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Abstract

To establish compliance with safety regulations, aircraft seats must undergo dynamic tests that evaluate structural performance and occupant protection. Title 14 of the Code of Federal Regulations, Part 25 [1], states that two dynamic tests, represented in Figure 1, are required: a 14G deceleration indicating a downward-forward impact loading (Test-1), and a 16G longitudinal deceleration (Test-2). The primary purpose of Test-1 is to assess the vertical lumbar forces experienced by the occupant, whereas Test-2 determines the structural adequacy of the seat, seat belt, and attachment fittings, as well as potential cabin hazard to occupants.

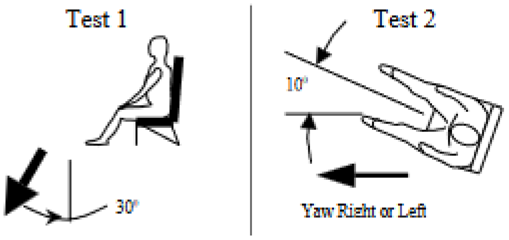

Figure 1: Dynamic Test conditions for seat certification [2].

A seat certification program is a costly, longstanding, and demanding process. Consequently, numerical methods are coming to prominence as they provide a more convenient way of testing new materials and designs. Furthermore, the guidelines to introduce Certification by Analysis (CBA) under certain conditions are being developed over the years [3] and it can soon become a reality when minor changes are to be applied to a previously certified baseline seat. In this matter, being extremely computationally efficient, Multibody Dynamic (MB) models can be a valuable alternative to Finite Element Analysis (FEA). The goal of this work is to develop a MB model of an aircraft seat assembly based on the plastic hinge technique approach [4] to improve the seat structural performance and assist with the Certification by Analysis.

The first stage of the methodology was to divide the seat assembly model shown in Figure 2a, into the proper number of bodies, and select the position of the joints restraining the relative motion between them, setting a mechanism capable of mimicking the seat's deformation pattern. The structural components within the seat's primary load path - the legs, the spreaders, and the cross tubes, were segmented into several bodies, as depicted in figure 2b. To simulate the elastic and plastic deformations of the seat, the bodies were connected by plastic hinges. A series of FEAs were performed, as in the work of [5, 6], to generate the constitutive models of the hinges. The MB model of the seat is combined with the MB model of the 50th percentile Hybrid II or FAA Hybrid III Anthropomorphic Test Devices (ATD).

(a) Finite Element (b) Multiboby model with 50th percentile FAA Hybrid III ATD.

Figure 2: Numerical models of the seat assembly

The MB model was validated by comparing the loads at floor fittings and seat-belt attachments, as well as the kinematics and relevant injury criteria to the occupant (ATD) obtained in the MB model, to the ones from experimental procedures for the dynamic certification tests 1 and 2.
The reasonable correlation between the MB model results and the test data, and the efficiency of the numerical method, enhanced the potential of these models for use in the optimization process of the seat components and the improvement of transportation safety.

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