UNIVERSITÀ DEGLI STUDI DI BERGAMO

INTERNATIONAL CAE CONFERENCE

FEM MODELLING OF PASSENGER SAFETY DEVICES IN AN ELECTRIC ULTRA-LIGHT VEHICLE

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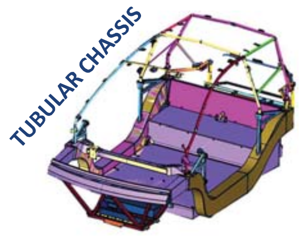
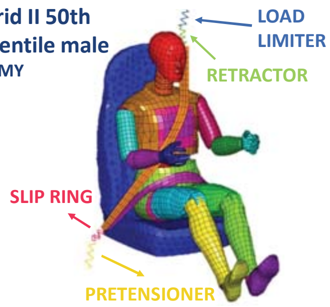
Nowadays electric and small vehicles are researched in order to decrease pollution and have smart mobility in our cities. Electric Ultra-Light vehicles (ULV) satisfy these requirements but their passenger safety performance is very low.

The possibility to **improve the passenger safety** of an ULV prototype derived from a heavy quadricycle is here investigated in case of frontal and side impacts.

An ODB (Offset-Deformable Barrier) and a SMB (Side Mobile Barrier) crash tests without any restraint systems were carried out in laboratory. The recorded data are the input of the explicit calculation adopted for the study.





SEAT BELTS

The retractor, the pretensioner, the load limiter and the pulley (belt sliding) are schematized by springs with specific property cards available in HyperCrash.

/PROP/TYPE32
/PROP/TYPE12
/PROP/TYPE4

AIRBAG – NITROGEN PROPERTIES

Volumetric viscosity	1.0 kg/(m·s)
Ratio of specific heats	1.4
Heat capacity at constant pressure	926000.0 J/(kg·K)
Temperature	780.0 K (constant)

- Uniform pressure in the airbag
- Ideal gas behavior
- Adiabatic conditions

DUMMY POSITIONING

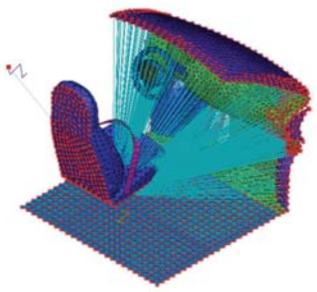
Before the simulation of the impacts, the dummy positioning phase is simulated by explicit calculation. A gravity load is applied.

400 ms

CABIN MODEL

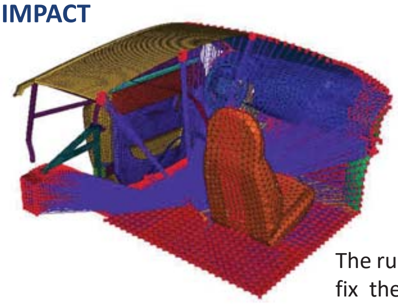
FRONTAL IMPACT

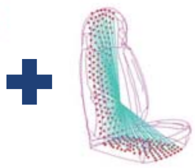
300 ms



The accelerations (in the three directions) registered during the crash test nearby the driver seat are imposed to the master node.

SIDE IMPACT

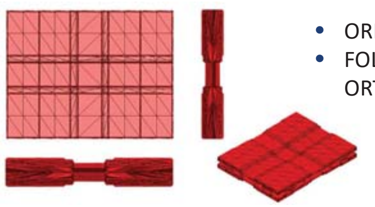




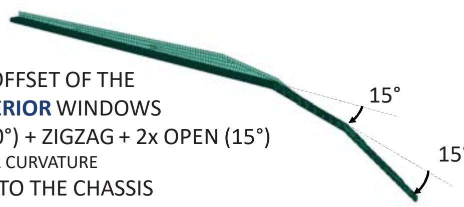
The rupture of the bolts which fix the driver seat occurs.

Only the transversal acceleration is imposed. The deformation of the door measured on the crashed vehicle is imposed.

FOLDED AIRBAG



- ORIGINAL SHAPE: CIRCULAR
- FOLDING: TUCK IN TWO ORTHOGONAL DIRECTIONS



- ORIGINAL SHAPE: OFFSET OF THE **ANTERIOR + POSTERIOR** WINDOWS
- FOLDING: OPEN (90°) + ZIGZAG + 2x OPEN (15°) REPRODUCING A-PILLAR CURVATURE
- PLACING: CLOSEST TO THE CHASSIS

RESULTS

Frontal impact:

	HIC	MAXIMUM ERROR	ΔM/M MASS SCALING	
NO DEVICES	6197.52	-24%	-	STOP*: 95 ms
ONLY AIRBAG	1182.08	-20%	2e-8%	STOP*: 100 ms
ONLY BELTS	9486.00	-45%	-	
▶ BOTH DEVICES	249.17	-14%	-	
NO PRETENS	344.45	-30%	1e-4%	

Side impact:

	HIC	MAXIMUM ERROR	ΔM/M MASS SCALING	
NO DEVICES	345.83	100%	1e160%	STOP*: 137 ms
ONLY AIRBAG	102.05	-10%	1e-2%	OTHER INJURIES
ONLY BELTS	804.84	-3%	6e-3%	CHEST INJURIES
▶ BOTH DEVICES	156.23	-10%	1e-2%	

* Stop simulation, after dummy positioning.

$$HIC_{36} = \max\left((t_2 - t_1)\left(\frac{1}{t_2 - t_1}\int_{t_1}^{t_2} a_R \, dt\right)^{2.5} \right) \qquad a_R = \frac{\sqrt{a_x^2 + a_y^2 + a_z^2}}{g} \qquad t_2 - t_1 = 36\text{ms}$$

LOWER PERFORMANCE $HIC < 1000$

HIGHER PERFORMANCE $HIC < 650$

CONCLUSIONS ▶ VERY HIGH PASSENGER SAFETY PERFORMANCE CAN BE ACHIEVABLE

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[4] *How air bag is made, How Products Are Made*, http://www.madehow.com/Volume-1/Air-Bag.html