

DEVELOPMENT OF NEW CRASHWORTHINESS EVALUATION STRATEGY FOR ADVANCED GENERAL AVIATION AND TRANSPORT AIRCRAFT SEATS

By

ALAN ADAMS

June 2001

ABSTRACT

Aircraft seats have traditionally been designed to comply with static strength requirements. Aircraft seat dynamic performance that shows both seat strength and the occupant impact protection characteristics must be a priority design objective. Crash safety of aircraft, specifically the protection of the occupants during a crash, is becoming increasingly important due to drastic increases in the number of severe injuries among the flying passengers. The aviation industry's desire to improve the crashworthiness of aircraft has resulted in the implementation of occupant spinal injury criteria for seat certification, in the Federal Aviation Regulations 23.562 and 25.562. Aircraft seats currently require extensive and costly dynamic testing in order to meet this criterion. This inefficient design process has driven the need for a simple and fast engineering design tool for predicting the severity of occupant spinal injuries.

The performance of the "Learfan" seat, which was tested in Lear-Fan drop test at NASA Langley Research Center, predicts the dynamic impulses specified in 14 CFR 25.562 as well as for the floor track acceleration measured during the full-scale drop test. The goal of this thesis is to contribute to low-cost Advanced General Aviation and Transport Evaluation (AGATE) crashworthiness compliance methodologies. The first approach is by constructing nonlinear seat model using LS-DYNA, a 3-D non-linear Finite Element Method (FEM) package to analyze the dynamic behavior of the seat under direct impact. From the analysis the properties of the seat are obtained and then used for analysis of biodynamic test configurations in the second phase of simulation. This approach uses the powerful and versatile Kinematics and Dynamic crash simulation program, MADYMO (Mathematical Dynamic Model). Multibody dynamic techniques are utilized to characterize the occupant behavior in event of a crash on two different seat configurations, one with standard rigid seat and the other utilizing a seat cushion. The occupant model is set up for a 50th percentile Part 572 Hybrid II anthropomorphic test dummy (ATD). In both approaches, FAR Part 23.562, and 15g crash pulses at 60° pitch angle with a initial velocity of 31 ft/sec for general aviation aircraft category under Test I and Test II dynamic conditions are simulated, and the dynamic behavior of the occupant and performance of both configurations seat are obtained.

Nonlinear stiffness characteristics for the occupant, and the seat components were determined using a combination of static compressive and dynamic crash experimental tests data. To demonstrate the capabilities of the

computer model, the results were obtained from the computer model then validated using full scale dynamic crash sled test data and static test conducted using the MTS-servo hydraulic stand in the Structures Laboratory at the National Institute for Aviation Research (NIAR). Finally to increase simulation accuracy, a third method is performed by coupling the two previous methods, which combines a three-dimensional dynamic model of the human body with the finite element model of the seat structure to accurately simulate an aircraft/occupant crash event.

The final results show the computer models can be used as a simple and fast seat design tool that accurately predict the dynamic response including an occupant spinal injury severity as well as the seat when subjected to a crash event.