Consensus Standards: Opportunities in Crashworthiness & Cabin Safety

The 8th Triennial International Fire & Cabin Safety Research Conference

October 26, 2016

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Introduction

- The Part 23 ARC and Regulatory Changes
- ASTM F44 – General Aviation Aircraft
- F3083-16 Standard Specification for Emergency Conditions, Occupant Safety and Accommodation
- Overall Vision
- Possible Next Steps?
  - Streamlined certification
  - CS-22 concepts
  - AGATE concepts
  - Numerical analysis
- Conclusions

The Part 23 ARC and Regulatory Changes

- Made recommendations regarding
  - Small airplane certification regulations
  - Certification process
  - Continued operational safety
- Designed to bring increased flexibility to the certification process for new aircraft
- Cost cutting, streamlined approval, increased safety

14 CFR Part 23 Reorganization Aviation Rulemaking Committee

to the

Federal Aviation Administration

Recommendations for increasing the safety of small general aviation airplanes certificated to 14 CFR part 23

June 5, 2013

The Part 23 ARC and Regulatory Changes

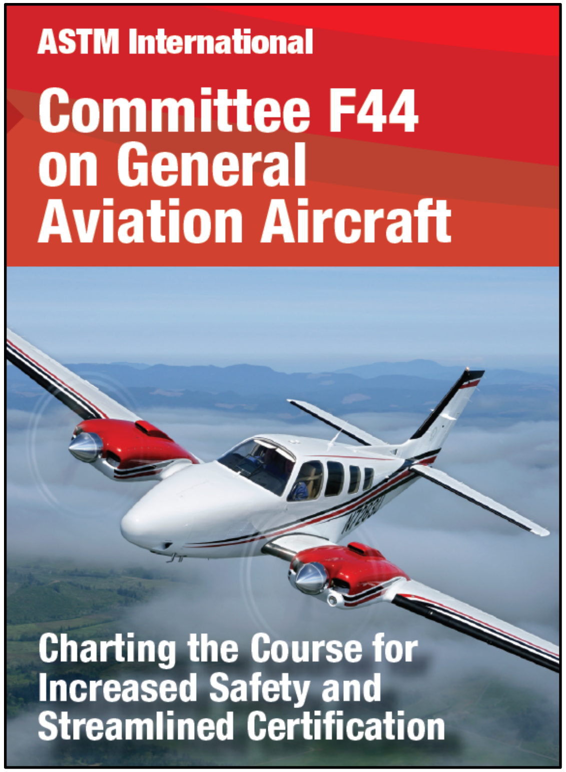
- EASA Advanced Notice of Proposed Amendment (Spring, 2015)
- FAA Notice of Proposed Rulemaking (Spring, 2016)
  - Revision of Airworthiness Standards for Normal, Utility, Acrobatic, and Commuter Category Airplanes
- General trend: simplified, higher level rules
- Striving for worldwide consistency among regulators
  - United States, Europe, Canada, Australia, China, Brazil…
- Regulators are actively involved with the ASTM F44 process

EASA
European Aviation Safety Agency

Federal Aviation Administration

ASTM F44 – General Aviation Aircraft

- Established in 2012, with 250 members around the world
- Developing consensus standards for small aircraft
- The committee is broken into the following main subcommittees:
  - General
  - Flight
  - Structures
  - Powerplant
  - Systems and Equipment
- Meetings are held in person twice a year, but travel is not required to participate



F44 Brochure [Pr].indd 1

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The Development of Standard F3083-16

Designation: F3083/F3083M – 16

Standard Specification for Emergency Conditions, Occupant Safety and Accommodations[1]

- Based upon 14 CFR 23, Amd. 62, EASA CS-23, Amd. 3 and EASA CS-VLA, Amd. 1
- Includes:
  - Emergency landing conditions
  - Seats and safety belts
  - Doors and emergency exits
  - Baggage and cargo compartments
  - Evacuation
  - Fire protection
  - Safety equipment

The Development of Standard F3083-16

- Varied language with the same safety intent across the three regulations was blended
- Some of the more notable variations from the Part 23 perspective:
  - CS-VLA 785, Seats, Safety Belts & Harnesses was incorporated as an exemption to the dynamic seat testing requirements of Part 23
    - No more than 2 seats
    - $W < 750$ kg (1653 lb)
    - $V_{stall} < 83$ km/h (45 kts)
  - This is consistent with existing FAA letters of exemption
- The former "commuter category" requirements for doors and emergency exits were clarified and modified to be consistent with the proposed removal of the commuter category.

Overall Vision

- Performance based standards encouraging full system design for crashworthiness
- Think Federal Motor Vehicle Safety Standards (FMVSS)
  - Specific accident scenarios are specified
  - Specific injury criteria or other performance criteria are specified
  - The manufacturer has considerable leeway in the approaches used to meet these requirements

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Overall Vision

- Some basic research has been done that might support this vision
  - Various scenarios have been tested
  - Various construction techniques have been tested
- Economies of scale just don't exist in aviation
- Can new technologies be leveraged? Can other approaches be used?

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theepochtimes.com

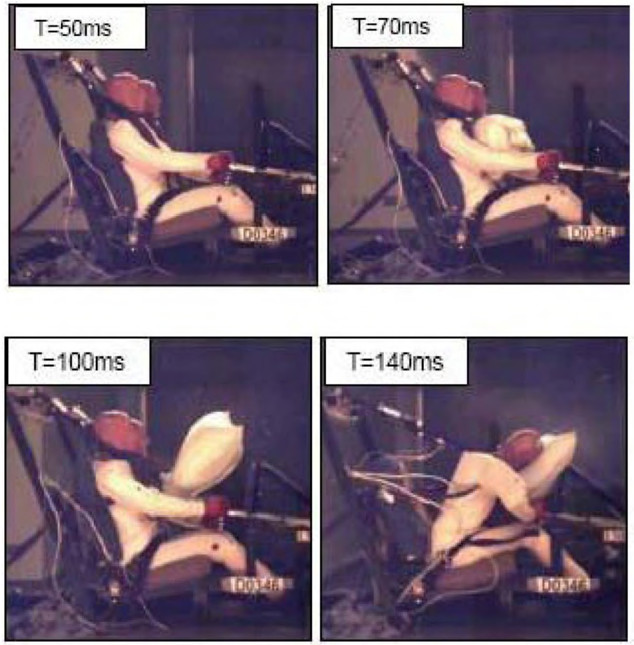
Possible Next Steps?

Seat Belt Certification

- An NPRM comment:
  - "…trying to enter into the TSOd seat belt market for the last 3 years [and] what we found was the overall expense of trying to loop through all the regulatory rules that are actually the same ASTM standards that the FAA uses…" was too great.

Airbag Certification

- An NPRM comment:
  - "…we could see a very large retrofit of airbags into single and dual engine aircraft…"
  - "…So maybe this rewrite will encourage MFGS to step up and make these products available to everyone…"



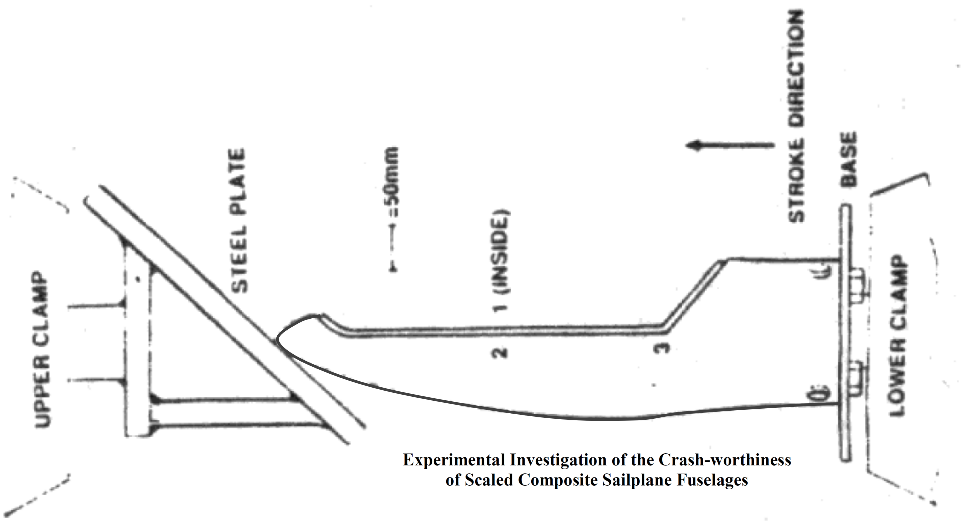
NTSB/SS-11/01
PB2011-917001

?New Technology? Certification

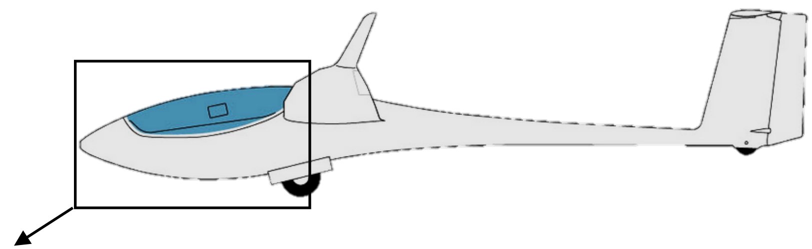
EASA CS-22, Sailplanes and Powered Sailplanes

AMC 22.561(b)(2)
Emergency Landing Conditions

For conventional (semi-reclined) seating configurations it is sufficient to demonstrate, that the main part of the cockpit, extending at least from the front control pedals (adjusted to the intermediate longitudinal position) to the rearmost headrest mounting or the wing attachment section whichever is further aft, including the harness attachments (ref. 1), meets the requirements of CS 22.561(b).



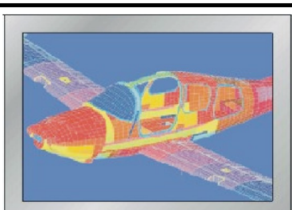
Experimental Investigation of the Crash-worthiness of Scaled Composite Sailplane Fuselages



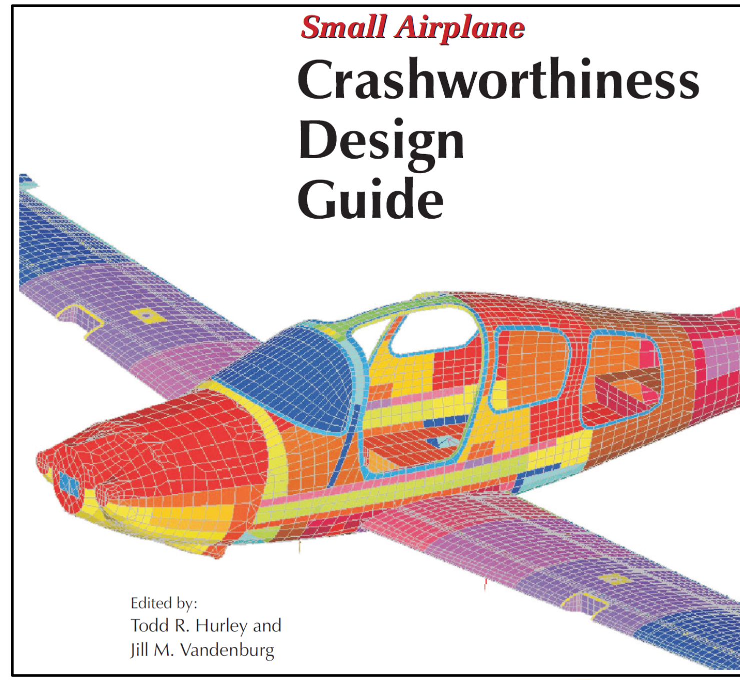
(2) An ultimate load of 9 times the weight of the sailplane acting rearwards and upwards at an angle of 45° to the longitudinal axis of the sailplane and sideward at an angle of 5° acts on the forward portion of the fuselage at a suitable point not behind the pedals. (See AMC 22.561(b)(2))

Possible Next Steps?

- Extensive research project resulting in publication of the Small Airplane Crashworthiness Design Guide in spring of 2002
- Commonly called AGATE (Advanced General Aviation Transport Experiments)
- Extensive design guidelines specific to general aviation aircraft
- Includes a proposed evaluation system



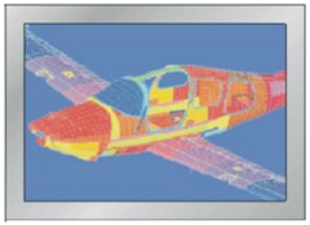
General Aviation Crashworthiness Design Evaluation



SIMULA

AGATE

Possible Next Steps?



General Aviation Crashworthiness Design Evaluation

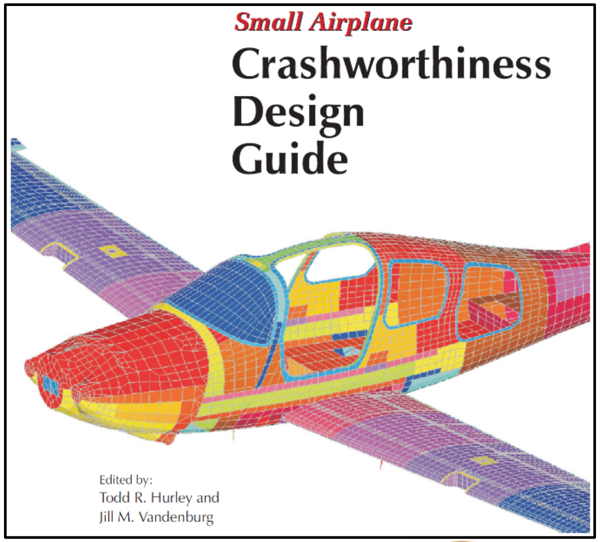
GENERAL AVIATION CRASHWORTHINESS DESIGN EVALUATION

When evaluating an aircraft from a crash-survival point of view, there are six basic factors that should be considered. These are:

1. Basic Airframe Crashworthiness
2. Crew Seats and Restraints
3. Passenger Seats and Restraints
4. Interior Crashworthiness
5. Post-Crash Fire Potential
6. Evacuation

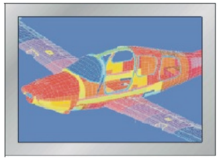
In order to develop a reasonable Crashworthiness Design Evaluation, weighted values have been assigned to the various factors. The percentage of weight assigned to each is based on their relative hazard potential. The six factors, along with their hazard potential, are as follows:

Factors	Hazard Potential (%)	Optimum Number	Actual Value
1. Basic Airframe Crashworthiness	28	200	
2. Crew Seats and Restraints	21	150	
3. Passenger Seats and Restraints*	15	110	
4. Interior Crashworthiness*	8	60	
5. Post-Crash Fire Potential	21	155	
6. Evacuation	7	50	
Totals	100	725	



SIMULA

Possible Next Steps?



General Aviation Crashworthiness Design Evaluation

Vertical Energy Absorption Capacity

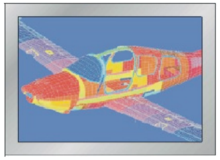
Optimum = 16 points
(For all seat types)

Some method should be provided in the seat structure to attenuate vertical impact forces to a value of less than 1,500 lb as a measured in the pelvic/lumbar load cell of the anthropomorphic test device (ATD, a.k.a. test dummy). This decelerative loading must be maintained through a minimum stroke of 3 in. in order to offer protection in the majority of fixed-wing aircraft accidents. However, a stroke of 4 to 6 in. is highly desirable. The evaluator should consider whether possible structural deformation, storage of items beneath the seat, or occupant foot placement could impede the seat stroke.

The seat vertical energy-absorption capacity can be rated as follows:

	Points
A. A seat with a discrete energy-absorber having a minimum of 5 in. of stroke	16
B. An energy-absorbing seat meeting FAR Part 562 and having 3 in. of total stroke	12
C. A crushable, expanded-foam cushion or other energy-absorbing device meeting FAR Part 562 minimum requirements	8
D. A slow-rebound foam (Confor foam, “Ensolite”, or “Ethafoam”) of 4-in. thickness	4
E. Elastic foam rubber cushion or no attenuating material	0

Possible Next Steps?



General Aviation Crashworthiness Design Evaluation

a. Resistance to Longitudinal Impact Loads (15 of the 50 total) **Optimum = 15 points**

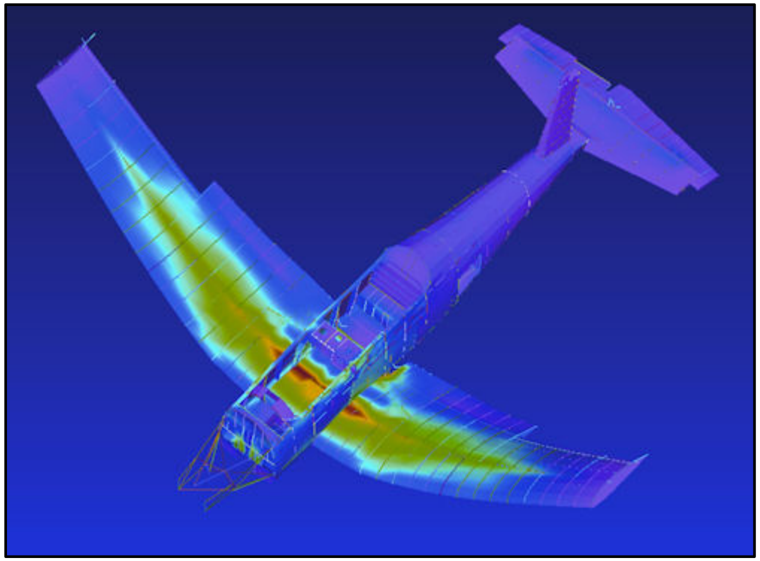
The evaluator should think of the fuselage as a tubular structure with masses concentrated at various locations. This tube should be able to sustain an impact on the end parallel to the fuselage axis without release of the massive items (engines, wings, seats, baggage, etc.). The optimum structure would resist these loads without diminishing the occupied volume or deforming in a way that releases attached items (such as seats). A monocoque structure that maintains a round or oval shape is ideal. This is because the longitudinal loading (primarily compressive) can be shared through the entire structure. However, the evaluator should examine the fuselage "splices" that are likely to fail during compression of the fuselage. This is especially important for longer-body general aviation aircraft. An alternative design, consisting of continuous beams running from the nose of the aircraft under the floor for the entire length of the occupied section, is good, but somewhat less desirable, since the longitudinal loads are carried by a relatively small portion of the structure.

b. Effect of Wing Separation on Cabin Occupants (15 of the 35 total) **Optimum = 15 points**

Evaluate as to whether the tearing away of the wing will be hazardous to the cabin occupants. The complete separation of the wing structure without effect on the seat occupants illustrates acceptable performance in this respect. Ideally, failure of the wing structure would not intrude on the occupied areas or tear the fuselage structure. The failure of the wing should not disrupt energy-absorbing features in the subfloor or seats, as can happen with a main spar that runs through the occupied areas.

Possible Next Steps?

- Automotive design relies heavily on numerical analysis for crashworthy design
- Is this an avenue for overcoming the lack of economies of scale in aviation?
- Can numerous crash scenarios be designed to without full aircraft crash testing?
- Can this approach be acceptable to regulators?
- Work continues…including at this conference



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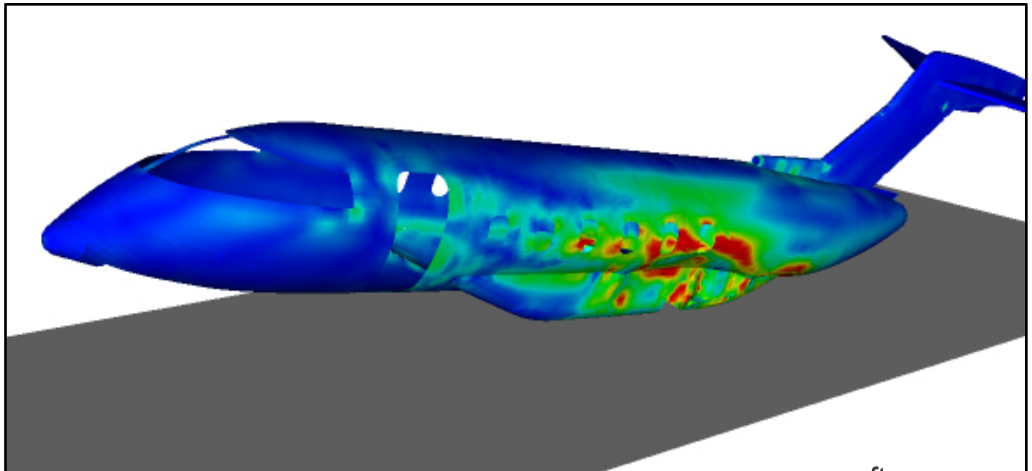

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Conclusions

- Change in the certification of small airplanes is on the horizon
- Worldwide standardization and simplified, higher level rules are coming from regulators
- ASTM F44, a consensus standards process, is developing a means of compliance to these new regulations
- This should allow new concepts to be incorporated into design standards in a more streamlined fashion
- The opportunities for growth include:
  - Smaller steps, such as less certification burden for using safety components in a design
  - Larger steps, such as whole aircraft, performance-based design standards
- Anyone can join the ASTM process and contribute!