

Advanced Materials

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Technology Bulletin

at the Center of Excellence for Composites and Advanced Materials



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ADVANCED MATERIALS IN TRANSPORT AIRCRAFT STRUCTURES

FEDERAL AVIATION ADMINISTRATION

NATIONAL INSTITUTE FOR AVIATION RESEARCH

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CECAM featured project

Certification by Analysis

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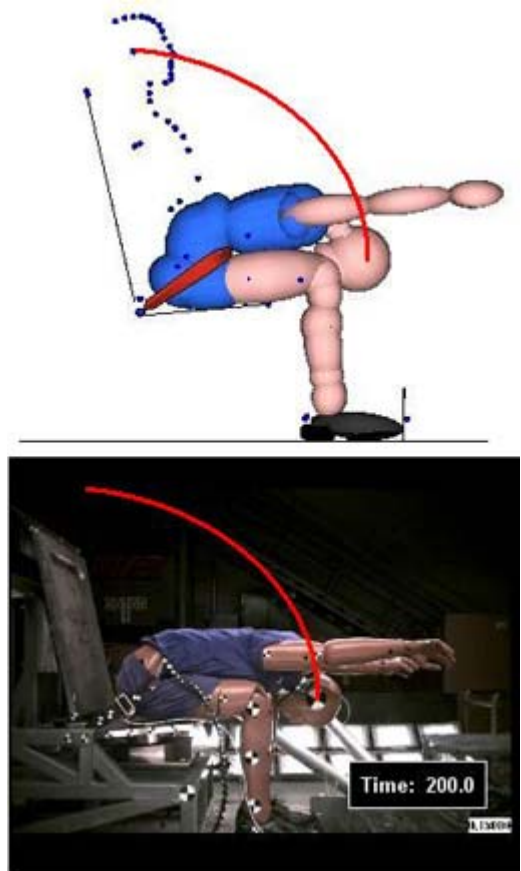
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Overview:

Physical testing is increasingly being replaced by numerical simulation models because it is a quicker and less expensive way to evaluate design concepts and design details. In the aerospace industry, crashworthiness numerical simulation methods are

primarily used at the very end of the product development process. Often they are applied to confirm the reliability of an already existing design or sometimes for further design improvements by means of optimization methods. There are a number of CAE (Computer Aided Engineering) tools that could be used for solving aircraft crashworthiness problems. These are best utilized by using a systems approach that uses a combination of CAE analyses, component tests, sled and/or full-scale tests.



Above right: Example of head path validation Hybrid III FAA.

FAA Advisory Circular (AC) 20-146 sets forth an acceptable means, but not the only means, for demonstrating compliance to the following by computer modeling analysis techniques validated by dynamic tests:

- Title 14 Code of Federal Regulation (14 CFR) parts 23, 25, 27, and 29
- The Technical Standard Order (TSO) associated with the above regulation, TSO C127/C127a.

Computer modeling analytical techniques may be used to do the following, provided all pass/fail criteria identified in §§ 23, 25, 27, or 29 are satisfied:

- Establish the critical seat installation/configuration in preparation for dynamic testing.
- Demonstrate compliance to §§ 23, 25, 27, or 29 for changes to a baseline seat design, where the baseline seat design has demonstrated compliance to these rules by dynamic tests. Changes may include geometric or material changes to primary and non-primary structure.

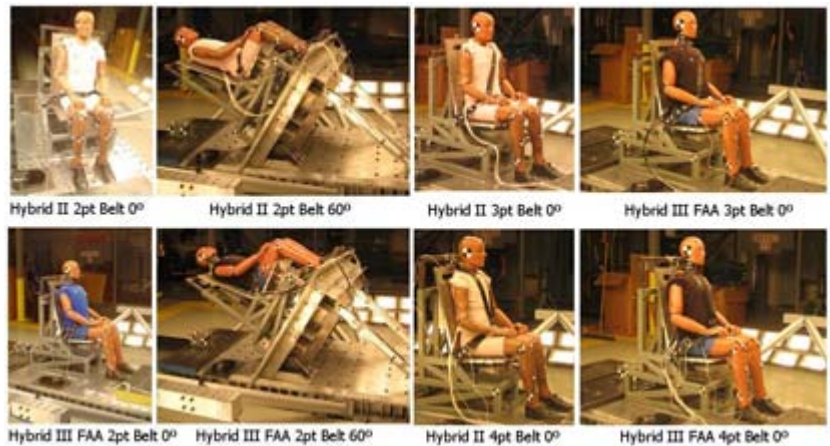
This AC provides generic guidance on how to validate the numerical model and under what conditions the model may be used in support of certification or TSO approval/authorization. AC 20-146 relies on the engineering judgment of the applicant and the FAA ACO to determine compliance. This AC could be enhanced if more specific data pertaining the modeling and validation procedures were defined, for example:

- Numerical Anthropometric Test Dummies (ATD) database validation criteria
- Structural seat numerical model / Testing validation criteria
- Material library with strain rate dependant mechanical properties for typical seat components
- Part joining modeling and failure criterion guidelines (rivets, welds, bolted joints, etc.)

Objective:

The intent of this research is to provide an overview of numerical modeling practices so that engineers can gain an understanding of the fundamental modeling methods, a feeling for the comparative usefulness of different modeling approaches and develop an appreciation of the modeling problem areas and limitations of current numerical models.

The research has been concentrated initially in the validation of Hybrid II and Hybrid III FAA numerical models. This is being accomplished by establishing partnerships with numerical ATD model developers. The National Institute for Aviation Research at Wichita State University has conducted a series of dynamic 14CFR 25.562 sled tests for typical aircraft configurations as shown in the image below. The results from these sled tests in conjunction with component calibration tests are used to evaluate the performance of the numerical ATDs.



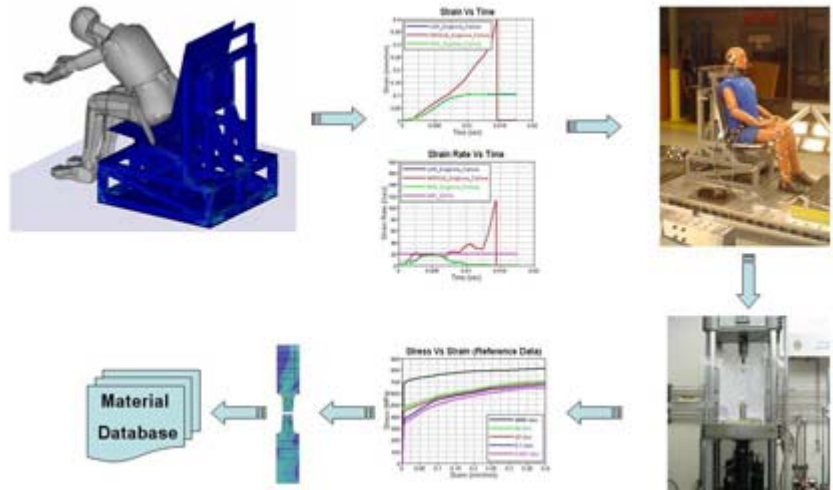
FAR25.562 Sled testing configurations.

Various numerical model validations that can quantitatively compare experimental and computational results over a series of parameters are being evaluated to objectively assess computational accuracy over the traditional qualitative graphical comparison.

Upon completion of the ATD databases validation process, the research will address the strain rate effects in the finite element modeling process of the seat structure. High strain levels are present in deformed crash components. Ignoring the strain hardening and strain rate effects in numerical models may lead to an underestimation of the energy dissipated and the structural performance of the aircraft seat. Currently there is no public domain strain rate dependant material database available for typical aluminums and steel grades used by seat manufacturers.

In order to define the appropriate strain rate domain for developing a material database, various seat components will be analyzed through analysis and sled tests of aircraft seats subjected to FAR 25.562 dynamic crash conditions. Using

this strain rate domain, the materials will then be tested at the coupon level for various strain rates. This data will be available in the future for seat manufacturers to be used in the development of numerical models.



Material database development process.

Expected Outcomes:

- Validation criteria and procedures for numerical Hybrid II and Hybrid III FAA databases.
- Dynamic sled tests setup and data collection protocols.
- Strain rate dependant material database for typical I aluminums and steels grades used by seat manufacturers.

For more information about the Center for Advanced Materials Performance at Wichita State University's National Institute for Aviation Research visit the [website](#).