Deviation Request UKTSO-C127c.Dev.001

For an UKTSO approval for CS-UKTSO applicable to Rotorcraft, Transport Aeroplane, and Small Aeroplane Seating Systems

(UKTSO-C127c)

Consultation Paper

1 Introductory Note

The UK CAA has received the following request for Deviation to a CS-UKTSO requirement in accordance with the provisions of Part 21.A.610.

In accordance with the UK CAA Design and Certification procedures, such deviation requests shall be assessed by the authority and be subject to a period of public consultation of not less than 3 weeks except if they have been previously agreed and published by the UK CAA.

All interested persons may send their comments referencing this Deviation Proposal number to the email address Certification.Airworthiness@caa.co.uk. The consultation period will close on 30 January 2026.

The final decision shall be published by the UK CAA.

2 UKTSO-C127c.Dev.001 Rotorcraft, Transport Aeroplane, and Small Aeroplane Seating Systems

2.1 Summary of Deviation

Deviates from CS-UKTSO Amendment 17, UKTSO-C127c, Section 3.1.1 to modify the pass/fail criteria and load value at which the upper torso restraint strap may slip off the ATD shoulder, during the rebound phase of the qualification test procedure defined by the minimum performance standard SAE AS8049/1b and SAE AS8049C, Section 5.3.9.7.

2.2 Original Requirements

Original test requirement stated in the following minimum performance standards.

- SAE AS8049C, 'Performance Standard for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft', dated August 2015 - Section 5.3.9.7 "Retention of Upper Torso Restraint Straps":

"Retention of the upper torso restraint straps on the ATD's shoulders can be verified by observation of photometric or documentary camera coverage. ***The straps must remain on the ATD's shoulder until the ATD rebounds after the test impact and the upper torso restraint straps are no longer carrying any load.*** *The straps must not bear on the neck or side of the head and must not slip to the upper rounded portion of the upper arm during that time period".*

- SAE AS8049/1b "Performance Standards for Side-Facing Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft", dated December 2016 - Section 5.3.9.7 "Retention of Upper Torso Restraint Straps":

"Retention of the upper torso restraint strap on the ATD's forward shoulder can be verified by observation of photometric or documentary camera coverage. ***The strap must remain on the ATD's shoulder until the ATD rebounds after the test impact and the upper torso restraint strap is no longer carrying any load.".***

2.3 Industry

Based on the test requirements specified in SAE AS8049C, and SAE AS8049/1B Section 5.3.9.7, there is ambiguity regarding the pass/fail criteria requirement for upper torso restraint (shoulder harness) retention on the Anthropomorphic Test Device (ATD) shoulder throughout the entire crash event, particularly during the rebound phase.

The standard mandates that the shoulder harness must remain on the ATD's shoulder "*until the ATD rebounds after the test impact and the upper torso restraint straps are no longer carrying any load.*".

Primary purpose of shoulder harness is to ensure passenger retention during impact phase and reducing occupant head trajectory, thereby improving passenger safety.

With reference to SAE AS6316, the impact phase is defined as "*the initial contact of the ATD with an object or surface.*". The rebound phase is defined as "*ATD movement in approximately the opposite direction to the inertial direction, irrespective of whether the ATD makes contact with anything. Contact that does not result in reversal of the direction of movement, remains 'impact' until such reversal occurs.*".

It can be understood, if the upper torso restraint strap maintains its position on the ATD's shoulder during the impact phase, it may slip off during the rebound phase while still loaded, as the load decays.

Therefore, the Industry proposes that a reasonably low load value within the restraint strap, not to exceed 890 N (200 lb), is considered acceptable at the point of restraint strap slippage during the rebound phase, subject to demonstration that all additional injury criteria shall still be met after the tension load in the strap first returns to 890 N (200 lb) and the seat experienced critical loading conditions for structural tests.

Means of Compliance (MOC) and justification are proposed in order to ensure an equivalent level of safety within the following sections.

2.3.1 MOC Proposal

The proposed load value has been selected on the basis of the review of a significant number of test videos shared by the Working Group members, across a variety of seat designs (e.g. premium/economy/business class seats, forward/side/aft/oblique facing seats, seats with machined adaptors, seats with standard upper torso restraint strap and pre-tensioner systems etc.) and various test conditions (i.e. leading/trailing shoulder structural and HIC/Occupant Injury tests). From these, it is evident that the ATD rebound phase, in its last phase, results in relatively low load carried by the shoulder harness for an appreciable amount of time. Slipping of the upper torso restraint strap from the ATD shoulder at such load value is considered reasonable, if complemented by additional substantiation related to structural performance of the seat and risk of occupant injury during rebound.

See Figure 1 for a conceptual illustration of upper torso restraint load plot.

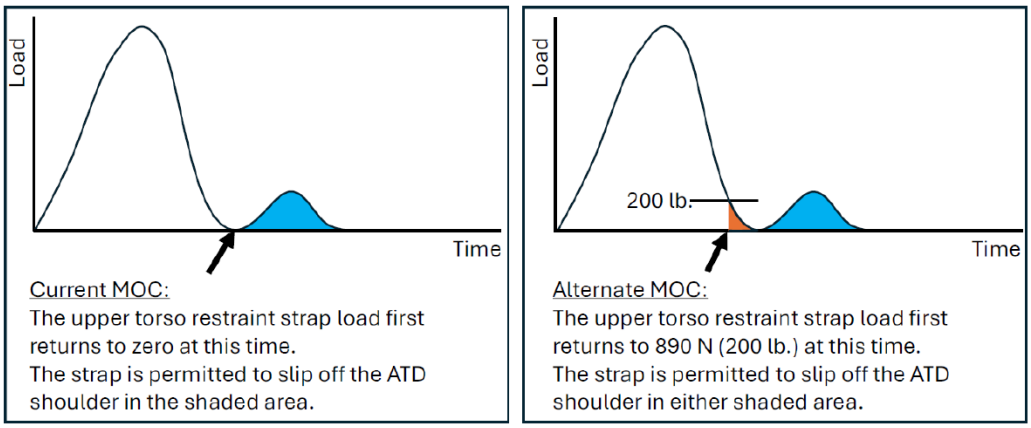

Figure 1 - Illustration of Upper Torso Restraint Strap Load Graph and MOC

The upper torso restraint strap shall meet either (a) or (b) below (this applies to tests with Hybrid II and FAA Hybrid III ATDs):

a) The shoulder strap shall remain on the shoulder until the tension load in the strap first returns to zero (i.e. after completion of the impact irrespective of any loading or slippage conditions observed after that time).

b) Alternatively, the upper torso restraint strap shall remain on the shoulder until the tension load in the strap first returns to 890 N (200 lb.) (i.e. during rebound), provided all the following conditions are met:

i. All additional injury criteria shall still be met after the tension load in the strap first returns to 890 N (200 lb.) Examples include but are not limited to HIC, Nij, significant concentrated loading on the neck, thoracic acceleration, generation of sharp edges, retention of items of mass and permanent deformation that could affect egress. Additional justification must be generated to justify that the loss of retention of the occupant during the rebound has no detrimental effect on the evaluation of structural performance of the seat and occupant injury.

ii. For 16g and 14g structural tests only, the seat experienced critical loading conditions. As a minimum, the assessment should include a review of the interface loads acquired during the dynamic test, lumbar loads as well as a comparative analysis with other dynamic tests performed on the same seat design (e.g. 16g structural test with strap on the leading shoulder).

2.3.2 Demonstration of Compliance

This paragraph provides guidance for the test setup and test assessment required to demonstrate compliance to the proposed Means of Compliance proposed in 2.3.1 above.

a) Visibility of Upper Torso Restraint retention on ATD Shoulder

i. To improve visibility of the shoulder retention on the ATD shoulder during the test, cut off the sleeve of the ATD T-shirt from the lateral edge of the ATD torso jacket, per Figure 2.

ii. Exposing the edge of the ATD torso jacket ensures that assessment of upper torso restraint strap retention is effectively established.

iii. To improve assessment of retention of upper torso restraint strap on the ATD, mark a point on the ATD torso rubber jacket with indelible ink (the use of tape or stickers in areas where it could reasonably be expected that the upper torso restraint strap will slide over it should be avoided), as clarified below:

1. The point shall be placed on the forward upper edge of the ATD torso jacket per Annex 1. This point will be used for test result assessment as clarified in 2.3.2(c)(ii) below.

2. The point shall be a circle of 10 mm (0.4 in.) maximum in diameter.

3. This point shall have high contrast to the torso strap colour and ATD torso rubber jacket. The size and contrast of the point shall be appropriate enough to facilitate tracking via high-speed cameras during the dynamic tests.

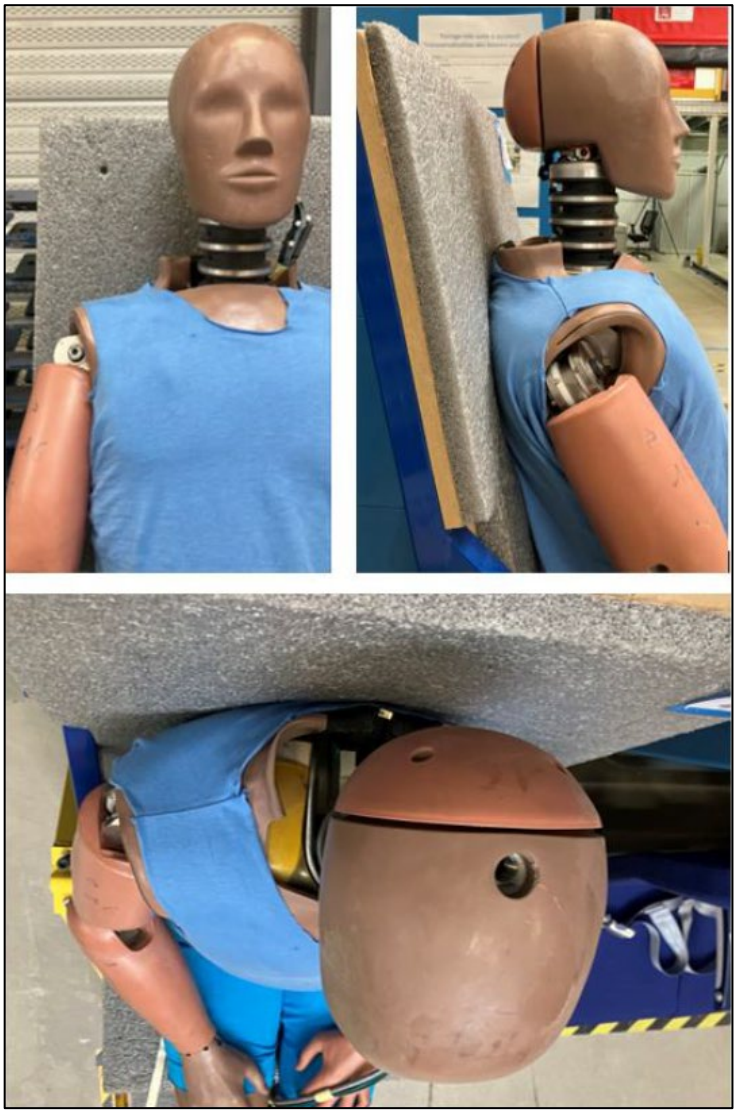

Figure 2 - Example of ATD T-shirt sleeve cut-off

b) Identification of Upper Torso Restraint Strap Retention

i. The upper torso restraint strap retention is identified via observation of photometric or documentary camera coverage.

ii. To improve visibility of the shoulder retention on the ATD shoulder during the test, use high speed cameras (preferably in colour), positioned such that assessment of the upper torso restraint strap movement across the ATD shoulder, up to the point it leaves the ATD shoulder is adequately captured. It is advisable to use multiple camera angles and adequate lighting to ensure a continuous view of the pertinent interactions is available. Consider the movement of ATD head/neck/limbs during the dynamic event to define appropriate camera positioning.

c) Review of test data (Pass/Fail)

i. Current Guidance:

On the load graph for the upper torso restraint load, identify the time at which the load has first returned to zero (i.e., after rebound phase).

1. If, at this time, the upper torso restraint strap is still on the ATD shoulder, the test is considered Pass (per the current guidance).
2. If, at this time, the upper torso restraint strap is no longer on the ATD shoulder, follow the steps in (ii) below.

ii. Alternate guidance:

On the load graph for the upper torso restraint load, identify the time at which the load first returns to 890 N (200 lb.) (i.e., during rebound). If no determination can be made regarding the visibility of the point (e.g. due to shifting of the ATD shirt, ATD legs or arms, as well as any features obstructing the camera views), the test should be considered as not valid. The test may be repeated with different cameras' placement.

1. If, at this time, the upper torso restraint strap is still on the ATD shoulder, as identified by the visibility of the point on the ATD torso jacket (as described in 2.3.2(a)(iii) and positioned per Annex 1), test is considered Pass, provided conditions in section 2.3.1(b) are also met.
2. If, at this time, the upper torso restraint strap covers the point partially on the ATD torso jacket (as described in 2.3.2(a)(iii) and positioned per Annex 1), the test is considered Fail.

Note: The visibility of the point on the ATD shoulder, as addressed on above paragraphs, can be considered valid to demonstrate the torso restraint strap behaviour also with respect to the current guidance. (i.e. torso restraint strap to remain on the shoulder after 890 N (200 lb.) and until zero load is reached).

2.4 Equivalent Level of Safety

As mentioned in paragraph 2.3.1, it is evident that the ATD rebound phase, in its last phase, results in relatively low load carried by the shoulder harness for an appreciable amount of time. Slipping of the upper torso restraint strap from the ATD shoulder at such load value is considered reasonable, if complemented by additional substantiation related to structural performance of the seat and risk of occupant injury during rebound.

a) From a seat structural perspective, following the impact phase, if the seat has surpassed both the peak upper torso restraint strap loads and seat leg fittings loads, the load in the seat structure is reducing (i.e., the seat has already experienced the critical loading condition). Therefore, the upper torso restraint strap may slip off the ATD shoulder while still carrying some load. At the point in time when the load in the upper torso restraint strap has reduced to 890 N (200 lb.), the peak seat leg fitting loads have reduced by an order of magnitude and has passed the time period in which the seat is critically loaded. A load value of 890 N (200 lb.) does not adversely affect the structural integrity of the seat during this time.
b) From the occupant safety perspective, once the ATD has entered the rebound phase, the upper torso restraint strap has successfully retained the ATD during impact. The load of 890 N (200 lb.) in the upper torso restraint strap is considered acceptable on the basis that:

i. The load is much lower than the maximum established load limit for the upper torso restraint strap.
ii. During the rebound phase, the motion of the ATD is dictating the load in the upper torso restraint strap, and it is not the load in the upper torso restraint that dictates the motion of

the ATD. Therefore, the load on the strap has no significant influence on the torso movement, rather, it is the torso movement that dictates the load value.

iii. The occupant trajectory, in any direction, and interaction with the surrounding structure does not change significantly during the period within which the load reduces from peak to zero (i.e., the rebound phase). Therefore, a load of 890 N (200 lb.) does not adversely affect the occupant injury characteristics during the last phase of the test. Any effect on occupant injury characteristics, as a result of the upper torso restraint strap slipping off the shoulder, are reviewed during occupant safety tests (HIC) and not during structural performance tests.

2.5 UK CAA position

We accept the deviation.

Annex 1
Marker Positioning on Upper Torso of ATD Jacket

1 Rationale

a. The purpose of the upper torso restraint strap is to limit upper torso excursion by supporting the torso with the strap placed diagonally across the torso.
b. Experience shows that sliding of the torso restraint strap off the top or the back of the ATD shoulder does not alter the position of the strap on the torso during rebound (i.e. the required support is offered to the forward surface of the upper torso).
c. By the time the strap slips from the front of the ATD shoulder, the position of the strap on the torso can more readily change.
d. Hence the critical threshold that determines the stability of the position of the restraint strap across the torso, is when the strap slips from the front of the shoulder.
e. In human anatomy, the front of the shoulder generally aligns with the forward surface of the neck.
f. To promote a consistent placement of the marker (or target), the latter should be positioned relative to hard points or structure within the ATD (i.e. the metallic ‘skeleton’).
g. A marker placed on the upper forward corner of the ATD torso at the edge of the torso jacket (at the shoulder cut out) can be used to assess the passage of the torso restraint strap beyond the critical threshold.
h. The forward vertical face of the FAA Hybrid III neck protective plate aligns approximately with the forward vertex of the cylindrical ‘neck’ structure of the ATD and can therefore be used to define the front of the shoulder. See Figure 3.
i. The Hybrid II ATD differs from the FAA Hybrid III at the neck and shoulder areas. A different approach is therefore proposed, which also aligns with the philosophy of the marker positioning on the FAA Hybrid III ATD. The marker positioning for the Hybrid II is taken from the flat surface of the ATD shoulder joint, as illustrated in Figure 4.

2 Proposal for FAA Hybrid III ATD

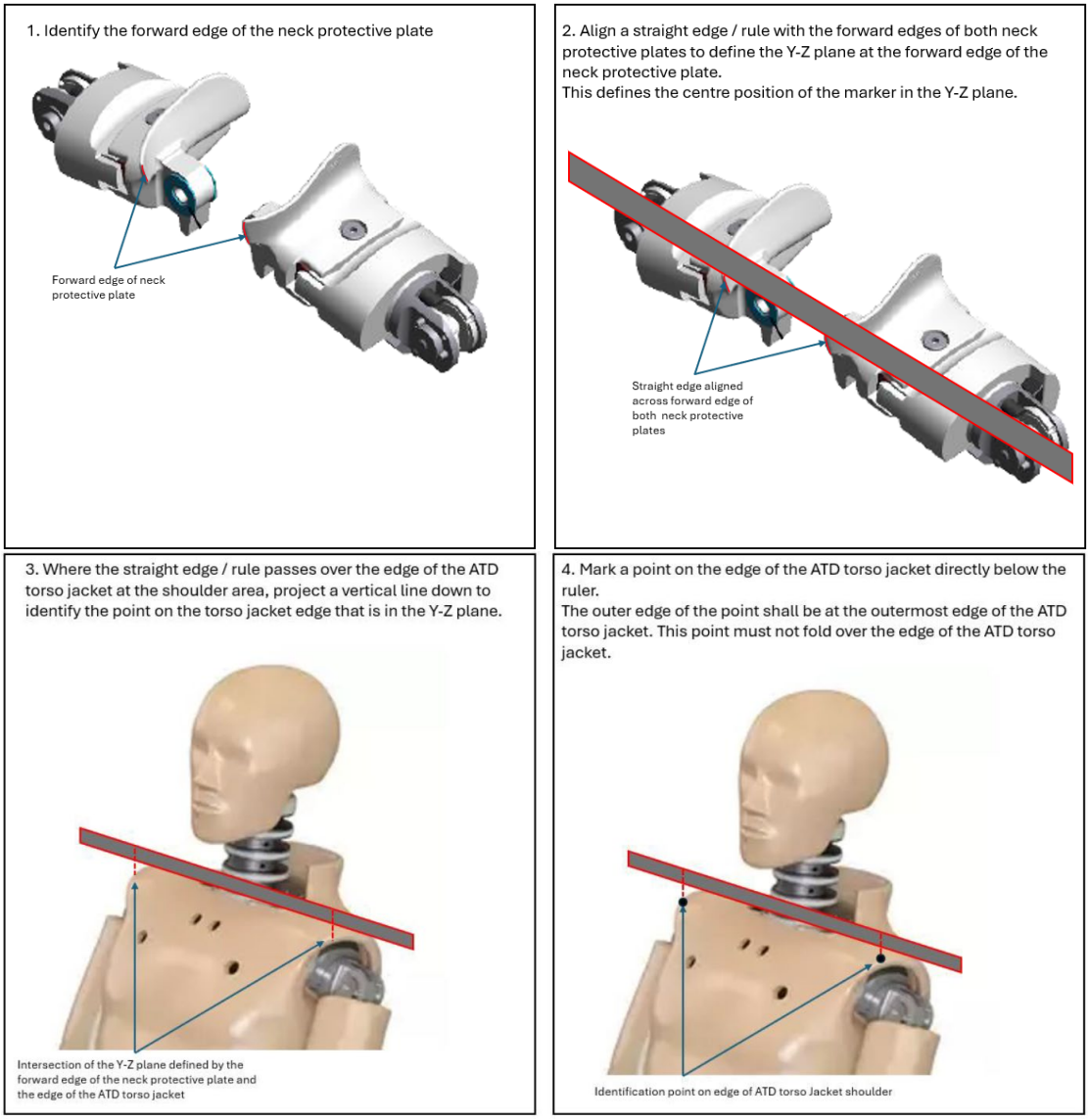

Figure 3 - FAA Hybrid III Marker Positioning on the ATD Shoulder

3 Proposal for Hybrid II ATD

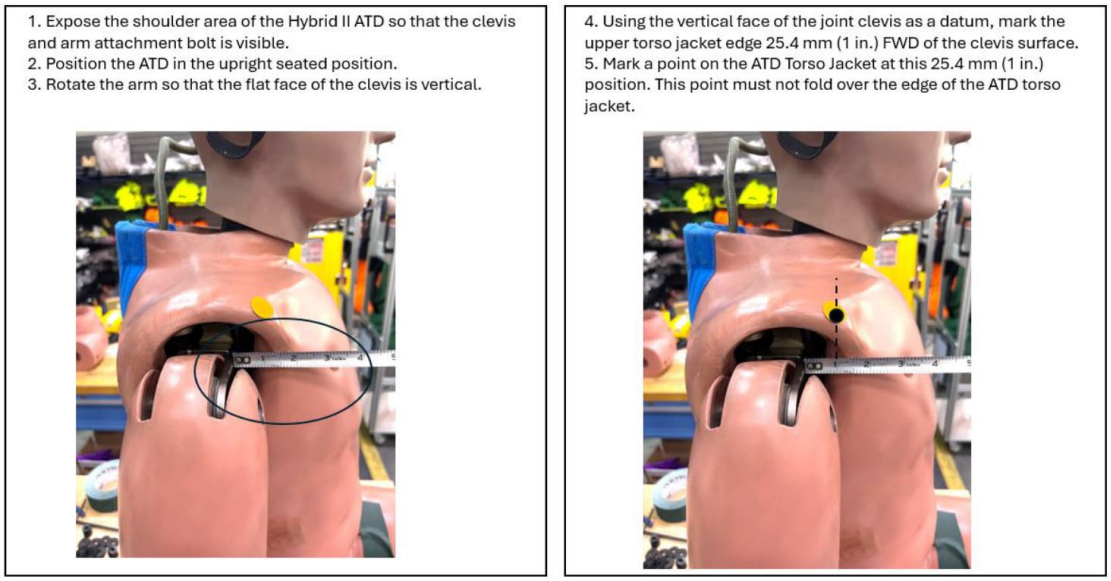

Figure 4 – Hybrid II Marker Positioning on the ATD Shoulder