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Addendum 9: United Nations Global Technical Regulation No. 9

United Nations Global Technical Regulation on Pedestrian Safety

Amendment 3

Established in the Global Registry on 26 June 2024

UNITED NATIONS

Section I, Statement of Technical Rationale and Justification,

Insert new paragraph 0, to read:

"0. Foreword:

UN Global Technical Regulation (UN GTR) No. 9, Pedestrian Safety, was established in the Global Registry on 12 November 2008. The development of the original GTR was discussed as "Phase 1" beginning with paragraph 0 bis. The GTR was amended by Corrigendum 1 on 12 November 2009, and by Corrigendum 2 and Amendment 1, affecting only the scope of the UN GTR, on 10 November 2010. Amendment 2 was established on 14 November 2018 and replaced the European Enhanced Vehicle-safety Committee (EEVC) lower legform impactor used for the bumper test with the flexible pedestrian legform impactor (FlexPLI). Development of Amendment 2 is discussed as "Phase 2" beginning with paragraph 133. Amendment 3 was established on [insert date when established] and added new requirements for vehicles equipped with a Deployable Pedestrian Protection System (DPPS). Amendment 3 is discussed as "Phase 3" beginning with paragraph 228. The informal working group that developed Amendment 3/Phase 3 notes that paragraph 122 in the discussion of Phase 1 has been superseded for vehicles equipped with a DPPS."

Paragraph 0 (former), renumber as Paragraph 0 bis

After paragraph 227. and section 7. (List of documents discussed in the IWG on UN GTR No. 9 – Phase 2), insert new subsection C, to read:

"C. Phase 3

228. Paragraphs 228 to 304 reflect the development of Phase 3 of UN GTR No. 9 and relate to the development of test provisions for vehicles equipped with Deployable Pedestrian Protection Systems (DPPS), including prerequisites, without changing the headform impactors and their corresponding parameters for tests to the bonnet top.

1. Introduction and General Background

229. During the fifty-sixth session of GRSP (9–12 December 2014) the expert from the Republic of Korea proposed to develop test provisions for active devices to further improve vehicle safety performance. It was noted that guidelines already existed for testing active bonnets (INF GR/PS/141 Rev. 1), however these were considered to be insufficient, and consent was sought from WP.29 and AC.3 to extend the IWG mandate on the development of phase 2 to UN GTR No. 9.

230. The proposal from the Republic of Korea to develop an amendment to UN GTR No. 9 on the testing of provisions for deployable systems of the outer surface to ensure an adequate protection of pedestrians was endorsed by AC.3 at its forty-eighth session (17 November 2016) and the IWG mandate on the development of Phase 2 was extended until December 2017.

231. The development of the test provisions for deployable systems was initiated by a Task Force under the umbrella of the IWG on phase 2 (TF-DPPS). After four meetings of TF-DPPS, the IWG mandate expired. Subsequently, AC.3 endorsed at its fifty-second session (14 March 2018) the transformation of TF-DPPS into a new Informal Working Group (IWG-DPPS).

232. TF-DPPS held the following meetings:

(a) 27–28 February 2017: Paris, France;

(b) 28–29 March 2017: Paris France;

(c) 7 September 2017: virtual;

(d) 21–23 November 2017: Berlin, Germany.

233. IWG-DPPS held the following meetings:

(a) 18–20 April 2018: Frankfurt/Main, Germany;

(b) 5–7 September 2018: Brussels, Belgium;

(c) 10 December 2018: Geneva, Switzerland;

(d) 12–14 March 2019: Paris, France;

(e) 3–4 September 2019: London, United Kingdom;

(f) 28 November 2019: virtual;

(g) 4–5 March 2020: virtual;

(h) 15–17 September 2020: virtual;

(i) 18 November 2020: virtual;

(j) 20–21 January 2021: virtual;

(k) 9–10 March 2021: virtual;

(l) 27–28 April 2021: virtual;

(m) 29–30 June 2021: virtual;

(n) 14–15 September 2021: virtual;

(o) 16–17 November 2021: virtual;

(p) 9–10 February 2022: virtual;

(q) 5–6 April 2022: virtual;

(r) 2–3 June 2022: hybrid;

(s) 18–20 October 2022: Paris, France: hybrid;

(t) 8–9 November 2022: virtual;

(u) 15–16 November 2022: virtual;

(v) 31 January–2 February 2023: Brussels, Belgium: hybrid;

(w) 12-13 April 2023: virtual;

(x) 24 April 2023: virtual;

(y) 19 June 2023: virtual;

(z) 29, 31 August 2023: virtual;

(z1) 8, 9 November 2023: virtual.

234. The meetings were attended by representatives of: Austria, European Commission, France, Germany, Italy, Japan, Republic of Korea, the Netherlands, Spain, United Kingdom of Great Britain and Northern Ireland, United States of America, European Association of Automotive Suppliers (CLEPA) and OICA.

235. The meetings were chaired by the expert of the Republic of Korea, while the secretariat has been provided by the experts of OICA since February 2017 (TF-DPPS1).

236. ECE/TRANS/WP.29/GRSP/2023/6 was proposed at the seventy-third session of GRSP as a complete draft of Amendment 3 to the UN GTR No. 9, including Part 1 and Part 2 and supersedes the other drafts previously submitted.

2. Principle of Deployable Pedestrian Protection Systems

237. DPPS should be activated as intended for pedestrian protection when the pedestrian is hit by a vehicle. To achieve this goal, the IWG agreed that requirements were needed to ensure that:

(a) The collision with the pedestrian is detected; and

(b) The existing headform requirements in the GTR are met for a 35km/h head impact velocity as well as for vehicle speeds below the deployment threshold of the DPPS.

Only contact sensors are taken into consideration for detection on current DPPS. It was discussed that in a possible "DPPS phase 2", non-contact sensors could be explored and comprehended.

238. This Regulation aims to improve protection from injury caused by a collision between the vehicle front and the pedestrian. To assure that a DPPS operates properly and offers at least the same level of pedestrian protection as a conventional passive system, the IWG agreed that the system provisions listed in paragraph 237 are a minimum requirement. Additionally, the IWG discussed the need for two other system requirements:

(a) Higher speeds - Assurance that a DPPS system will deploy safely at pedestrian impact speeds above 40 km/h;

(b) Body loading - Assurance that pedestrian body loading of a DPPS will not compromise its effectiveness prior to head impact.

These needs may exist for DPPS systems in particular, as opposed to conventional passive systems. Members of the IWG expressed their concerns that at higher speeds, actuator limitations may prevent the timely deployment of a DPPS, while the negative effects of body loading may be exacerbated by a deployed system without sufficient support. Some IWG members found that a reasonable bonnet clearance at the location and prior to the head impact is needed to prevent a hard head contact due to a collapsing bonnet.

239. At this time, the IWG agreed that a regulatory need is not known with enough certainty to warrant the development of test procedures and requirements related to higher impact speeds and body loading. In other words, current DPPS systems that meet the requirements listed in paragraph 237 may also account for higher impact speeds and body loading. However, further research or the development of future DPPS may result in insights for which the effect of pedestrian body loading and protection at higher speeds may be required. Additionally, future accidentology may reveal a prominent safety need exists in current DPPS systems due to body loading and impacts at higher speeds. In either case, the UN GTR will be reviewed and adapted if and where necessary.

240. At the request of the United States of America, the IWG decided that, based on a determination by each Contracting Party or regional economic integration organization, the fulfilment of all provisions may be required to be demonstrated using the dynamic test option of Annex 1.

241. Since the expressions "static test" and "dynamic test" are not uniformly used within different Regulations and their test procedures, the IWG DPPS discussed about how to define static and dynamic tests for the purpose of testing DPPS. In this context, the IWG agreed upon defining a "static test" as a headform impact on the DPPS in the deployed position. A "dynamic test", on the other hand, is defined as a synchronised headform impact on the DPPS during its deployment.

3. Detection test area, lateral offset leg versus head

242. As one of the fundamental prerequisites to account for the potential safety benefits of DPPS, the pedestrian needs to be detected during an accident prior to head impact on the vehicle. IWG discussed the required width of the area on the vehicle front where a pedestrian needs to be detected in order to purposefully initiate the system.

243. An earlier Task Force study was recalled by the expert from Germany in which it was shown that pedestrian impacts take place over the entire vehicle width (TF-BTA-6-07). In a later IWG meeting, Laboratoire d'Accidentologie et Biomécanique (LAB) presented an analysis of fatal French accidents contained within the Etudes Détaillées d'Accidents (EDA) database (IWG-DPPS-18-08). The LAB analysis revealed that for all cases in which a pedestrian was struck outside the longitudinal frame rails of the vehicle, accounting for approximately 15–20 per cent of the vehicle width, there were no subsequent head impacts to the bonnet (though about one-third of the cases did result in pelvis impacts to the bonnet). Thus, in principle and ideally, a detection of pedestrians in nowadays DPPS should be required accordingly.

244. Also, it was agreed that in many cases the pedestrian may tend to spin off at the outer widths of typically angled or V-shaped vehicle front-end surfaces, without a head-to-bonnet impact. This effect is even more present when using a leg impactor as pedestrian surrogate without attaching any mass of a pedestrian hip, torso, arms, neck, and head, consequently limiting the load on the sensing system and therefore not being representative for a pedestrian.

245. In the light of these observations, IWG investigated further definitions of a detection area.

246. The expert from Japan proposed that the detection area – which would differ from the leg test area – be the area in the lateral direction of the vehicle in which activation of the DPPS is ensured in a vehicle-to-pedestrian impact (Task Force Document DPPS-3-03). The reason given was that: only in this area a head impact test would be allowed with activated DPPS, while outside this area the DPPS was supposed to remain deactivated.

247. The expert from Germany suggested to use the bumper test area (BTA) as already defined for the lower extremity injury risk assessment based on the tests with the lower legform impactor. Since the FlexPLI was also chosen as verification impactor and the BTA is well elaborated and established, the expert from Germany reasoned that existing definitions could be applied.

248. The expert from European Automobile Manufacturers' Association (ACEA) also referred to current regulatory definitions and proposed to apply the lower leg test area defined in Amendment 2 to UN GTR No. 9 as required confirmation of sensing capabilities for DPPS homologation or self-certification (IWG-DPPS-1-08).

249. The expert from OICA suggested to define the outer boundaries of the detection area by the width between the corner reference points (CRPs) (CRPs, the intersections of the side reference lines and the bonnet leading edge reference line), projected to the upper bumper reference line (IWG-DPPS-4-05). It was noted by IWG participants that when a vehicle has multiple or continuous intersections between the Bonnet Leading Edge Reference Line (BLERL) and the Side Reference Line (SRL), the most outboard point is used as the CRP. It was also noted that the distance between right and left CRPs can be narrowed easily by a minor, cosmetic redesign of the vehicle front end. Such a redesign would have no effect on the legform test zone but could lead to large differences in CRP locations and thus greatly affect the DPPS detection test area. Therefore, the IWG abstained from further discussions on the use of the CRP in defining the detection test area.

250. An independent expert proposed a required percentage of the vehicle width (around the longitudinal vertical centreplane as its centre) as detection test area, with a subtraction of no more than 12.5 per cent of the vehicle width but a maximum of 250mm at each side of the vehicle. The independent expert's proposal also stated that the detection test area should be no less than the BTA (IWG-DPPS-5-09). It was explained that with a percentage all vehicles

would be equally treated, regardless their effective width: however, big cars should not be allowed to further reduce the detection area, beyond 250mm on each side.

251. The expert from Germany subsequently provided an update to the independent expert's proposal wherein the vehicle width was defined as the width at the cross-section of the front axle, without rear view mirrors or rear-view mirror substitute systems, so that the proposed detection test area was not linked to the width of the deployed area of the DPPS (IWG-DPPS-7-10). Examples of four current vehicle models were displayed to show how the detection test area based on the 12.5 per cent stipulation was greater than the BTA.

252. Japan investigated the outer most boundary of the detection area proposed by Germany and confirmed that it covers the headform test area for vehicles equipped with DPPS currently available on the market in Japan. Thus, Japan accepted the detection area proposed by Germany. However, it was suggested that in cases where the sensing width is narrower than the width of the detection area, the DPPS would be allowed to only be activated within the sensing width (IWG-DPPS-9-09). The rationale was that the lateral offset between the lower extremity impact and the pedestrian head impact after wrap around would be considered as small.

253. The group examined indications regarding the possible lateral offset between lower extremities and head in pedestrian accidents with passenger cars.

254. The expert from Japan presented Post-Mortem-Human-Subject (PMHS) tests, Human Body Models (HBM) finite element simulations and dummy tests where the lateral movement of the pedestrian's head until the head impact on the vehicle front was small. It was concluded that the impact locations of the head and the leg would not differ much (IWG-DPPS-10-04).

255. The expert from Germany examined some cases from the German In-Depth Accident Study (GIDAS) database for real world trajectories of pedestrians. The sample showed in several cases a significant lateral offset between the first leg impact and the subsequent pedestrian head impact. They concluded that laboratory test conditions with stationary test specimen do not always reflect real world impact conditions in an appropriate way (IWG-DPPS-10-09).

256. The expert from Japan proposed that the pedestrian accidents scenario assumed under the current UN GTR No. 9 is the case when the vehicle impacts the stationary pedestrian from the side, and the pedestrian accidents scenario assumed in the test for DPPS should be the same as the current UN GTR No. 9. Japan found that, for consistency reasons, a consideration of the pedestrian kinematics with significant lateral offset between the pedestrian's leg impact and the subsequent head impact would require such a consideration with modified impact angles also during component tests. However, Japan also showed that this would not be in the scope of the IWG and beyond the minimum requirements as specified in the GTR (IWG-DPPS-11-03).

257. The expert from Germany clarified the objective of the IWG, which was not limited to clarification of the current practice, but also to develop new and more detailed requirements, where needed, to ensure a correct activation and design for vulnerable road user protection. Since the detection of pedestrians is one of the indispensable prerequisites and DPPS needs to be correctly activated, real world conditions under consideration of pedestrian trajectories with a considerable offset between leg and head impact need to be taken into account to provide for at least the same level of protection as conventional systems without DPPS (IWG-DPPS-11-05).

258. The expert from Japan presented a literature review of real-world accident data and concluded that a walking pedestrian hit laterally by a vehicle would be a representative accident scenario (IWG-DPPS-12-07) which is reflected by the current UN GTR No. 9 test procedures. The expert from Germany found that also a large number of oblique impacts were included in the share of given lateral impacts which need to be taken into consideration with respect to the leg versus head offset. It was added that UN GTR No. 9 would not only cover lateral but also oblique impacts, since the outer skin of the vehicle front would be, in most cases, not parallel to the moving trajectory of the crossing pedestrian and thus not perpendicular to the velocity vector of the impactor during the impact. Regarding the

pedestrian accidents scenario assumed for DPPS, other contracting parties supported Germany's proposal, but Japan did not accept it. However, because the detection area proposed by Germany covers the headform test area for vehicles equipped with DPPS currently available on the market in Japan, Japan accepted the detection area proposed by Germany regardless the difference of assumption for the pedestrian accidents' scenario for the tests.

259. The expert from German Association of the Automotive Industry (VDA) explained possible shortcomings of the BTA definition when applied to the DPPS detection test area. For the lower leg injury assessment, the BTA is defined by the greatest of the following areas: (a) the area limited by the corners of bumper, moving on either side 42mm inboard; (b) the outermost ends of the bumper beam, moving on either side 42mm inboard. The expert from VDA took exception to the use of the bumper beam in defining the detection test area for DPPS applications (IWG-DPPS-14-04). They presented conditions that exist on two production vehicles, in which structures are appended to the bumper beam, but only for certain markets, in order to fulfil corresponding crash test requirements. These structures have the effect of extending the BTA. Hence, if the structures were used to stipulate the DPPS detection test area, there would exist different detection test areas for different markets.

260. Further discussion on bumper beam structures ensued. The expert from OICA described the structures as "optional" and insufficient to serve as a pressure tube backstop. Additionally, they extend outboard into an area in which the fascia covering is curved (outboard to the corners of bumper as defined by the 30° gauge). These two factors preclude the ability to install a sensing tube that could generate enough signal to trigger a DPPS actuator as described in a previous VDA analysis (IWG-DPPS-12-08).

261. A working subgroup of the IWG analysed current examples of DPPS on the market to guide a decision on how to proceed with a suitable definition for the detection test area. This survey included twelve production vehicles with different sizes and body styles. For each vehicle, the following widths were noted: the car manufacturer-reported width of sensing, a possible detection test area determined by the 12.5 per cent/250mm stipulation, and a possible detection test area determined via the lower leg Bumper Test Area (BTA) criteria: the 30° gauge and the bumper beam (IWG-DPPS-18-07).

262. The survey revealed that the width of sensing can also extend outboard of the detection test area when defined by the relevant 30° corner gauge contact points and into an area where a glancing blow will occur. In the vehicle survey, the 12.5 per cent-based width of the detection test area was wider than the corner gauge-based "geometry" in most of the vehicles surveyed. This shows that – at least to a certain extent – it is feasible to overcome the "spin off/low signal" issue brought up in IWG-DPPS-12-08.

263. The vehicle survey showed one instance where the corner gauge-based detection test area was greater than the 12.5 per cent-based detection test area. In this case, the reported width of sensing was even greater. This shows that it is feasible to enforce the corner gauge-based detection test area when it is wider than the 12.5 per cent-based width.

264. The vehicle survey also showed that some of the vehicles had reported widths of sensing that would not have met the width requirement of the detection test area as determined by the 12.5 per cent stipulation or the corner gauge. This means that with phase 3 of UN GRT No. 9, new vehicles will have a greater width of sensing relative to many vehicles not fulfilling this requirement.

265. Based on the discussions, the bumper beam has been excluded from the stipulation for the DPPS detection test area. Furthermore, the exclusion is consistent with a performance-based standard. If it was included, it would partly act to prescribe the sensing tube technology and the form of the bumper beam itself. Originally, the bumper beam was considered because sensing technology that uses a pressure tube typically operates by using the beam as a hard surface to "back up" the tube. It was reasoned that if the beam is of a certain length, it is feasible to require the tube (and the sensing area) to be the same length: in three vehicles of the survey, the width of the bumper beam underlying the fascia exceeded the 75 per cent stipulation. However, this misleadingly assumes that the beam will always be made of a rigid, tubular structure and that pressure tube technology is used. In fact, the survey showed that accelerometers were used in four of the vehicles. A Regulation should not prescribe a

particular technology or stand in the way of new technologies, such as different sensing technologies or bumper beams that take on different materials, shapes and functions.

266. The IWG finally agreed upon the minimum width of the detection test area being the vehicle width minus 12.5 per cent (but not more than 250mm) on each side but extending at least up to the points 42 mm inboard of each corner of bumper.

4. Test procedures for the sensing systems of DPPS and selection of the verification impactor

267. For verification of the functionality of the DPPS sensing system, component tests will be performed with the FlexPLI, representing the lower extremities of a 50th percentile male for injury assessment of knee and tibia injuries. The use of the FlexPLI as sensing impactor was agreed following extensive investigations.

268. Contact biofidelity was considered to be an indispensable property of such a sensing impactor. The IWG-DPPS found that, when verifying the ability of a contact sensor to detect a pedestrian, the relevant properties of an impactor are the total mass, mass distribution, moments of inertia, centre of gravity, impactor width, bending stiffness and the local stiffness / compression behaviour in impact direction were highly relevant properties of an impactor for the signals in use with contact sensors. While most properties of the FlexPLI were accepted to be very reliable due to its design specifications, two complementary studies were carried out to ensure its biofidelic and repeatable local stiffness.

269. The first study, carried out by Concept Tech, investigated time histories of different pedestrian surrogates and HBMs for identical load cases. It concluded the FlexPLI had, in principle, an appropriate contact biofidelity to work as a representative pedestrian surrogate for sensing issues (IWG-DPPS-3-03).

270. The second study, carried out by The Federal Highway Research Institute (BASt) and an independent expert in cooperation with ACEA members, focused on the intrusion during inverse tests at impact speeds typical for the lower deployment threshold of DPPS within the typical time interval for detection of pedestrians. Here, two different setups were used, covering the height dimensions as required by Research Council for Automobile Repairs and UN Regulation No. 42 (Front and rear protection devices) which need to be fulfilled by a high number of vehicles. It could be shown that the double integral of the filtered impactor acceleration signal, representing the intrusion, was within a small range with satisfactory coefficients of variation (IWG-DPPS-6-04, IWG-DPPS-7-09 and IWG-DPPS-9-11).

271. The IWG-DPPS concluded that the FlexPLI was currently the best available pedestrian surrogate which could be used as an impactor for the sensing verification of the system for the time being.

272. The IWG emphasized that, due to the complexity of testing the DPPS, the test provisions laid down represent a limited range of typical load cases. It is therefore seen as due care of the vehicle manufacturer that any DPPS would ensure the necessary protection (e.g. for a variation of speeds and pedestrian statures) in order to act as intended in the event of a collision with a pedestrian for a variety of pedestrian statures.

5. Determination of Head Impact Time and wrap around distance

273. The pedestrian Head Impact Time (HIT) is defined as the elapsed time subsequent to the time of first contact of the Pedestrian surrogate (neglecting forearms and hands) with the vehicle outer surface and the time of first contact of its head with the vehicle outer surface. IWG decided to use two kinds of HIT determination depending on the application (static or dynamic test) as a compromise of technical feasibility (i.e. for pedestrian airbags) and the consideration of worst-case scenarios:

(a) "HIT_for decision" (HIT_d) represents the worst case and is determined with the deployed DPPS. The HIT_d is compared to the total response time and used to decide

whether a test on the DPPS is to be done on a deploying (dynamic test) or on a statically deployed system (static test).

(b) HIT_s (s for synchronisation) is determined with the undeployed DPPS, as for airbags a deployed position is difficult to define. HIT_s is used to synchronise the test trigger time of a dynamic test in the case of a deploying system.

274. The IWG discussed three methods of determining HIT:

(a) Use of HBM simulations;

(b) Use test dummies and physical testing;

(c) Use of a "generic" approach.

275. IWG ultimately agreed to propose a procedure using HBM simulations based upon a procedure on Euro New Car Assessment Programme No. TB024, as an initial DPPS amendment.

276. For DPPS to work as intended, it is necessary that the system in question is activated in due time.

277. The HIT_d of pedestrians of the relevant statures needs to be compared with the total response time (TRT) of the DPPS.

278. This comparison provides the basis for whether headform tests to the vehicle front are performed with the DPPS either statically in undeployed or in deployed position, or dynamically onto a deploying system.

279. The IWG DPPS understood that HBM simulations were the common method for determination of the HIT. In order to ensure comparability and applicability of HBM for that purpose, a qualification procedure for HBMs was developed within a subgroup of the IWG DPPS, led by the experts of Austria and OICA. All Generic Vehicle (GV) Models used for the qualification are made available as Addendum 5 of Mutual Resolution No. 1 (M.R.1) of the 1958 and the 1998 Agreements ECE/TRANS/WP.29/1101 by Austria.

280. Given its limitations, the IWG recognized the qualification procedure being applicable for the determination of HIT and Wrap Around Distance (WAD) only. The simulation procedure described is limited to HBM qualification for the determination of HIT and related WAD and not suited to qualify for injury assessment in any pedestrian or other crashworthiness regulations.

281. A subgroup of the IWG on DPPS investigated the corridors required for the qualification of HBMs for HIT and WAD determination. It was unanimously agreed that realistic HIT and WAD strongly depend on biofidelic whole-body kinematics of the HBM. However, a required location of the Acetabulum (AC) at the time of head impact, as e.g. described by means of a corridor, is not seen as an appropriate kinematic criterion. It was therefore, for the time being, abstained from introducing AC corridors for the HBMs at HIT; however, the values will be recorded for monitoring purposes and evaluated during a possible next phase of GTR9 towards the introduction of significant, meaningful kinematic criteria for biofidelic and reliable HBM trajectories.

282. In order to create an independent baseline, reference simulations have been used to determine requirements and tolerances described in Addendum 5 of M.R.1 "**Specifications for the Qualification of Human Body Models for Pedestrian HIT Determination for DPPS (DPPS HBMs)"**. The HBMs that were used for these reference simulations have been validated by comparing their simulation responses (HIT, kinematics) with PMHS tests. The background concerning the validation of reference HBMs are available in Annex B of Addendum 5 of M.R.1 of the 1958 and the 1998 Agreements ECE/TRANS/WP.29/1101.

283. For the qualification of HBMs, GV Models are used. These GV Models are available on the ECE website and described in M.R.1 Addendum 5. The GV Models are only used to run simulations with the individual HBM on the specific computational environment and compare the results with reference corridors. This comparison is needed to ensure similar head kinematics as the reference HBMs. Therefore, the individual HBM qualifies as tool for HIT determination for the DPPS assessment. The GV Models were developed as very

simplified impact structures which show consistent behaviour when applied in the different Finite Element (FE) software packages, are robust and approximate impact conditions within the range full vehicles, while not representing any specific car with all details. The GV Models are developed to simulate the kinematics of HBMs up to the time of head contact. The information on the development of the GV Models is documented in IWG-DPPS-25-05.

284. A plausibility check of the GV Models using a rigid impactor is described in Annex C of Addendum 5 of M.R.1 of the 1958 and the 1998 Agreements ECE/TRANS/WP.29/1101. In the GV Models, a hard stop is implemented as contact between the outer and inner layer to avoid instabilities of the foam and increase the robustness and comparability between codes of the GV Models. The foam material's stiffness is exponentially increasing after ~80 per cent compression to additionally avoid negative volumes within the foam in case of high local deformation.

The intrusion with HBMs on the GV Models may be different from that with the rigid impactor because of the bigger HBM surface contacting the GV Models. Therefore, it is unknown, if bottoming out with HBM on the GV Model occurs frequently and has an influence on either HIT or head position result for reference HBMs or a new HBM.

285. The IWG discussed the different levels of abstraction when assessing a DPPS system. The real vehicle to pedestrian accident (first level) is replicated with a physical headform test against the vehicle front (second level). For the determination of the test conditions and the state of the DPPS during the headform test (fully deployed, deploying or undeployed), the HIT is determined during HBM simulations on the actual vehicle model (third level). In order to ensure the HBM working as intended, they are qualified during simulations against GV Models by comparing their HIT with those of validated reference HBM (fourth level). The GV Models used during this qualification process should approximate trajectories and HIT comparable to those in simulations against actual vehicle frontends. This verification is done by means of impactor tests vs the GV Models (fifth level). Since the aim is a comparison of simulation tools (HBM), the GV Model does not have to represent any actual vehicle model but just to produce robust and to some extent comparable (not identical) results, to ensure that a HBM is working as intended with regard to its trajectories.

286. However, the injury assessment abilities of HBMs are not validated. Therefore, and as of now, HBMs may not be used for injury assessment in any pedestrian or other crashworthiness regulation.

287. The simulation procedures with the qualified HBMs and the actual vehicle model for HIT determination are described in Annex 2 "HIT determination simulation".

288. Concerning the linear regression explanation, IWG has discussed different options to determine HIT versus WAD graphs for the decision of a static or a dynamic test mode and a system triggering for the dynamic testing. IWG considered two methods – the "linear regression method" and the "dot-to-dot method" – and recognized that each method has pros and cons. Both Japan and Korea preferred the "dot-to-dot method" because the method is mathematically more accurate, by using the simulated HIT values as agreed upon in Annex 2, and the linear regression method may have low correlation (IWG-DPPS-5bis-04 (Japan), IWG-DPPS-6-05 (Korea)). Other Contracting Parties and NGOs were in favour of the "linear regression method", because the method is practical to figure out the corresponding HIT values to WADs and may also be used to extrapolate HIT for WADs lower than six years old or higher than 95th percentile adults (IWG-DPPS-6-06 (OICA)). **In this context, for reasons of likelihood and practicability, it is assumed that the HIT always increases with increasing WAD.** Finally, the IWG agreed on the "linear regression method" to figure out HIT values after extensive discussions on both methods.

289. Japan proposed to allow the use of physical test tools to predict HIT in addition to numerical tools. Performance requirements and test procedures for full scale pedestrian dummies have been specified in a published Society of Automotive Engineers (SAE) technical standard (SAE J 2782) and test results for an existing pedestrian dummy have been reported in SAE J 2868. Due to the availability issue of the SAE standards and the upcoming update of J 2868, Japan also proposed to seek a way to transpose the contents of the SAE standards into UN GTR No. 9. As a result of discussion, IWG agreed to consider developing

further modifications to this amendment to incorporate the allowance of the use of physical test tools to predict HIT after the phase 1 of this activity is complete.

6. Protection at speeds below lower deployment velocity threshold

290. To protect the head of a pedestrian in the event of a collision, DPPS usually provide additional clearance between the bonnet and underlying hard structure. However, since DPPS are only activated at and above a lower deployment velocity threshold, head protection at head impact velocities equivalent to the vehicle speed below this threshold must be demonstrated in order to ensure the same level of protection as conventional passive systems. For that purpose, headform tests are performed at these impact velocities on the undeployed DPPS and their results compared to the biomechanical limits which also apply for the compliance tests.

291. Members of the IWG found wide variations of the ratio between head impact velocity and vehicle impact speed (between 0.68 and 1.5 for a car impact speed of 40km/h) in former studies. When taking into account the ratio for the legal requirements (head impact velocity of 35 km/h corresponding to a vehicle speed of 40km/h), the IWG finally decided to use a rounded ratio of 0.9 for the verification tests at lower deployment velocity threshold. Therefore, for the DPPS to demonstrate the fulfilment of this prerequisite, head impact tests are to be performed at an impact velocity which is 0.9 times the vehicle lower deployment velocity threshold.

7. Total Response Time measurement

292. Since it is critical that the DPPS is deployed before the pedestrian's head contacts the vehicle for pedestrian protection in a pedestrian-to-vehicle collision, how to measure TRT (ST+DT) needs to be verified. The specific conditions for the verification test were reviewed. The impact speed and location were decided as equal to the conditions for defining HIT, and the FlexPLI, which is the same impactor for sensing system verification, was selected for the test.

293. There were concerns about how to conduct a headform test when the bonnet is still deploying towards its maximum height. Whereas static tests are able to save time but may differ from actual test results with moving DPPS, dynamic tests can be performed in actual conditions but may take a longer time. The IWG concluded that dynamic tests should be conducted for the case, subsequently, TRT should be measured from the time of first contact of the FlexPLI with the vehicle outer surface to the time that DPPS reaches its maximum deployment height first.

8. Headform test options

294. Depending on the degree of fulfilment of the prerequisites, the compliance tests with adult and child headform impactors are performed on the static DPPS in either the undeployed or the deployed state, or on the deploying DPPS.

295. The IWG discussed several approaches to define tolerances for the validation tests of the different height and time values specified by the manufacturer. Two main sources for tolerances were identified: a) the variation of parts due to production process (geometry, assembly, material properties, micro gas generator propellant), b) different methods to measure the Sensing Time during compliance testing. Experts of VDA explained that Deployment Height, Deployed Position and Deployment Time strongly depend on the variation of parts and their assembly so that a great portion of the specified values are related to the specified tolerances during production processes. Therefore, a percentage of the specified values would appear to be most convenient as tolerances for Deployment Height, Deployed Position as well as Deployment Time. VDA added that the scatter of Sensing Time, on the other hand, strongly depends on the procedure of time measurement (electronical, visual, etc.) in the test lab. It was recommended to introduce tolerances on this measurement

as absolute values. Therefore, a time corridor around the specified Sensing Time was introduced.

296. A protection at speeds below the lower deployment velocity threshold and the appropriate detection of a pedestrian are both indispensable requirements for vehicle approval or compliance.

297. Furthermore, only those headform tests qualify for being performed on the deployed DPPS, where during simulations with qualified HBM on the deployed DPPS, the HIT_d is proven to be greater than the TRT.

298. Where a pedestrian is not detected or any relevant HBM fails the qualification procedure, all tests are to be performed on the undeployed DPPS.

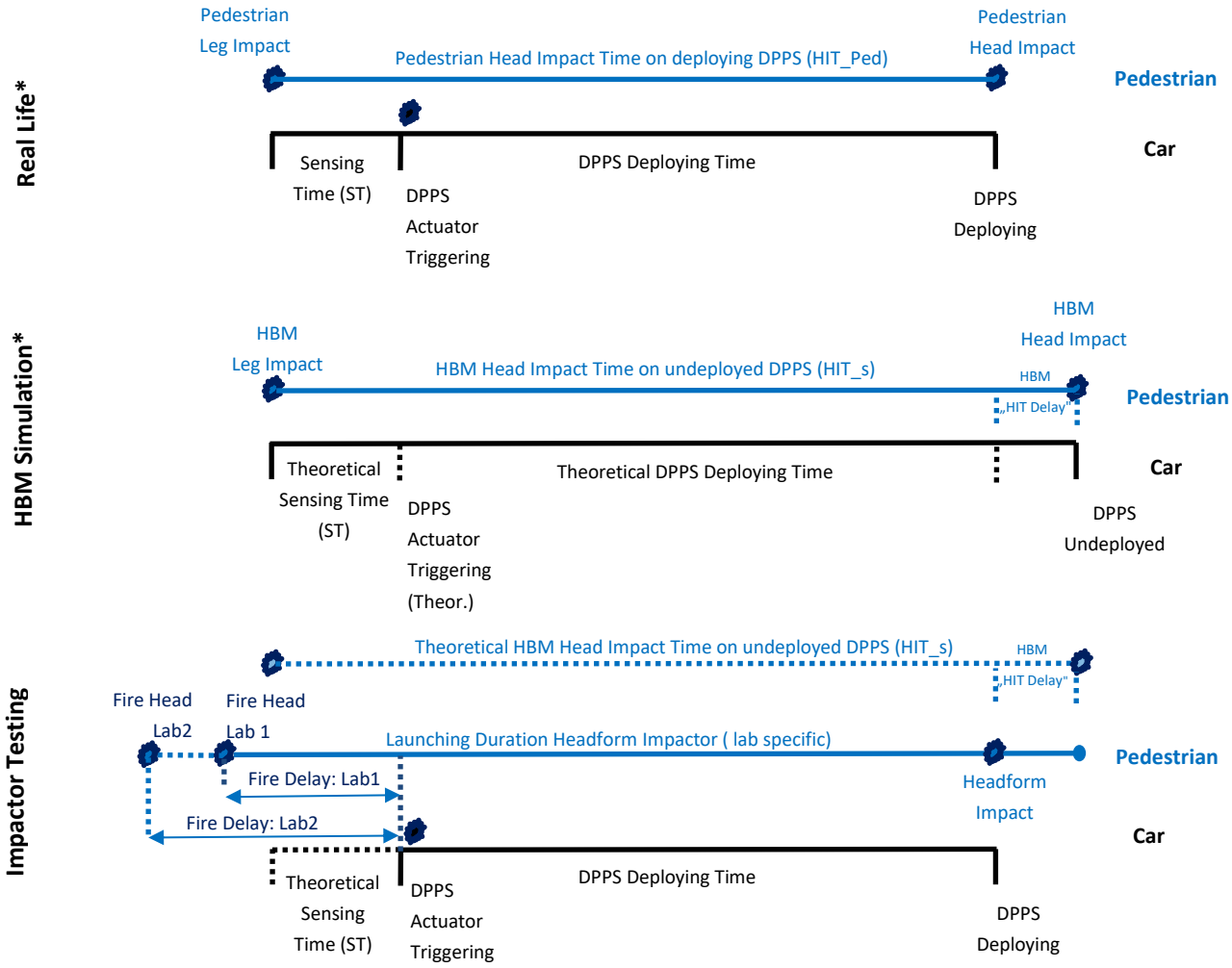
299. In the remaining cases, where the HIT_d is smaller than or equals the TRT, or when requested by the contracting party, dynamic tests are to be performed on the deploying DPPS. Synchronisation of the headform impactor and the DPPS during dynamic tests are to be derived from the generated regression line out of HIT_s as a function of WAD during simulations on the undeployed DPPS.

300. For the dynamic test option, the IWG investigated possible misinterpretations of the calculated and actual launching time of the headform impactor during dynamic tests. Since the fire delay between the initiation of the launch of the headform and the triggering of the DPPS actuators is, amongst other things, based on the HIT of the HBM on the undeployed DPPS (HIT_s), but the actual headform impact takes place on the deploying DPPS (see Figure 1 (a)), the actual launching duration will deviate from the calculated one, as depicted in Figure 1 (b).

This needs to be taken into account in the course of verification of ambient conditions for dynamic tests.

Figure 1 (a)

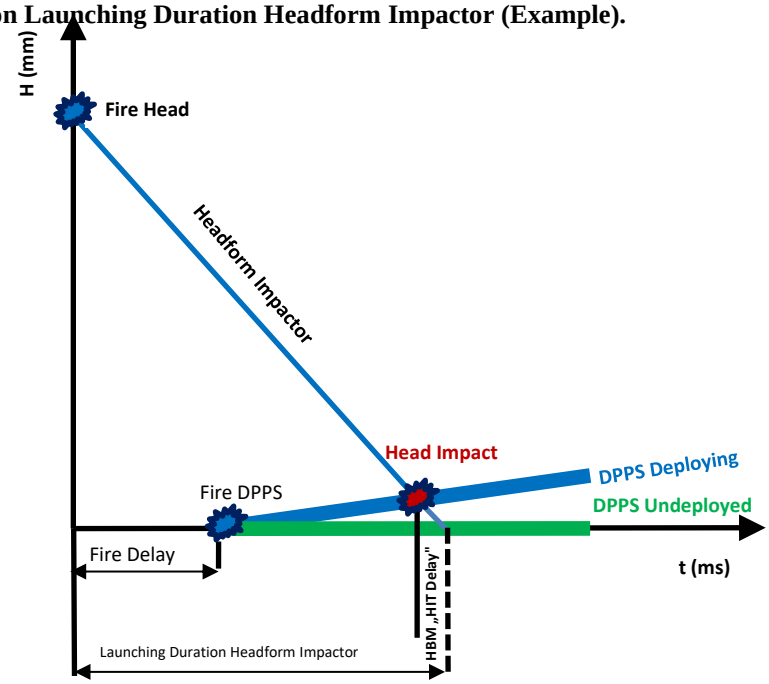
Transfer of real life accident situation with deploying DPPS to ambient conditions for impactor testing.



*** Assumption:**
Identical trajectories, kinematics of Pedestrian and HBM

Figure 1 (b)

Effect of DPPS Deployment on Launching Duration Headform Impactor (Example).



9. Head test area

301. Two approaches to define the head test area for vehicles fitted with DPPS were discussed, either in an undeployed position, or in a deployed position.

302. All IWG members agreed on defining the area in an undeployed position for dynamic testing of DPPS, including pedestrian airbag systems.

303. The expert from Korea proposed that the head test area should always be defined in an undeployed position for consistency. The Korean expert was concerned about an inconsistent test area depending on the test mode (static or dynamic), and also pointed out that there might be pragmatic issues to define the test area in the deployed position for a static headform test, especially, when the static test has to be partially conducted. On the other hand, manufacturers claimed that the test area defined in a deployed position makes more sense because the headform actually contacts a deployed bonnet in case of the static test.

304. After extensive discussions, the IWG decided to define the head test area in an undeployed position at all times.

10. List of documents discussed in the TF-DPPS and IWG-DPPS on UN GTR No. 9 Amendment 3

Doc. No.	*Rev.*	*Name*
DPPS-1-01		1st Meeting Agenda
DPPS-1-02	1	Minutes of the First Meeting
DPPS-1-03		Task Force Outline
DPPS-1-04		Test Procedure of Deployable Systems for Pedestrian Protection (Korea)
DPPS-1-05	1	OICA proposal based on GRSP-58-31 as revised during the meeting – 20170227

Doc. No.	*Rev.*	*Name*
DPPS-1-06		Comments on Scope (Japan)
DPPS-1-06-Appendix		Comments on Scope – Appendix (Japan)
DPPS-1-07		Euro NCAP Pedestrian Testing Protocol v8.3 December 2016 (Germany)
DPPS-1-08		JNCAP Ped Active Device Test Protocol (unofficial) (Japan)
DPPS-1-09		Testing Deployable Bonnet Systems within Euro NCAP (Germany)
DPPS-1-10		Bonnet Deflection of Deployable Bonnet Systems (Germany)
DPPS-1-11		Industry Understanding on Rulemaking (OICA)
DPPS-1-12		Input bonnet deflection discussion (OICA)
DPPS-2-01	1	2nd meeting agenda
DPPS-2-02	1	Minutes of the 2nd meeting
DPPS-2-02-Annex		Annex to the minutes of the 2nd meeting: Attendance list
DPPS-2-03	3	Requirements Overview DPPS (Korea)
DPPS-2-04		Prerequisites for Deployable Bonnet Systems in Deployed State (Germany)
DPPS-2-05	1	Comments on OICA proposal (Japan)
DPPS-2-06		Comments on document TF-DPPS/1/05 Rev. 20170227 (Japan)
DPPS-2-07		Comments BASt on OICA Input Presentation (Germany)
DPPS-2-08		OICA comment for static and dynamic test (OICA)
DPPS-2-09		Marking of Deployable Bonnets: Differences of Bonnet Marking Positions and Challenges in Performance Assessment (OICA)
DPPS-2-10		Explanation JNCAP details for Items for DPPS Amendment (Japan)
DPPS-2-11		Development Head Test Procedure (Germany)
DPPS-2-12		Text for validation of simulation methods (OICA)
DPPS-2-13		Comments on document TF-DPPS/2/04 (OICA)
DPPS-2-14		Development of a Head Impact Test Procedure for Pedestrian Protection (Germany)
DPPS-2-15		Validity of a Headform to be used for a Specific Impact Test Speed Condition (Japan)
DPPS-2-16		Comments on document TF-DPPS/2/13 (Germany)
DPPS-3-01	Corr 1	3rd meeting agenda
DPPS-3-02	Corr 1	Minutes of the 3rd meeting

Doc. No.	*Rev.*	*Name*
DPPS-3-03		Definition of sensing area (Japan)
DPPS-3-04		Proposal for Definition of Head Impact Test Area (Japan0
DPPS-4-01	1	4th meeting agenda
DPPS-4-02		Minutes of the 4th meeting
DPPS-4-03		Scope and Limitations of the PDI-2 (OICA)
DPPS-4-04		Static and Dynamic Testing of Deployable Systems (OICA)
DPPS-4-05		Marking + Deployed Position (OICA)
DPPS-4-06		JASIC proposals for document TF-DPPS/1/05-Rev.1 (Japan)
DPPS-4-07		Validity of Applying the Current Headform at Low Impact Speed (Japan)
DPPS-4-08		Dynamic Headform Test (Synchronization) (Korea)
DPPS-4-09		Discussion Issues for DPPS Testing (Korea)
DPPS-4-10		Alternative Determination of Head Impact Time (BGS)
IWG-DPPS-1-01		1st IWG-DPPS meeting agenda
IWG-DPPS-1-02	1	1st IWG-DPPS meeting notes
IWG-DPPS-1-03	2	IWG-DPPS Terms of Reference
		IWG-DPPS-1-03bis ECE-TRANS-WP29-2018-162e ToR official
IWG-DPPS-1-04	Corr 1	Presentation of the Euro NCAP CoHerent Project (Tu Graz)
IWG-DPPS-1-05		Comments: Deploy Height vs. Fully Deployed (OICA)
IWG-DPPS-1-06		Comments: Dynamic Testing (OICA)
IWG-DPPS-1-07		Comments: Pedestrian Sensing Impactor (OICA)
IWG-DPPS-1-08		ACEA Input: Definition of Sensing Width (ACEA)
IWG-DPPS-1-09		Summary of Compliance Test Procedure for Pedestrian Protection (Korea)
IWG-DPPS-1-11		Head Impact Time of Human Body Models (BASt)
IWG-DPPS-2-01	1	2nd IWG-DPPS meeting agenda
IWG-DPPS-2-02	1	2nd IWG-DPPS Meeting notes
IWG-DPPS-2-03		Summary Report Meeting 14 June 2018 (Sub-group Prerequisites)
IWG-DPPS-2-04	2	Contracting Parties' positions on DPPS amendments
IWG-DPPS-2-05	2	Proposal: Decision on Deployed Testing of DPPS (OICA)
IWG-DPPS-2-06	1	Proposal for a Rev. 4 of Document TF-DPPS/2/03
IWG-DPPS-2-07		Summary of SAE Standard for Full-Scale Pedestrian Dummy (Japan)

Doc. No.	*Rev.*	*Name*
IWG-DPPS-2-08		Quick check of proposed logic to not activate DPPS outside of sensing width (OICA)
IWG-DPPS-2-09		2nd IWG-DPPS Attendance list
IWG-DPPS-2-10		JLR Presentation on synchronisation comparison (OICA)
IWG-DPPS-3-01		3rd IWG-DPPS Agenda
IWG-DPPS-3-02		4th IWG-DPPS Minutes
IWG-DPPS-3-03		Leg impactors and HBM simulation comparison for detection (CONCEPT)
IWG-DPPS-3-04		Study of Application of Upper Leg form to sensing test (Japan)
IWG-DPPS-3-05		Principle of a test procedure for Human Body Model numerical simulation (OICA)
IWG-DPPS-3-06		Attendance list
IWG-DPPS-4-01	1	4th IWG-DPPS Agenda
IWG-DPPS-4-02	1	Draft minutes +BAST comments
IWG-DPPS-4-03		Task 27 (deploy bonnet) (OICA)
IWG-DPPS-4-04		System Information Requirement (Korea)
IWG-DPPS-4-05		Sensing width proposal (OICA)
IWG-DPPS-4-06		Upper Leg Form Sensing Update (JASIC)
IWG-DPPS-4-07		Ped Dummy Test Procedure proposal (OICA)
IWG-DPPS-4-08		Marking of bonnet deployed/undeployed (OICA)
IWG-DPPS-4-09		Attendance list
IWG-DPPS-5-01		Draft agenda
IWG-DPPS-5-02		Draft minutes
IWG-DPPS-5-03		Marking (Korea)
IWG-DPPS-5-04		1st tentative draft
IWG-DPPS-5-05		Intended height test condition (JASIC)
IWG-DPPS-5-06		Sensing Impactors comparison (JASIC)
IWG-DPPS-5-07		Basis for General Wording Proposal (Germany)
IWG-DPPS-5-08		GRSP & WP29 report
IWG-DPPS-5-09		Detection Area Width (Germany)
IWG-DPPS-5bis-01		Draft agenda
IWG-DPPS-5bis-02		Draft skype minutes
IWG-DPPS-5bis-03		IDIADA -HIT calculation feedback (Spain)
IWG-DPPS-5bis-04		HIT calculation feedback (JASIC)
IWG-DPPS-5bis-05		ULF study 2013 (Altran)

Doc. No.	*Rev.*	*Name*
IWG-DPPS-5bis-06		ULF study 2013-conclusion for detection (Altran)
IWG-DPPS-6-01	2	6th DPPS draft agenda
IWG-DPPS-6-02		6th IWG-DPPS Minutes
IWG-DPPS-6-03		V2 of draft text proposal (IDIADA)
IWG-DPPS-6-04		Sensing Impactor for DPPS (Germany)
IWG-DPPS-6-05		HIT-WAD calculation (Korea)
IWG-DPPS-6-06	2	HIT-WAD _Timing (OICA)
IWG-DPPS-6-07		Positioning of Ped HBM-v0 (OICA)
IWG-DPPS-6-08		Draft text proposal- updated (JASIC)
IWG-DPPS-6-09		Marking-up sketches (OICA)
IWG-DPPS-7-01		draft agenda
IWG-DPPS-7-02		IWG-DPPS 7-draft minutes
IWG-DPPS-7-03		Dynamic Static Test (Korea)
IWG-DPPS-7-04		Test Area (Korea)
IWG-DPPS-7-05		Draft-Annex (Korea)
IWG-DPPS-7-06		THUMS Overview (Toyota)
IWG-DPPS-7-07		Positioning of Ped HBM (OICA)
IWG-DPPS-7-08		GHBMC_M50-PS_Mo (GHBMC)
IWG-DPPS-7-08add		GHBMC addendum-publications (GHBMC)
IWG-DPPS-7=09		Flex-PLI as Sensing Impactor for UN-R127 - Contact Fidelity (Germany)
IWG-DPPS-7-10		Detection Area Width (Germany)
IWG-DPPS-7-11		Generic-Vehicle-Models (TU Graz)
IWG-DPPS-8-01		IWG - draft agenda
IWG-DPPS-8-02		Draft minutes
IWG-DPPS-8-03		Draft text Annex 2 organisation (Korea)
IWG-DPPS-8-04		FlexPLI Biofidelity for Detection - intermediate report (BASt/BGS)
IWG-DPPS-9-01		Draft Agenda
IWG-DPPS-9-02	2	Official minutes
IWG-DPPS-9-03		GTR9 Preamble for FlexPLI as detection impactor (BASt/BGS)
IWG-DPPS-9-04		Proposal GTR9 DPPS Sensor Detection (BASt/BGS)
IWG-DPPS-9-05		UNR127 amendment justification for FlexPLI as detection impactor (BASt/BGS)
IWG-DPPS-9-06		GRSP report

Doc. No.	*Rev.*	*Name*
IWG-DPPS-9-07		Dynamic Static Test comparison (Korea)
IWG-DPPS-9-08		Comments on Korea Proposal for Draft Amendment (Japan)
IWG-DPPS-9-09		Proposal for Condition of Activation of DPPS (Japan)
IWG-DPPS-9-10	1	OICA – HIT simulation (OICA)
IWG-DPPS-9-11		Sensing FlexPLI Impactor Final Evaluation (BASt – BGS)
IWG-DPPS-9-12		Comment on IWG-DPPS-9-09 (BASt)
IWG-DPPS-10-01		Draft Agenda
IWG-DPPS-10-02		Draft Minutes
IWG-DPPS-10-03		IDIADA -Explanation_pressure_data-requirement (Spain)
IWG-DPPS-10-04		Leg_Head_Impact_Location_JASIC (Japan)
IWG-DPPS-10-05		HIT-HBM -TB024 simplification for Regulation (OICA)
IWG-DPPS-10-06		Ped-HBM-Certification for HIT Draft (OICA)
IWG-DPPS-10-07		Decision list
IWG-DPPS-10-08		UN webpages proposals to store Generic Vehicle Models (UN Secretariat)
IWG-DPPS-10-09		Detection Area- Lateral offset of head-Accident Data (BASt)
IWG-DPPS-11-01		Draft Agenda
IWG-DPPS-11-02		Draft Minutes
IWG-DPPS-11-03		Pedestrian Kinematic Assumptions GTR9 (Japan)
IWG-DPPS-11-04		Suggestion on Introduction of HIT Numerical Simulation (Japan)
IWG-DPPS-11-05		Clarification of IWG-DPPS scope (BASt)
IWG-DPPS-11-06		Comment for Detection Area (ACEA)
IWG-DPPS-11-07		Decision list
IWG-DPPS-12-01		Draft agenda
IWG-DPPS-12-02	1	Minutes
IWG-DPPS-12-03		Sensitivity Analysis Pressure Data Requirement (IDIADA)
IWG-DPPS-12-04		Sensitivity Analysis Pressure Data Requirement-GTR9 (IDIADA)
IWG-DPPS-12-05		Pressure Data Requirement-UNR127 (IDIADA)
IWG-DPPS-12-06		Comments on Priority of HIT Prediction Method (Japan)
IWG-DPPS-12-07		Pedestrian Kinematic Assumptions GTR9 (Japan)
IWG-DPPS-12-08		Detection Area II (VDA_SMMT-CCFA)
IWG-DPPS-12-09	1	Clarification for HIT Regression (VDA-SMMT-CCFA)
IWG-DPPS-13-01		Draft agenda

Doc. No.	*Rev.*	*Name*
IWG-DPPS-13-02	1	Minutes
IWG-DPPS-13-03	1	Updated Decision_List
IWG-DPPS-13-04		Consolidated draft proposal of DPPS GTR9 amendment - 210906
IWG-DPPS-13-05		revised 5-04 Pressure Data Requirement (IDIADA)
IWG-DPPS-13-05	1	Rev1 wording for CP options
IWG-DPPS-13-06		System Specifications Proposal (IDIADA)
IWG-DPPS-13-07		Participant list
IWG-DPPS-14-01	1	Official agenda
IWG-DPPS-14-02		Draft minutes
IWG-DPPS-14-03		Comment on HIT calculation-tool and HIT-WAD diagram (Japan)
IWG-DPPS-14-04		Sensing-width (VDA-CCFA)
IWG-DPPS-14-05		DPPS-HBM qualification procedure status (IWG subgroup)
IWG-DPPS-15-01	1	Draft agenda
IWG-DPPS-15-02		Draft & official minutes
IWG-DPPS-15-03		HBM qualification for GTR draft (TF-HBM subgroup)
IWG-DPPS-15-04	3	Draft1 & 2 technical requirements, then working ECE-TRANS-WP.29-GRSP-2022-02e tech requirements
IWG-DPPS-15-05	1	Preamble
IWG-DPPS-16-01	1	Draft & official agenda
IWG-DPPS-16-02	1	Draft & official minutes
IWG-DPPS-16-03		Draft Preamble
IWG-DPPS-16-04		Modified ECE-TRANS-WP.29-GRSP-2022-02e tech requirements
IWG-DPPS-16-05		Annex2_pedestrian_Human_Body_Model_qualification
IWG-DPPS-16-06		Annex3_HIT_determination_simulation
IWG-DPPS-16-07		Proposal HIT vs TRT requirement- OZ
IWG-DPPS-16-08		HIT vs TRT Explanation- OZ
IWG-DPPS-16-09		HBM-Simulations_Flow-Chart_AB
IWG-DPPS-16-10		Condition_for_Static_Test_in_Overshoot_Duration_JAMA
IWG-DPPS-17-01	1	Draft agenda
IWG-DPPS-17-02		Draft minutes
IWG-DPPS-17-03		GRSP-71-26e - DPPS status report
IWG-DPPS-17-04		Decision list

Doc. No.	*Rev.*	*Name*
IWG-DPPS-17-05		Status_Nr_Simulation subgroup
IWG-DPPS-17-06		Annex2_Pedestrian_Human_Body_Model_Qualification
IWG-DPPS-17-07		Annex3_HIT_Determination_Simulation
IWG-DPPS-17-08		Draft preamble
IWG-DPPS-17-09		modified ECE-TRANS-WP.29-GRSP-2022-02e tech requirements
IWG-DPPS-17-10		Overall Flowchart DPPS_ALIGNED with Annex 23
IWG-DPPS-18-01	1	Draft & official agenda
IWG-DPPS-18-02	1	Draft & official minutes
IWG-DPPS-18-03		Annex2_Pedestrian_Human_Body_Model_Qualification
IWG-DPPS-18-04		Annex3_HIT_Determination_Simulation
IWG-DPPS-18-05		modified ECE-TRANS-WP.29-GRSP-2022-02e tech requirements
IWG-DPPS-18-06		Deployment test procedure doubts
IWG-DPPS-18-07		Sensing width-anonymised - Industry
IWG-DPPS-18-08		LAB_Pedestrian_DPPS_area detection width.pptx
IWG-DPPS-18-09		Action list
IWG-DPPS-18-10		Draft Wording Preamble GTR9 wrt Detection Area.docx
IWG-DPPS-18-11		Decision list
IWG-DPPS-18-12		Status Annexes 2 3 Subgroup
IWG-DPPS-18-13		Vehicle width additional fender - definition of RVW
IWG-DPPS-19-01	1	Draft & official agenda
IWG-DPPS-19-02	1	Draft & official minutes
IWG-DPPS-19-03		IDIADA wording subgroup results
IWG-DPPS-19-04		Marking undeployed
IWG-DPPS-19-05		Technical requirements 9Nov
IWG-DPPS-19-06		Preamble (17-08 merged with 18-10)
IWG-DPPS-19-07		Action list
IWG-DPPS-19-08		Annex3_HIT_Determination_Simulation
IWG-DPPS-19-09		Annex2_Pedestrian_Human_Body_Model_Qualification
IWG-DPPS-20-01	1	Draft & official agenda
IWG-DPPS-20-02	1	Draft & official minutes
IWG-DPPS-20-03		Action list
IWG-DPPS-20-04		Preamble 16Nov22
IWG-DPPS-20-05		Technical requirements 16Nov22

Doc. No.	*Rev.*	*Name*
IWG-DPPS-20-06		(OZ) Proposal Overshoot Phase
IWG-DPPS-20-07		(BH-IDIADA)_Dynamic Testing Sync
IWG-DPPS-21		ECE-TRANS-WP.29-GRSP-2023-xx final GTR0-03 proposal IWG-DPPS.docx
IWG-DPPS-21		ECE-TRANS-WP29-GRSP-2023-yy MR1 Amend-4 from IWG-DPPS.docx
IWG-DPPS-21-01	1	Draft & rev1 agenda
IWG-DPPS-21-02	1	Draft & official minutes
IWG-DPPS-21-03		Action list
IWG-DPPS-21-04		Preamble GRSP-72-08
IWG-DPPS-21-05		Technical requirements GRSP-72-09
IWG-DPPS-21-06		Status report GRSP-72-11
IWG-DPPS-21-07	7	consolidated draft.rev1-7- updated 24Jan-15 Feb.2023
IWG-DPPS-21-07		consolidated final - updated 15 Feb.2023
IWG-DPPS-21-08		Dummy_comparison_with_HBM_rev1 Japan-draft
IWG-DPPS-21-09		Dummy_proposal_for_text_of_preamble Japan
IWG-DPPS-21-10	7	Proposal Overshoot Phase (BAST)
IWG-DPPS-21-11	1	Decision_List & Decision_List with text check
IWG-DPPS-21-12	1	smallest_HBM (BAST)
IWG-DPPS-21-13	1	Comments to Document Comparison bet. HBMs (Annex 2) and Pedestrian Dummy (BAST)
IWG-DPPS-21-14	1	only_Annex2-3 update (CK)
IWG-DPPS-22	1	ECE-TRANS-WP.29-GRSP-2023-06e.pdf GTR9-03 Proposal
IWG-DPPS-22	1	ECE-TRANS-WP.29-GRSP-2023-07e.pdf MR1 Addendum 5 proposal
IWG-DPPS-22-01	1	Draft agenda
IWG-DPPS-22-02	1	Draft & official minutes
IWG-DPPS-22-03	1	Head impact time verification (VDA)
IWG-DPPS-22-04	1	consolidated Doc with all changes GTR and UNR- 13Apr23
IWG-DPPS-22-05	1	AC in preamble proposal
IWG-DPPS-22-06	1	Action list updated
IWG-DPPS-23-01	1	Draft agenda
IWG-DPPS-23-02	1	Draft minutes
IWG-DPPS-23-03	1	Test Rig Synchronization for DPPS
IWG-DPPS-23-04	1	Overall Flowchart DPPS_23

Doc. No.	*Rev.*	*Name*
IWG-DPPS-23-05	1	consolidated doc with all changes GTR and UNR 24Apr23
IWG-DPPS-23-06	1	modified_ECE-TRANS-WP29-1101-Amend-5
IWG-DPPS-23-07	1	OZ small group on tolerances Proposal on 28Apr2023
IWG-DPPS-23-08	1	GRSP-73-10 MR1-Amend4 Addendum5 GVM consolidated 28Apr, 11May
IWG-DPPS-23-09	1	GRSP-73-11 MR1-Amend5 Addendum6 HBM informal 28Apr
IWG-DPPS-23-10	1	GRSP-73-12 GTR9-03 informal doc
IWG-DPPS-23-11	1	GRSP-73-13 IWG-DPPS final status report
IWG-DPPS-24-01	1	draft agenda
IWG-DPPS-24-02	1	Draft minutes
IWG-DPPS-24-03	1	MR1_related_to_IWG-DPSS -CK
IWG-DPPS-24-04	1	2023_06_28_GV-Models_DPSS
IWG-DPPS-24-05	1	2023.06.16 - Structure_IM
IWG-DPPS-25-01	1	Draft_agenda
IWG-DPPS-25-02	1	Draft & official minutes
IWG-DPPS-25-03	5	GTR9-03 DPPS amendment draft
IWG-DPPS-25-04	4	MR1_related_to_IWG-DPSS draft
IWG-DPPS-25-05		Documentation Generic Vehicle Models
IWG-DPPS-25-06		OICA draft preamble on GV Models-f
IWG-DPPS-25-07		OICA background on preamble on GV Models
IWG-DPPS-26-01	2	Draft_agenda
IWG-DPPS-26-02	1	Draft minutes
IWG-DPPS-26-03	1	GTR9-03 DPPS amendment draft – last modifications with comments
IWG-DPPS-26-04	1	GTR9-03 DPPS amendment draft – consolidated last modifications-clean
IWG-DPPS-26-05	1	GTR9-03 DPPS final status report – updated for Dec23 GRSP
IWG-DPPS-26-06		MR1 amend 4 draft – consolidated last modifications

"

Part II, Text of the Regulation,

Paragraph 3., amend to read:

"3. Definitions

When performing measurements as described in this Part, the vehicle shall be positioned in its normal ride attitude.

In case of the vehicle equipped with a deployable pedestrian protection system (DPPS) as defined in paragraph 3.16., the measurements shall be taken with the system undeployed.

If the vehicle is fitted with a badge…

…"

Paragraph 3.24. ("Assessment Interval" (AI)), renumber as paragraph 3.3.

Paragraphs 3.3. to 3.14.(former), renumber as paragraphs 3.4 to 3.15.

Insert new paragraphs 3.16. to 3.19., to read:

"3.16. "Deployable Pedestrian Protection System (DPPS)" means a technical system, which is activated for head protection of a pedestrian in the event of a collision of the vehicle with a pedestrian. It comprises a deployment module, together with other related components required for its function, such as bonnet, sensors, or wiring, etc.

3.17. "Deployment module" means a unit, comprising components, such as airbags, springs, or pyrotechnic actuators, etc., that are used to change the vehicle outer surface from a position of normal use in the vehicle to a deployed position.

3.17.1. "Initiation of the deployment module" means, at the option of the manufacturer, either the moment when visible movement of the actuator is initially detected, or the moment when the triggering signal is sent from the electronic control unit to the deployment module.

3.18. "Deployment Time (DT)" means the duration from the initiation of the deployment module(s) until the DPPS reaches its maximum deployment height for the first time. Measurement shall be done on the outer surface of the DPPS, in the area above the lifting device(s).

3.18.1. "Deployed position" means the position of the vehicle outer surface equipped with a DPPS that can be maintained by the system after its activation, as shown in Figure 1-1 of Annex 1.

3.18.2. "Undeployed position" means the position of the vehicle outer surface equipped with a DPPS when the DPPS is not activated.

3.19. "Detection test area" is the area designated to detect a pedestrian in order to activate the deployable system. The width of the detection test area shall be the relevant vehicle width, minus a distance from each side of 12.5 per cent of the relevant vehicle width, but not more than 250mm from each side. The detection test area must not be smaller than the area inboard of the corners of bumper (CoB) minus a distance of 42mm on each side, as measured horizontally and perpendicular to the longitudinal median plane of the vehicle. (see Figure 11)."

Paragraphs 3.15. to 3.18.(former), renumber as paragraphs 3.20 to 3.23.

Insert new paragraph 3.24., to read as follows:

"3.24. "The pedestrian Head Impact Time (HIT)" is defined as the elapsed time subsequent to the time of first contact of the pedestrian surrogate (neglecting forearms and hands) with the vehicle outer surface and the time of first contact of its head with the vehicle outer surface.

There are two kinds of HIT :

3.24.1. HIT_d : to decide whether the physical head test on the deployable system can be done dynamically or statically. The HIT_d is determined with the deployed DPPS.

3.24.2. HIT_s : to synchronise the test rig for dynamic testing. The HIT_s is determined with the undeployed DPPS."

Paragraphs 3.19 to 3.23.(former), renumber as paragraphs 3.25. to 3.29.

Insert new paragraph 3.30., to read as follows:

"3.30. "Outer surface" means those components of the vehicle, which may be contacted by the pedestrian in case of an accident. The outer surface may include the bumper, the bonnet, the fenders, but also external airbags or other components."

Paragraphs 3.25. and 3.26.(former), renumber as paragraphs 3.32 and 3.33.

Insert new paragraphs 3.34. to 3.36., to read:

"3.34. "Relevant Vehicle Width (RVW)" is the maximum width of the vehicle without devices for indirect vision, measured on or in front of a vertical transverse plane passing through the front axle of the vehicle.

3.35. "Sensing Time (ST)" means the duration from the time of the first contact of the flexible lower legform impactor (FlexPLI) with the vehicle outer surface to the initiation of the deployment module.

3.36. "Sensors" are pedestrian contact sensors that detect a pedestrian contact with the front of the vehicle. These sensors include, but are not limited to, accelerometers, fibre optic sensors, pressure sensors, etc."

Paragraphs 3.27. to 3.29. (former), renumber as paragraphs 3.37. to 3.39.

Insert new paragraphs 3.40. to 3.42., to read:

"3.40. "Testing of the DPPS":

The headform impact tests on the DPPS can be performed in three ways: statically, dynamically or combined.

3.40.1. "Static testing" means the launch of the headform on a DPPS being in the deployed position.

3.40.2. "Dynamic testing" means the synchronised launch of the headform onto the deploying DPPS at the appropriate HIT_s.

3.40.3. "Combined testing" means a mixed set of tests on a DPPS in which a given test is run either statically or dynamically.

3.41. "Testing time" for static time constraint means the timeframe after the DPPS reaches its deployed position in which the headform test to the DPPS is to be performed (see Figure 1-2 of Annex 1).

3.42. "Total Response Time (TRT)" means the duration from the time of first contact of the FlexPLI with the vehicle outer surface to the time the DPPS reaches its maximum deployment height for the first time. It is the sum of the ST and DT."

Paragraphs 3.30 to 3.32 (former), renumber as paragraph 3.43 to 3.45.

Figure 1, the title, amend to read:

"Figure 1.
Bonnet leading edge reference line (see paragraph 3.6.)"

Figure 2, the title, amend to read:

"Figure 2.
Bonnet rear reference line. (see paragraph 3.7.)"

Figure 3, the title, amend to read:

"Figure 3.
Template (see paragraph 3.7.)

Figure 4, the title, amend to read:

"Figure 4.
Marking of intersection between bonnet rear and side reference lines (see paragraph 3.7.)"

Figure 5A, the title, amend to read:

"Figure 5A.
Corner of bumper example (see paragraph 3.15., note that the corner gauge is to be moved in vertical and horizontal directions to enable contact with the outer contour /front fascia of the vehicle)"

Figure 6, the title, amend to read:

"Figure 6.
Impact and target point (see paragraphs 3.26. and 3.38.)"

Figure 7, the title, amend to read:

"Figure 7.
Lower bumper reference line, LBRL (see paragraph 3.28.)"

Figure 8, the title, amend to read:

"Figure 8.
Side reference line (see paragraph 3.37.)"

Figure 9, the title, amend to read:

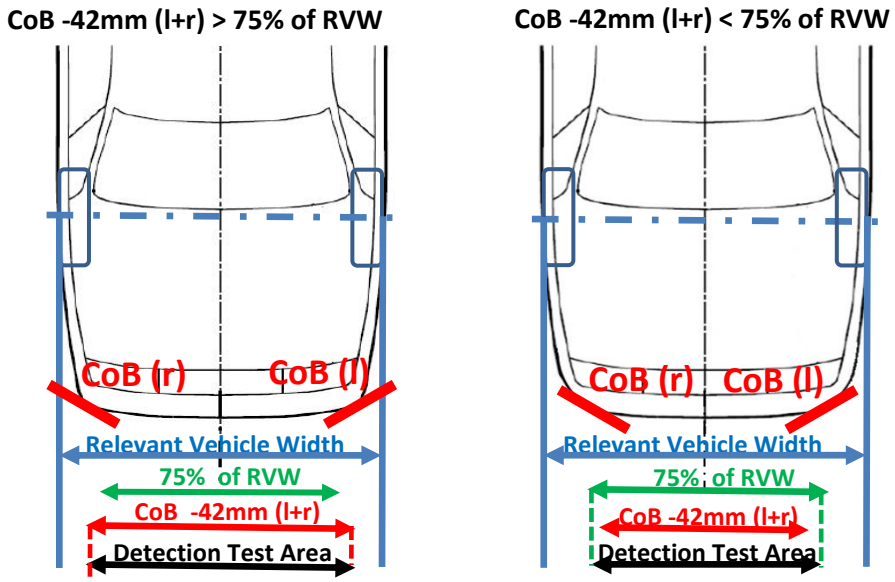
"Figure 9.
Upper bumper reference line, UBRL (see paragraph 3.43.)"

Figure 10, the title, amend to read:

"Figure 10.
Wrap around distance (WAD) measurement (see paragraph 3.44.)"

Insert new Figure 11, to read:

"Figure 11
Determination of the Detection Test Area (see paragraph 3.19): examples



Figures 11 to 30 (former), renumber as Figures 12 to 31.

Paragraphs 5.2., 5.2.1. and 5.2.2., amend to read:

"5.2. Headform tests

When tested as a DPPS, the test conditions and requirements in Annex 1 shall apply.

5.2.1. Child headform to the front structure:

When tested in accordance with paragraphs 7.2., 7.3. and, if applicable, Annex 1, the HIC shall comply with paragraph 5.2.3.

5.2.2. Adult headform to the front structure:

When tested in accordance with paragraph 7.2., 7.4. and, if applicable, Annex 1, the HIC shall comply with paragraph 5.2.3."

Insert new paragraph 6.2.4., to read:

"6. Test specifications

6.2. Preparation of the vehicle

…

6.2.4. When tested as a DPPS, the vehicle shall be adjusted as specified in the test procedure defined in Annex 1."

Insert new Annexes 1 to 2, to read:

"**Annex 1**

Test Procedure for the Deployable Pedestrian Protection Systems

1. Prerequisites

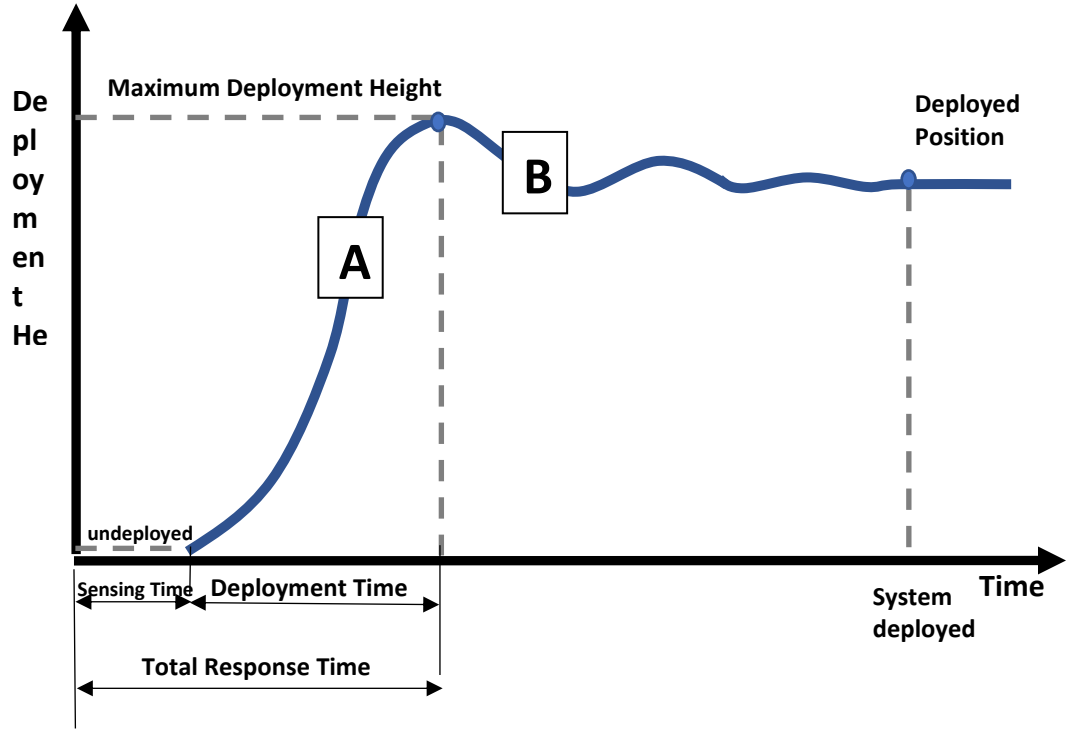
If all of the following prerequisites are met, the vehicle shall be tested with the DPPS activated as intended (as described below) for the entire headform test area.

Based on a determination by each Contracting Party, a Contracting Party may either allow static tests, dynamic tests, and a combination thereof, or stipulate dynamic tests only.

For DPPS to be assessed statically, dynamically or combined, it will be necessary for the vehicle manufacturer to identify detailed information highlighted in this Annex before any testing begins. The vehicle manufacturer shall identify all necessary information regarding detection of pedestrians and the deployment of the system. Based on the evidence identified, activation of the system in the headform test will be determined.

The principle of testing the DPPS is as follows:

Figure 1-1
Deployment Time History Curve



(a) In case of HIT_d < TRT, the headform test shall be performed dynamically;

(b) In case of HIT_d ≥ TRT, the headform test may be performed either statically at a height no more than the deployed position or dynamically.

1.1. If any of the prerequisites from paragraphs. 1.2 to 1.7. are not met, the vehicle shall be tested with the DPPS in the undeployed position.

1.2. System specification:

As a Contracting Party option, a technical description of the DPPS components shall be identified by the manufacturer. This shall be accompanied by the following information:

1.2.1. For the sensing system:

(a) Sensor type (e.g. pressure, optical, acceleration, etc.);

(b) Sensor locations;

(c) Operation process (including the lower deployment threshold speed of the DPPS).

1.2.2. Deployment information:

(a) Technology of the DPPS (airbag, active bonnet, etc.);

(b) Mechanism explanation;

(c) Component description (lifting system (e.g. actuator), hinge, latch, etc.);

(d) Deployed position information (not required for dynamic testing);

(e) TRT (ST and DT separately) information (~~not required~~ for dynamic testing, ST only);

(f) Evolution of system stability (e.g. pressure or force versus time diagram) (static testing, only).

1.3. The marking of the headform test areas of the DPPS shall always be done in undeployed position, for static, dynamic or combined testing.

1.4. Headform test for protection below the lower deployment threshold speed of the DPPS.

1.4.1. The vehicle outer surface shall remain in undeployed position.

1.4.2. The test procedures specified in paragraphs 7.2. to 7.4. of this Regulation shall apply with the impact speed specified at 0.9 times the lower deployment threshold speed. The allocation of the HIC1700 and HIC1000 Zones may differ from those at nominal velocity (9.7 m/s) headform impact tests according to paragraph 5.2.4 of this Regulation.

1.4.3. The HIC shall comply with paragraph 5.2.3. of the Regulation.

1.5. HBM shall be qualified according to Addendum 5 of Mutual Resolution No. 1 (M.R.1). HIT information shall be documented according to Annex 2 of this Regulation.[1]

1.6. Verification of the prerequisites for deployed static tests: Deployed Position, Maximum Deployment Height, ST and DT as illustrated in the deployment time history curve (see Figure 1-1 of this Annex).

The values specified by the manufacturer shall be verified by using appropriate tracking means, such as high-speed videos, accelerometer, or laser at the reference points as indicated by the manufacturer (on the lifting devices). The tolerance for the ST is -5ms/+3ms on the specified value, whereas the other tolerances are ±20 percent on the specified values respectively. If a measured value is within the defined tolerances, the values specified by the manufacturer shall be used. Otherwise, the measured values shall be used.

1.7. Sensing System Verification

[1] Will be updated with DPPS Phase 2 (HIT determination by a generic approach option).

1.7.1. The vehicle manufacturer shall specify the lowest speed of activation (lower deployment velocity threshold) of the DPPS.

1.7.1.1. For the system deployment verification, sensor activation tests with the FlexPLI, as specified in paragraph 6.3.1.1. of this Regulation, shall be performed within the detection test area at the DPPS lower deployment velocity threshold.

1.7.2. A test with the FlexPLI shall be performed at nominal velocity (11.1m/s) at vehicle centreline (Y0).

1.7.3. Where a test is performed within the tolerances as specified in paragraph 3 of this Annex, but below the ~~nominal~~ lower deployment velocity threshold or outside the detection test area and the system does not deploy, the test must be repeated.

1.7.4. If the system is not activated during any of the verification tests, all headform tests shall be conducted in undeployed position according to paragraphs 7.2. to 7.4. of this Regulation.

1.7.5. For tests with stationary vehicle: the vehicle shall be set to the normal running condition as specified by the manufacturer for a vehicle speed corresponding to the particular use case.

2. Verification of the Total Response Time and /or Sensing Time at Nominal Velocity

2.1. TRT shall be confirmed by using the FlexPLI at the vehicle speed at 11.1 m/s and at the vehicle centreline (Y0).

2.2. ST is measured either independently, or during a TRT measurement test, at the vehicle speed as specified in this Regulation and at the vehicle centreline (Y0).

2.2.1. If the measured ST is within a tolerance of -5ms/+3ms, the value specified by the manufacturer shall be used. Otherwise, the measured value shall be used for the test. For dynamic testing, only ST shall be verified.

2.2.2. For tests with stationary vehicle: the vehicle shall be set to the normal running condition as specified by the manufacturer.

3. Tolerances

For verification tests of paragraphs 1.7 and 2 of Annex 1 with the FlexPLI, the following tolerances shall apply:

3.1. For tests with a moving vehicle impacting the stationary impactor: Target speed: ±0.6 m/s: impact accuracy: ±50 mm.

3.2. For tests with a propulsion system propelling the impactor against the stationary vehicle:

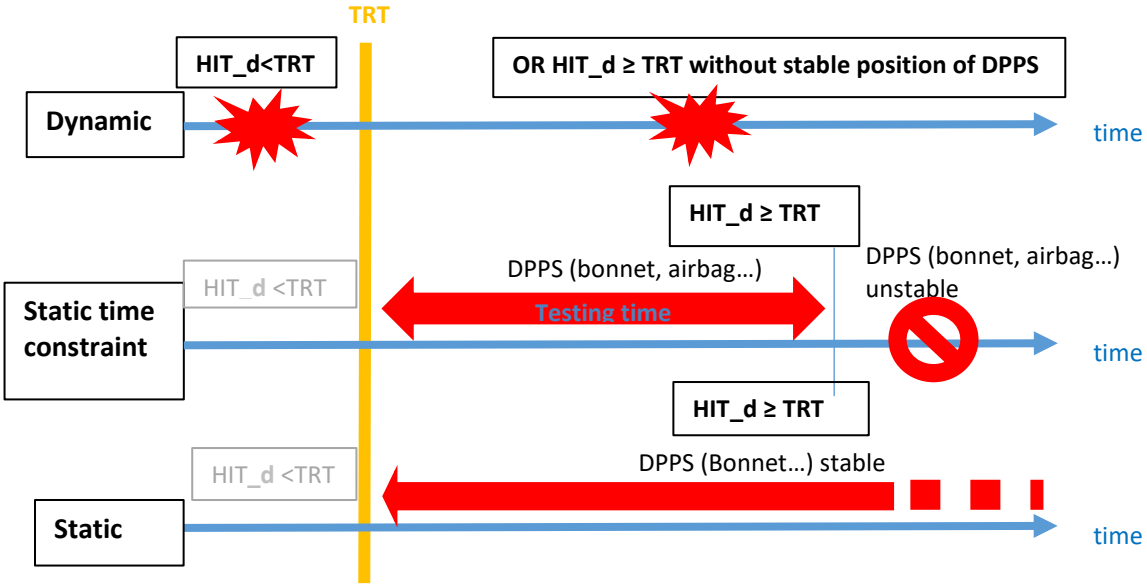
Target speed, impact accuracy, angle tolerances are those of the performance tests, as in paragraph 7.1. of the Regulation.

4. Headform Test Procedure at Nominal Velocity (9.7m/s)

The selection of impact points and the allocation of the HIC1700 and HIC1000 zones shall always be based on and related to the test area with undeployed DPPS.

4.1. Static test option:

If the vehicle manufacturer opts for the static test procedure, the following conditions shall be fulfilled. If so, the headform tests on the headform test area shall be performed statically.



If any of the following conditions are not met, the headform tests on the headform test area shall be performed dynamically.

4.1.1. Where the vehicle manufacturer has demonstrated by numerical simulations on the deployed DPPS, that HIT_d ≥ TRT for the smallest selected pedestrian stature, as defined in Annex 2, then all tests may be performed statically.

4.1.2. The vehicle outer surface shall represent the deployed position (see Figure 1-1, B section) within the specified tolerances, while the resisting force is considered:

4.1.2.1. Static time constraint condition, linked to the resisting force:

When there is a constraint on time for the stability of the system and HIT_d ≥TRT, the launching time of the headform impactor shall ensure that the system remains stable (tolerance ±10 per cent of corresponding resisting force), as identified by the manufacturer (prerequisite in paragraph 1.2. of Annex 1).

Based on the evolution of system stability (see Figure 1-2), a decision can be made on how to perform the test. During the static tests it shall be ensured that the resisting force of the DPPS is equivalent to the actual situation at HIT.

Figure 1-2
Timeline for dynamic, static time constraint and static testing representing real life conditions

4.1.2.2. Appropriate means (e.g. actuator surrogates) may be used to ensure that the corresponding resisting force of the DPPS is reached.

4.1.3. The test procedures specified in paragraphs 7.2. to 7.4. of this Regulation shall apply.

4.1.4. Test accuracy at impact location

4.1.4.1. Prior to conducting the static tests at 9.7 m/s, one headform test at the discretion of the test laboratory may be conducted on the undeployed DPPS to confirm that impact velocity and impact location are within tolerances.

4.1.4.2. If the tolerances for impact speed and location are met during the test on the undeployed DPPS, there is no requirement to prove that these tolerances are still met during the static tests, provided that test inputs remain the same.

4.1.4.3. Alternative methods to demonstrate the test accuracy may also be accepted.

4.2. Dynamic test option

4.2.1. The dynamic verification of a DPPS is based on a headform test performed on the DPPS, where the headform launch device and DPPS deployment are synchronised to achieve the correct HIT_s.

The following steps are conducted:

4.2.1.1. Test accuracy at impact location

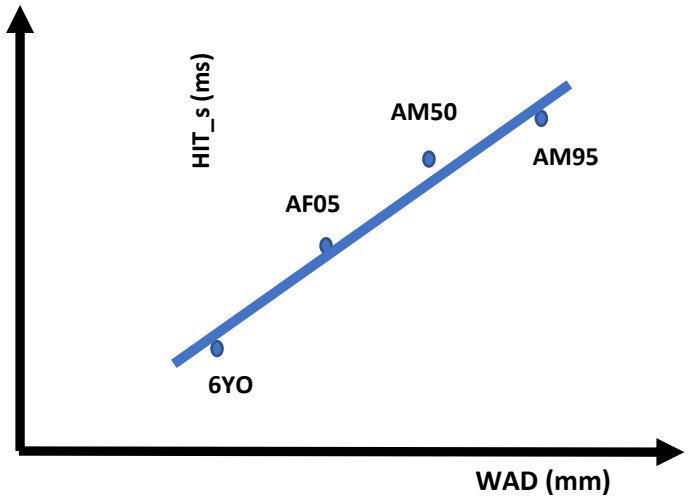
Prior to conducting the dynamic tests at 9.7m/s, one headform test at the discretion of the test laboratory shall be conducted on the undeployed DPPS to confirm that impact velocity and impact location are within tolerances.

If the tolerances for impact speed and location are met during the undeployed test, there is no requirement to meet these tolerances during dynamic tests, provided test inputs remain the same.

4.2.1.2. To enable dynamic testing to be conducted, HIT_s and ST are required inputs, which shall be established by the following:

(a) HIT_s (see Fig. 1-3 hereafter, obtained from Annex 2, Figure 2-3).

Figure 1-3
Head Impact Time(s for synchronisation) versus Wrap Around Distance (HIT_s vs WAD)



(b) ST is determined from the manufacturer prerequisite or sensor verification test, carried out at the vehicle centreline (Y0).

4.2.1.3. Fire Delay

The test facility shall ensure that the head impact occurs at the correct time relative to the deployment of the DPPS, taking into account the HIT_s for the corresponding WAD of the head impact point from Figure 1-3 and ST, as shown in the example in Figure 1-4 (a) below.

"Fire Delay" is the elapsing time between the initiation of the headform launch and the initiation of the DPPS deployment module.

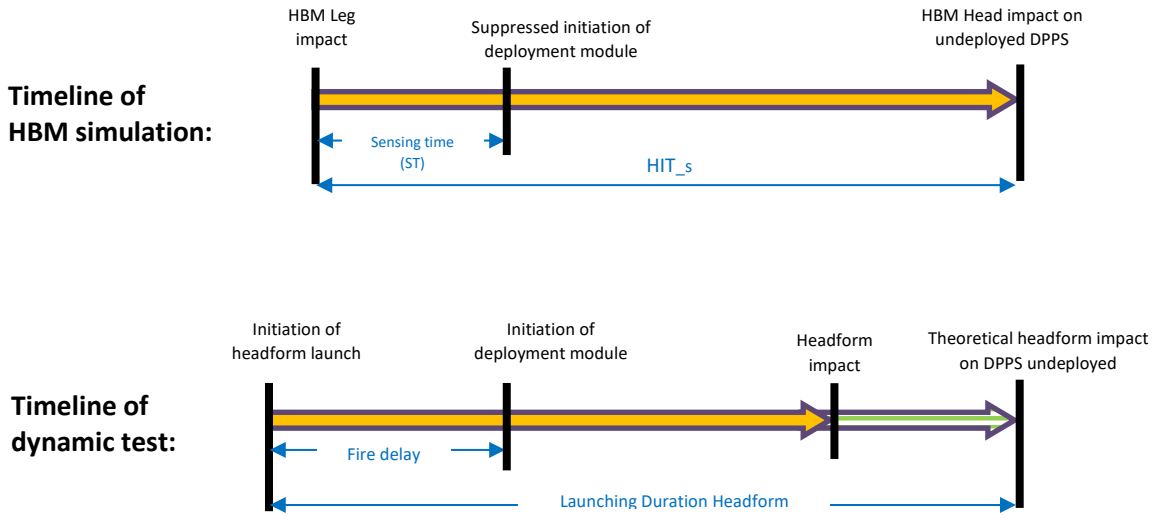
It is determined according to the equation:
Fire Delay = Launching Duration Headform Impactor – (HIT_s – ST).

The "Launching Duration Headform Impactor" is rig-specific and is the time period between launching of the headform impactor and the theoretical time of head impact on the undeployed DPPS. Due to the DPPS deployment during

testing, the actual launching duration of the headform impactor is expected to differ from the calculated launching duration headform impactor (time difference: see example in Figure 1-4 (b)).

Figure 1-4 (a)

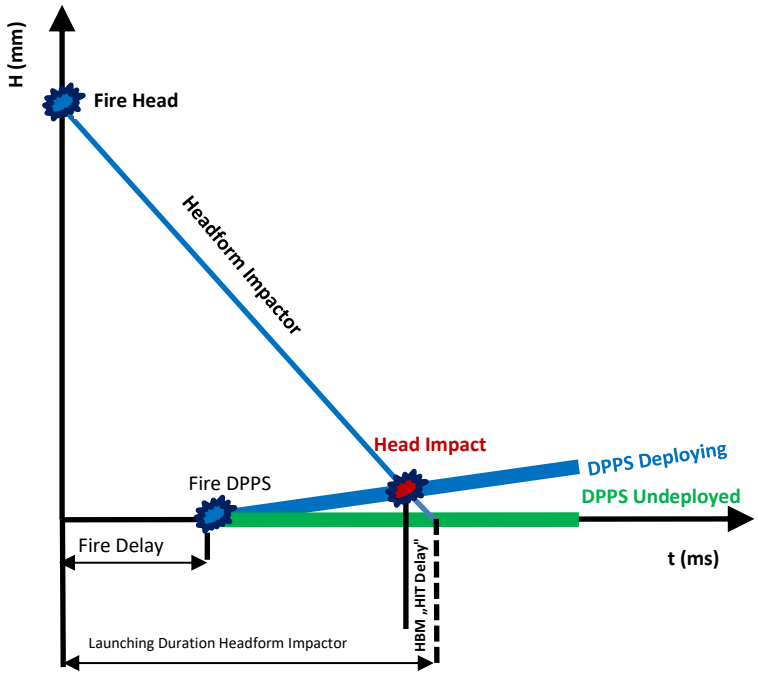
Synchronization of Test Rig and DPPS Deployment (Example).



Fire delay = Launching duration headform impactor - (HIT_s - ST)

Figure 1-4 (b)

Effect of DPPS Deployment on Launching Duration Headform Impactor (Example).

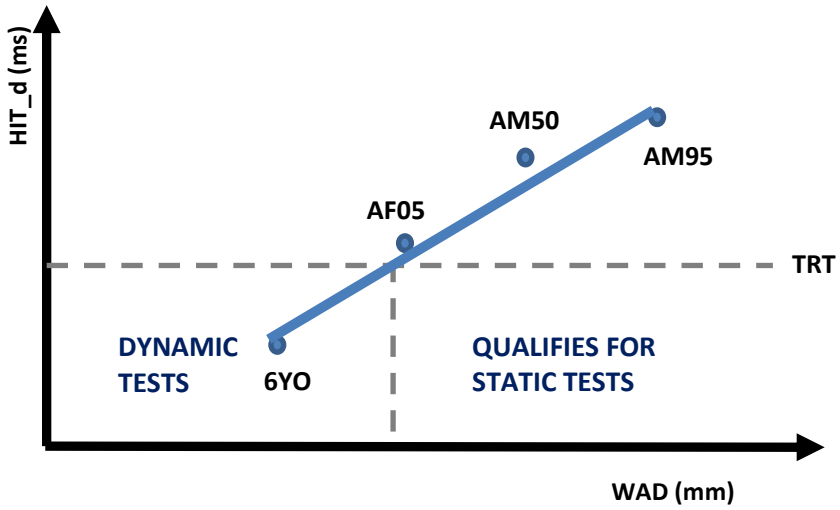


4.3. "Combined" test option:

Combined static and dynamic tests may apply, at manufacturer's choice.

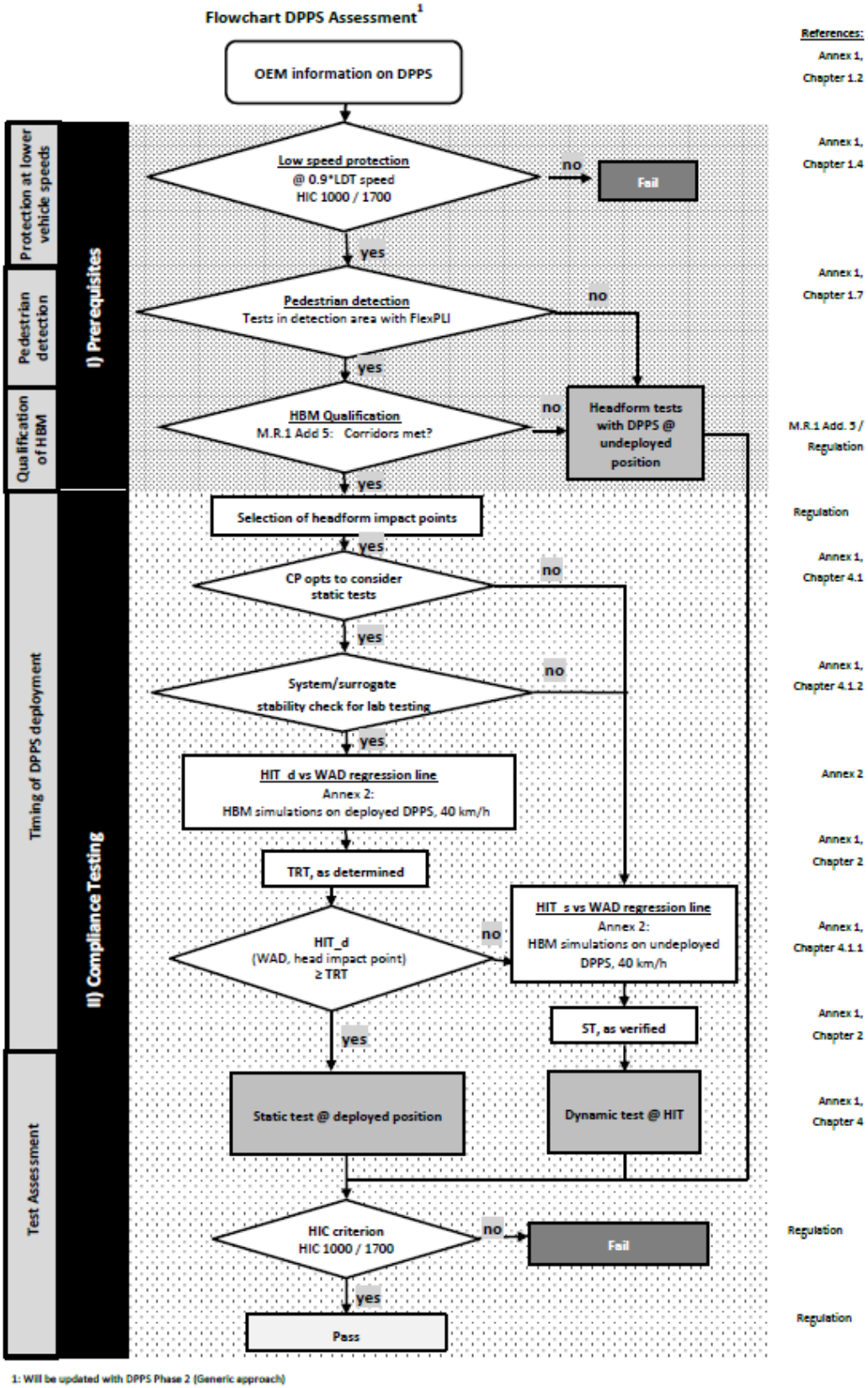
If the headform test area consists of sections where the HIT_d at the corresponding impact point is less than TRT (HIT_d <TRT) , as in the A section in Figure 1-1, and sections where the HIT_d at the corresponding impact point is greater than or equal to TRT (HIT_d ≥TRT, as in the B section in Figure 1-1, then all test points forward of the corresponding WAD (HIT_d < TRT) shall be tested dynamically. The remaining section of the headform test area may be tested statically (see Figure 1-5 below, obtained from Annex 2, Figure 2-2).

Figure 1-5
Scheme of HIT_d vs WAD for Combined Testing



Annex 1 - Appendix

Flowchart DPPS Assessment Guideline

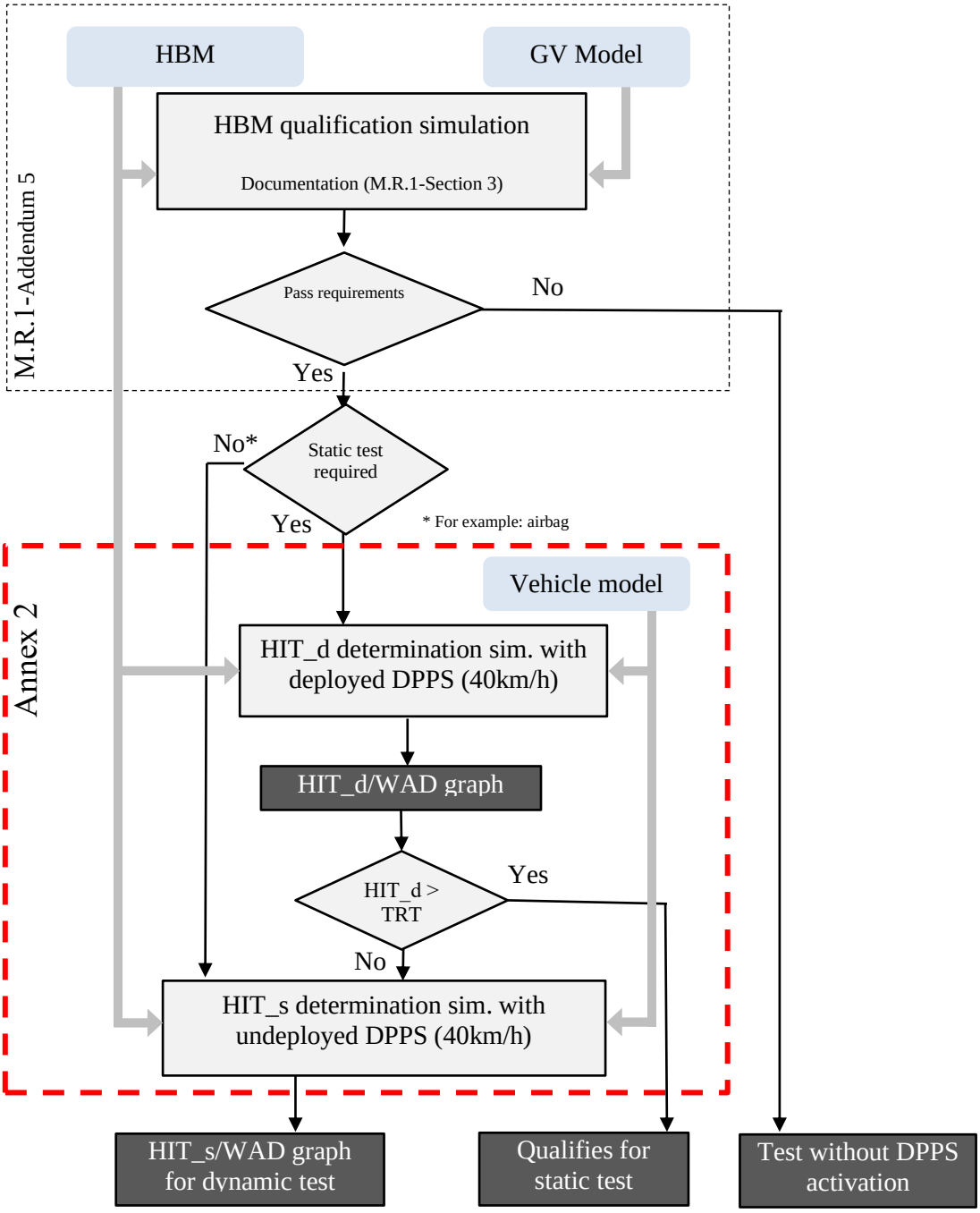


Annex 2

Head Impact Time (HIT)- Determination Simulation

1. Introduction

An HIT-Determination simulation is a computer simulation for determination of HIT over WAD in the DPPS vehicle model for deriving the test conditions for the assessment of deployable systems as specified in the Annex 1.



1.2. Definitions

For the purposes of this annex:

1.2.1. "Generic Vehicle (GV) Models" are generic replications of car fronts representing three vehicle categories: Family Cars (FCR), Roadsters (RDS), Sports Utility Vehicles (SUV). (The shape of the generic Multi-Purpose-Vehicle (MPVs) was found to lay in between the generic FCR and generic SUV and is therefore covered already.) The vehicle models provide representative shapes for the selected vehicle categories as well as median structural response upon pedestrian impact in terms of force- deflection characteristics and are modelled to be robust and transferable to all considered explicit Finite Element (FE) codes.

1.2.2. "Human Body Model" (HBM) is understood as a virtual geometric and mechanical representation of the human body, which takes the human anatomy into consideration. The procedure described in this Annex refers to HBMs used for the simulation of pedestrian impacts. Pedestrian models which are required for GTR No. 9 shall be selected from the following statures, a six-year-old (6YO), 5th percentile female (AF05), 50th percentile male (AM50) and 95th percentile male (AM95).

1.2.3. "HBM qualification simulation": A computer simulation (HBM vs. GV Model) providing evidence that the specific HBM simulation is comparable with reference simulations and shows consistent results – in particular referring to HIT and WAD. The reference simulations are based on models which have been validated by comparing their simulation response with PMHS tests. Another purpose is to make sure that models give comparable results with varying hardware or software environments when applied for a specific purpose.

1.3. General Requirements

1.3.1. It shall be ensured that the HBMs used in this Annex comply with all requirements within Addendum 5 of Mutual Resolution No.1 (M.R.1). The qualification results shall be documented as specified in Addendum 5 of M.R.1.

1.3.2. Only those HBM statures selected according to paragraph 2.2. of this Annex shall be qualified.

1.3.3. The pedestrian HBM that is qualified is the very same model as used for HIT determination simulations. This applies to:

(a) Version of the HBM;

(b) Node-Position of every single node of the HBM;

(c) Identical material cards (including fracture mode), contact cards, control cards and constraints;

If available:

(d) identical initial element stresses/strains;

(e) identical initial contact penetrations/contact forces.

1.3.4. Furthermore, all simulations (qualification and HIT determination) shall be performed with consistent settings. This applies to:

(a) Solver-Version and type (e.g. processing type, precision, parallelisation);

(b) The time-step used for simulations;

(c) Time-step settings (relating to initial and dynamic mass scaling);

(d) Contact settings (between HBM and Vehicle);

(e) Control settings which are affecting the pedestrian model.

2. Procedure

2.1. Impact Simulations

Pedestrian models shall be selected from the following statures, a six-year-old (6YO), 5th percentile female (AF05), 50th percentile male (AM50) and 95th percentile male (AM95). The pedestrian position and stance to be used in the model is defined in Addendum 5 of M.R.1. The pedestrian model has to be positioned, such that the head centre of gravity (CoG) is aligned with the vehicle centreline.

The vehicle model has to be positioned in the setup such that the vehicle ground level is aligned with the ground level used in the qualification simulations.

As described in Addendum 5 of M.R.1, the HBM shall be exposed to a vertical acceleration field constituting the gravitational loading.

A local vehicle coordinate system has to be initially aligned with the global coordinate system defined in Addendum 5 of M.R.1 and shall be connected to the vehicle model CoG.

The initial speed of the vehicle model has to be prescribed and is 40 km/h for all simulations. The y and z motion of the car has to be constrained and the motion in x-direction must not be constrained.

2.2. Selection of HBMs

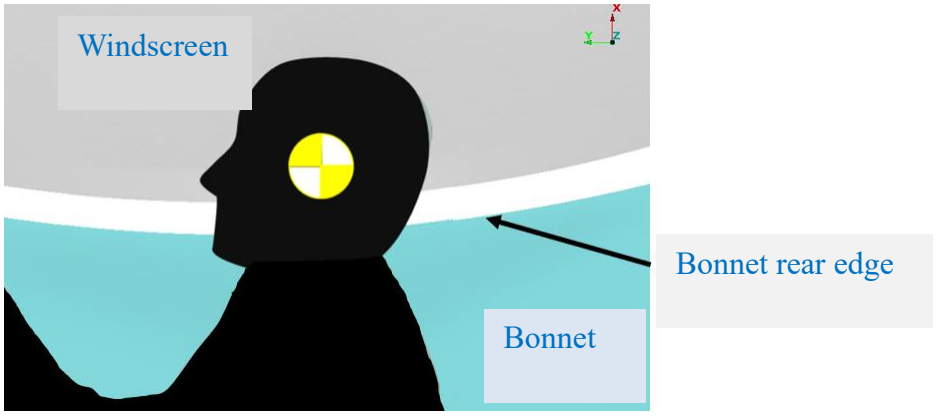
The selected HBMs (needed to draw the WAD/HIT-line in the evaluation) are those HBMs where the head hits the DPPS properly, which is when:

- there is a contact between the head and DPPS.
- at time of this contact the x-coordinate of the CoG of the head is between the smallest and largest x-coordinate of the DPPS at y=0.

Simulations with the next tallest HBM shall also be performed, but only to prove that this HBM does not hit the DPPS properly.

If only one HBM hits the DPPS properly, the next tallest HBM shall also belong to the selected HBMs.

Figure 2-1
Example (where the CoG of the head lies behind the DPPS at time of contact. This HBM does not hit the DPPS properly (only contact with chin of HBM))



2.3. Output Requirements

It shall be confirmed that the following outputs have been generated from each simulation, time history curves of:

(a) x and z coordinate of HC and AC in the global coordinate system;

(b) x displacement of vehicle CoG in the global coordinate system;

(c) Resultant acceleration of HC;

(d) Contact forces (between vehicle and HBM without upper extremities, vehicle and HBM head and total contact force);

(e) Total hourglass and internal energies of the total setup;

(f) Mass increase.

All shall be plotted every 0.1ms or less.

Furthermore, animations of the simulations shall be generated with an output interval of 1ms.

2.4. Quality Checks

The following Quality Checks shall be performed:

(a) Contact force (between HBM and vehicle) is zero at simulation start;

(b) Total energy remains constant within a 15 per cent tolerance;

(c) Hourglass energy ≤ 10 per cent of the total energy;

(d) Artificial mass increase is less than 3 per cent.

2.5. Calculation of Head Impact Time

Time of first contact is defined as the first time where the contact force is not zero anymore.

The Head Impact Time (HIT) is defined as the elapsed time subsequent to the time of first contact of the HBM (neglecting forearms and hands) with the vehicle outer surface and the time of first contact of its head with the vehicle outer surface.

If this method is for any reason not applicable, an appropriate alternative method may be applied and shall be reported.

2.6. Determination of WAD corresponding to HIT

For the determination of the WAD, a point on the surface of the vehicle is necessary. This point is defined as follows (all coordinates relative to the local vehicle coordinate system):

At time of first head contact with the DPPS the point

$(x_{head}, 0, z_{head})$

where:

x_{head} is the x-coordinate; and

z_{head} is the z-coordinate of the CoG of the head

will be projected orthogonally onto the surface of the undeployed vehicle. (If there are multiple projection points take the one with the highest x value.)

Compute the WAD for this point rounded the nearest full millimetre.

3. Documentation

3.1. General

The following information shall be documented:

(a) Date of report;

(b) Name of car manufacturer;

(c) Type and release version of software (FE-software package name, revision and version);

(d) Name and version of the HBM;

(e) Specification of car.

Images showing the front view and side view of the pedestrian, at t0 and at the time of head impact shall be added to the report.

3.2. Consistency with qualification simulations

For all simulations Table 2-1 shall be filled in.

Table 2-1
Check of consistency between qualification and HIT determination simulations

Checklist for simulation settings	Consistent between qualification and HIT determination simulations:
Identical HBM	Y/N
Solver Version	Y/N
Timestep	Y/N
All other control settings	Y/N

3.3. Quality Checks

For all simulations Table 2-2 shall be filled in.

Table 2-2
Quality Checks

Verification evaluation criteria	Allowed	Observed	Pass:
Coefficient of friction between Vehicle and HBM	0.3		Y/N

Verification evaluation criteria	Allowed	Observed	Pass:
Head centre of gravity is positioned at vehicle centreline	Y=0 mm		Y/N
Contact force between HBM and vehicle at simulation start	0		Y/N
Change in total energy throughout simulation	≤15%		Y/N
Amount of hourglass energy relative to total energy	≤10%		Y/N
Artificial mass increase relative to total mass of the setup	≤3%		Y/N

3.4. Results of HIT determination simulations

For those HBMs that are selected according to paragraph 2.2. of this Annex, the computed HIT-Values and corresponding WADs have to be filled into the following Tables 2-3 and 2-4.

If HIT_d ≥ TRT for all HBMs, simulations on the undeployed DPPS are not required.

Table 2-3
HIT_d Simulations on DPPS in Deployed Mode

HBM	WAD (mm)	HIT_d (ms)
6YO		
AF05		
AM50		
AM95		

Table 2-4
HIT_s Simulations on DPPS in Undeployed Mode

HBM	WAD (mm)	HIT_s (ms)
6YO		
AF05		
AM50		
AM95		

For each simulation, the following diagrams shall be documented:

(a) ACx and HCx as a function of time;

(b) ACz and HCz as a function of time;

(c) HCz as a function of HCx and ACz as a function of ACx;

(d) Total Contact Force between HBM and vehicle as a function of time;

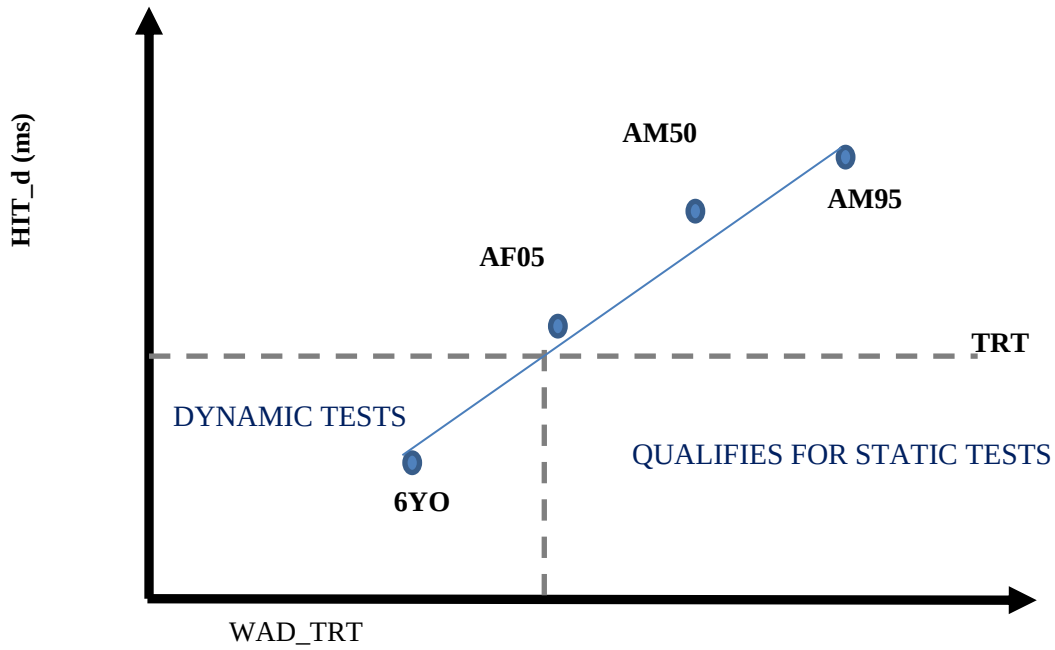
(e) Total, kinetic, internal and hourglass energy as a function of time.

4. Evaluation

4.1. HIT_d Simulations with Deployed DPPS

Based on the results of Table 2-3, a graph shall be plotted using a linear regression line for comparison with TRT in the diagram as shown in Figure 2-2.

Figure 2-2
Wrap Around Distance versus Head Impact Time_for decision (WAD vs HIT_d)



4.2. HIT_s Simulations with Undeployed DPPS

Based on the results of Table 2-4, a graph shall be plotted using a linear regression line as shown in Figure 2-3. The lines have to be extrapolated in both directions.

Figure 2-3
Wrap Around Distance versus Head Impact Time_s (s for synchronisation) (WAD vs HIT_s)