



## Occupant Modelling and 'Expecting', Computational Pregnant Women Model

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### Introduction

The development of crash test dummies in the form of physical or computational models has helped improving the safety of occupants in vehicles. Computational occupant models and computer aided simulation have become an important tool to investigate safety. Below evolution stages of automotive safety design and crash test dummies are examined together.

Recent improvements of computational pregnant women models and plans for its further improvements are explained.

### Occupant Models and Safety

Safety systems and devices prevented and reduced the severity of injuries in case of an accident in the past decades. Car manufacturers and research institutes have been working to improve the safety of cars through design for a long time. Experimental crash tests with ATDs (Anthropometric Test Devices) are used in crash tests since 1950. The computational modelling of occupant and its environment modelling has also offered a useful alternative to experimental methods to improve vehicle safety since 1970s.

Hybrid III	1976	1976	Injury criteria developed,
SID	1979		
P Series Child Dummies	1982	1982	Side impact tests and side beam installation, child airbag dummy
		1985	Airbags installed
CRABI	1991		
THOR, SID IIs, *Hybrid III 2D, 3D, *SID 3D	1994	1994	Side airbags introduced
*Hybrid III 5th 3D, *TNO P3	1996	1996	Active head restraint, side airbags for small occupants
RID, MAMA2B	2001	2001	Smart airbags and seat belts
		2002	Correct seat belt position for pregnant women
WorldSID, Q series, *MAMA 2B 3D	2003	2003	Frontal airbag sensors, extended and pretensioner seat belts,
*FEA Pregnant model	2006	2006	Passenger airbag cushion dual,
*'Expecting' pregnant model(LU)	2008	2008	Rear curtain airbags, head rest improved
Q10, SID IIs D	2009	2010	Seat belt for pregnant women designed (LU)

\*Computational Occupant Model

Chronological improvement of physical and computational Anthropometric Test Devices and automotive safety design

Especially, in the last decade, computational modelling has offered a greater level of anatomical detail and an improved biofidelic response over ATDs. For instance, the results from the series of 'Expecting', pregnant women simulation suggest that the use of a three-point seat belt with an airbag offers the greatest protection to the fetus for frontal crash impacts.

### Pregnant Occupant Models

- Early pregnant women models were developed in 2000-2006.

**A fetus was not included.**

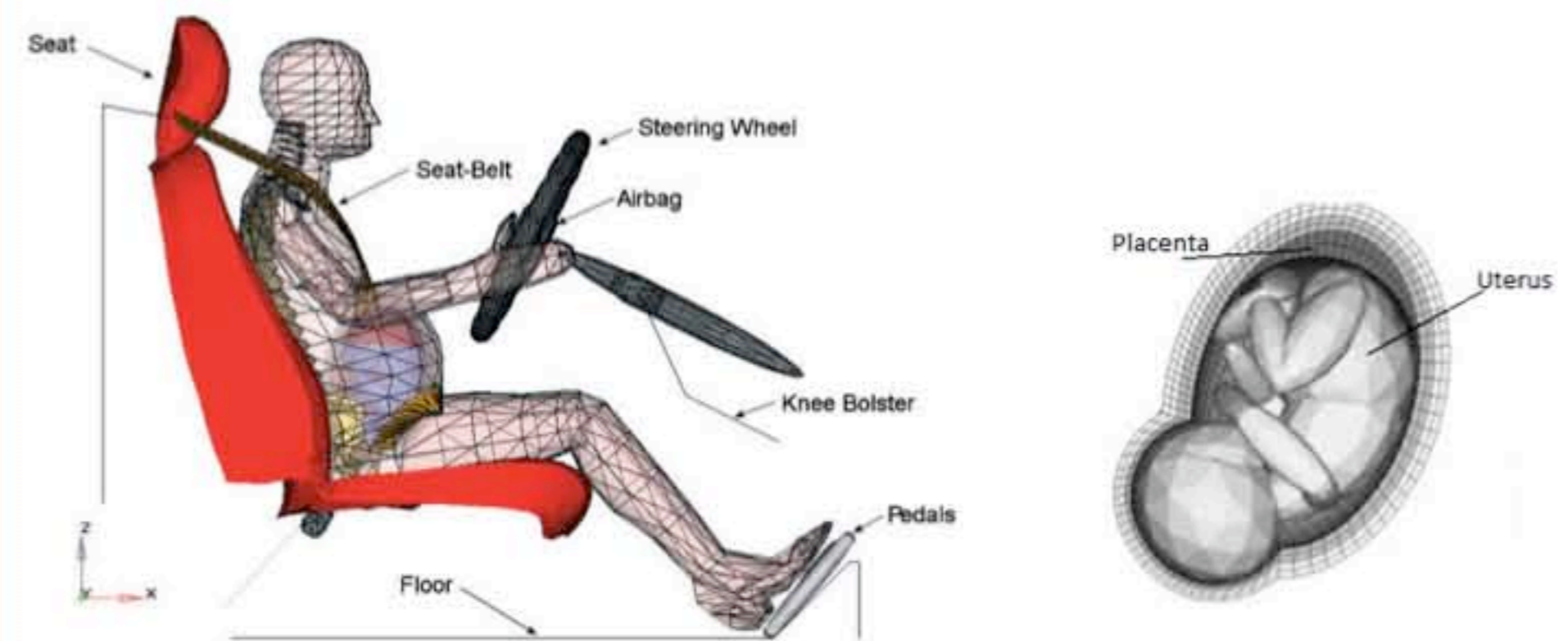
The significant solid mass of the fetus is an important factor for injury analysis.

- Earlier models represent a woman at around the 30<sup>th</sup> week of gestation in terms of abdominal size and shape.

**Most of the serious problems start after the 30<sup>th</sup> week.**

- Earlier anthropometric details of pregnant women were not defined correctly.

**Anthropometric changes in pregnant women are not limited to abdomen.**

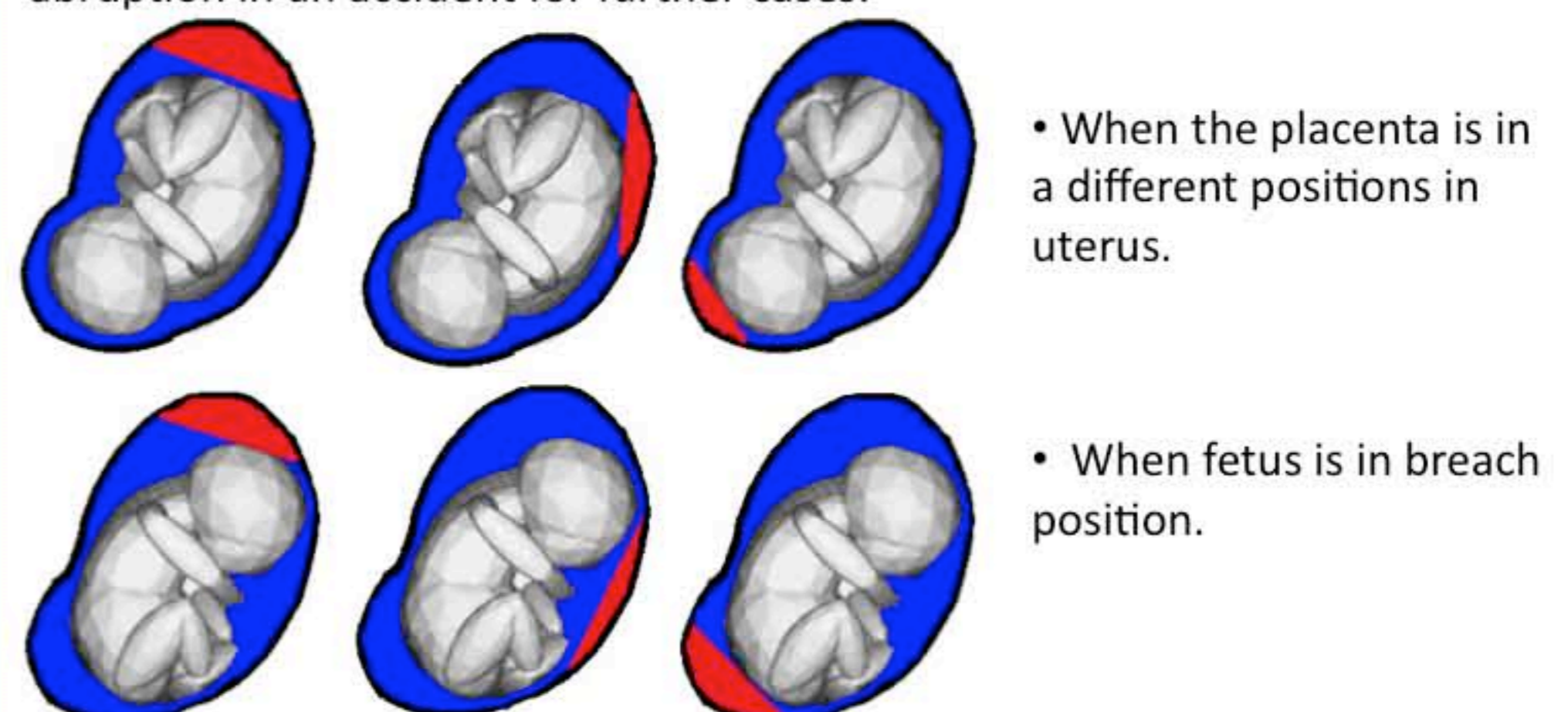


Pregnant occupant model and fetus, 'Expecting' simulation

- 'Expecting' is the first computational pregnant model realistically representing with a **multi-body fetus** within a finite element uterus capable of predicting the stresses and strains on the uterus and placenta. It is generated at Loughborough University.
- 'Expecting' model represents **the 38<sup>th</sup> week of gestation**.
- 'Expecting' is the first pregnant female model **based on the sitting anthropometric details** of pregnant women.

### Future Work

The uterus and placenta will be remodelled to incorporate recently available data into 'Expecting' and to investigate the risks of placental abruption in an accident for further cases:



- When the placenta is in a different positions in uterus.

- When fetus is in breach position.