Seating Systems

Presented to: TSO Workshop

By: Patrick T. Farina, P.E. AIR-624

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Federal Aviation Administration

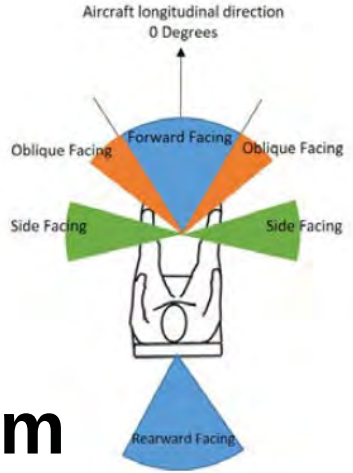
Seating Systems Overview

- **TSO-C127c, *Rotorcraft, Transport Airplane, and Small Airplane Seating Systems***
- **TSO-C127d, *Rotorcraft, Transport Airplane, and Small Airplane Seating Systems***
- **Unrestrained Upper Torso Forward Flail**
- **Work In Progress – Not TSO-C127…yet?**
- **Restraints; TSO-C22g, TSO-C114**

Seating Systems Overview

- **TSO-C100c, *Aviation Child Safety Device***
- **TSO-CTBD, *Airbags***
- **TSO-C72*, Individual Floatation Devices***
- **TSO-C13, *Life Preservers***
- **ATD – Time for a Change**
- **Request for Comments: FRN 2022-16565**
- **Selected Registration Questions**

TSO-C127c



- **Released 31 August 2020**
- **TSO-C127b sunset March 1, 2022**
- **Expanded definition of a seating system**
  - Forward and Rearward Facing - up to an angle of 18˚ relative to the aircraft longitudinal axis (RALA)
  - Side Facing - 80˚ to 100˚ RALA
  - Oblique Facing - greater than 18˚ and ≤ 45˚ RALA

TSO-C127c

- **SAE AS8049C**
  - Performance Standard for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft
- **SAE ARP5526D**
  - Aircraft Seat Design Guidance and Clarifications
- **SAE AS6316**
  - Performance Standards for Oblique Facing Passenger Seats in Transport Aircraft

TSO-C127c

- **SAE AS8049/1B**
  - Performance Standards for Side-Facing Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft

TSO-C127c: SAE AS8049C Appendix highlights

- **Inflatable material flammability – horizontal**
- **Sensor Driven restraints - airbags, pre-tensioners, deployable panels**
- **FAA Hybrid III or Hybrid II ATD**
- **Interaction of ATD head with Hybrid II and use of FAA Hybrid III (subsection 5.4.11, page 20 & 21 of the TSO)**
  - Head rotation and neck injury (head/chin hang ups)

TSO-C127c: SAE AS8049C Errata

iv. M_{yc} = 100 lbf ft in extension
and
(3) Peak upper neck Fz is below 937 lbf in tension and 899 lbf in compression.

(c) If testing is first conducted with the Hybrid II ATD and the interaction could cause serious human injury as defined in paragraph (a)(2), (e.g., chin snagging on a horizontal seat back feature), then subsequent testing may be accomplished with the FAA Hybrid III or equivalent. To show acceptability using the FAA Hybrid III or equivalent:

(1) the ATD must be positioned so the chin will strike above the seat feature which caused the unacceptable interaction in the initial Hybrid II ATD test.

(2) testing must demonstrate the same behavior as shown with the Hybrid II ATD in order for the safety demonstration to be valid, and

(3) the loads in (b)(1) and (b)(2) must be reported. and (b)(3)

(4) If the test demonstrates an acceptable interaction per paragraph (a)(1) and the loads in (b)(1) and (b)(2) are below the limits, no further substantiation is necessary.

(5) Due to differing chin shape and neck stiffness, the chin of the FAA Hybrid III ATD or equivalent may or may not hang up on the seat feature. If the head stops, the stop time may exceed 10ms as long as the loads in (b)(1) and (b)(2) are not exceeded.

- **Next TSO release will correct subsection 5.4.11**

TSO-C127c: General Aviation Commuter Flammability

- **Type C-C seats (commuter part 23 Amdt. 23-62)**
  - AS8049C 3.4.1.3
    - Seatbelts, and shoulder harnesses may not have an average burn rate greater than 2.5 inches per minute
- **Type C-NL4 (Level 4 part 23 Amdt. 23-64)**
  - AS8049C 3.4.1.4
    - All materials on C-NL-4 seats must be self-extinguishing

TSO-C127c: C-NL4 self-extinguishing

- **How did that happen?**
  - 2017 release of part 23 Amdt. 23-64

§ 23.2325 Fire protection.

(a) The following materials must be self-extinguishing –

(3) For level 4 airplanes, materials in the cockpit, cabin, baggage, and cargo compartments.

TSO-C127c: C-NL4 self-extinguishing

- **Compliance Showing § 23.2325 Method 1**
  - Federal Register /Vol. 81, No. 251 / Friday, December 30, 2016 Docket No.: FAA–2015–1621, Amdt 23-64, Final Rule, *Revision of Airworthiness Standards for Normal, Utility, Acrobatic, and Commuter Category Airplanes*
    - "The FAA will accept the use of the prescriptive means of compliance contained in former part 23 as one way to show compliance with new part 23."

TSO-C127c: C-NL4 self-extinguishing

- **Compliance Showing § 23.2325 Method 2**
  - Federal Register /Vol. 87, No. 48 / Friday, March 11, 2022, Docket No. FAA–2022–0217; Notice No. NOA–23–22–01 *Accepted Means of Compliance; Airworthiness Standards: Normal Category Airplanes*

TSO-C127c: C-NL4 self-extinguishing

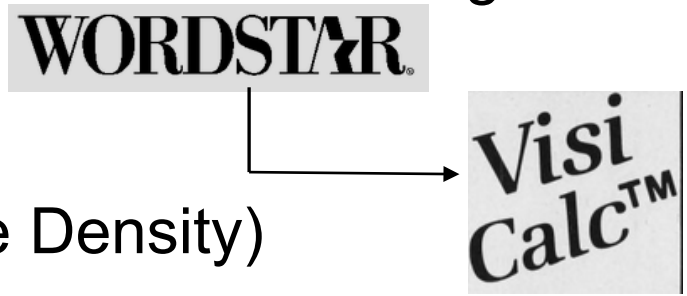
- **Compliance Showing § 23.2325 Method 2**
  - ASTM F3083/F3083M—20a Standard Specification for Emergency Conditions, Occupant Safety and Accommodations
    - Very similar to § 23.853 pre amendment 23-64

TSO-C127c: C-NL4 self-extinguishing

- **TSO-C127c Application Impact**
  - Minimum Performance Standard is self-extinguishing
  - This engineer has not seen a non–treated webbing capable of meeting self-extinguishing
  - Recommend request for deviation to the TSO until FAA releases TSO-C127d

TSO-C127d – in Planning Stage

- **FAA is tracking revision to SAE**
  - AS8049 as it moves from a word file to something akin to an Excel Spreadsheet
  - ARP5526 (Seat Design)
  - ARP6199 (Heat Release/Smoke Density)



- **Incorporation of § 25.853 (2019 NPRM)**
  - https://www.regulations.gov/docket?D=FAA-2019-0491

Unrestrained Upper Torso Forward Flail

- **Already addressed in the TSO via AS8049C 3.2.1 …to provide occupant protection…**
- **SAIB 2023-08, *Promotion of Safety Enhancing Features for Certain Transport Passenger Seat Configuration*, issued 01 August 2023**
  - https://drs.faa.gov/browse/excelExternalWindow/DRSDOCID15263128432023080119560 4.0001

Unrestrained Upper Torso Forward Flail

- **Draft - AC 25.562-1b Change 2**
  - Removes Policy Memorandum ANM-115-05-14, *Policy Statement on Acceptable Methods of Compliance with § 25.562(c)(5) for Front Row Passenger Seats*, dated December 14, 2005
  - Expands determination of front row seats, inclusion of installations that allows for unrestrained forward movement

Unrestrained Upper Torso Forward Flail

- **Draft - AC 25.562-1b Change 2 (continued)**
  - What is a front row seat?
    - “Front-row seats are those located directly aft of a partition, monument, or any other commodity certificated to 9g. Front-row seats also include any other seat installation that allows for unrestrained forward movement, such as seats installed at a large pitch and seats located directly aft of seat-related furniture such as consoles and walls of pod seats.”

Unrestrained Upper Torso Forward Flail

- **Draft - AC 25.562-1b Change 2 (continued)**
  - Adds guidance when dynamic testing shows obvious and unacceptable injurious interactions of the head and neck
  - Use of FAA Hybrid III or Hybrid II ATD
  - No head contact is ok, but new guidance on restraining upper torso
  - Head Contact HIC 1000 or less

Unrestrained Upper Torso Forward Flail

- **Draft - AC 25.562-1b Change 2 (continued)**
  - Can still use head path arc to show no head contact
    - Must address unrestrained upper torso forward flail
  - ATD Head interaction during HIC testing guidance
    - Several issues identified with non classical design of seat back features
    - New and novel safety devices introducing new injury mechanisms

Unrestrained Upper Torso Forward Flail

- **Draft - AC 25.562-1b Change 2 (continued)**
  - ATD Head interaction during HIC testing guidance
    - Head rotation about vertical axis relative to torso
    - Head or chin snag resulting in tension on neck
  - Can use either FAA Hybrid III or Hybrid II
    - Certain responses with HII may need retest with FAA HIII
    - Use FAA Hybrid III, have all the data rather than test twice

Unrestrained Upper Torso Forward Flail

- **Draft - AC 25.562-1b Change 2 (continued)**
  - Guidance is not the panacea for all designs
    - Nij looked good and so did head twist!

Unrestrained Upper Torso Forward Flail

- **Draft - AC 25.562-1b Change 2 (continued)**
  - Implementation/grace period will be 2 (two) years from date of issuance

Not TSO-C127: SAE AS6960

- **Performance Standard for Seat Furnishings in Transport Aircraft**
  - The stuff that makes a fancy seat but not attached to the seat

Not TSO-C127: SAE AS6960

- **FAA Notice of Availability (NOA)**
  - Section 3.2.3, an acceptable means of compliance with §§ 25.601 and 25.1301(a)(4) for preventing hazards of entrapped devices
- https://www.federalregister.gov/documents/2023/08/04/2023-16094/accepted-means-of-compliance-airworthiness-standards-transport-category-airplanes

Restraints; -C22g, -C114

- **TSO-C22g *Safety Belts* Released (1993)**
- **TSO-C114 *Torso Restraint Systems* (1987)**
- **Both are based on SAE AS8043 (1986)**
  - Revision C released May 2023
- **Next revision may include reference to SAE ARP6073 *Webbing Service Life for Occupant Restraints***

TSO-C100c Aviation Child Safety Device (ACSD)

- **Released in 2012**
- **Based on SAE AS5276/1 2000**
  - Reaffirmed in 2019
- **Next revision SAE or FAA will revise AS5276/1 paragraph 6.3**
  - Is: …3 µs
  - Should be: …3 milliseconds

TSO-CTBD Airbags

- **SAE SEAT committee is restarting its effort to write consensus standards for airbags**
- **FAA expectation is that it will incorporate standards that could be drawn from the stabilized airbag special conditions**
- **ASTM is on a similar path, limited to General Aviation**
- **FAA will evaluate for possible new TSO**

TSO-C72 Floatation Devices

- **Released 1990 – self-contained within the TSO**
  - Not life preservers
  - Self-inflatable & Non inflatable

- **Industry consensus committees (IEEE, SAE, ASTM, ASME…) have not approached FAA to revise current requirements**

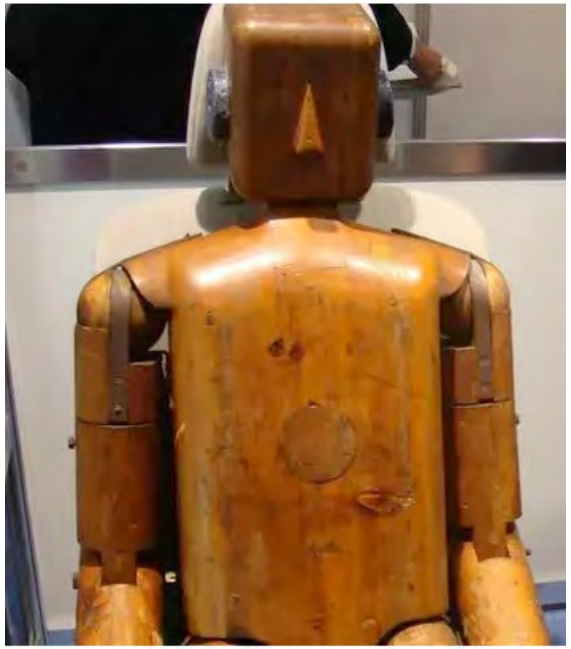
TSO-C13g Life Preservers

- **Released 2017 – no longer self-contained within the TSO**
- **Based on SAE AS1354 2016**
  - Revision A is a Work In Progress

https://www.youtube.com/watch?v=d_XaIQTT5WI

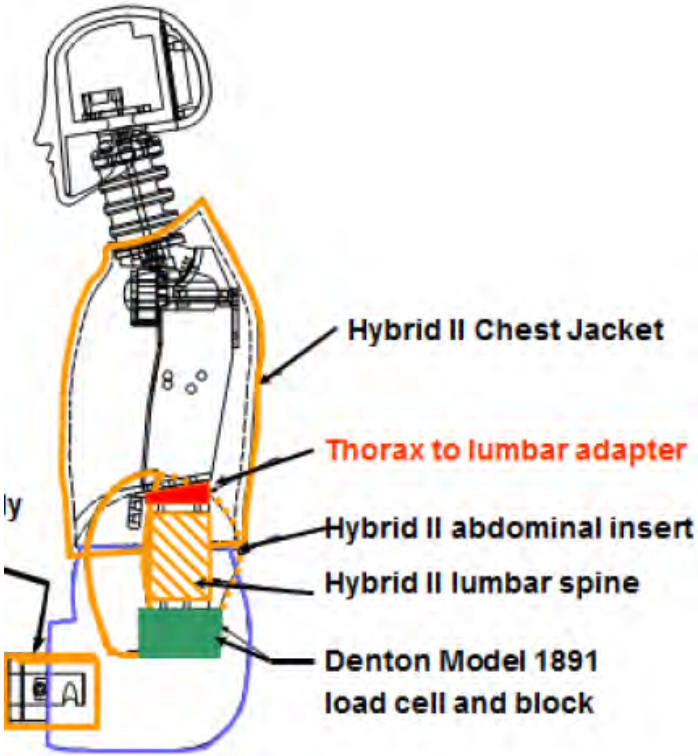
Time for a Change

- **1973 Hybrid II ATD inducted into 49 CFR Part 572 and used ever since by aviation**
- **1986 Hybrid III is adopted as and alternative for automotive**
- **1991 Hybrid III is used exclusively to show compliance to § 571.208**



Time for a Change

- **FAA policy memo for creation of FAA Hybrid III equivalent to Hybrid II**
  - Policy AIR-100-3-3-2000
- **HIII is over 50 years old, not used in Automotive for 32 years**



Request For Comments

- **Federal Register / Vol. 87, No. 148 / Wednesday, August 3, 2022, Document Number:2022-16565**
- ***Request for Comments in Minimum Seat Dimensions Necessary for Safety of Air Passengers (Emergency Evacuation)***
- **https://www.govinfo.gov/content/pkg/FR-2022-08-03/pdf/2022-16565.pdf**

Several comments received

- **Grouped under Passenger Comfort**
  - Center of Disease Control and Prevention: latest numbers people gaining weight not height
  - Anthropomorphic Research: men have wider shoulders and women larger hips, need to take this into account for seat sizes
  - Seat Recline: people want it locked out tired of people “in their space”
  - Service Animals: need space at feet and this space is reduced
  - Blood Clots and Deep Vein Thrombosis: sitting too long in cramped area
  - Germs: on armrests and shared spaces

End of Formal Presentation

- **Q&A Time**
- **But first…**

A Few Registration Questions

- **Policy PS-AIR100-9/8/2003, Classification of Design Changes to TSO-C39b, TSO-C127, and TSO-C127a Articles – Is it ever going to be updated?**
- https://drs.faa.gov/browse/excelExternalWindow/58284CD6F89BBCF686256DB9004FE606.0001
  - January 2019 SAE SEAT Committee member proposed that the Committee create an Industry White Paper on the classification of seat (E)TSO major and minor changes
  - Existing policy could be updated to reflect the latest TSO revision and provide more examples relevant to today's seat designs; however, current content is acceptable. Certification Branches are using policy at their discretion

A Few Registration Questions

- **Policy PS-AIR100-9/8/2003 (continued)**
  - EASA finds evolution of the TSO revisions to be significant enough to justify the need to critically review the content of the FAA policy to determine if any adaptions/integrations need to be implemented
  - FAA is waiting for proposal of changes to the policy from industry
  - Add your voice, be part of the committee https://www.sae.org/standards/development/committee-participation

A Few Registration Questions

- **Definition of Sharp Edges & Serious Injury**
- **But first a look at the SAE standards on which the TSO is based and the regulations**
  - Dive into various historical presentations
    - Dynamic Impact Workshops at CAMI
    - SAE SEAT Committee meetings

The Standard & TSO-C127c

- **AS8049C**
  - 3.2.2 Seat elements shall be designed so that, when evaluated under the test conditions of this document, they do not generate hazardous projections that could significantly contribute to injury to occupants that are seated or moving about the airplane or that could impede rapid evacuation

The Regulation – “protect each occupant”

- **§ 23.2270 Emergency conditions. (amdt 64)**
  - (a) The airplane, even when damaged in an emergency landing, must protect each occupant against injury that would preclude egress…
- **§ 23.562 (amdt 62)**
  - (a) Each seat/restraint system for use in a normal, utility, or acrobatic category airplane, or in a commuter category jet airplane, must be designed to protect each occupant during an emergency landing…
- **§ 25.562**
  - (a) The seat and restrain system in the airplane must be designed as prescribed in this section to protect each occupant during an emergency landing condition…
- **§ 27.562**
  - (a) The rotorcraft, although it may be damaged in an emergency crash landing, must be designed to reasonably protect each occupant…
- **§ 29.562**
  - (a) The rotorcraft, although it may be damaged in a crash landing, must be designed to reasonably protect each occupant…

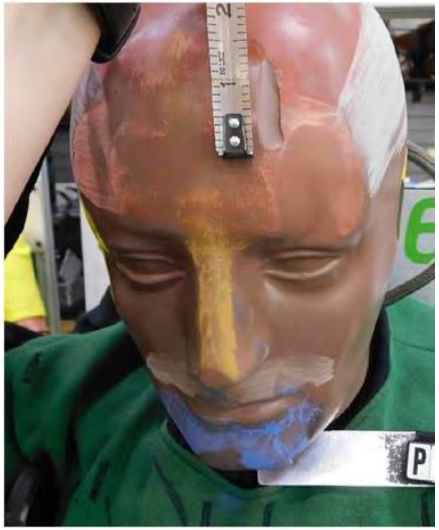
A Few Registration Questions

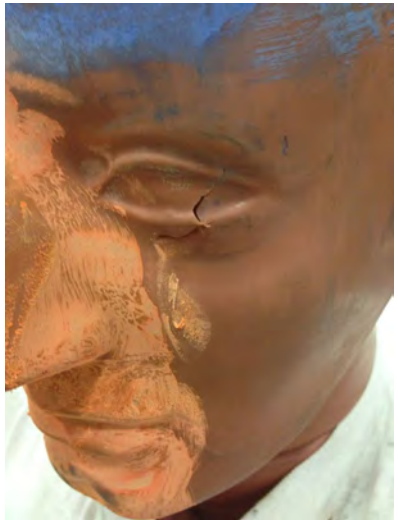
- **Definition of Sharp Edges & Serious Injury**
- **Sharp Edges**
  - Rather than definition, let us look at performance requirements
  - The following is a summary statement is a summary of CFR and guidance

Allow no hazards that will contribute to the injury of occupants that could lead to impeding rapid evacuation

Injury During the Survivable Crash Impact

- **Seat damage continues to cut the ATD**



Injury Evaluation: Egress

- **SAE ARP5526D 3.12.2**
  - NASA Standard 3000 Volume I (NASA–STD-3000 Vol I), *Man-Systems Integration Standards*, Revision B, July 1995, Section 6.3.3
  - UL 1439, *Standard for Tests for Sharpness of Edges on Equipment*, Edition 4, February 26, 1998, with revisions through 6/1/2004
- **The design criteria from NASA and the use of the edge tester during a post-test edge evaluation may determine that the edge is will not be injurious during egress**

Injury Evaluation: Impact

- **AS8049D – 5.3.9 Data Analysis**
  - 5.3.9.16 Post-Test Evaluation of Sharp Edges and Protrusions
    - Cuts and damage to the ATD skin during a dynamic test does not constitute pass/fail criteria for determining if serious injury would occur to the occupant under the dynamic load conditions. It indicates that the area of contact on the seat must be evaluated against the above criteria.
- **Seat evaluations could use more clarification and possibly examples**
- **FAA has requested SAE to continue to refine criteria**

A Few Registration Questions

Definition Serious Injury

- Title 14 Aeronautics and Space
- Chapter I Federal Aviation Administration, Department of Transportation
- Subchapter C - Aircraft
- Serious Injury not defined in 14 CFR § 1.1
- Has roots in §§ 23.785(c), 25.785(b), 27.785(a), and 29.785(a)

A Few Registration Questions

Definition Serious Injury (cont'd)

- Policy ANM-03-115-31, Policy Statement on Conducting Component Level Tests to Demonstrate Compliance with §§ 25.785(b) and (d)
  - Sharp or injurious edges or features could cause additional injury and thus impede occupants from exiting the airplanes after a crash; they are therefore not acceptable

A Few Registration Questions

- **National Transportation Safety Board - NTSB**
  - Title 49 Transportation
  - Subtitle B Other Regulations Relating to Transportation
  - Chapter VIII National Transportation Safety Board
  - Part 830 Notification and Reporting of Aircraft Accidents or Incidents and Overdue Aircraft, and Preservation of Aircraft Wreckage, Mail, Cargo, and Records

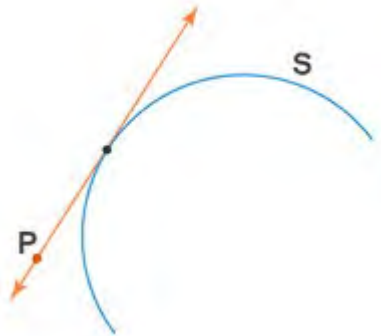
A Few Registration Questions

- **§ 830.2 Definitions. As used in this part the following words or phrases are defined as follows:**
- **Serious injury means any injury which:**
  1) Requires hospitalization for more than 48 hours, commencing within 7 days from the date of the injury was received;
  2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose);
  3) causes severe hemorrhages, nerve, muscle, or tendon damage;
  4) involves any internal organ; or
  5) involves second- or third-degree burns, or any burns affecting more than 5 percent of the body surface.

https://www.ecfr.gov/current/title-49/subtitle-B/chapter-VIII/part-830/subpart-A/section-830.2

A Few Registration Questions

- **National Highway Transportation Administration – NHTSA (nhtsa.gov)**
  - Model Minimum Uniform Crash Criteria (MMUCC) Guideline https://www.nhtsa.gov/mmucc-0



A Few Registration Questions

- **NHTSA MMUCC**

Suspected Serious Injury (A): A suspected serious injury is any injury other than fatal which results in one or more of the following:

  - Severe laceration resulting in exposure of underlying tissues/muscle/organs or resulting in significant loss of blood
  - Broken or distorted extremity (arm or leg)
  - Crush injuries
  - Suspected skull, chest or abdominal injury other than bruises or minor lacerations
  - Significant burns (second and third degree burns over 10% or more of the body)
  - Unconsciousness when taken from the crash scene
  - Paralysis

A Few Registration Questions

- **States which may hold TSOA Aircraft Seats (2019)**
  - https://definitions.uslegal.com/s/serious-bodily-harm/ cites a state code that defines serious bodily injury as “bodily injury which involves a substantial risk of death, unconsciousness, extreme physical pain, protracted and obvious disfigurement, or protracted loss or impairment of the function of a bodily member, organ, or mental faculty.”
  - North Carolina § 14-32.4: "Serious bodily injury" is defined as bodily injury that … or permanent or protracted loss or impairment of the function of any bodily member or organ
  - Texas Penal Code: Sec. 1.07. DEFINITIONS “Serious bodily injury” means …. impairment of the function of any bodily member or organ
  - California PEN § 243 (f)(4): “Serious bodily injury” means a serious impairment of physical condition…protracted loss or impairment of function of any bodily member or organ; ....

A Few Registration Questions

- **While we are talking serious injury let us touch upon Glass (2019)**
  - EASA – does not allow glass throw
  - FAA – similar Large Glass Panels Special Conditions 747-8 https://www.federalregister.gov/d/2017-05331
    - The glass component installation must retain glass fragments to minimize the danger from flying glass shards or pieces
- **A 1995 CDC report defines serious eye injury as "an injury resulting in permanent and significant, structural or functional ocular change."**

A Few Registration Questions

- **Integration of IFE into TSO-C127**
  - 2011 AIR100-12-120-105, *Policy Statement on SAE Aerospace Information Report 6448, Gaining Approval for Seats with Integrated Electronics in Accordance with AC21-49 Option 7b*
  - AC 21-49, *Gaining Approval of Seats with Integrated Electronic Components, 2011*
  - SAE AIR6448, *Gaining Approval for Seats with Integrated Electronics in Accordance with AC21-49 Option 7b* – cancelled
  - SAE ARP6448A, *Gaining Approval for Seats with Integrated Electronics in Accordance with AC 21-49 Section 7.b, rev 2021*

A Few Registration Questions

- **TSO for IFE**
  - Several Electronic/Electrical TSO's exist that state "Passenger Information and Entertainment Service and passenger-owned devices are not included in this TSO"
  - Although IFE systems are installed in the seating system they are not under the minimum performance standard of the seating system, TSO-C127

A Few Registration Questions

- **Which ATD should I use?**
  - FAA Hybrid III instrumented as appropriate to obtain lumbar, femur, Head Injury Criteria, Nij…
  - Draft AC 20-126A Change 1 recommends use of FAA HIII

A Few Registration Questions

- **eVTOL TSO-C127?**
  - eVTOL currently being certified under § 21.17(b)
    - Generally using part 23 Amendment 64, the Performance based rule or ASTM
    - Detailed Design Standard (DDS) and Means of Compliance Issue Papers are used to develop occupant protection

A Few Registration Questions

- **eVTOL TSO-C127 (continued)**
  - SAE AS6849, Performance Standards for Passenger and Crew Seats in Advanced Air Mobility (AAM) Aircraft
  - Three seat types, Forward/Aft facing only
    1. D-C, Conventional T/O & Landing
    2. D-V, Vertical T/O & Landing
    3. D-VC, Capable of both D-C & D-V
  - In the FAA Policy queue for TSO consideration

A Few Registration Questions

- **Can I get an incomplete TSO-C127 Approval – (ie. no flammability)?**
  - See Order 8150.1D
    - 9-1. Incomplete TSO Articles or Multiple Function Articles. An incomplete TSO article is one that provides a major and independent function that is specified in the TSO. A multiple function article is an article for which more than one TSO have been approved by the TSOA. This will generally be a component of the overall system that has a standalone function. (Refer to AC 21-46)

A Few Registration Questions

- **Incomplete TSO-C127 (continued)**
- **Sample Template has location for;**
  - *Add the following, when it applies; This is an incomplete system intended to provide the following functions: (List functions.)*
  - It may be more succinct to identify what is lacking in the TSO Authorization rather than what is compliant

8150.1D https://drs.faa.gov/browse/excelExternalWindow/DA469579EF6A2EBD862580EA00704777.0001
21-46 https://drs.faa.gov/browse/excelExternalWindow/22F35EBA0DCFD1C6862580E3006097E8.0001

A Few Registration Questions

- **(E)TSO and related reference material (AS8049, AC 25.562-1, etc.) are mainly focused on fixed wings aviation seats. Are the agencies willing to fill this gap and/or issue some specific common practice/guidance material?**
  - Join an Industry Standards Committee to affect Standards and Recommended Practice

A Few Registration Questions

- **AC guidance xx.562**
  - AC 23.562-1, 1989
  - AC 27-1B Change 9, 2006
  - AC 29-2C Change 8, 2006
  - AC 25.562-1B Change 1, 2015
- **ACs are generally based on AC 25.562-1 as it is the most up to date AC**

A Few Registration Questions

- Reality – applicants MOC and Test plans sometimes refer to part 25 AC but ensure that requirements comply with their parts (23, 27, 29)
- It is on FAA Policy list to update however for part 23, ASTM may develop guidance that the FAA can accept via a Notice of Availability

Questions/Contact

patrick.farina@faa.gov

Cabin Safety Section, AIR-624

562.627.6721