Development and Examination of Dynamics Models for the Assessment of Spinal Injury from Repeated Impact in High Speed Planing Boats

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ABSTRACT

High speed planing boats are used in both military missions and civilian settings for craft interdiction and for rapid insertion and extraction of forces into low to medium threat environments. ISO-2631 Part 5, the standard for repeated impacts to seated occupants, is as good or better than any other injury criterion, although its intrinsic neural net has severe limitations for application to vertical impacts above +4g and below 0g. The goal of this research is to create and validate a new low-order dynamics metamodel for predicting vertical impact to the human spine using a Madymo (TNO, Inc) simulation of a seated occupant under predominantly vertical impacts. A set of data was collected during three multi-hour, multi-day sea trials using volunteer occupants and Hybrid III dummies in the high speed planing crafts. Craft vertical acceleration time histories were used as input to both a new low-order human dynamic metamodel and to the current ISO-2631 Part 5 dynamics and injury model. Measured seated occupant lumbar spinal acceleration time histories were used to assess the output of these dynamics models. Though it generally matches the experimental data up to 4g, the results of these models indicate that the ISO-2631 Part 5 neural network dynamics model substantially underestimates lumbar spinal accelerations for impacts larger than 4g and can predict nonphysical acceleration time-histories even within its stated range of validity, due to the use of belted occupant data in its development. The newly developed metamodel matches well with the experimental lumbar acceleration response over the entire measured range of high speed planing craft impacts (0 – 14 g) and is applicable for use in the assessment of injury from repeated impact in high speed planing craft.