« Development and evaluation of a new rider airbag safety system for thorax protection »

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Abstract : A study performed by INRETS, in 2007, describes injuries of motorized two-wheelers injured in a road crash between 1996 and 2003 and recorded by the Rhone Road Trauma Registry in France. Through this study, it seems than 50% of severely injured riders sustained severe chest injuries and 44.8% suffer from severe head injuries. The presented paper focuses on the use of the numerical simulation to predict rib fractures in case of motorcyclist accident and to evaluate a new safety system: an airbag integrated in a jacket. Different simulations, with and without airbag were performed to evaluate the influence of various parameters: impact velocities, variation of the impact zone, use of different types of impact (perpendicular and lateral position of the pendulum). The human model used is HUMOS model, developed and validated from the HUMOS European project.
For each configuration test, we analysed the load versus time curve of the pendulum and we measured the chest compression allowing the evaluation of ribs fractures. We used the AIS score to analyse the benefit of this new safety system.
The study showed that the airbag system increases the security of the motorcyclist. Indeed, for each simulations test, performed with airbag, no injuries were noted when the airbag was used, for impact speeds up to 40 km/h.
The next step of the study will consist in simulating real motorcyclist accidents based on accidentology approach. The aim will be to analyse the motorcyclist behaviour in case of direct impact on a car.

Motorcycle

< 1% of the traffic but 15 % of deaths

1981 (NHTSA, Los Angeles area), nearly 4,500 motorcyclist crashes analysed *[1]:*

- Injuries to the chest and head = the most deadly injuries
- No effective security systems to prevent or reduce the thorax injuries

2002, a study performed by Krauss confirmed this observation *[2]* :

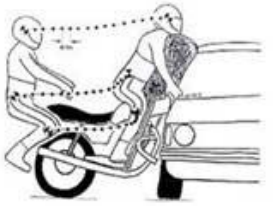
- Safety helmet allowed reducing severe head injuries
- But little safety system to reduce the severity of thoracic injuries

1996 -> 2003 (Rhone Road Trauma Registry in France) *[3]*:

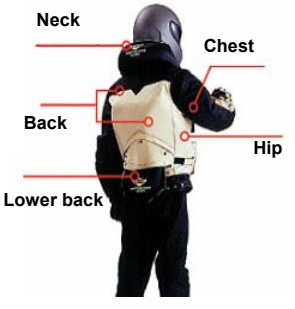
- 50% of severely injured riders due to severe chest injuries
- 44.8% suffer from severe head injuries

Study context

❑ Motocycle airbag
(source Honda)



❑ Airbag jacket
(source Helite)



Drawback :

- Trigger time
- Cable connection

Objectives :

- **Improving passive safety of motorcycles**
- **Evaluate new safety system**

Project ANR-Predit PROMOTO Introduction

Accidentology, Experimental (subsystem tests and crash tests) and numerical (Multibody and FEM) approaches

INRETS

- DD (Bron)
- LBA (Marseille)
- UMRESTTE (Bron)
- MA (Salon)

HOLDING TROPHY

API r&d

Plastex

Altair Development France

Innovation Intelligence

Development of the physical airbag

Numerical approach : FEM

ANR Agence Nationale de la Recherche

ADEME

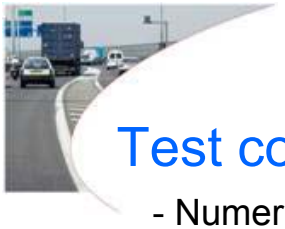
mecalog France

INRETS

API r&d

HOLDING TROPHY

PREDIT



Materials & Methods

Test configurations

- Numerical simulations performed with the HUMOS model (with and without airbag)
- HUMOS project : 50th percentile European Human Model (1998-2001)
- HUMOS model : local (subsystem tests) and global (sled tests) validation *[4-7]*

2 different configurations :

- **Configuration 1**
  - *Impact on the lower sternum*
  - *Impact speed : 12, 16, 19 km/h*
  - *Impactor: flat pendulum (mass 12kg) perpendicular / impact area*

- **Configuration 2**
  - *Impact on the upper sternum*
  - *Impact speed : 10, 20, 30, 40 km/h*
  - *Impactor : flat pendulum (mass 12kg) parallel / the impact area*

Analysis method

- Evaluation of the applied load
- Evaluation of the chest deflection
- Evaluation of the injury report based on the AIS *[8]*

with : AIS = -3.78 + 19.56 ***C*** ***C*** *= % chest compression*

Note : **Correspondence between AIS and rib fractures** ***[9]***

AIS 1: 1 rib fracture

AIS 2: 2-3 rib fractures

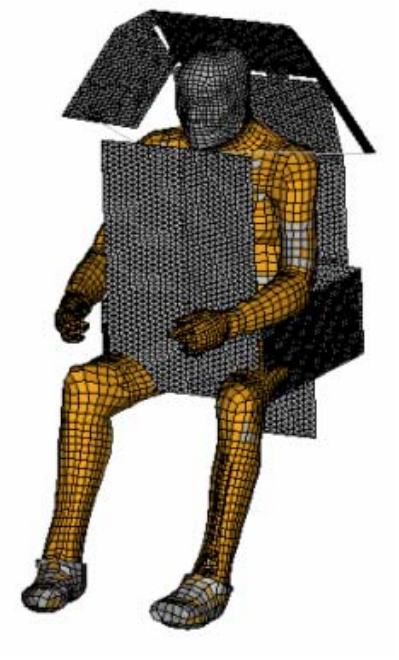
AIS 3: > 3 on one side =< 3 on the other side

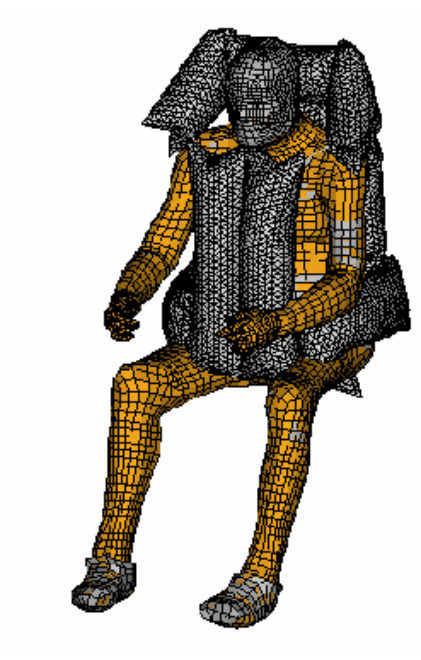
AIS 4: > 3 rib fractures on the both side, flail chest

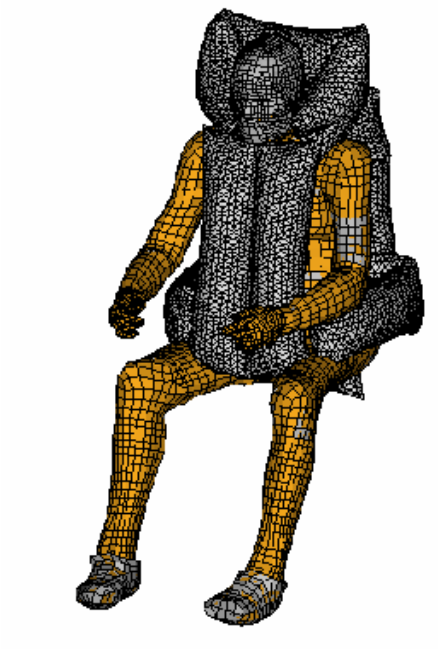
AIS 5: bilateral flail chest

Inflation of the airbag

Pressure Airbag = 1.4 bar



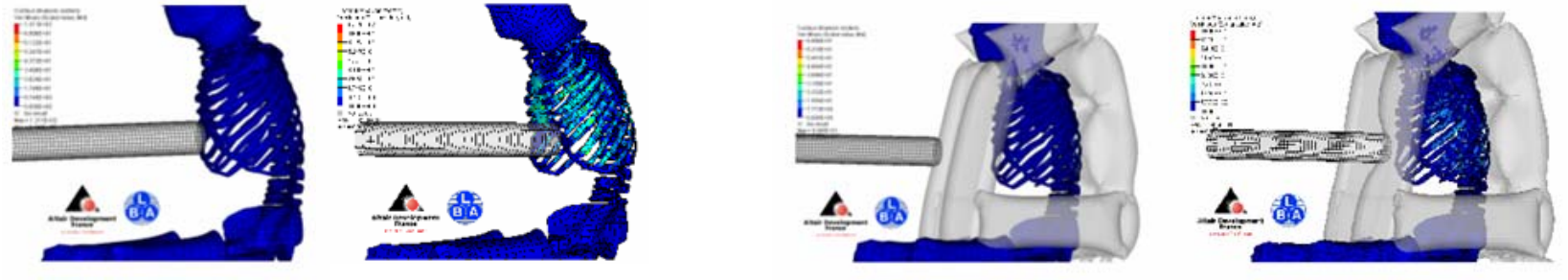




Results

- **Configuration 1**

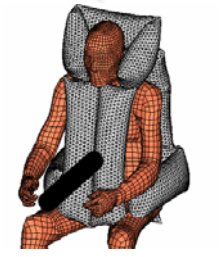
Kinematics Comparison



Rib stress comparison

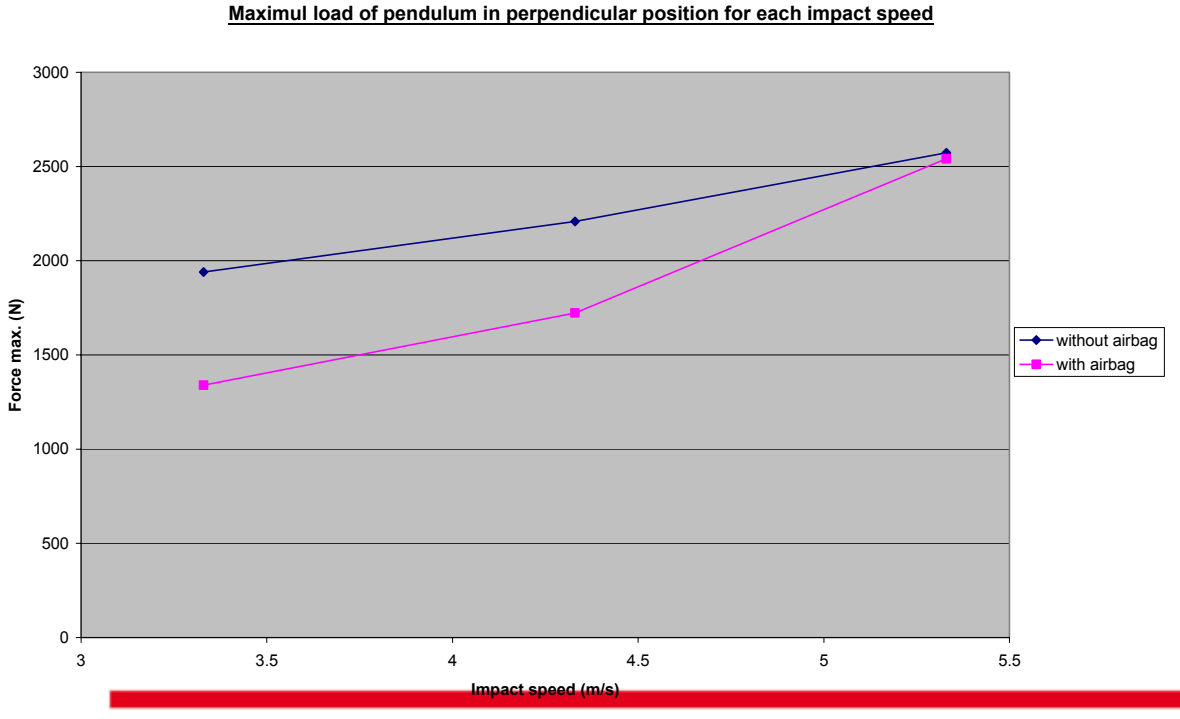
Results : Second step

- **Configuration 1**



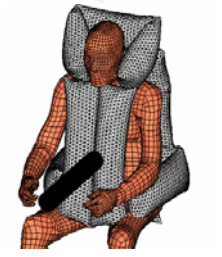
Comparison of maximum applied load, with and without airbag

- *F_{max} decrease of 32 and 21% respectively for V= 12 and 16 km/h, with airbag*
- *F_{max} decrease only of 1.5% V = 19 km/h, with airbag*



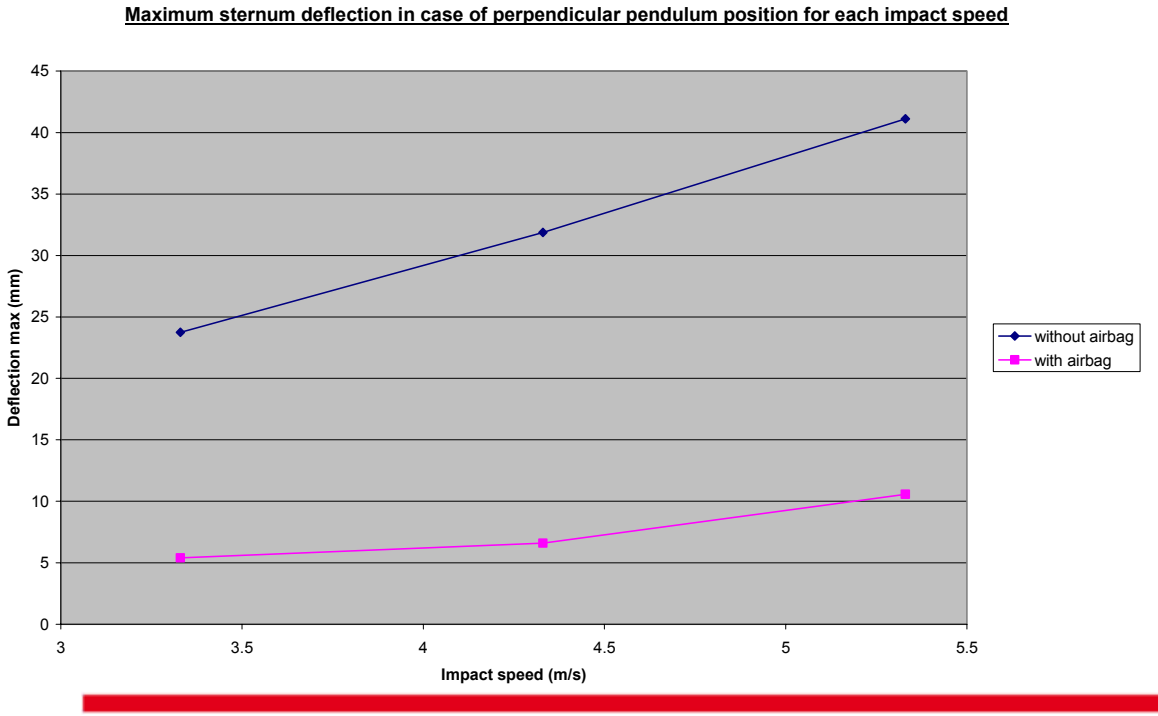
Results

- **Configuration 1**



Comparison of maximum chest deflection, with and without airbag

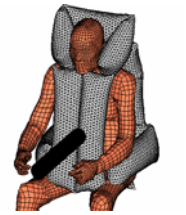
- *Strong decrease of chest deflection for the 3 impact speeds, with airbag*
- *At 19 km/h, 10 mm deflection with airbag against 40 mm, without airbag*



Results

• Configuration 1

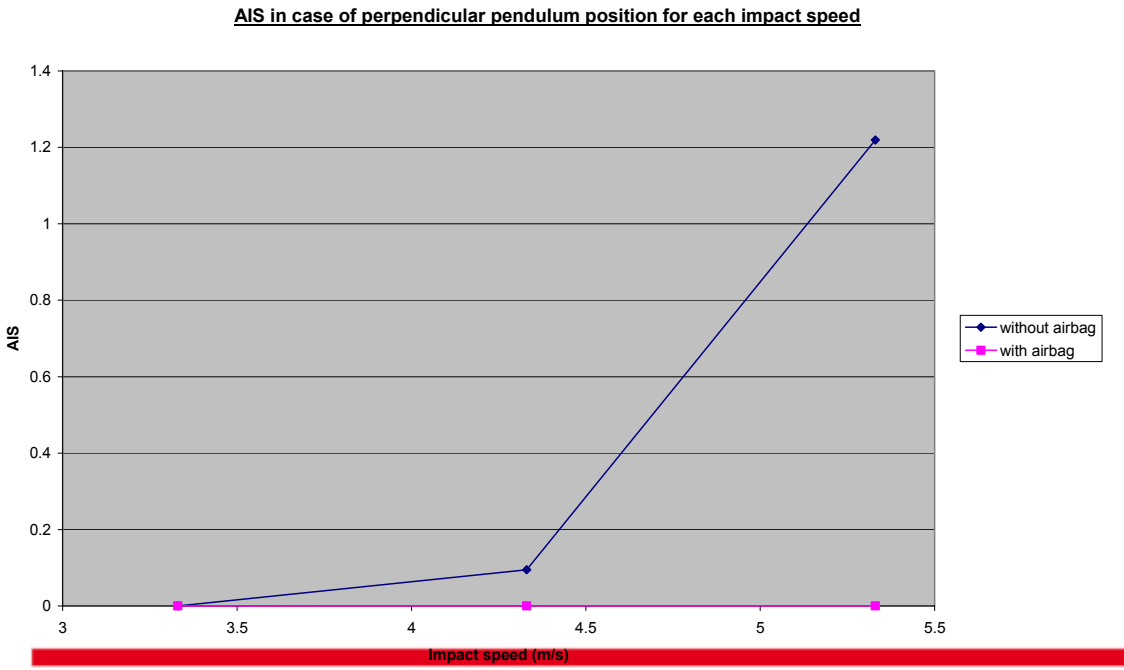
Comparison of injury assessment, with and without airbag



- *Same injury report with and without airbag for low impact speeds (<16 km/h) – AIS ~ 0*
- *Minor injury report at 19 km/h*

  AIS = 1.3 without airbag

  AIS = 0 with airbag

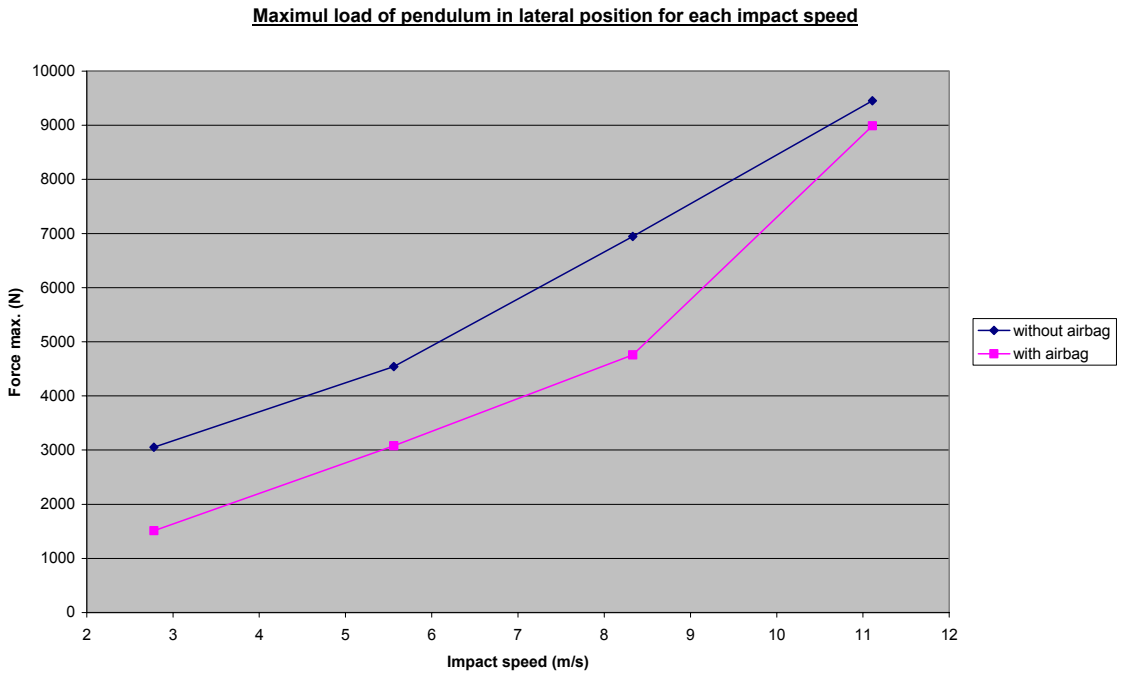


Results : Second step

- **Configuration 2**

Comparison of maximum applied load, with and without airbag

- *F_{max} decrease of 50, 32 and 21% respectively for V = 10, 20 and 30 km/h with airbag*
- *F_{max} decrease only of 5% for V = 40 km/h with airbag*



Results

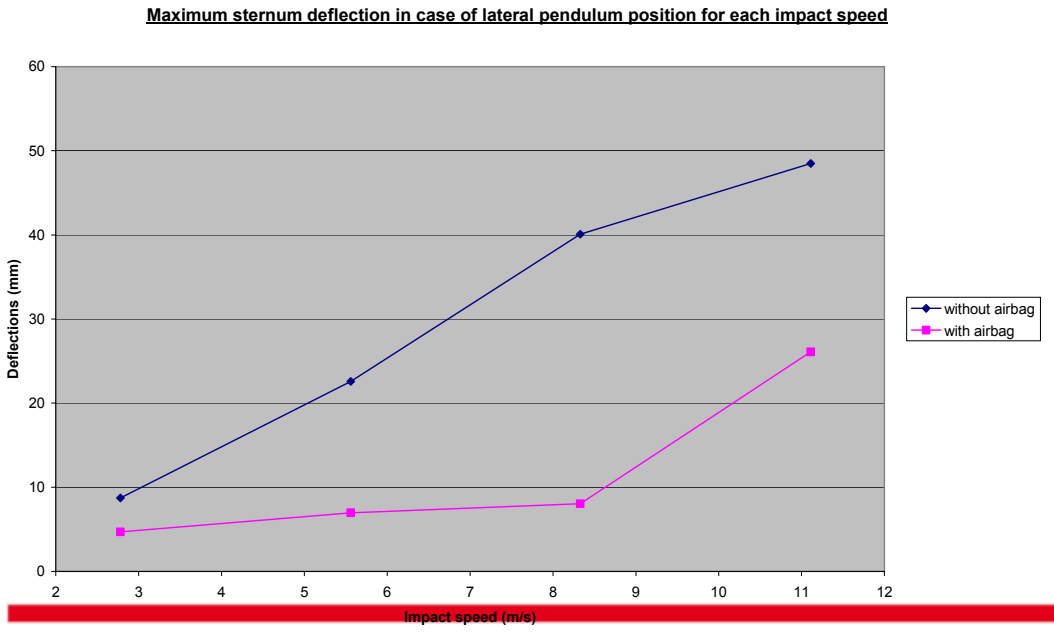
- **Configuration 2**

Comparison maximum of chest deflection, with and without airbag

- Strong decrease of chest deflection for impact speed between 10 to 30 km/h with airbag

- At 30 km/h, deflection close to 10 mm with airbag against 40 mm without airbag

- For test with airbag at 40 km/h, strong increase of the chest deflection (more than 300%) as compared to the test at 30 km/h



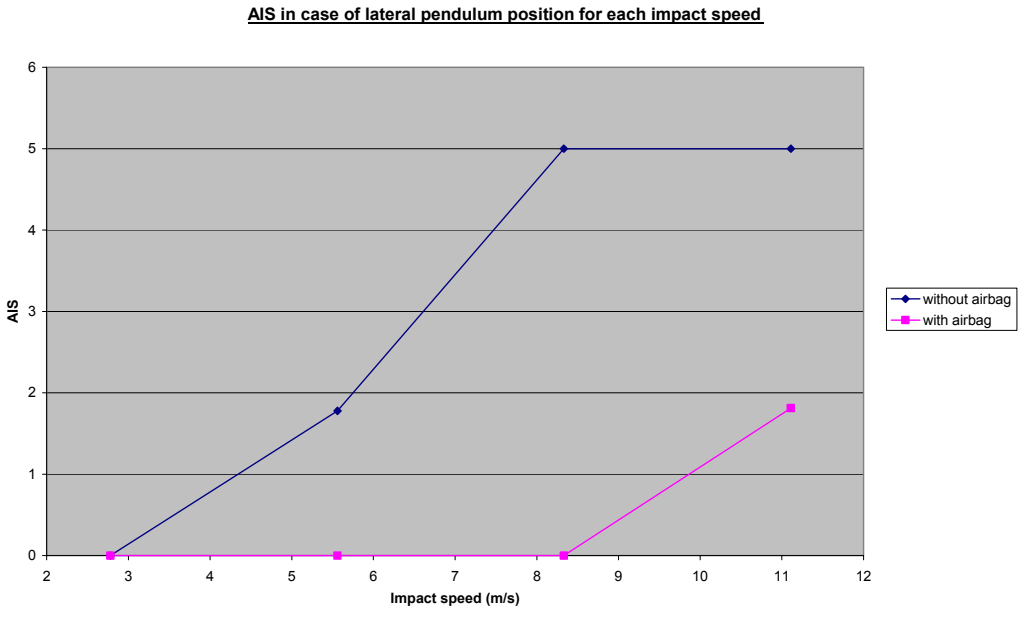
Results

- **Configuration 2**

Comparison of injury assessment, with and without airbag

- At 30 km/h without airbag, serious injury report (AIS = 5+) as compared to the test with airbag (no injury observed, AIS = 0)

- At 40 km/h with airbag, injury report not null (AIS = 1.8, one or two rib fractures) but largely decreased as compared to the test without airbag (AIS = 5+, bilateral flail chest)



Discussion : Second step

Configuration 1

- *Applied load strongly decrease with airbag (impact energy dissipated) until 16 km/h*
- *No injury was observed when the airbag was used*

Configuration 2

- *Applied load strongly decrease with airbag until 30 km/h (31%)*
- *At 40km/h the applied load with and without airbag are similar*
- *Chest deflection strongly decrease at 30 km/h (80%) and 40 km/h (47%) with airbag*
- *Chest deflection strongly decrease => Good injury assessment:*
  AIS = 0 up to 30 km/h and AIS < 2 in the case of impact at 40 km/h

Airbag fully plays its role

Notes : Impact speeds are in agreement with the ones estimated by Hurt [1981].
- Median pre-crash landing speed was estimated to 29.8 mph
- Median crash landing speed closed to 21.5mph (35 km/h).

Conclusion & Future Works

- The main objective was:

- To develop and evaluate the benefit of an integrated airbag jacket

- According to our results, we can note:

- Using the applied load on the chest as unique injury criterion raises strong limitations

- Benefit of the airbag for the biker (AIS = 0) seems significant

- Future works

- Perform other tests to extend the model validation

- Evaluate the airbag in a whole accident car/motorcyclist configuration

- Acknowledgments

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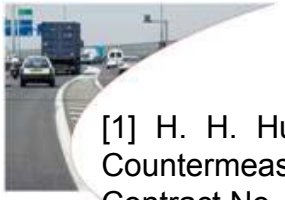

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