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(34th GRSP, 8-12 December 2003,
Agenda item A.6.)

Status of Research Work of EEVC WG 15 „Compatibility Between Cars“

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34th Session of WP.29/GRSP Geneva, 8 - 12 December 2003

European Enhanced Vehicle-safety Committee
Working Group 15

Car Crash Compatibility and Frontal Impact

Terms of Reference
September 2003

Established in February 1996, the first phase of research (1996–2001) was aimed at gaining a better understanding of frontal impact crash compatibility between cars. In March 2002, the mandate was extended to September 2005. Following the merging of EEVC WG 16 (Advanced Frontal Impact Protection) with WG15 and the start of the ”VC COMPAT” project, the mandate was extended to November 2006.

Terms of Reference continued

The revised Terms of Reference are:

- Develop a test procedure to assess car frontal impact compatibility. Work will concentrate on car to car frontal compatibility whilst also considering the effects on other accidents such as impacts with the side of cars, trucks, pedestrians and roadside obstacles;
- Establish criteria to rate frontal impact compatibility;
- Identify potential benefits from improved frontal impact compatibility;
- Research will continue into the understanding of frontal impact protection, to help ensure that steps to improve frontal impact compatibility will also lead to improved front impact protection;
- Co-ordinate the EEVC contributions to the IHRA working group on Compatibility and Advanced Frontal Impact.

The Working Group will report its findings and will propose a test procedure in November 2006.

Main Topic at the moment:

Give advice to and guide the VC VOMPAT project commenced in March 2003 for a period of three years. The project is funded by the EU-Commission.

Objective of the VC COMPAT Project:

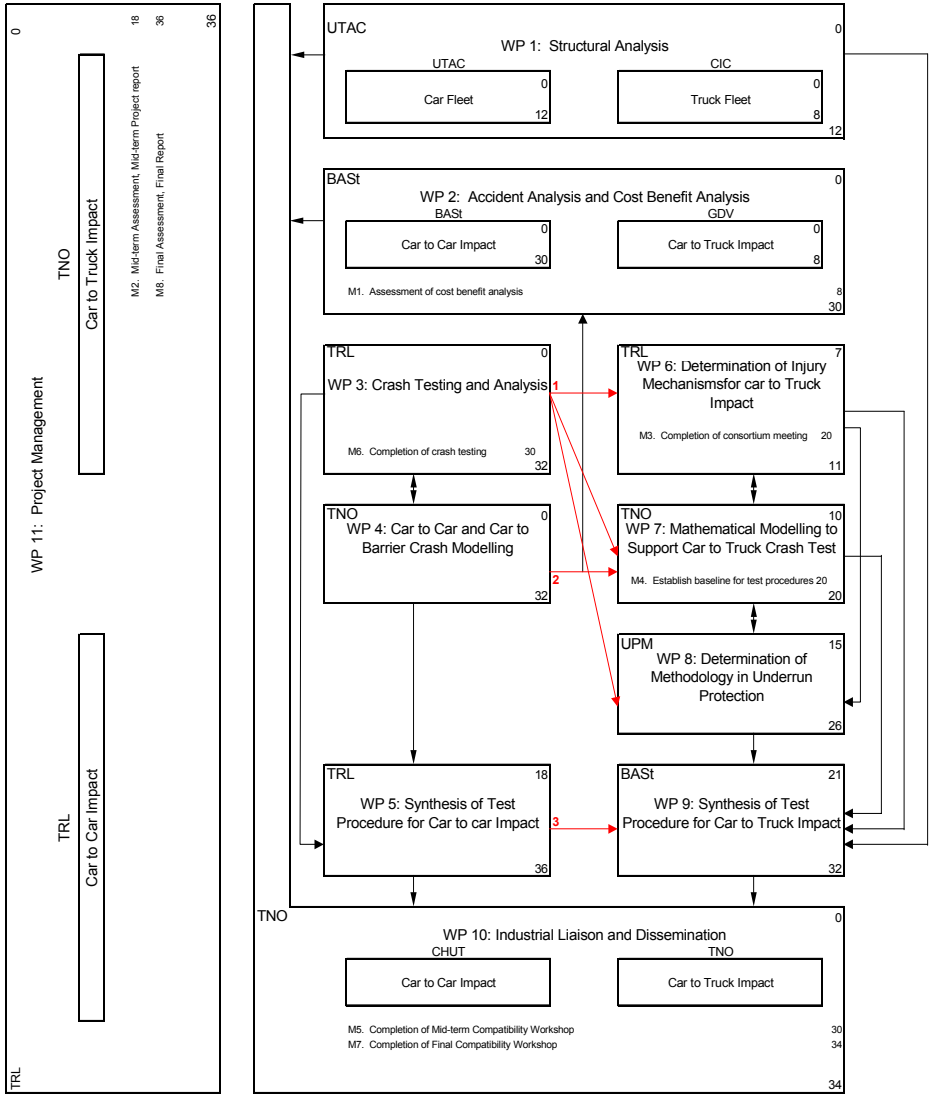
To draft legal test procedures to assess

- car to car crash compatibility
- (EEVC WG 14: car to truck crash compatibility)

Status November 2003:

- Structure Analysis (UTAC) due for March 2004
- Cost benefit study (BASt) due for November 2003
- Prepare test programme

EEVC WG 15, Compatibility Between Cars



VC COMPAT Workplan

EEVC WG 15, Compatibility Between Cars

EEVC COMPAT Workplan

WP 1: Structure Analysis - UTAC	
Car Fleet - UTAC	Truck Fleet - CIC

WP 2: Accident Analysis & Cost-Benefit Analysis - BASt	
Car to Car Impact - BASt	Car toTruck Impact - GDV

WP 3: Crash Testing & Analysis - TRL

WP 4: Car to Car & Car to Barrier Crash Modelling - TNO

WP 5: Synthesis of Test Procedure for Car to Car Impact - TRL

WP 10: Industrial Liaison and Dissemination - TNO	
Car to Car Impact - ChUT	Car toTruck Impact - TNO

WP 11: Project Management -TRL	
Car to Car Impact - TRL	Car toTruck Impact - TNO

Benefit

total number of occupants potentially beeing saved		Optimistic limit		Pessimistic limit		No. regarding all national fatalities (severe injured)	Percentage fraction of basic regarding main unit / %
		No	%	No	%	No	%
Fatal Occupants	Great Britain	***543***	***31,42%***	***343***	***19,85%***	***1728*** *(1728)*	***100%*** *(100%)*
	Germany	***1021***	***23,23%***	***606***	***13,79%***	***4396*** *(4396)*	***100%*** *(100%)*
Severely injured	Great Britain	***10504***	***52,36%***	***8130***	***40,53%***	***20061*** *(20061)*	***100%*** *(100%)*
	Germany	***36208***	***35,35%***	***22224***	***21,70%***	***102416*** *(102416)*	***100%*** *(100%)*

Next step: Estimation of target population on European level

Two test procedure candidates:

- **Full Width Test** with deformable face and high resolution load cell wall
- **Offset Deformable Barrier Test** with progressive deformable barrier and high resolution load cell wall.

Other Considered Test Procedures:

- EEVC frontal impact test and high resolution load cell wall
- Overload test
- Mobile deformable barrier to car (idea NHTSA).

Full Width Barrier With Deformable Element and Load Cell Wall

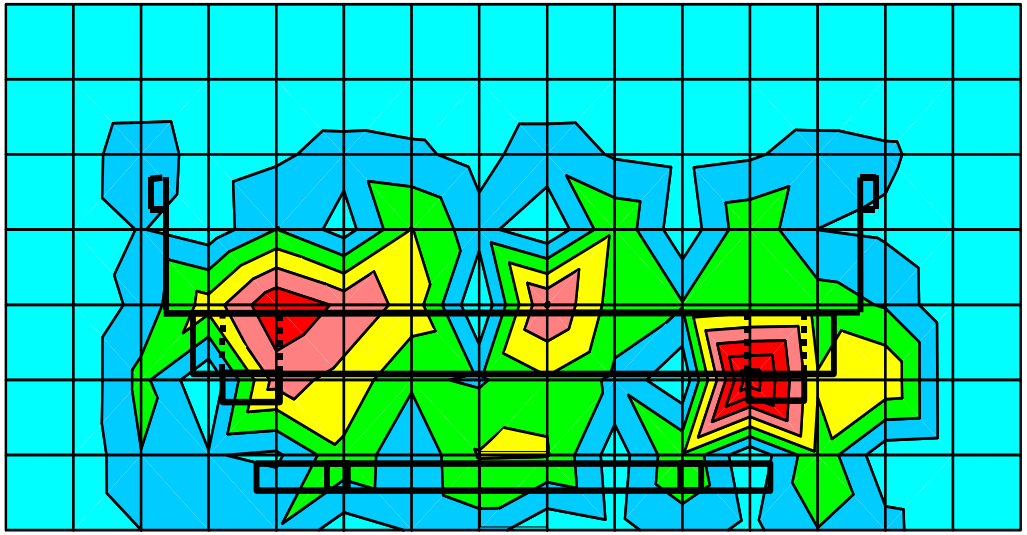
Full Width Test With Deformable Element

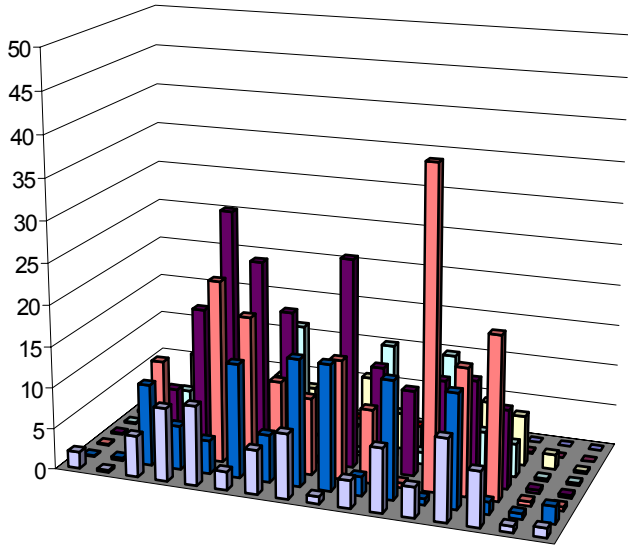
Pre and post test front view, Resultant barrier deformation

Full Width Test With Deformable Element

Maximum Force Distribution Behind Deformable Element

150mm 0.34MPa & 150mm 1.71MPa





Full Width Barrier Evaluation

HOMOGENITY ASSESSMENT

- Cell homogeneity
  - Overall force distribution
- Row homogeneity
  - Vertical force distribution
- Column homogeneity
  - Horizontal force distribution

Full Width Barrier Evaluation

CELL HOMOGENEITY

$$V_c = \frac{\sum_{i=1}^{n_C} (L - f_i)^2}{n_c}$$

V_c = Cell homogeneity assessment

L = Target load level

f = Peak cell force

n_c = Number of cells in the smoothed footprint

- Indicates the overall force distribution

Full Width Barrier Evaluation

ROW HOMOGENEITY

$$V_r = \frac{\sum_{j=1}^{n_r} \left[\frac{L.n_{cl} - \sum_{i=1}^{n_{cl}} f_{ij}}{n_{cl}} \right]^2}{n_r}$$

V_r = Row homogeneity assessment
L = Target load level
f = Peak cell force
n_c=number of columns in the smoothed footprint
n_r = number of rows in the smoothed footprint

- Indicates the vertical force distribution

Full Width Barrier Evaluation

COLUMN HOMOGENEITY

$$V_{cl} = \frac{\sum_{j=1}^{n_{cl}} \left[L.n_r - \sum_{i=1}^{n_r} f_{ij} \right]^2}{n_{cl}}$$

V_{cl} = Column homogeneity assessment

L = Target load level

f = Peak cell force

n_r = number of rows in the smoothed footprint

n_{cl} = number of columns in the smoothed footprint

- Indicates the horizontal force distribution

Full Width Barrier Evaluation

HOMOGENEITY ASSESSMENT MEASURE

$$V = a * V_c + b * V_r + c * V_{cl}$$

V = Homogeneity Assessment
a = cell weighting
V_c = Cell assessment
b = row weighting
V_r = Row assessment
c = column weighting
V_{cl} = Column assessment

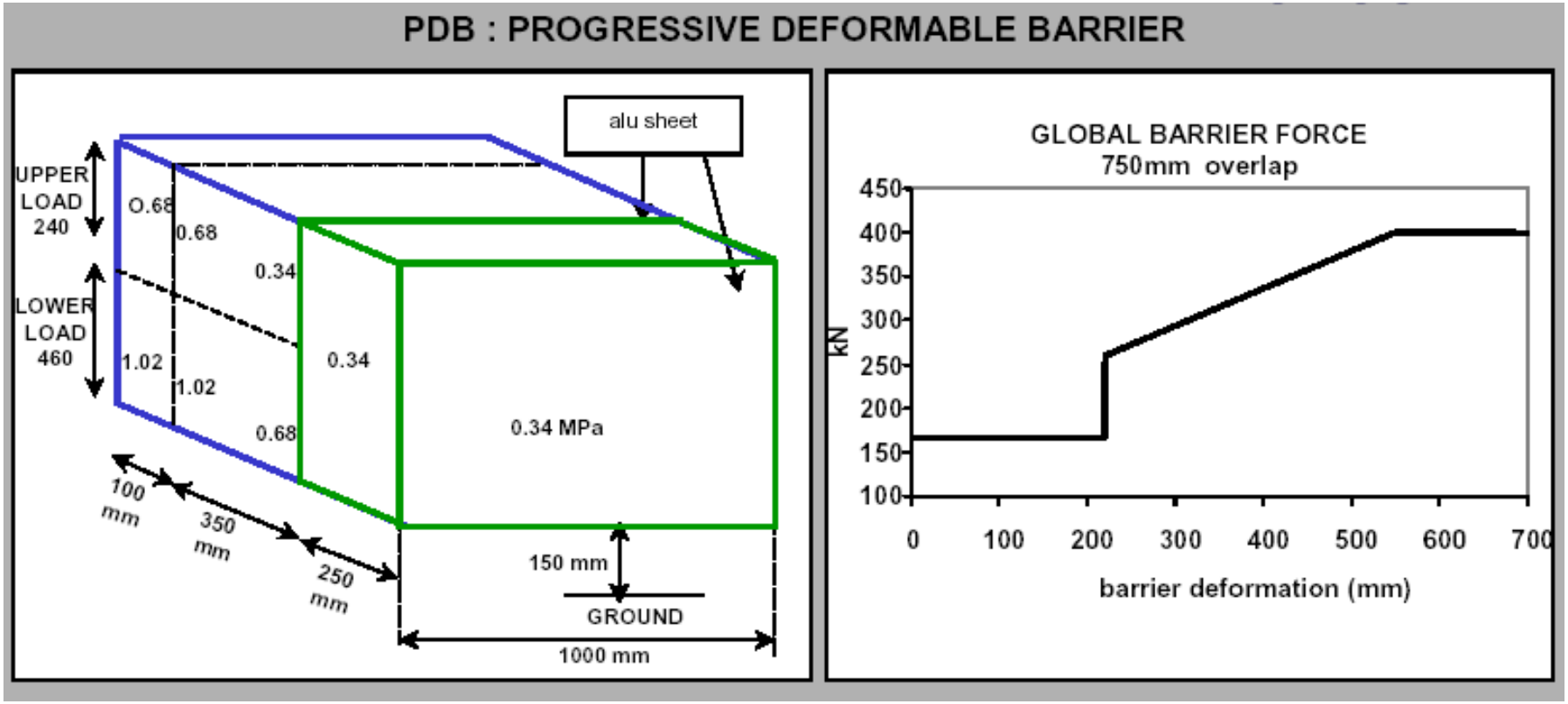
Development of Progressive Deformable Barrier (PDB)

OLD PDB V3

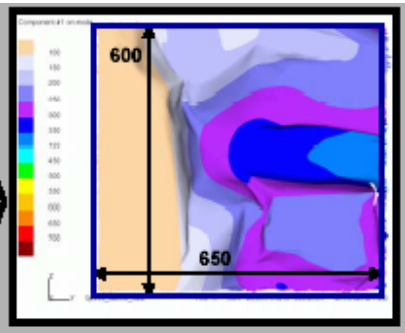
CURRENT PDB V7 (exists for 2 years)

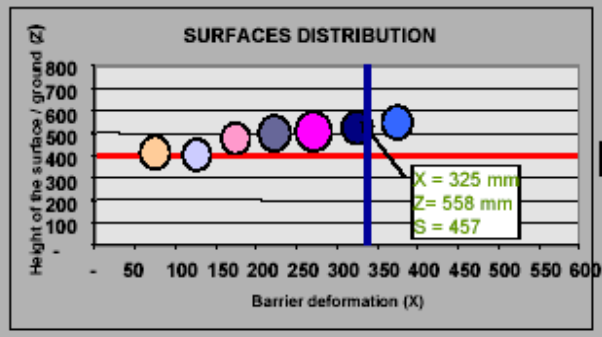
Stiffness and geometry never changed since the first developments (1997)

Dimensions and Global Stiffness of PDB



Homogeneity Assessment of the Progressive Deformable Barrier (PDB)





Z limit (Z lim)

X limit (X lim)

For each surface (Si) –color- :

Average height : Zi

Average deformation : Xi

$\sum (Zi / Zlim)4 * (Xi/Xlim)2 * Si$

AGRESSIVENESS SCALE

12

1

⇨Half an hour is needed to digitize the barrier

⇨Assessment is automatic and based on geometry and stiffness

Initial Test Matrix

No	Test Configuration	Vehicle	Partner to perform test	Current Status
1	**Full width**	**SMART**	**BASt**	**Complete**
2	**Full width**	**Honda CRV**	**TRL**	**Complete**
3	**Full width**	**Volvo XC90**	**CHUT**	**Test date TBD**
4	**Full Width**	**Mercedes E class**	**UTAC**	**Complete**
5	**PDB**	**Honda CRV**	**TRL**	**Complete**
6	**PDB**	**Volvo XC90**	**CHUT**	**Test date TBD**
7	**PDB**	**Mercedes E class**	**UTAC**	**Complete**

Possible Sets of Legal Frontal Impact Tests to Assess Compatibility:

Set 1:

- PDB Test Procedure replacing ECE R.94 (structure test) with barrier deformation analysis
- Maintain or/and improve restraint system tests

Set 2:

- Maintain ECE R. 94 (structure test)
- Full Width Barrier Test With Deformable Front Face (restraint test, additional airbag sensing).

EEVC WG15 – DOC 142b **Draft September 18, 2002**

List of:

Parameters to be Considered in Assessing Compatibility Test Procedure

Structural interaction

- ***Reproduction of frontal car to car accident structural loading***
- ***Show vertical force/deformation distribution of the car front***
- ***Show horizontal force/deformation distribution of the car front***
- ***Show time history of local forces/deformations***
- ***Potential to show strength of lateral connections between load paths***
- ***Potential to show strength of vertical connections of horizontal load paths.***

Parameters to be Considered in Assessing Compatibility Test Procedure (continued)

Frontal Unit Force

- ***Reproduction of collapse modes of load paths***
- ***Show time history of total forces***
- ***Potential to show optimum energy absorption of car front structures***
- **Compartment Strength to Maintain Compartment Integrity**
- ***Potential to measure compartment strength***
- ***Potential to evaluate compartment integrity.***

Parameters to be Considered in Assessing Compatibility Test Procedure (continued)

Other

- ***Simplicity of test procedure***
- ***Repeatability of test procedure***
- ***Reproducibility of test procedure***
- ***Potential to harmonise with existing legal test procedures for frontal impact.***
- ***Applicability to all vehicle types***
- ***Availability of objective assessment criteria.***

Conclusion:

Both favourite test procedures are under critical consideration and further development:

- PDB:
  - deformation assessment
  - assessment criteria
- Full width:
  - deformable element stiffness (desirable no penetration)
  - homogeneity criteria
  - definition of area to be assessed.