Evaluation Of The Injury Risks Of Truck Occupants Involved In A Crash As A Result Of Errant Truck Platoons

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I. INTRODUCTION

Platooning is an extension of Cooperative Adaptive Cruise Control (CACC) that realizes automated lateral and longitudinal vehicle control while moving in tight formation with short following distances. It is unknown whether the capacity and adequacy of existing roadside safety hardware is sufficient to resist a potential impact from a fleet of multiple trucks at high speed, which may occur as a result of errant truck platoons. It is also unknown how these impacting trucks might interact with roadside safety barriers after leaving their platoon and what the occupant risks associated with such impacts are.

In this study, a methodology was developed to simulate a single tractor-van trailer impact into a concrete barrier. The methodology was applied to examine how the existing roadside safety devices will perform under multiple impacts at close proximity during a potential impact from a fleet of multiple trucks at high speed, which may occur as a result of errant truck platoons, and to evaluate the injury risks of truck occupants.

II. METHODS

This study involved developing a simulation methodology for multiple impacts into selected roadside safety devices based on Manual for Assessing Safety Hardware (MASH) test level 5 (TL5) criteria [1]. An existing proprietary tractor-van trailer finite element (FE) model developed in LS-Dyna was used in the impact simulations. The barrier FE model was developed [2] and impacted consecutively by five tractor-van trailers at an angle of 15.2 degrees and speed of 83.2 km/h about 10,516 mm from the upstream end of the barrier. The first tractor-van trailer impact simulation was validated against the crash test before any following impact simulations were run.

The cabin model of the tractor-van trailer was extracted and used to develop the cabin-only model. The seats, steering wheel column, and other truck interior structures were added and corresponding FE models developed [3]. Then, the FE models of Hybrid –III and THOR dummies were seated and the models of seatbelt systems developed. The motion of cabin-only model was prescribed based on the displacement time histories of eight nodes recorded in the tractor-van trailer during barrier impact FE simulation. Four of these nodes are located on the cabin floor and the other four nodes are located on the cabin roof.

Objectives of this study are to understand:

a. **Barrier Strength:** Does the barrier contain and redirect impacting vehicle?

b. **Vehicle Stability:** Does the vehicle roll during impact event?

c. **Occupant Risk:** What are the risks of injuries to drivers?

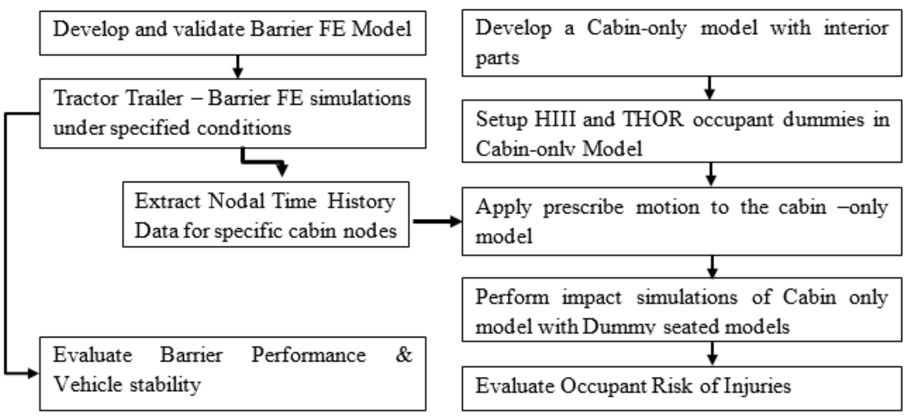

Fig. 1. Objectives and Overall Research Methodology.

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III. INITIAL FINDINGS

All five impacting tractor-van trailers were successfully contained and redirected by the barrier model. The tractor-van trailers stayed upright and rollover did not occur after the simulated impact events (Fig. 2a). After the fifth impact, from the initial position, i.e., position before first impact, permanent barrier displacement of 75 mm was observed. Tractor-van trailer impacting the barrier and barrier damage after fifth impact, represented by numerical erosion, were observed (Fig. 2b). Partial failure of reinforcement occurred at the region of impact due to plastic strain.

Drivers were expected only in the first and the last (5th) platoon truck, so only these simulations were performed with dummies seated in the simplified cabin model. Even though some motion of the dummies during the first and fifth^{h} impacts were observed, the seatbelt systems restrained the occupants wellon the seat and consequently protected them from the impact with interior parts (Fig. 2 c-d).

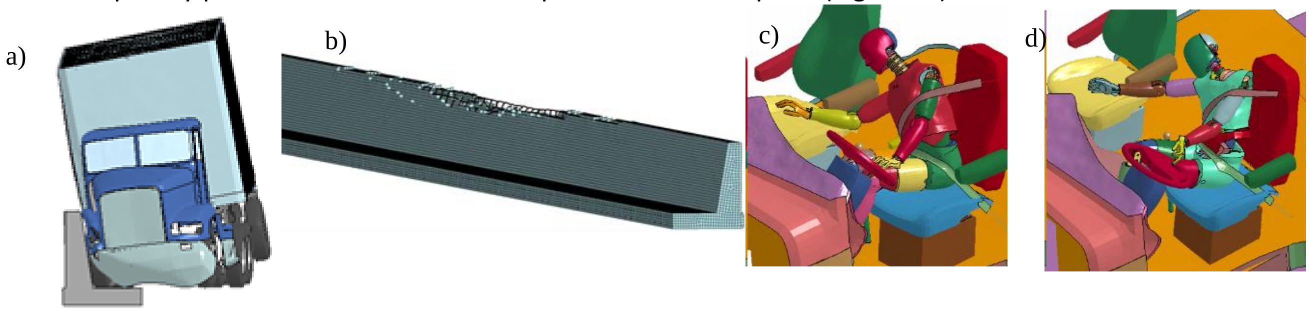

Fig. 2. a). Tractor-van trailer impacting Manitoba barrier, b). Concrete erosion – after fifth impact c) Hybrid III and d) THOR dummy during the collisions

The values of maximum injury values recorded during the crash simulation showed to be much below the Injury Assessment Reference Value (IARV) which suggests low injury risk for both tractor drivers (Truck 1 & 5). Three injury values (Head Injury Criterion (HIC), chest deflection and femur axial forces) were less than 10% of IARVs. The predicted Occupant Injury Measure (OIM) values [4], calculated by summarizing the body parts AIS3+, from both FE dummy models were higher than 85%, which corresponds to relatively low injury risks for occupants.

TABLE I
OCCUPANT INJURY MEASURE (AIS3+)

OIM	Hybrid-III (%)	THOR (%)
Truck#1	87.53	88.91
Truck #5	90.16	91.40

IV. DISCUSSION

FE analysis suggest that the selected barrier is potentially able to contain and redirect all five tractor-van trailers at given impact conditions. Although the first impact was validated against the crash test, conducting multiple impacts in order to validate the simulation results are recommended. Numerical investigation with THOR and Hybrid III dummy models seated in driver postures suggest low occupant injury risks during all impacts. However, the evaluation of the injury risks of occupants in various seated postures are recommended in future. Using biofidelic human models, e.g., GHBMC, in these truck crash simulations may improve the accuracy of the injury risks of truck occupants, so they are recommended in future studies as well.

V. REFERENCES

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