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Analysis of the consequences of car to micromobility user side impact crashes

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1 INTRODUCTION

Mobility has changed in recent years in cities worldwide, thanks to the strong rise in vehicles of micromobility. Bicycle riding is the most widespread micromobility transport mode, followed by stand-up electric scooters (e-scooters). This increase in its use has also led to an increase in related crashes. Both cyclists and e-scooter riders are vulnerable road users and are likely to sustain severe injuries in crashes, especially with motor vehicles.

The crashes consequences involving cyclists and other micromobility users have already investigated using numerical simulation software, such as MADYMO and PC-Crash. Most of them have been focused on bicycles and electric bicycles, whereas only few of them have analyzed e-scooter crashes consequences. Posirisuk et al. [1] carried out a computational prediction of head-ground impact kinematics in e-scooter falls. Ptak et al. [2] analyzed the e-scooter user kinematics after a crash against SUV when the e-scooter drives into the side-front of the vehicle, a side B-pillar crash and a frontal impact initiated by the e-scooter to the front-end of the vehicle. However, they did not study the consequences of a car to e-scooter side impact crashes. Xu et al. [3] did study these crashes but considering electric self-balancing scooters that are less widespread than e-scooters.

Current study focuses on the consequences of a car to micromobility user (cyclist and e-scooter rider) side impact crashes. The analysis is based on numerical simulations with PC-Crash software.

2 METHODOLOGY

In order to assess the consequences of a car to micromobility user side impact crash, different scenarios have been simulated with PC-Crash software (see Figure 1). PC-Crash is a crash reconstruction program allowing the user to perform simulations with multibody objects that collide with 3D vehicle mesh models [4]. In the current study, a bicycle (length: 1.821 m, width: 0.6 m, height: 0.992 m, weight: 15 Kg), an e-scooter (length: 1.180 m, width: 0.680 m, height: 1.232 m, weight: 16 Kg) and their riders (height: 1.75 m, weight: 80 Kg) multibody systems have been used. The vehicle model corresponds to a Ford Focus 2.0 TDCi (length: 4.340 m, width: 1.840 m, height: 1.490 m, weight: 1300 Kg, wheelbase: 2.640 m).

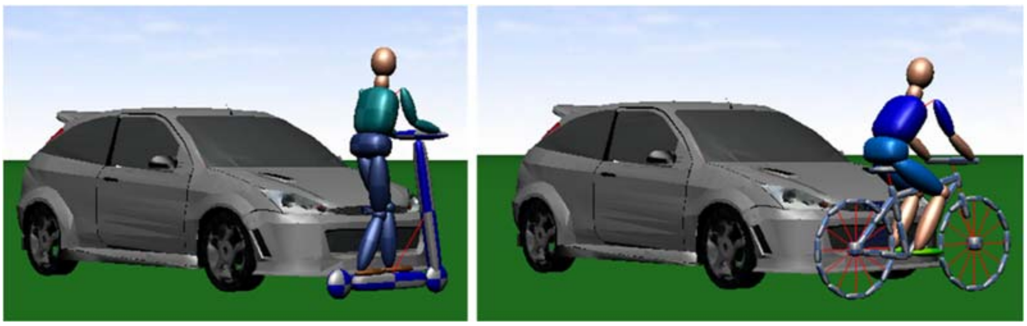

Figure 1: Scenarios simulated with PC-Crash.

Traffic crash scenarios simulate lateral impact at a right-angle intersection. Numerical simulations have been conducted at various motor-vehicle impact speeds (from 25 km/h to 50 km/h). The results of these simulations have been analyzed considering the chest acceleration and the HIC (head injury criterion). Federal Motor Vehicle Safety Standards adopted HIC as injury criterion with the safety margin of HIC15=700. Besides, 3 millisecond chest acceleration criterion has also been considered, whose safety threshold is 60 g, according to FMVSS 208.

3 RESULTS

Considering the results of the simulations, the variation in the chest acceleration and in the HIC15 as a function of the motor-vehicle speed has been studied (see Figure 2). In the case of chest acceleration, the 60 g threshold is never exceeded. However, when a car-e-scooter crash occurs at 50 km/h the chest acceleration is closed to 50 g, that can be considered very high value. On the other hand, both in car-e-scooter crash and in car-bicycle crash, HIC increases as motor-vehicle speed increases. When the car approaches at 45 km/h, in both cases the HIC exceeds the safety margin of 700, being in any case higher when the crash is between the car and the e-scooter.

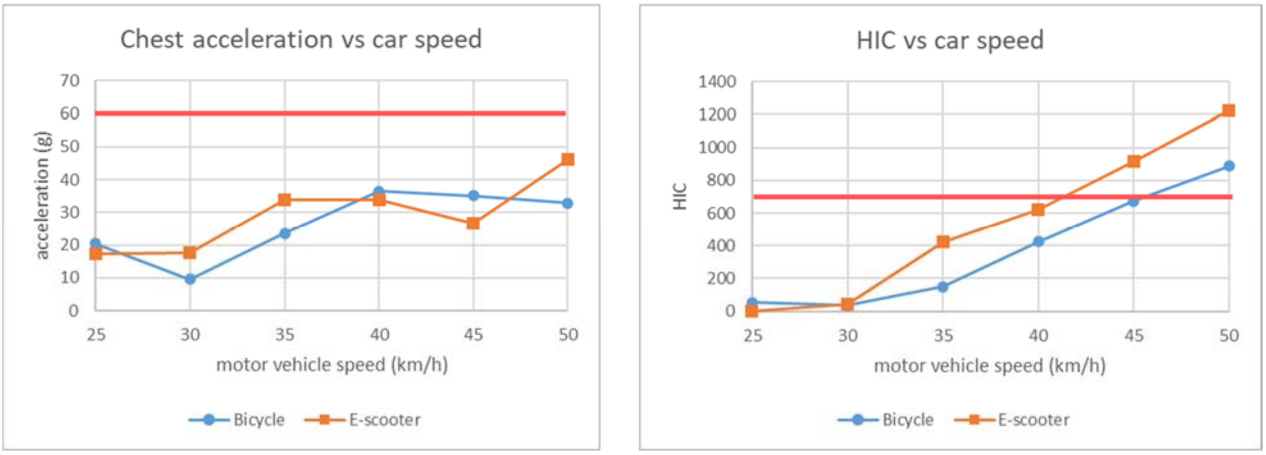

Figure 2: Variation of chest acceleration and HIC as a function of motor vehicle speed..

4 CONCLUSIONS

The mobility patterns and lifestyles have changed thanks to the strong rise of micromobility, especially bicycles and e-scooters, becoming a serious safety concern. The risk of a crash is greater at intersections and their severity is also greater there due to the interaction between micromobility vehicles and motor-vehicles.

The consequences of a car to micromobility user (cyclist and e-scooter rider) side impact crash have been analyzed based on the results of different scenarios simulated with PC-Crash. Results showed that riding a bicycle is safer that riding an e-scooter since the observed HIC is lower. However, in both cases, motor-vehicle speeds close to 45 km/h increase probability of serious injury and even death of the rider.

ACKNOWLEDGEMENTS

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