Comparison of Automotive & Commercial Aviation Occupant Injury Criteria

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Agenda

- Introduction
- Comparison of Injury/Pass-Fail Criteria
- Summary of Challenges
- Proposed Path Forward

The Past

- From beginning of transport safety research in 1940s, the goal was
  - to understand the mechanism of injury commonly observed,
  - prevent or reduce fatal injuries
  - and increase likelihood of survivable crashes
- The goal remains the same to <u>this present day</u>
- While automotive and aerospace safety regulations have the same origin, there are many differences that have evolved over time

John Stapp during a high G-force test, June 1954 [1]

[Reference at end of presentation]

The Present

- This presentation will compare the current automotive and commercial aviation occupant Injury/ Pass-Fail Criteria. The comparison is not intended to be a comprehensive list but rather to present an objective way to illustrate the similarities and differences
- Pace of development and refinement of objective criteria for commercial aviation, still lags development of new designs and not in pace with introduction of new concepts and technologies
- Some of these issues present major challenges for commercial aviation seat manufacturers to design and certify

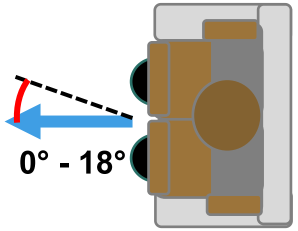
Comparison of Injury/ Pass-Fail Criteria – Forward Facing

Summary of Test Cases

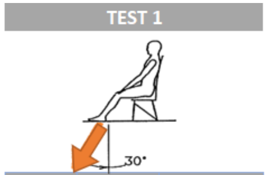
	Commercial Aviation	Automotive [2]

Frontal

Commercial Aviation

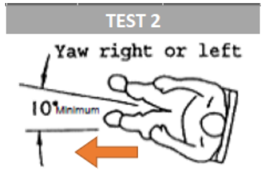


TEST 1



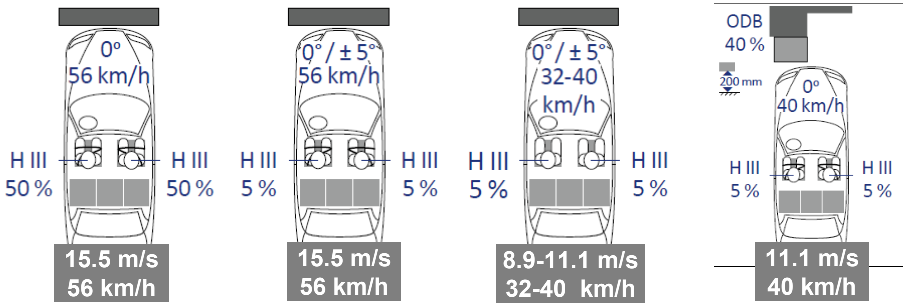
Pulse	Rise Time	ΔV
Δ 14G	0.08 s	10.7 m/s 38.4 km/h

TEST 2



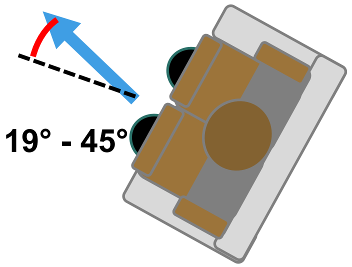
Pulse	Rise Time	ΔV
Δ 16G	0.09 s	13.4 m/s 48.3 km/h

Automotive [2]



Oblique

Commercial Aviation



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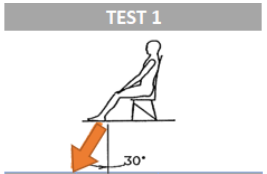

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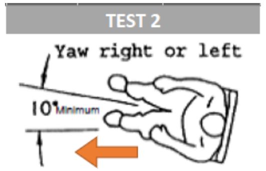

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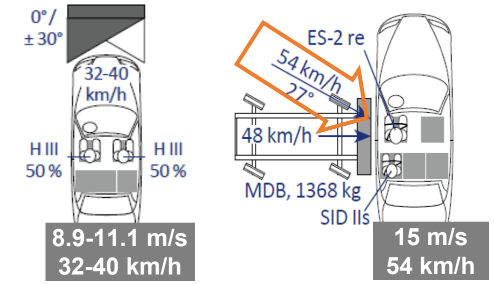
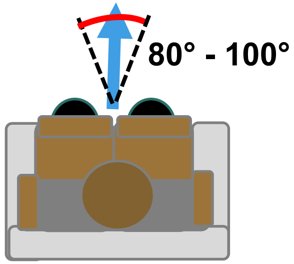


Side

Commercial Aviation



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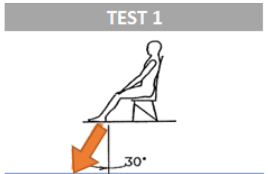

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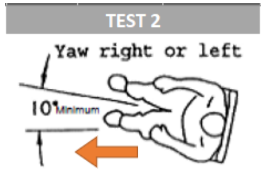
TEST 2



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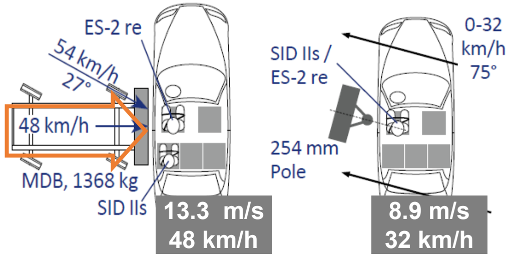


Highlighting similarities and differences between Commercial Aviation and Automotive

Comparison of Injury/ Pass-Fail Criteria – Forward Facing

			HEAD		NECK		CHEST		SPINE
Automotive	ATD		Hybrid III 50%	Hybrid III 5% F	Hybrid III 50%	Hybrid III 5% F	Hybrid III 50%	Hybrid III 5% F	No injury evaluation methods or criteria available
	Injury Criteria	Current	HIC_{15} < 700	HIC_{15} < 700	N_{ij} < 1 F_z (tens) - 4.17 KN F_z (comp) - 4 KN	N_{ij} < 1 F_z (tens) - 2.62 KN F_z (comp) - 2.52 KN	a_{3ms} - 60g Deflection - 63 mm	a_{3ms} - 60g Deflection - 52 mm	
		Proposed	Brain Injury (BrIC)		No injury evaluation methods or criteria available		No injury evaluation methods or criteria available		
Commercial Aviation	ATD		Hybrid II 50 % or FAA Hybrid III 50%		FAA Hybrid III 50%		Hybrid II 50 % or FAA Hybrid III 50%		Hybrid II 50 % or FAA Hybrid III 50%
	Injury Criteria	Current	HIC < 1000 (HIC *unlimited*)		N_{ij} < 1 F_z (tension) - 4.17 KN F_z (compression) - 4KN Head Rotation < 105°		< 1750 lb (7.78 kN) Restraint Load		< 1500 lb (6.67 kN) Lumbar Compression
		Potential	Brain Injury (BrIC) [3]		Combined loading injury criteria [3]		a_{3ms} - 20g (during rebound) [3]		a_{3ms} - 20g (during rebound) [3]
	Subjective Criteria		- Injury potential of secondary impacts during rebound - Post-test cuts on ATDs - Sharp edge Evaluation of impacted surfaces - Glass escape from video monitor impact		- Combined loading of neck - rotation and bending - No injury metric exists - Rebound impact directly on neck not acceptable - Neck must not impact any surface that would produce concentrated loading on the neck		No injury evaluation methods or criteria available		- Significant concentrated loading on spine not acceptable

Side Facing and Oblique Facing Seats present additional challenges

Additional injury criteria not specified in regulations

Subjective interpretation makes determination of pass/fail complicated and time-consuming

Comparison of Key Factors and Associated Challenges

	Automotive	Commercial Aviation	Challenges for Commercial Aviation
Occupant Kinematics	Shorter, Controlled displacement *(shoulder belts, airbags)*	Large, uncontrolled displacement *(typical lap belts)*	• Injury/ Pass-Fail Criteria development, considering injury mechanisms as well as injury mitigation that are different due to large uncontrolled displacement
Cabin/Test Environment	Enclosed and compact cabin	Typically, no surrounding considered	• Uncontrolled ATD movement due to open cabin environment • Feasibility of including surroundings (sidewall, doors etc.) could induce additional complexity
Test Cases	Test cases more precise and objective criteria	Test cases with more subjective criteria	• Subjective criteria leads to variability in compliance finding, cost/weight/schedule impacts to address late changes

Comparison of Key Factors and Associated Challenges

	Automotive	Commercial Aviation	Challenges for Commercial Aviation
Regulatory Model	Injury/ Pass-Fail Criteria planned and developed by industry	Regulators establish Injury/ Pass-Fail Criteria	• Industry is fully dependent on regulators' interpretation of current Injury/ Pass-Fail Criteria, especially on subjective criteria
Use of Simulation	Extensive use of simulation for prediction and mitigation of occupant injury	Acceptance of simulation for prediction and mitigation of occupant injury has been slow	• Industry still not mature enough to predict injury through simulation

Summary of Challenges for Aircraft Cabin Interiors

- New Injury/ Pass-Fail Criteria and requirements being introduced in a fragmentary approach over the past few years, as for example neck injury and occupant free flail for forward facing seats
- Potential introduction of newer Injury/ Pass-Fail Criteria like brain injury mechanism without adequate research and/or accident data
- Subjective requirements continue to be used without development of standardized evaluation methods, leads to variance in compliance determination as for example:
  - Subjective evaluation of ATD kinematics during dynamic event
  - Combined twisting and bending loading on neck
  - Subjective evaluation of brace position for airbags

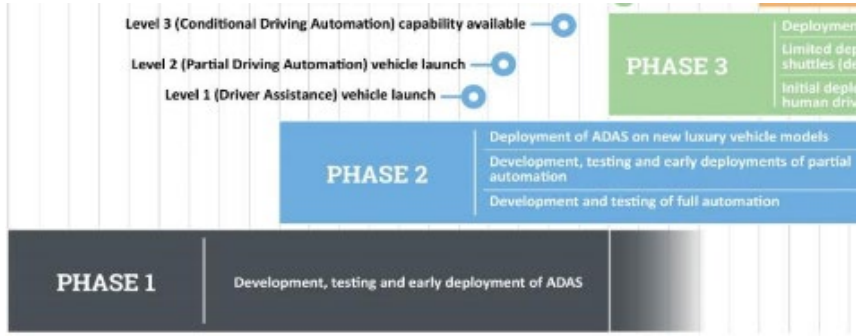
Current and future challenges for seat manufacturers

Summary of Challenges for Aircraft Cabin Interiors

- Limited research and collaboration between regulators and industry in the identification and development/refinement of Injury/ Pass-Fail Criteria, as for example:
  - introduction of neck Injury/ Pass-Fail Criteria derived from automotive (which was not thorough) without adequate research of occupant kinematics for aircraft cabin interior
- Industry lags developing standards (in collaboration with regulators) for new designs and technologies.

The Future (Proposed Path Forward)

- Development of a safety roadmap including Injury/ Pass-Fail Criteria for commercial aviation in collaboration among FAA and industry
  - This safety roadmap will benefit both FAA and industry, long-term, in developing and certifying new technologies enhancing overall passenger safety
  - Availability of a safety roadmap will enable industry to plan and prepare for newer Injury/ Pass-Fail Criteria and requirements
  - With combined support of regulators and industry, a roadmap, will ensure a predictable path-forward towards increasing the level of safety and advance new technologies
- Comprehensive plan and execution of regulator-Industry collaborated research
  - To develop standards for new designs and technologies
  - To develop objective pass-fail criteria for injury evaluation



Example roadmap from automotive industry

Advanced Driver Assistance Systems & Vehicle Automation Technologies [4]

Development of a Safety Roadmap for Commercial Aviation is an essence of time

References

1. Smithsonian Air and Space Museum
2. SafetyCompanion 2022, carhs Gmbh
3. Occupant Injury and Seats & Airbag Observations – FAA presentation at SAE Seat Committee, 8th March, 2022
4. Center for Automotive Research