



# Development of Legislation on Frontal Impact Protection

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# Overview

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[http://ec.europa.eu/enterprise/automotive/projects/report\\_frontal\\_impact.pdf](http://ec.europa.eu/enterprise/automotive/projects/report_frontal_impact.pdf)

# Objectives

- Gather and evaluate all available information related to a potential update of Regulation 94
- Provide recommendations for potential update to Regulation 94, in particular those relevant to the review currently being performed by the GRSP informal working group on frontal impact

# Approach (1)

- Step 1:
  - Review existing legislation for frontal impact testing both within Europe and internationally
    - Consumer testing
  - Review existing accident analysis literature for Europe
  - Review dummies used in current legislative testing and those currently under development
  - Review proposed new and modified test procedures
    - Compatibility
  
- Step 2
  - Identify potential options to improve frontal impact legislation

# Approach (2)

- Step 3
  - Evaluate potential options and make recommendations for way forward
    - Needs identified in accident data
    - Potential for unintended consequences
    - Potential for further development to include compatibility measures
    - Relationship with present international requirements
    - Cost benefit

Note: Industry were consulted as part of this review

# Potential options to improve legislation (1)

- Main Options

- 1. No change
- 2. Replace the current R94 ODB test with a Progressive Deformable Barrier (PDB) test
- 3. Add a full width high deceleration test to the current R94 ODB test procedure
  - Rigid or deformable barrier?
- 4. Combination of options 2 and 3

# Potential options to improve legislation (2)

- Supplementary options

- Dummy related

- A. Incorporate the THOR-Lx, and possibly the THOR upper leg, as a retro-fit to the Hybrid III dummy

- Other

- B. Extend the scope of the Directive to include N1 vehicles, in particular those less than 2.5 tonnes, and all M1 vehicles
- C. Add a steering wheel movement lateral displacement limit of 100 mm to current vertical and horizontal limits
- D. Add an appropriate footwell intrusion criterion and associated limit
- E. Assess rear seated positions

Note: Other minor supplementary options include:

- Front seat position – longitudinal adjustment
- Hybrid III dummy – neck shield

# Evaluation of potential options

- Whether the option will address the needs identified in the accident studies
- Potential for unintended consequences
- Potential for further development to include measures to assess and control compatibility
- Relationship with present international requirements
- Cost-benefit
- Issues that require further investigation to ensure suitability for regulatory application

Note: Industry consulted as part of evaluation

# Main option 1: No change

- Needs identified from accidents
  - Will not address full width overlap principle accident type
  - Will not fully address deceleration related restraint induced injuries
- Potential for unintended consequences
  - Encouragement of frontal force mis-match between light and heavy vehicles which is detrimental for compatibility
- Potential for compatibility measures
  - Low; some potential to measure frontal force levels
- Relationship with current international requirements
  - Good; already virtually a defacto worldwide test procedure
- Cost benefit
  - In short term benefits will continue to be accrued as vehicle fleet is updated to remove non-regulatory compliant vehicles and more cars achieve high Euro NCAP star ratings
- Industry response
  - Majority of manufacturers supported this option
- Issues
  - Frontal force levels
    - Mismatch between light / heavy cars - monitor in Reg and / or EuroNCAP tests
    - Possible dis-beneficial effect in side impact

## Main option 2: Replace ODB with PDB

- Needs identified from accidents
  - Will not address full width overlap principle accident type
  - Will not fully address deceleration related restraint induced injuries
  - Help improve replication of loading experienced in car to car impacts
- Potential for unintended consequences
  - High energy absorption capability of PDB could permit design of vehicles with a reduced front end crumple zone and in theory rigid vehicles
    - Illustrated by series of ODB and PDB tests performed by BAST



Note: Introduction of full width test in parallel with PDB would at least limit potential unintended consequence

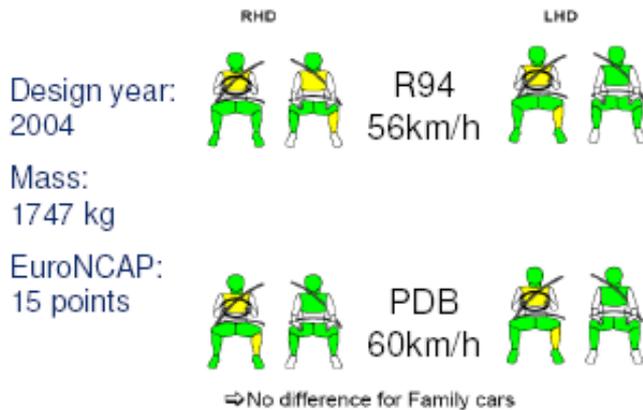
## Main option 2: Replace ODB with PDB

- Potential for compatibility measures
  - High; candidate parameters proposed for structural interaction and frontal force levels aspects of compatibility
- Relationship with current international requirements
  - Poor; to maintain current relationship necessary for consumer test programmes and other approval bodies that use ODB to also switch to PDB
- Cost benefit
  - PDB aims to equalise test severity for light and heavy vehicles and hence improve some aspects of compatibility
    - Substantial benefit estimated for improved compatibility by VC-COMPAT project (700 – 1300 fatalities in EU15) but what fraction of this PDB could deliver is unknown
      - Currently benefit analysis is being performed by France as part of GRSP frontal impact informal working group activities; report scheduled Dec 2009
    - PDB may deliver no benefit
      - French and Japanese test data shows little/no difference in dummy injury criteria for ODB and PDB tests with modern design cars. Note: dummy injury criteria below Regulatory performance limits
      - Regulatory change must enforce changes to vehicle design to deliver guaranteed benefit

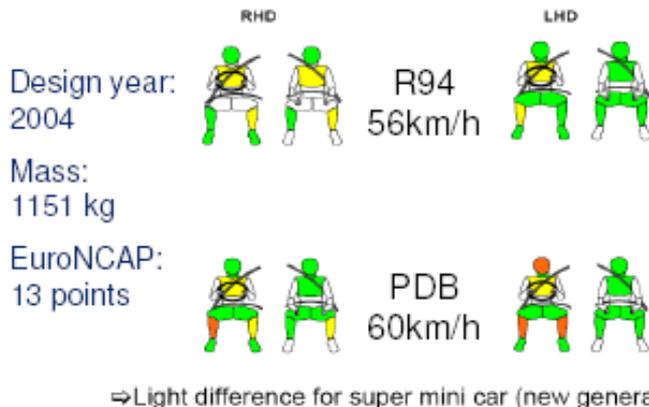
# Main option 2: Replace ODB with PDB

- Cost benefit (continued)

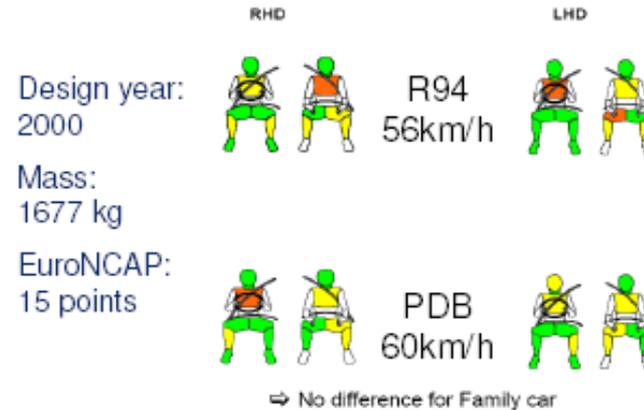
## 2- SELF PROTECTION: Dummies FC1



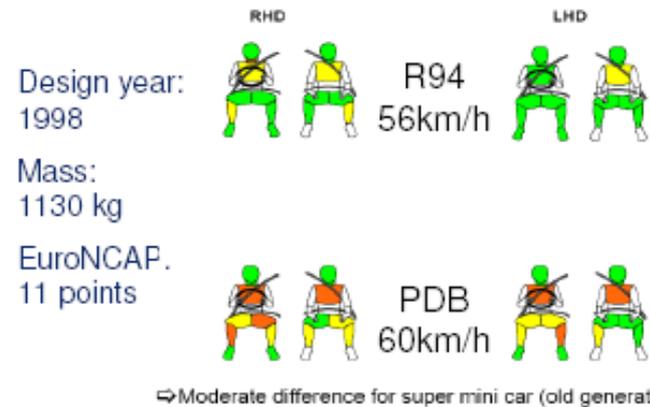
## 2- SELF PROTECTION: Dummies SMC1



## 2- SELF PROTECTION: Dummies FC2



## 2- SELF PROTECTION: Dummies SMC 2



# Main option 2: Replace ODB with PDB

- Industry response
  - Majority of manufacturers (9 from 11) did not support
    - No evidence that it would result in any benefit
    - Potential unintended consequence that could allow design of unsafe cars with insufficient energy absorption capability
  - Two manufacturers did support
    - Resolves problems with current R94 barrier, in particular equalises test severity
- Issues
  - More accurate assessment of benefits and costs
  - Further investigation to assess the risk of the potential unintended consequence
  - Other
    - Confirmation that self protection levels will be at least maintained, that test severity will be equalised and PDB stiffness is appropriate for future vehicles
    - Confirmation of repeatability and reproducibility of test

# Main option 3: Add a full width test

- Needs identified from accidents
  - Will address full width overlap principle accident type and deceleration related restraint induced injuries
  - Note: improved dummy required for assessment of advanced restraint systems and thorax injury
- Potential for unintended consequences
  - None; already used in many parts of world
- Potential for compatibility measures
  - Rigid face
    - Medium; metrics to control a vehicle's stiffness and geometry under development
  - Deformable face
    - High; candidate metrics proposed for structural interaction aspect of compatibility
- Relationship with current international requirements
  - Good; would aid harmonisation as full width test already used in many parts of world
    - Rigid face better for harmonisation than deformable
    - Test speed; 56 km/h would harmonise with USA, 50km/h with countries such as Canada and Japan

# Main option 3: Add a full width test

- Cost benefit

- Benefit

- APROSYS project estimated substantial potential benefit based on assumption that full width would improve restraint systems which in turn would reduce restraint induced injury
  - 3% of car occupant fatalities and 6% of serious injuries; equivalent to 430 fatalities and 6,017 serious injuries in EU15 countries; monetary value approx €2,000 million

- Costs

- To meet R94 equivalent limits €455 million

- Cost benefit ratio

- Assuming R94 limits will deliver potential benefit cost benefit ratio is 1:4
- However, more stringent limits and other measures probably needed
  - Adaptive restraint systems
  - Improved dummy for assessment of restraint induced injury, in particular the thorax

# Main option 3: Add a full width test

- Industry response
  - Majority of manufacturers supported with proviso that benefit could be shown clearly in regulatory impact assessment
    - 50 km/h test speed preferred for harmonisation
- Rigid or deformable barrier face
  - Rigid
    - Better for harmonisation
  - Deformable
    - More realistic assessment of vehicle's crash sensing capability
    - Better for assessment of compatibility
  - Recommended to use rigid face in short term as deformable face could be added later for compatibility purposes if needed
- Issues
  - Determination of appropriate performance criteria and limits
  - Update of cost benefit analysis

## Main option 4: Combination of options 2 & 3

- Effectively summation of component options with additional advantage that the full width test will at least limit and possibly resolve the potential unintended consequence with the PDB test
  - High energy absorption capability of PDB could permit design of unsafe vehicles with insufficient front-end energy absorption capability
- Full width test would limit stiffness of vehicles because it would not be possible to design a restraint system to provide adequate occupant protection for the compartment deceleration pulse produced by excessively stiff vehicles

# Supplementary options: dummy related

- Lower extremity
  - Replace Hybrid III lower legs with THOR-Lx (THOR-Lx/HIIIr)
  - Likely to be cost beneficial
    - Large frequency and impairment costs of lower extremity injuries
  - Not ready for regulatory application
    - Test procedure details need to be written
      - How to position dummy foot to make representative assessment of protection
    - Robustness, repeatability, reproducibility
    - Cost benefit
- Upper leg
  - Replace Hybrid III upper leg with THOR upper leg
  - Likely to be cost beneficial
  - Not ready for regulatory application
    - Injury risk functions
    - Robustness, repeatability, reproducibility
    - Cost benefit

Note: In principle this option was supported by manufacturers although noted that not ready for regulatory application yet

## Supplementary options: other

- Extension of scope (N1 and M1 up to 3.5 t)
  - Evidence of significant benefit to include N1 (Light Commercial Vehicles) in terms of self protection
  - Concern that inclusion of N1 vehicles may make them more aggressive and cause compatibility (partner protection) problems
  - Extend scope after measures to control compatibility are introduced
- Steering wheel lateral (Y) movement ( $< 100$  mm)
  - Provide stable platform for airbag deployment
  - Already included in Euro NCAP assessment
  - Benefits likely to be low
- Footwell intrusion
  - No criterion under development currently
  - Lower extremity injuries occur without significant footwell intrusion
    - Hence dummy based assessment method should be able to provide greater benefit assuming appropriate tool and assessment principle can be found

## Supplementary options: other

- Assessment of rear seat positions
  - Accident analysis indicated problem with low seat belt wearing rate in rear
  - Unlikely to have benefit to cost ratio  $> 1$  because of low occupancy rate
  - Shown that risk of injury higher for rear seat occupants compared to front seat occupants for elderly
    - Testing of rear seat position could be deemed necessary to ensure equivalent protection in all seating positions
  - Shown to be feasible to assess rear seat occupant protection without affecting assessment of front seat position in full width test
  - If included effect on child restraints and pelvis anthropometry and sensitivity to submarining of Hybrid III dummy should be considered

# Conclusions and recommendations

- In EU25 about 41,000 road accident fatalities per year of which about 10,000 occur in car frontal impacts
  - Indicates much potential to improve Reg 94 further
- Over past 10 years number of road accident fatalities has decreased year on year
  - Strong evidence to suggest that Reg 94 has contributed to this
- Potential options to improve Reg 94 identified and evaluated
  - Main options
    1. No change
    2. Replace current ODB test with PDB test
    3. Add full width test
    4. Combination of 2 & 3
  - Supplementary options
    - Dummy related: retro-fit THOR-Lx and possibly THOR upper leg to Hybrid III dummy
    - Other: extension of scope, steering wheel movement criterion, footwell intrusion criterion, assessment of rear seat position

# Conclusions and recommendations

- No main option currently ready for regulatory application without much further work, in particular to assess cost benefit implications
  - Benefit analysis is currently being performed by France for option 2
- However, option 3, 'add full width test' shows most promise
  - Large potential benefit
  - In general supported by manufacturers
- Review of literature highlighted lack of accident data available to review frontal impact situation in Europe - last comprehensive European analysis performed over 10 years ago
- Recommend European accident analysis performed to help set priorities for improvements to Regulation 94
  - Identify number of casualties in accident configurations not covered by Regulation 94 test procedure
    - Will provide initial approximation of target population size for potential changes, which is first step of benefit analysis
  - Compare performance of vehicles in crashes similar to Reg 94 test
    - Will help to identify any weaknesses in current test



# **Do You Have Any Questions?**