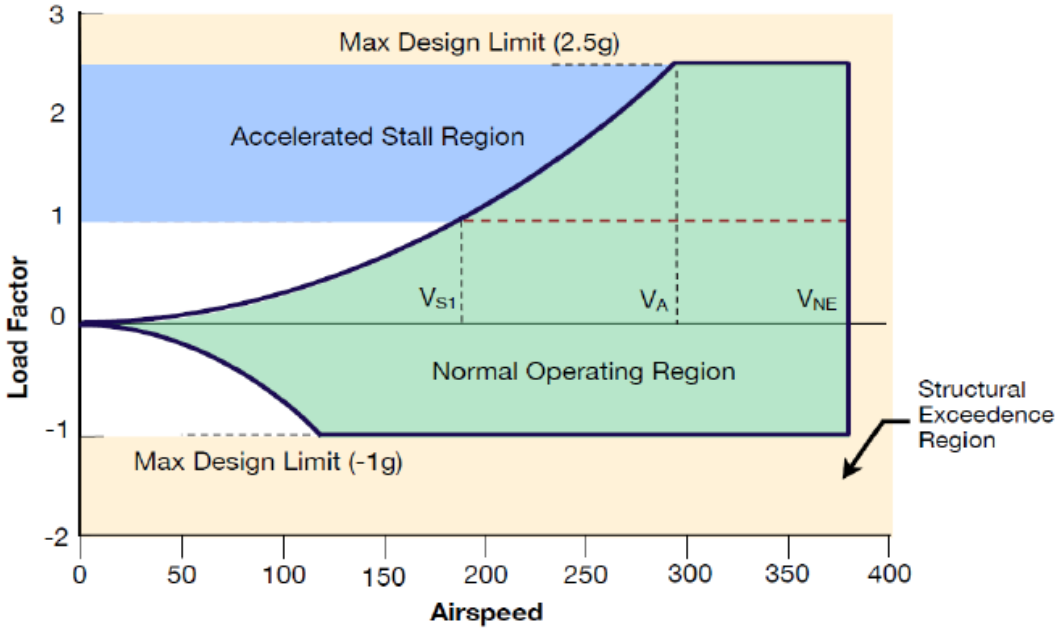
SME Pilot Assessment Option

Data Packages Support:

- SOC from the airplane manufacturer/data provider confirming SME pilot assessment on engineering/development simulator when additional objective data are provided
  - Boeing data packages provide sufficient objective tests
  - Providing text to support a Statement of Compliance (SOC)
    - States that stalls were evaluated on a Boeing Engineering Simulator by a SME Pilot with stall experience on that airplane model
    - Note, Long Beach airplane models used customer simulators for development and SME pilot evaluation
- Recommended qualification path is to rely on the SME Pilot evaluation in our Boeing engineering/development simulator (i.e. SOC)
- Precludes the need for a SME Pilot evaluation on a sponsor's device

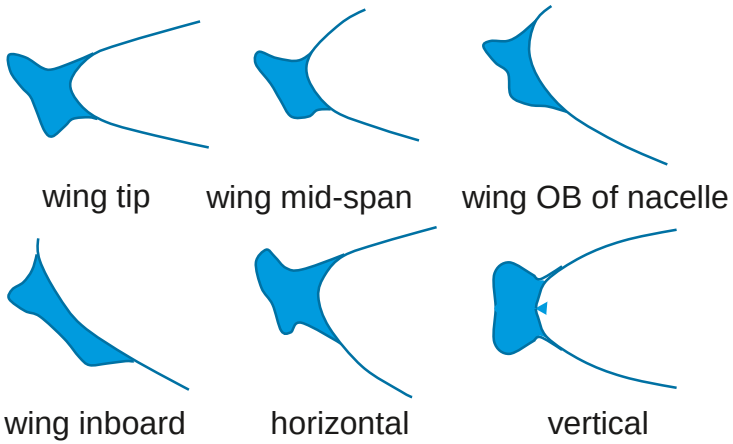
V-n Diagram

- Load Factor Limits
  - Boeing provides flight maneuvering load acceleration limits (load factor) from the Airplane Flight Manual.
  - Larger structural acceleration limits should not be used.
- Stall Speed Limits
  - Boeing provides reference stall speeds (typically as a function of weight, flap, gear)
  - IOS 1-g Stall Speed line is a general reference and does not need to have detailed accuracy (cg, altitude, etc.) for intended use



Icing Characteristics

- Aerodynamic Effects
  - Coefficients
  - Typically wind tunnel data, updated with flight test data with artificial ice shapes
  - Important to understand what is modeled – not everything is modeled and varies by airplane



- Ice Weight
  - Weight effects insignificant
  - Guidance in EET documents

    For large transport category airplanes, the total weight increment due to ice buildup on the airplane is less than approximately 1000 lbs. This increment is considered insignificant in terms of airplane weight as well as airplane performance and handling qualities/characteristics, and is therefore neglected in the Boeing Engineering Simulation. The dominant icing effects come from aerodynamic effects. Boeing recommends not modeling the weight increment due to ice.

- Adding guidance information
  - TAI failed modeling
  - Stick shaker icing increments

Severe Engine Icing – Fan Icing (d.3)

- Boeing believes airplane/engine types susceptible to engine fan icing should include vibration effects, dependent on FCOM procedures and training plan
- Issue 2 (d.3, special effects p.2.a, AMC 13): recognition of ice accumulation and execution of the required response.
    - *When the aircraft/engine has encountered a severe icing environment*
    - *Fan blades accumulate ice and present high levels of vibration.*
    - *The vibration is mostly noticeable when operating at low power settings.*
    - *Ice will shed when engine N1 speed is increased to a high power setting*
    - *When the ice is shed the fan vibration will return to normal levels.*
    - *When the N1 speed is decreased, the ice will accumulate again.*
    - *The logic then is disabled when the environment conditions improve.*

- Severe engine icing effects add on to the basic engine model
    - 747-400, 757-200, 767-300ER, 767-400ER with Pratt and Whitney engines do not have FCOM fan ice removal procedures and therefore do not have models
- 787-8/9 and 737-8(MAX) core models currently include effects for engine fan icing
- Temporary supplements created until data can be incorporated into core model documents

Industry Communication

Boeing EET Communications and Guidance

- Extended Envelope Industry Letter
  - Released in 2015, 2016, 2017, 2018
  - 2018 update addressed CS-FSTD(A) Issue 2
- Industry Presentations
  - US – Simulator Technical Issues Group (STIG)
  - Europe – European FSTD Technical Group (EFTeG)
  - Others –Flight Simulation Engineering Maintenance Conference (FSEMC)
  - Boeing Flight Operations Symposium

Questions?