Federal Aviation Administration

Guidance Statement on Flight Safety Analysis Methodology Descriptions

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I. Discussion

Title 14 Code of Federal Regulations § 450.115(c) requires an applicant to submit a description of the flight safety analysis methodology. Each subset analysis of the flight safety analysis contains application requirements to this effect. For example, § 450.117(d)(1) requires an applicant to submit a "description of the methods used to characterize the vehicle's flight behavior throughout normal flight, in accordance with § 450.115(c)." This document provides guidance to help operators develop methodology descriptions. The FAA evaluates all aspects of a methodology description to determine whether it is valid, to the standard required by § 450.101(g):

> *Validity of the analysis.* For any analysis used to demonstrate compliance with this section, an operator must use accurate data and scientific principles and the analysis must be statistically valid. The method must produce results consistent with or more conservative than the results available from previous mishaps, tests, or other valid benchmarks, such as higher-fidelity methods.

As flight safety analysis is often quite sophisticated, a description of the methods sufficient to evaluate validity may be quite extensive. This document builds upon Advisory Circular 450.115-1 *High Fidelity Flight Safety Analysis*, and 450.117-1 *Trajectory Analysis for Normal Flight*, and other previously accepted methodologies which provide specific guidance for satisfactory content for a valid methodology description. However, a new method that has not been accepted by the community may necessitate more justification in order to establish validity.

There are three general aspects to a methodology description: content, rigor, and depth. The content needs to 1) address each element of the regulations for the subject sub-analysis (e.g., constraints, objectives, and application requirements) with a scope and level of fidelity sufficient to comply with § 450.115(a) and (b), and 2) cover each element of § 450.115(c). The content should also describe the intended usage and limitations for each proposed method. The rigor of the description should ensure that the logic is clearly described, mathematics are complete, and evidence presented and analyzed. The depth of the detail should be sufficient to be objectively verifiable. In many cases, details may be provided by references to other materials including appropriate literature and/or validated and verified software. Documents should use formatting suitable for technical reports and be free from grammatical and cross-referencing errors. Documents should include unambiguous information to track revisions.

The following provides additional guidance regarding the requirements of § 450.115(c):

1. *The scientific principles and statistical methods used*;

   This should include reference data and mathematics that are used to describe the physical phenomena and the associated uncertainties. Modeling should be based on established physics, valid statistical methods, and/or empirical data. The depth of the detail should include equations and/or examples, but not necessarily algorithm implementation. It is also important to describe clearly how the different elements of the analysis are integrated.

2. *All assumptions and their justifications*;

   There are two types of assumptions in a methodology: 1) the scope and applicability that the methodology is intended to cover (e.g., identified phases of flight or parameter ranges), and 2) the physical phenomena that can have a significant influence on the model outputs. These assumptions should be stated clearly at relevant points within the narrative, and it is helpful to summarize in a list of key assumptions.

3. *The rationale for the level of fidelity;*

   This should discuss the fidelity of the approach and the explanation of how this was determined. Fidelity means the accuracy of the results when compared to the real world, so this usually involves a discussion of the biases and uncertainties associated with the method (ideally quantitative).

4. *The evidence for validation and verification required by § 450.101(g);*

   DoDI 5000.61 can be used as a reference and provides an overview of V&V for modeling and simulation. The rigor of V&V depends on the level of criticality of the model (so IV&V is not always necessary). Software development plans typically describe verification processes. Validation efforts may occur at the model and/or sub-model level.

5. *The extent to which the benchmark conditions are comparable to the foreseeable conditions of the intended operations;*

   Benchmark conditions are situations where the modeling approach has been compared to data available from previous mishaps, tests, or other valid benchmarks, such as higher- fidelity methods. The conditions should be compared to the intended scope of the methodology, and the methodology description should identify the regimes where the actual conditions modeled are closer to and further from the benchmarks.

6. *The extent to which risk mitigations were accounted for in the analyses.*

   This describes how mitigations (e.g., flight safety system, hazard areas, launch commit criteria) are incorporated in the flight safety analysis process and methods. At a minimum the mitigations should include those described in the functional hazard analysis.

A complete methodology description should include an overview discussion for each methodology guiding the reader to where each required element may be found. It is usually convenient for sub- analysis descriptions to be separate documents, and often, even within a regulation section, there may be multiple methodology documents. For example, § 450.121(b) states that a debris analysis must include a vehicle impact and breakup analysis. The methodologies for determining breakup criteria (structural limits), debris catalog, and debris propagation/dispersion are often in separate documents. Many descriptions may reference a common document, such as a software development plan to discuss how software implementations undergo verification, in accordance with § 450.115(c)(4).