FRONT ROW OCCUPANT RESPONSE IN AIRCRAFT SEAT ENVIRONMENT

John Humm[1], Frank Pintar[1], Narayan Yoganandan[1], Brian Peterson[2]

David Moorcroft[3], Amanda Taylor[3], Rick DeWeese[3]

1 Department of Neurosurgery, Medical College of Wisconsin,
9200 West Wisconsin Avenue, Milwaukee, WI, 53226, USA

2 Milwaukee County Medical Examiner's Office
933 West Highland Avenue, Milwaukee, WI, 53233, USA

3 Civil Aerospace Medical Institute
6500 S. MacArthur Blvd, Oklahoma City, OK, 73169, USA

ABSTRACT

Safety standards for commercial aircraft specify that passenger seats must protect occupants from serious head injury during emergency landing conditions. Occupants of front row seats, in particular, are at risk due to potential head contact with interior cabin walls. A current method intended to mitigate this risk is use of restraints that minimize occupant head excursion. These include low elongation conventional lap belts and a special belt configuration called the Y-belt. The Y-belt design has an additional top segment installed at a shallow angle such that it carries most of the occupant restraint load and reduces forward pelvis rotation, resulting in less head excursion. The reduction in head translation maximizes cabin space utilization by allowing the seat to be placed closer to the wall. Previous comparisons of occupant response with Y-belt and standard lap belts have been limited to Anthropomorphic Test Devices (ATDs), and injury biomechanics of this restraint loading are not well understood. The aim of the current study is to compare the response of Post Mortem Human Surrogates (PMHS) and ATDs for conventional lap and Y-belt restraints using a matched-paired test matrix.

Occupant was placed on a custom seat approximating standard aircraft geometry with an open-back design to provide an unobstructed view of the back of the occupant. The seat was fixed to the top of a servo acceleration sled to simulate frontal loading using the Code of Federal Regulations Part 25.562 Emergency Landing dynamic condition for horizontal impacts. Four-inch-thick bottom seat cushion was used for all tests. Low-elongation, polyester webbing material was used for all belts. Accelerometers and angular rate sensors were mounted to the head, spine and pelvis. Load cells were used to measure restraint forces. Onboard and off board high speed video recorded gross occupant motion. Sets of non-collinear retroreflective markers at salient locations measured the three-dimensional rigid body kinematics using a twenty-camera motion capture system.

Injuries to the PMHS were severe. For the standard belt, transection of the vertebral column was observed at T4-5, bilateral proximal femoral shaft fractures, and multiple bilateral rib fractures with flail chest. Femur fractures were likely caused by the lap belt which slipped down from the anterior superior iliac spine of the pelvis and sheared the femurs just distal to the greater trochanter. Transection was probably due to distraction of the thorax caused by extreme flail of

the upper torso. The Y-belt PMHS test demonstrated transection of the L5-S1 joint and rib fractures on the left anterior lateral aspect of the thorax. Injury to the spine was more inferior in the Y-belt test and likely due to the additional constraint of the pelvis by the top strap which seemed to limit the anterior motion the pelvis relative to the seat.

This study is the first to examine the effect of standard and Y-belt restraints on a PMHS in a frontal impact in the aviation environment.