# Evaluation of Occupant Response and Injury Metrics for Pole Crash Scenarios

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## I.  INTRODUCTION

Vehicle impacts with fixed roadside structures such as poles can result in severe injuries and represent a significant portion of road fatalities in North America. The Fatality Analysis Reporting System (FARS, NHTSA) reported 1113 crashes involving poles in the U.S. in 2009, which resulted in 1759 fatalities [1]. The current North American response metrics include Ride-Down Acceleration (RA, average acceleration over 10ms) and Occupant Impact Velocity (OIV, approximate impact velocity between the occupant and vehicle interior) [2], which infers occupant response from the vehicle kinematics. To improve the crash safety of pole structures, it is essential to understand occupant response and how it relates to the accepted response metrics.

## II.  METHODS

Detailed numerical models of a full vehicle [3], Hybrid III ATD [4] and a validated deformable steel pole model were integrated (Fig. 1) to investigate frontal impact scenarios at 30, 50 and 70 kph. The vehicle model was enhanced to include an airbag, restraint system and seat model. The occupant response was evaluated using the Head Injury Criterion ($HIC_{15}$, threshold 700), chest compression (CC, threshold of 50 mm), RA and OIV.
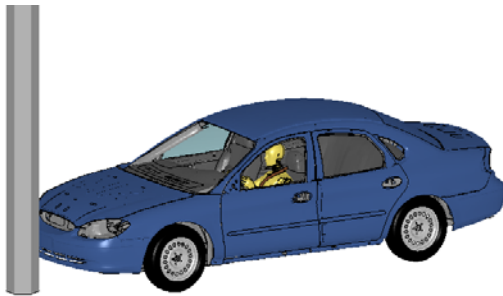


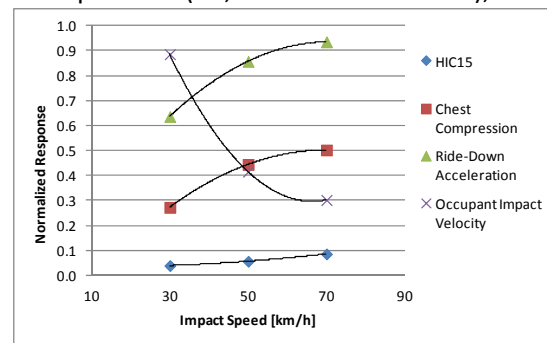Fig. 1: Integrated pole, vehicle, occupant model



Fig. 2: Comparison of response metrics

## III.  RESULTS

The impact resulted in deformation of the pole and vehicle, decelerating the vehicle. The occupant was decelerated in a controlled manner by the air bag and seat belt system. The injury metrics were predicted and normalized by their threshold values (Fig. 2).

## IV.  Discussion and Conclusions

For the impact cases considered, the injury metrics did not exceed the threshold values (i.e. 1.0 on the normalized plot); however, RA was predicted to be close to the threshold for a 70 kph impact. The RA demonstrated a trend similar to CC but with much higher predicted values, providing a conservative estimate of occupant response. OIV did not follow the same trend as the other metrics, and was very high for the 30 kph scenario. This was attributed to lack of consideration of modern safety systems. Future work will consider other pole types and improved crashworthiness using occupant-based injury metrics.

## V.  References

[1] NHTSA, FARS, http://www-fars.nhtsa.dot.gov/QueryTool/QuerySection/CaseListingReport.aspx, 2011.
[2] Sicking D et al, Recommended Procedures for the Safety Performance Evaluation of Highway Features, 2007.
[3] Opiela KS, Finite element model of Ford Taurus. FHWA / NHTSA Finite Element Model Archive, 2008.
[4] Humanetics Innovative Solutions, H350 ATD v 7.1.6, 2011.

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