A Pedestrian Version of the Piper 6 Year Old Child Model

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I. INTRODUCTION

According to recent US statistical data, 21% of all children motor vehicle traffic fatalities in the country were pedestrian. Recently, the European New Car Assessment Programme (Euro NCAP) introduced a new procedure to certify Human Body Models (HBMs) relative to their use for evaluating the deployment of active pedestrian protection systems [1]. The protocol requires simulating impacts with four HBM sizes including a 6 year-old child. Toyota Motor Corporation and Toyota Central R&D Labs in Japan, developed jointly the THUMS 6 year-old child model [2]. The Global Human Body Model Consortium developed the GHBM Pedestrian 6 year-old simplified model [3]. During the Piper European project, a 6 year-old child occupant finite element (FE) model available under an open source license was developed and validated [4]. This study presents the development of a LS Dyna pedestrian version of the Piper 6 year old child model.

II. METHODS

The Piper 6yo model version 1.0.0 was used as a basis for the pedestrian model. The Euro NCAP protocol specifies posture requirements for a 6 year-old pedestrian HBM to be used for the certification. The requirements consist in a target value and associated tolerances of a set of body joint angles and coordinates of anatomical landmarks. The model was positioned according to these requirements. First the flesh and skin around the shoulder, elbows, hip and knee joints were removed. Then the model was repositioned using Primer by rotating the previously mentioned joints to match the target values. Subsequently the skin and the internal surface of the flesh were created using Hypermesh and a tetrahedral mesh similar to the original model was created, additionally shoes were added. The Piper framework was then used together with adjusted piper metadata for the pedestrian child model to adjust the position of the head and the angle of the ankles. According to recent anthropometrical data, the median height of a 6 year old child is between 117.8cm [5] and 120.1cm [6], the Piper model however has a stature of 114.3cm. Particularly the lower extremities of the Piper seemed too short which can be observed when looking at the ratio of the trochanteric and iliospinale height to the total stature (Table I) [7]. Considering these discrepancies, the Piper model was scaled trying to match both the trochanteric height and the stature. Finally, the model was impacted laterally at 50km/h according to the Euro NCAP protocol using the four generic car models developed in [8] representing a family car (FCR), a sport utility vehicle (SUV), a roadster (RDS) and a multi-purpose vehicle [MPV]. Trajectories of the head centre (AC), T12 and the acetabulum centre (AC) were recorded as well as the HC acceleration and velocity and the contact forces between the vehicle parts and the different body regions. In addition, the head impact time (HIT) defined as the time lapse between the first contact of the bumper to the right leg and the contact of the head to the car was calculated [1].

III. INITIAL FINDINGS

The scaled model is illustrated in Figure 1, Table I shows that it meets closely the reference anthropometrical data as well as body mass repartition requirements defined in [9].

TABLE I
ANTHROPOMETRY AND MASS REPARTITION

	ANTHROPOMETRIC MEASUREMENTS			MASS REPARTITION (% OF TOTAL MASS)			
	HEIGHT (CM)	TROCHANTERIC HEIGHT RATIO	ILIOSPINALE HEIGHT RATIO	HEAD	NECK	TRUNK	EXTREMITIES
REF. DATA	117.8-120.1	0.488	0.538	16.7	2.4	51.2	29.7
PIPER UNSCALED	114.3	0.459	0.532	16.1	1.5	49.9	32.5
PIPER SCALED	117.3	0.475	0.547	15.9	1.3	49.6	33.2

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Furthermore, the model meets the Euro NCAP positioning requirements as can be seen in Table II.
The mesh quality of the pedestrian version was compared to that of the occupant and proved similar.

TABLE II
PIPER MODEL POSTURE COMPARED TO ENCAP REQUIREMENTS

	LENGTH (MM)					ANGLE (°)							
	PX	*PY*	*ACZ*	*HCX*	*HCZ*	*K*	*M*	*G*	*H*	*T*	*U*	*V*	*W*
REF. VALUE	199	152	640	6.5	1117	89	106	164	175	98	70	140	160
TOLERANCE	5%	15%	2%	16%	1%	3°	5°	3°	5°	3°	3°	5°	10°
PIPER SCALED	204	152	630	6	1125	89	104	164	177	98	68	140	164

Figure 2 to 5 present the trajectories of HC, T12 and AC relative to the four generic car models impacts, all simulations ran until the termination time without numerical instability. The HIT was 50.5, 33.0, 54.3 and 47.0ms respectively for the FCR, SUV, RDS and MPV impacts.

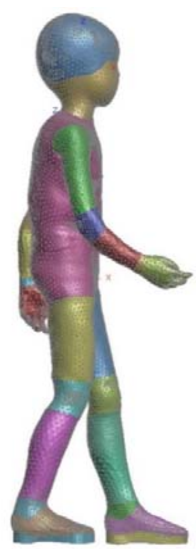

Fig. 1: Piper pedestrian model.

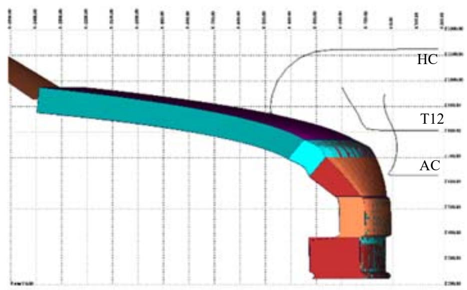

Fig. 2 FCR trajectories at 50km/h.

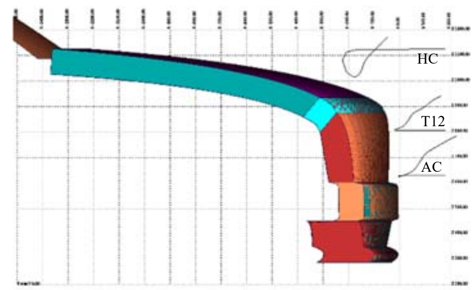

Fig. 3: SUV trajectories at 50km/h.

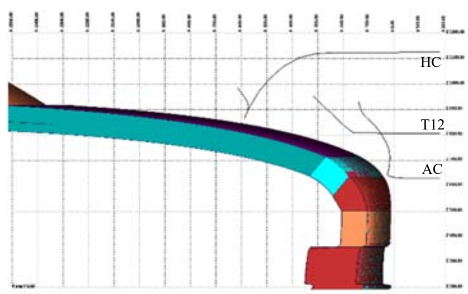

Fig. 4: RDS trajectories at 50km/h.

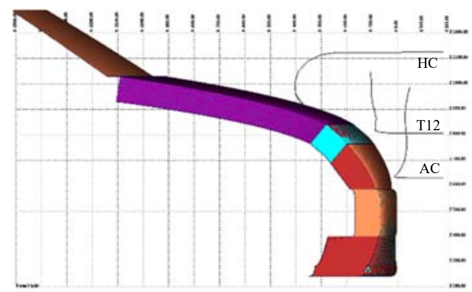

Fig. 5: MPV trajectories at 50km/h.

IV. DISCUSSION

In the present study a 6 year-old pedestrian child FE model under an open source license is presented. The model meets the requirements of the Euro NCAP protocol in terms of posture and proved numerically stable for impact at 50km/h against generic car models. To date, Euro NCAP has not defined specific requirements in terms of trajectory and HIT for 6 year-old children models. Comparison with commercially available 6 year-old child models would be necessary to develop these requirements. Additionally, a Pamcrash and an Abaqus version of this model are under development and will be released under open source license.

V. REFERENCES

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