

Dynamic Simulation Requirements

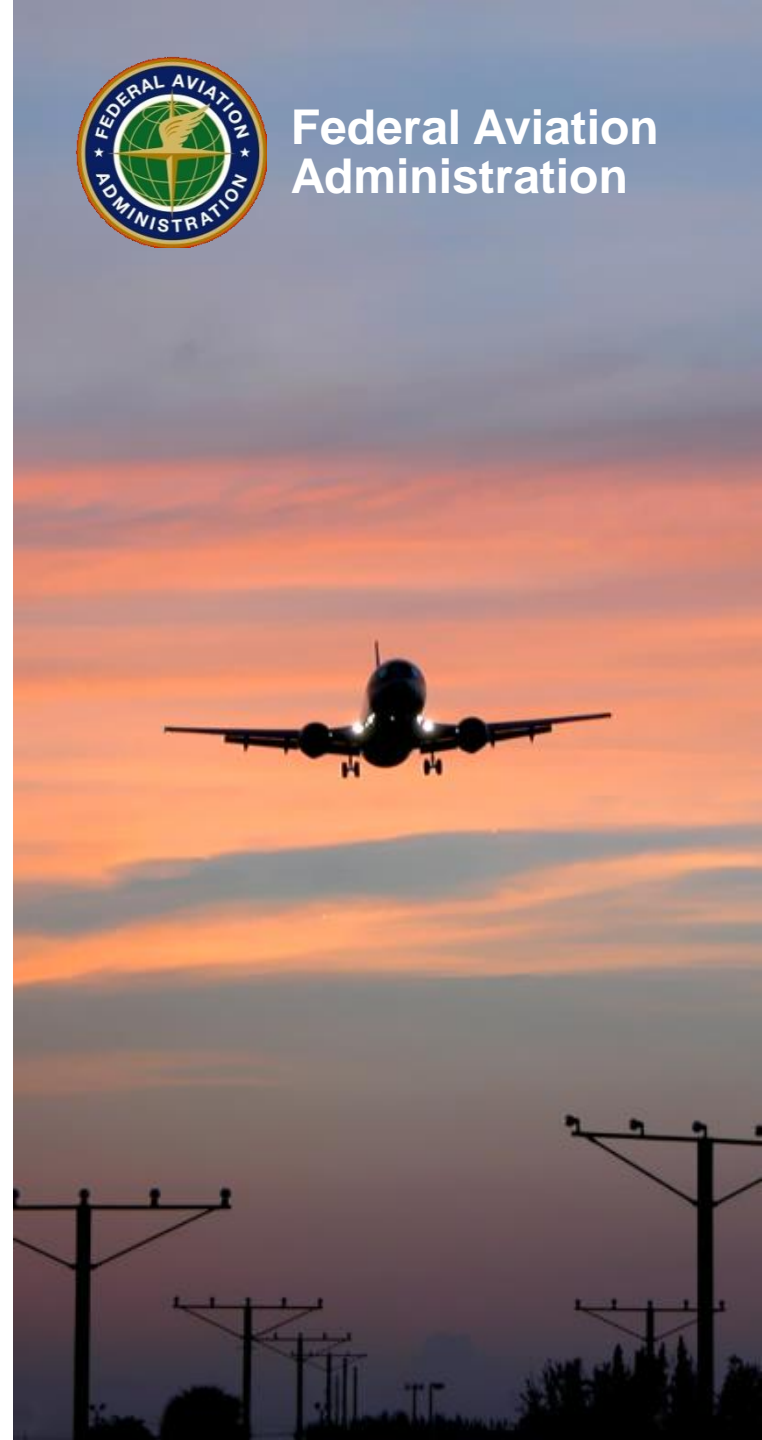
Presented to: *Use of Dynamic Analysis Methods
in Aircraft Certification Workshop*

By: *Joseph A. Pelletiere, Chief
Scientific and Technical Advisor for
Crash Dynamics*

Date: *August 2016*



Federal Aviation
Administration



Overview

- **TSO Implications**
- **Top level requirements from AC 20-146a**
- **Discussion**



Compliance with the TSO

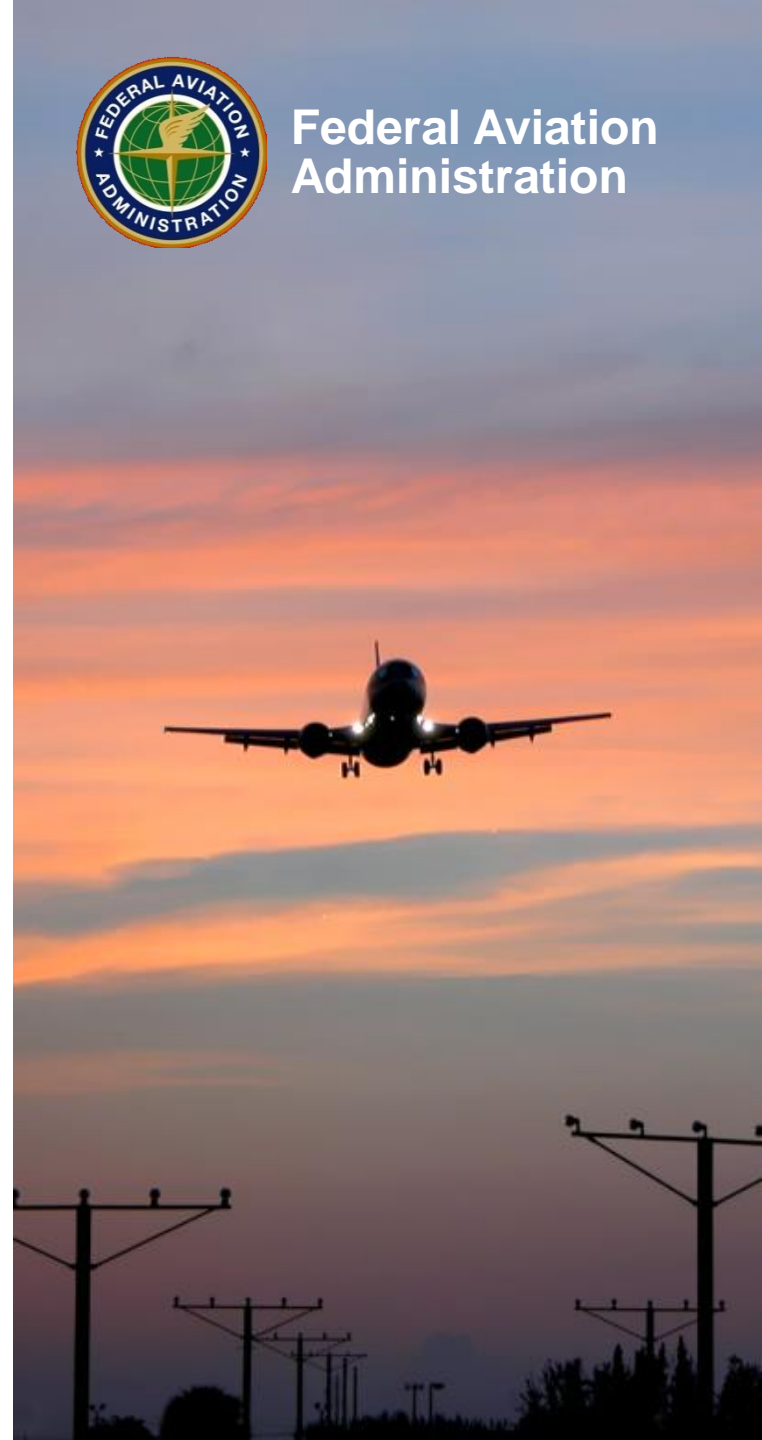
Presented to:

By:

Date:



Federal Aviation
Administration



What is a TSO?

- **A Technical Standard Order (TSO) is a Minimum Performance Standard, defined by the FAA, used to evaluate an article.**
 - An article can be a material, part, component, process, or appliance.
 - Each TSO covers a certain type of article.
- **When authorized to manufacture an article to a TSO standard, this is referred to as a “TSO Authorization.” Receiving a TSO Authorization is both a design and production approval.**

What is a TSO?

- Receiving a TSO Authorization is **not an approval to install** and use the article in the aircraft. It means that the article meets the specific TSO and the applicant is authorized to manufacture it.



Compliance with TSO

- **21.616 Responsibility of holder**
 - *(c) Ensure that each manufactured article conforms to its approved design, is in a condition for safe operation, and meets the applicable TSO*
 - If TSO specifies a specific substantiation method, applicant **must** use that specified method unless approval is obtained for a deviation per 21.618
 - Must show article maintains an equivalent level of safety using this alternate method

Compliance with TSO (cont'd)

- If TSO states testing *OR* analysis, applicant can use analytical modeling without a deviation
- **AC 20-146 provides guidance for seats on:**
 - How to validate the computer model
 - Under what conditions the model may be used in support of TSO authorization and design changes
 - If proposing to model vs. test, supply data proving model represents testing conditions/environment
- **FAA considering development of general M&S guidance**

Example – Seats

- **TSO-C127b requirement**
 - *“Initial qualification of a seat shall be performed by static and dynamic tests. Subsequent qualifications related to design changes to seats of a similar design may be performed by rational analysis based on existing qualification test data.”*
- **Using M&S for initial qualification would require a deviation**
- **M&S can be beneficial to assist in:**
 - Identifying critical case test scenarios
 - Evaluating minor changes to a tested configuration

Example – Emergency Evacuation Slides, Ramps, Ramp/Slides, and Slide/Rafts

- **TSO-C69**

- “The device must be demonstrated by tests or analysis, or a combination of both, to be seaworthy in an open sea condition with maximum sustained winds of 17 to 27 knots and waves of 6 to 10 feet... If analysis is used, the analysis must be approved by the manager of the FAA office having purview of the manufacturer's facilities...”

- **Deviation not required**

- **Analysis needs to be approved by FAA**

- M&S is an acceptable analysis method

Example – Seat Attachment

- AS 8049 par. 5.3.3.5.e.1:
 - “...both tests are required unless it can be shown by rational analysis that testing one attachment structure in its critical condition substantiates the other attachment structure...”
- Testing OR analysis are acceptable methods of substantiation, given the above condition is met

AC 20-146a - Highlights

- **Out for public comment**
 - Only a light update
 - Basis for future updates
- **Guidance on how to Validate and when it can be use to support certification**
- **Does not change or grant exemptions/deviations from regulations**



AC 20-146a – Highlights - Verification

- **Definition adapted from ASME**
- Verification is the process of determining that a computational model accurately represents the underlying mathematical model and its solution. This critical step precedes validation, as it is important to minimize errors before progressing. Verification is broken into two components, code verification and calculation verification. Calculation verification is further divided into temporal and spatial convergence.

AC 20-146a – Highlights - Verification

- **Code Verification**
- Code verification is the process of determining that the numerical algorithms are correctly implemented in the computer code and of identifying errors in the software, (refer to ASME V&V 10-2006). It helps ensure the mathematical model and solution algorithms are working correctly, that is, the code solution predicts the analytical solution.

AC 20-146a – Highlights - Verification

- **Calculation Verification**
- Calculation verification, also called solution verification, is the process of determining the solution accuracy of a particular calculation, (refer to ASME V&V 10-2006). The goal of calculation verification is to show that numerical errors, because of incomplete spatial or temporal convergence, in the system response quantities of interest are minor compared to the errors allowed in validation comparisons.

AC 20-146a – Highlights - Verification

- **Calculation Verification**
- Temporal Convergence
 - Courant criteria
 - Mass scaling
- Spatial Convergence
 - Mesh refinement

AC 20-146a – Highlights - Validation

- **High level general requirements**
- Test-Simulation comparison methodology
- Limits on some regulatory requirements
 - Based on statistical principles
 - 95% confidence in value being below regulatory limit
- Specifics to seats and ATD's
- Still missing the complete process portion

AC 20-146a – Highlights – Configuration Control

- **Computer Hardware and Software**
- Certification data produced by a computer model should be performed on the same hardware and software platform on which the validation was conducted. If a different software version and/or hardware platform is used, the applicant should revalidate the model using the new configuration in accordance with § 2X.307.

AC 20-146a – Highlights

- **Discussions on:**
 - Usage and limitations
 - FAA Technical meetings
 - Follow general certification plan and methodology
 - Documentation
 - General description

Questions to consider

- **What is the appropriate margin of safety for Analysis?**
- **When are quasi-static properties applicable?**
- **What is the statistical basis to recommend for material properties?**
- **Is it appropriate to model test fixtures?**
- **How should simulation data be treated?**
- **Composite modeling?**

Future Questions

- **What is common amongst the disciplines?**
 - Verification – Code and Calculation
 - Validation method
 - Configuration control
 - Meetings
 - Documentation
 - Others?
- **What details are necessary?**