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Validity and reliability of vehicle collision: crash pulse recorders for impact severity and injury risk assessment in real-life frontal impacts

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Abstract:

The general objectives of this thesis were to study the importance of valid and reliable data from real-life collisions, especially the effects of inaccurate data on analyses of leg injury risks. Furthermore an objective was to develop and validate an on-board measurement device for acceleration measurements, to be used in reconstructions of primarily frontal impacts. The final objective was to conduct a large fleet field study to evaluate parameters influencing injury risks in real-life frontal car collisions. Neck injuries in frontal impacts, and frontal impacts with small partial overlap were examined more in depth.

An error influence study was conducted where synthetic random errors of different magnitudes were added to the calculated change of velocity in a database with fatal crashes (NASS). It was found that the consequences of using real-life collision data with low validity and reliability can have serious negative implications. Impact severity measurements with low accuracy will decrease the slope of the injury risk curve and smooth the distributions of collisions and injured occupants. The role of injury prevention may therefore be underestimated.

The CPR enables us to determine several parameters derived from the measured crash pulses and is a useful tool in vehicle collision analyses. In this thesis, the CPR was validated in full-scale crash tests. The systematic error of ΔV computations was found to be -3.9 km/h and the standard deviation was 2.2 km/h.

From the results of approximately 150 collisions, it was found that the shape of crash pulses differed substantially. It was found that change of velocity and mean and peak accelerations relate to injury risk, where either large changes of velocity, high mean or high peak accelerations may lead to severe injuries. It was also found that large changes of velocity do not necessarily lead to severe injuries.

The most important influencing factor for the risk of sustaining long-term consequences from an AIS1 neck injury was found to be the difference between mean acceleration or change of velocity in the mid and last part of the crash pulse. The deceleration of the occupant immediately after seatbelt contact seemed to explain the risk of sustaining long-term consequences to the neck. Changes in the seat-belt system may decrease this risk.

It was found that impacts with an overlap below 30%, often resulting in glance-off, account for a large part of severe injuries, where injuries to the head, leg and chest dominated. The injuries in severe such impacts seemed to be mainly related to intrusion. The architecture of the frontal structure of vehicles was found to be important for the vehicle performance in this type of impacts. A reconstruction

method for frontal collisions with glance-off based on crash pulse recorder measurements is proposed, where the closing velocity may be estimated from the recorded crash pulse and the length of the contact areas.

It is recommended to use on-board measurement devices to record relevant impact severity parameters more than is done today. A deeper knowledge of the relation between impact severity and the risk of injury can help to design a more crashworthy road transportation system. The crashworthiness of the entire road traffic system should be designed with respect to acceleration levels and the risk of intrusion rather than to change of velocity.

Keywords: crash recorder, crash pulse recorder, impact severity, injury risk, real-life impacts, measurement accuracy, neck injuries, long-term consequences, reconstruction