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# Prerequisites for Testing of Deployable Bonnets Systems in deployed State

**2<sup>nd</sup> Meeting of Task Force Deployable Pedestrian protection Systems (TF-DPPS)  
Paris, March 28<sup>th</sup> & 29<sup>th</sup>, 2017**

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# Background



- **At the 1st meeting of the Task Force on Deployable Pedestrian Protection Systems (TF-DPPS) BAST has given an overview of Euro NCAP prerequisites for testing of deployable bonnet systems in the deployed or deploying state (see document „ 2017.01.31 - Testing DBS within Euro NCAP”).**
- **At the same meeting, BAST has introduced a proposal for a maximum bonnet deflection due to pedestrian body loading (see document „ 2017.01.31 - Bonnet Deflection of DB Systems“).**
- **[Members of] OICA rejected the proposal to be design restrictive and to penalize active bonnets compared to passive bonnets. (see document „Pedestrian Safety: Deflection of Bonnets in Active Pedestrian Protection Systems”).**
- **The objections from [members of] OICA were answered by BAST within a separate document (see document „Comments on OICA Presentation: Pedestrian Safety: Deflection of Bonnets in Active Pedestrian Protection Systems). Besides, BAST is addressing this concern, introducing modified prerequisites for active bonnets being tested in the deployed position.**
- **This document gives on overview of these prerequisites for active bonnets being tested in the deployed state as proposed by BAST to be implemented within GTR9.**

# General



- When involved in real world vehicle to pedestrian accidents, vehicles equipped with deployable bonnet systems need to actually provide the protection potential as suggested within pedestrian component testing (TA or self certification)
- Therefore, for impact locations being tested with the bonnet in the deployed state, the following five prerequisites have to be met:
  - **Criterion #1: Pedestrian detection (HTD)**
  - **Criterion #2: Protection at speeds below the deployment threshold of the bonnet**
  - **Criterion #3: Protection at higher impact speeds, i.e. speeds beyond the vehicle speed corresponding to impactor velocities of 35 km/h (assumption: 40 km/h)**
  - **Criterion #4: Correct timing of the bonnet deployment (HIT > TRT)**
  - **Criterion #5: Actual bonnet protection level subsequent to pedestrian body loading**

# Criterion #1: Pedestrian detection



Given that the whole range of pedestrians is affected by an appropriate functionality of deployable bonnet systems, it is required that all pedestrians are detected by the sensing systems of the deployable bonnet systems.

This functionality needs to be checked with tests using a surrogate representing the hardest to detect (HTD) pedestrian.

If the pedestrian detection requirement is met, all headform tests are to be performed in the deployed state of the bonnet (provided that criteria 2-5 are met, too).

# Criterion #1: Pedestrian detection

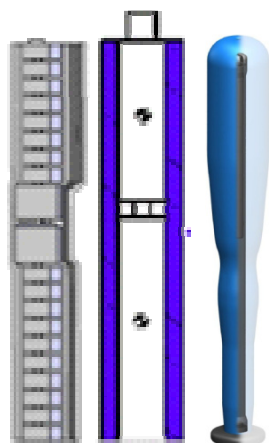


- **Default test tool for giving evidence for the system to detect the hardest to detect pedestrian (HTD): PDI2**
- **In case of using the PDI2, no CAE data for justifying the HTD is needed.**
- **In case of abstaining from the use of PDI2 as representative for the HTD, the vehicle manufacturer needs to demonstrate with an alternative tool the sensor system's ability to detect a range of pedestrian statures (6YO, 5th, 50th, 95th) resulting in head contacts with the vehicle. However, a combination of physical testing and simulations is still needed for the demonstration of the suitability of the sensor system for the range of pedestrian sizes:**
  - **Simulations (minimum two per stature) at vehicle centreline and end of bumper test zone to identify the HTD pedestrian and to support the use of an alternative test tool**
  - **Minimum output parameters: bumper force, effective mass, energy, bumper intrusion, acceleration (if used as trigger)**

# Criterion #1: Pedestrian detection



- Physical testing is to be used for assessing the capability of the sensing system.
- Besides PDI2, a surrogate for the „upper limit“ pedestrian will be used.
- At least the PDI2 (HTD) test farthest from the sensor is to be witnessed by the TA authority.
- Minimum output parameters: HS film, documentation of test location and test speed, actuator trigger time, evidence of initiation of the system deployment.
- Test matrix:



Source:  
GTR9

Source:  
Otubushin  
& Pauer, 2012

Test	Impactor	Impact point	Speed	Output
1	PDI2/HTD <sup>1</sup>	<ul style="list-style-type: none"> <li>• Directly on localised sensor e.g. accelerometer +/- 50mm. If the sensing system uses a combination of contact strip switches and localised accelerometers, the positions of the accelerometers should be used to define the impact locations.</li> <li>• For non-localised sensor systems, such as contact switches, test the vehicle centreline.</li> </ul>	LT <sup>2</sup> +/-2km/h	<ul style="list-style-type: none"> <li>• High speed film</li> <li>• Actuator trigger time</li> <li>• Initiation of deployment</li> </ul>
2	PDI2/HTD	Bumper test zone end, left or right hand side, +/- 50mm.	LT +/-2km/h	<ul style="list-style-type: none"> <li>• High speed film</li> <li>• Actuator trigger time</li> <li>• Initiation of deployment</li> </ul>
3	PDI2/HTD	Farthest from sensor(s) if not tested already, +/- 50mm.	LT +/-2km/h	
4 <sup>3</sup>	GTR9 detailed in Section 6.3.1.1 of Part B or FlexPLI to account for larger/heavier pedestrian	Directly on localised sensor e.g. accelerometer, +/- 50mm. For non-localised sensor systems test directly in line with the front longitudinal member to produce the highest acceleration levels on the impactor. This test may be performed using a representative surrogate with equivalent mass and stiffness to prevent damage to instrumentation.	40km/h +/-2km/h	

Notes:

1. HTD = Other appropriate hardest to detect (as defined by section 2.2.2);
2. LT = Lower deployment Threshold.
3. The impactor for test 4 may be chosen by the vehicle manufacturer.

Source:  
Euro NCAP  
Pedestrian Testing Protocol

## Criterion #2: Low speed protection



Since passive systems with non-deployable bonnets provide a certain level of protection also at lower impact speeds, deployable bonnet systems are also required to have a certain level of protection at speeds at the lower deployment threshold of the deployable system.

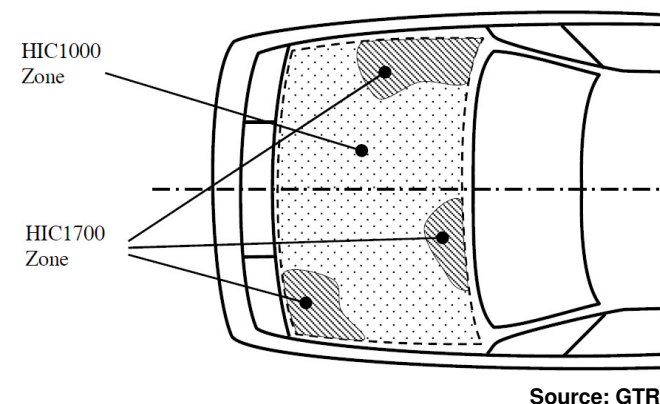
This protection level needs to be checked with impactor tests to the undeployed bonnet at speeds at the lower deployment threshold (e.g. 20 km/h) of the system.

If the low speed requirement is met, all headform tests are to be performed in the deployed state of the bonnet (provided that criteria 1 and 3-5 are met, too).

## Criterion #2: Low speed protection



- The low speed protection criterion is applicable to all vehicle parts that are affected by the deployable systems.
- The vehicle manufacturer needs to provide data, giving evidence that no impact point within the HIC 1000 zone as defined in Section 5.2.4 of Part B shall produce a head performance criterion ( $HIC_{15}$ ) of more than HIC 1000 during a headform impact on the undeployed bonnet at the lower deployment threshold speed.
- He furthermore needs to provide data, giving evidence that no impact point within the HIC 1700 zone as defined in Section 5.2.4 of Part B shall produce a head performance criterion ( $HIC_{15}$ ) of more than HIC 1700 during a headform impact on the undeployed bonnet at the lower deployment threshold speed.
- A minimum of three [by the TA authority] selected verification tests is to be performed.
- The tests are to be performed with the adult headform impactor in the adult headform test area and with the child headform impactor in the child headform test area as defined in Section 3 of Part B.





## Criterion #3: High speed protection



Since passive systems with non-deployable bonnets provide a certain level of protection also at higher impact speeds, deployable bonnet systems are also required to have a certain level of protection at speeds beyond vehicle speeds corresponding to impactor velocities of 35 km/h (assumption: 40 km/h).

This protection level needs to be checked with a HTD pedestrian surrogate test beyond a vehicle speed corresponding to an impactor velocity of 35 km/h.

A physical test using the PDI2 or alternative HTD surrogate at 50 km/h or higher to demonstrate the initiation of the bonnet deployment must be performed.

The test needs to be performed at vehicle centreline or as far as possible away from the localized sensor, but within the bumper test zone.

Minimum output parameters: HS film, evidence of initiation of the system deployment

If the high speed requirement is met, all headform tests are to be performed in the deployed state of the bonnet (provided that criteria 1-2 and 4-5 are met, too).

## Criterion #4: System timing

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With a correct timing of the deployable bonnet system it needs to be ensured that the actual head protection level is equal to the level suggested by the fully deployed bonnet during impactor testing.

If the system timing requirement is met, all headform tests are to be performed in the deployed state of the bonnet (provided that criteria 1-3 and 5 are met, too).

## Criterion #4: System timing

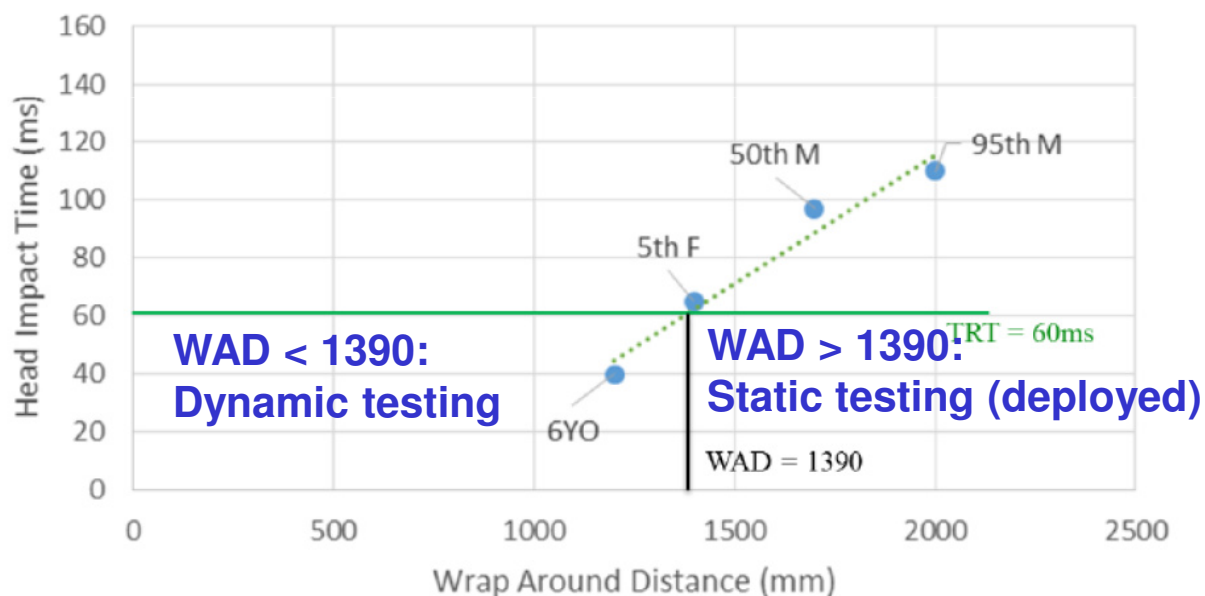


- Impact points that are not affected by the deployable bonnet system are to be tested with the bonnet in the undeployed state.
- Simulations are to be performed, with pedestrian models and codes representing the 6YO, 5th, 50th and 95th, at vehicle centreline.
- Simulations are to be performed with all pedestrian statures resulting in head to bonnet contact at vehicle speeds of 45 km/h with the bonnet in undeployed state.
- Pedestrian stances specified in Section [xxxx]
- In case of a system (other than airbag system) is fully deployed and remaining in the intended position prior to the HIT of the smallest appropriate pedestrian stature, all headform tests are to be performed with the bonnet in fully deployed position.
- Where the system is not fully deployed prior to the HIT of any appropriate pedestrian stature, all impact points forwards of the corresponding WAD are to be tested dynamically.
- Systems which do not remain in a permanently deployed position are to be tested dynamically for all impact points.

# Criterion #4: System timing



- For each pedestrian impact location, the corresponding WAD and HIT are to be determined from simulation.
- A best fit line between all WAD vs HIT plots as well as the TRT of the system (provided by the vehicle manufacturer) are to be depicted in one graph.
- From the graph, the test method for all impact points (deployed position or dynamically) can be determined, e.g.:



Source: Euro NCAP Pedestrian Testing Protocol

## Criterion #5: Actual protection level



Given that deployable bonnets may have reduced support from their peripheral structures compared to passive systems, it is required that head protection is not compromised due to their introduction.

At the point and time of head impact it is therefore essential that the actual level of protection due to the introduction of the active bonnet is equal to the level suggested by the deployed bonnet when being tested with headform impactors according to GTR9 (performance requirement or clearance requirement, at the choice of the vehicle manufacturer).

If the actual protection level requirement is met, all headform tests may be performed in the deployed state of the bonnet (provided that criteria 1-4 are met, too).

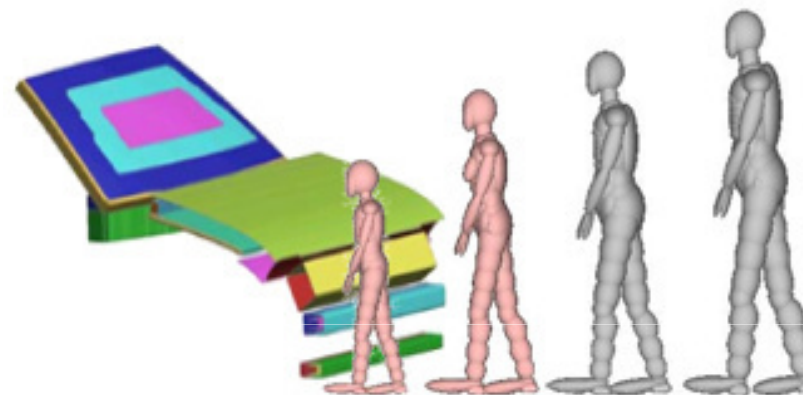
# Criterion #5: Actual protection level



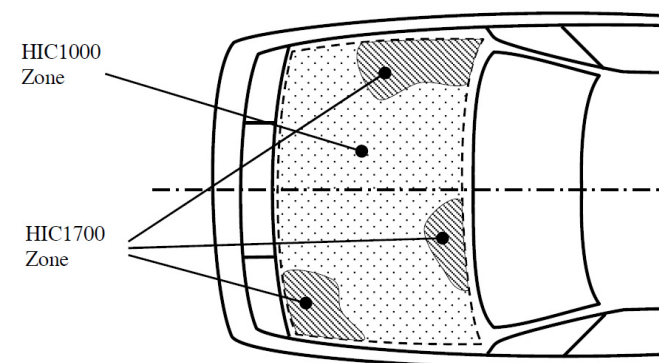
For a demonstration of the performance requirement being met, numerical simulations at vehicle speeds of 40km/h with the human body models of all appropriate sized pedestrians (6YO child, 5<sup>th</sup> female, 50<sup>th</sup> male, 95<sup>th</sup> male) having their first contact point at vehicle centreline are performed on the bonnet in deployed state.

For each human body model simulation, where the head is contacting the vehicle front inside the moveable test area and within the HIC 1000 zone as defined in Section 5.2.4 of Part B, the head performance criterion ( $HIC_{15}$ ) on the deployed bonnet must not exceed HIC 1000.

Where the head is contacting the vehicle front inside the moveable test area and within the HIC 1700 zone as defined in Section 5.2.4 of Part B, the head performance criterion ( $HIC_{15}$ ) on the deployed bonnet must not exceed HIC 1700.



Source: Zander, Ott, Wisch, Fornells, Hynd, Lundgren, Pipkorn, Burleigh.  
„Injury criteria for external road users.“  
SENIORS expert meeting on September 16, 2016



Source: GTR9

# Criterion #5: Actual protection level



For demonstration of the clearance requirement being met, a minimum of three numerical simulations at 40km/h inside the moveable test area with the appropriate sized pedestrians (6YO child, 5<sup>th</sup> female, 50<sup>th</sup> male, 95<sup>th</sup> male) that load the least supported parts of the bonnet top, are performed. For each head impact location,

either the sum out of vertically measured deployment height and the vertically measured clearance of the undeployed bonnet, both at head impact point, minus the vertically measured deflection of the deployed bonnet must be greater than 80 mm:

$(h2 + h3) - z2 > 80$  mm, see Figure x,

or the bonnet underneath the head must not reach the underlying structure when the head of the HBM impacting the pre-loaded bonnet.

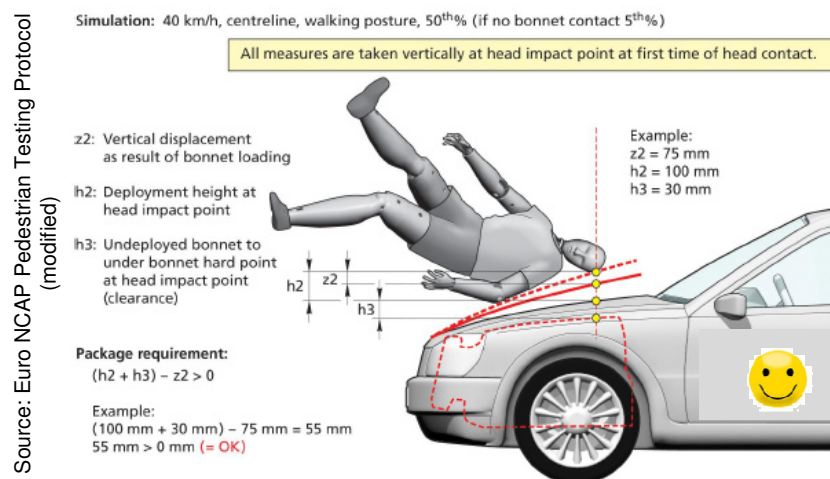


Figure x

## Example

Deployment height h2 = 120 mm

Deflection of active / deployed bonnet

z2 = 75 mm

Clearance of passive / undeployed bonnet h3 = 50 mm

Requirement:  $(h2 + h3) - z2 > 80$

$(120 \text{ mm} + 50 \text{ mm}) - 75 \text{ mm} > 80$

→ ok

# Conclusions



**For deployable bonnet systems to withstand injury risks occurring during real life impact situations, the verification of five prerequisites prior to [TA] impactor testing is proposed by BAST.**

**Criterion #1 is a functionality check of the deployable bonnet system to ensure the detection of the hardest to detect pedestrian prior to head impact.**

**Criterion #2 ensures a certain level of protection also at lower impact speeds.**

**Criterion #3 ensures a certain level of protection also at higher impact speeds.**

**Criterion #4 is a functionality check of the deployable bonnet system to ensure the system in the correct position at the time of head impact.**

**Criterion #5 is a performance / clearance requirement (at the choice of the vehicle manufacturer) of the deployable bonnet system to ensure the head protection level not being compromised due to upper body contact.**