# Performance of a Numerical Model of the ES-2re as a Function of Impact Angle

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Historically, anthropomorphic test device (ATD) construction and instrumentation has been optimized for the loading direction the ATD is intended to evaluate. The Hybrid II was designed to evaluate a frontal impact with a conventional restraint. The Hybrid III was designed to evaluate airbag interaction in a frontal impact. For purely side impacts, the US SID and ES-2re ATDs were developed. The optimization of these ATDs limits the ability of the ATD to predict occupant injury in an impact direction different from the design basis. With the introduction of herring bone configurations in transport category aircraft, there is a need to evaluate oblique angles, however no ATD has been designed to specifically evaluate these angles.

An occupant seated in a pod seat in a herring bone configuration is likely at risk of head, neck, thoracic, abdominal, and leg injuries due to contact with the surrounding structures. The only ATD in 49 CFR Part 572 that has the measurement capability to predict these injuries is the ES-2re. Risk of thoracic injury is measured by three linear potentiometers attached to the ribs; because of the orientation of these potentiometers, off-axis loading in the xy plane will not be accurately recorded. Visual inspection of the torso also suggests that off-axis loading in the xz plane will result in interaction between the lower rib and the abdominal compartment. This interaction will likely damage the rib.

Because of the concerns with the ability of the ES-2re to accurately capture the injury risks of an obliquely facing occupant and the risk of damage to the physical ATD, a series of numerical simulations of the ES-2re were performed to provide information on the performance of the ATD at loading angles between 45 and 90 degrees from the aircraft centerline. A model of the ES-2re was seated in a rigid seat with either a full wall or an armrest. The 14 CFR Part 25.562 Test 2 pulse (16g peak, 90 ms rise time, 44 ft/s velocity change) was used. A no-penetration contact was defined between the abdomen and each of the three ribs. The animation of each simulation was viewed to determine the effect of any interaction between these parts of the ATD. The injury criteria listed in FAA policy memo PS-ANM-25-03-R1 were calculated to evaluate the change in values as a function of impact angle.