A. STATEMENT OF TECHNICAL RATIONALE AND JUSTIFICATION

I. Safety Need

Each year, thousands of pedestrians and cyclists are struck by motor vehicles. Most of these accidents take place in urban areas where serious or fatal injuries can be sustained at relatively low speed, particularly in the case of children.

This proposed global technical regulation is based on data from the International Harmonised Research Agenda (IHRA)[1] Pedestrian Safety working group (IHRA/PS). The data was sourced from Australia, Germany, Japan and the United States. Data from IHRA[2], Germany[3], Italy[4], the UN ECE[5], Spain[6], Canada[7], the Netherlands[8], Sweden[9], and Korea[10] indicate that, annually: in the European Union about 8,000 pedestrians and cyclists are killed and about 300,000 injured; in North America approximately 5,000 pedestrians are killed and 85,000 injured; in Japan approximately 3,300 pedestrians and cyclists are killed and 27,000 seriously injured; and in Korea around 3,600 pedestrians are killed and 90,000 injured.

The IHRA/PS study indicates the following:

a. Distribution of the Injuries

Comparing the ages of those involved, statistics show the highest frequency of accidents is for children of 5 to 9 years old, and for adults over 60 years old. Children (aged 15 and under) account for nearly one-third of all injuries in the dataset, even though they constitute only 18 per cent of the population in the four countries included in the IHRA data.

The frequency of fatal and serious injuries (AIS 2-6) is highest for the child and adult head and adult leg body regions.

Insert Tables from PS 131

Each of these body regions covers more than 30 per cent of total accidents. This proposed global technical regulation (gtr) focuses on protecting these body regions.

The major source of child head injuries is the top surface of the bonnet/wing, while adult head

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[1] IHRA is an inter-governmental initiative that aims to facilitate greater harmony of vehicle safety policies through multi-national collaboration in research.

[2] A list of reference documents is listed in the Appendix to this global technical regulation. The documents are available on the UNECE WP.29 website http://www.unece.org/trans/main/welcwp29.htm. IHRA data are set forth in document number 3 of the informal group on pedestrian safety (INF GR/PS/3) http://www.unece.org/trans/doc/2002/wp29grsp/inf-gr-ps-3e.ppt#262,1,1st meeting of the Informal Group on Pedestrian Safety, and in document number 31 (INF GR/PS/31).

[3] INF GR/PS/12, 13 and 25

[4] INF GR/PS/14

[5] INF GR/PS/15

[6] INF GR/PS/16

[7] INF GR/PS/20

[8] INF GR/PS/21

[9] INF GR/PS/41

[10] INF GR/PS/70

injuries result from impacts to the top surface of bonnet/wing and windscreen area. For adult leg injuries, the major source is the front bumper of vehicles.

b. Crash Speeds

Crash speeds between vehicles and pedestrians were collected from pedestrian accident data and the cumulative frequency of the crash speeds shows that a crash speed of up to 40 km/h can cover more than 75 per cent of total pedestrian injuries **[Need to elaborate a little and provide citation. Is this all AIS?]** in all regions. If a speed of up to 40 km/h is considered, it will significantly reduce the levels of injury sustained by pedestrians involved in frontal impacts with motor vehicles.

c. Target Population for this gtr

The IHRA injury data indicate the injury distribution by body regions. It was found that 40 km/h or less pedestrian vehicle impacts accounted for 58 percent of child head-to-hood contacts, 40 percent of adult head-to-hood contacts, 19 percent of adult head-to-windshield contacts and 50 percent of adult leg-to-bumper contacts. Further, hood impacts account for 41 percent of child head injuries and 19 percent of adult head injuries; windshield impacts represent 49 percent of adult head injuries; and bumper impacts account for 64 percent of adult leg injuries. Based on these distributions of injuries by injury source and vehicle contact area, the target population for this proposed gtr is 24 percent of all child pedestrian head injuries, 17 percent of all adult pedestrian head injuries, and 32 percent of adult leg injuries.

d. Applicability to Motor Vehicle Categories

The maximum benefit from making vehicles pedestrian friendly would occur if all types of vehicles comply with these technical provisions, but it is recognized that their application to heavier vehicles (large trucks and buses) could be of limited value and may not be technically appropriate in their present form. For this reason, the scope of application is limited to passenger cars, sport utility vehicles (SUV), light trucks and other light commercial vehicles. Since these vehicle categories represent the vast majority of vehicles currently in use, the proposed measures will have the widest practicable effect in reducing pedestrian injuries.

II. SUMMARY: DESCRIPTION OF THE PROPOSED REGULATION

When an adult pedestrian is struck by a vehicle, the first impact is generally between the pedestrian knee region and the vehicle's front bumper. Because this initial contact is below the pedestrian's center of gravity, the upper body begins to rotate toward the vehicle. The pedestrian's body accelerates linearly relative to the ground because the pedestrian is being carried along by the vehicle. The second contact is between the upper part of the grille or front edge of the bonnet and the pedestrian's pelvic area. The pedestrian's legs and pelvis have reached the linear velocity of the vehicle at this point and the upper body (head and thorax) are still rotating toward the vehicle. The final phase of the collision involves the head and thorax striking the vehicle with a linear velocity approaching that of the initial striking velocity of the vehicle. Research has shown that the linear head impact velocity is about 90 percent of the initial contact velocity.

Through the pedestrian accidents analysis, it has been concluded that child and adult heads and adult legs are the body regions to be most affected by contact with the front end of vehicles. On vehicles, the bonnet top, the windscreen and the A-pillars are the vehicle regions mostly identified with a high potential for contact. According to the IHRA/PS study, the above-mentioned areas can cover more than 65 per cent of the fatal and serious injuries.

Based on these study results, the informal group prioritized the development of approaches to simulate a pedestrian impact and encourage countermeasures that will improve pedestrian protection. This gtr would improve pedestrian safety by requiring vehicle bonnets and bumpers to absorb energy more efficiently when impacted in a 40 kilometer per hour (km/h) vehicle-to-pedestrian impact, which accounts for more than 75 per cent of the pedestrian injured accidents reported by IHRA/PS of the injury frequency.

This gtr consists of two sets of performance criteria applying to: (a) the bonnet top and windscreen; and (b) the front bumper. Test procedures have been developed for each region using sub-system impacts for adult and child head protection and adult leg protection.[11]

The head impact requirements will ensure that bonnet tops and windscreens will provide sufficient head protection when struck by a pedestrian. The bonnet top would be impacted with a child headform and an adult headform at 35 kilometers per hour (km/h). The head performance criterion (HPC)[12] must not exceed 1,000 over 1/2 of the child headform test area and must not exceed 1,000 over 2/3 of the combined child and adult headform test areas. The HPC for the remaining areas must not exceed 1,700 for both headforms.

The leg protection requirements for the front bumper would require bumpers to subject pedestrians to lower impact forces. This gtr specifies that the vehicle bumper is struck at 40 km/h with a legform that simulates the impact response of an adult's leg. Vehicles with a lower bumper height of less than 425 millimeters (mm) are tested with a lower legform developed by TRL, while vehicles with a lower bumper height of more than 500 mm are tested with an upper legform. Vehicles with a lower bumper height between 425 mm and 500 mm are tested with either legform chosen by the manufacturer. In the lower legform to bumper test, vehicles must meet limits on lateral knee bending angle, knee shearing displacement, and lateral tibia acceleration. In the upper legform to bumper test, limits are placed on the instantaneous sum of the impact forces with respect to time and the bending moment on the test.

The performance requirements and test procedures of this gtr are discussed in detail in later sections of this preamble.

III. PROCEDURAL BACKGROUND

During the one-hundred-and-twenty-sixth session of WP.29 in March 2002, AC.3 concluded their considerations of priorities for developing future global technical regulations. WP.29 adopted the 1998 Global Agreement Programme of Work, which included pedestrian safety, and decided to start the work on pedestrian safety at the thirty-first session of GRSP in May 2002, by

[11] To develop these test procedures, the group carefully studied the availability of the pedestrian dummy as an alternative method for the test procedures. Presently, there is no test dummy which could be considered suitable for regulatory use and so this group decided to select subsystem test methods which are readily available, and which have the necessary reliability, repeatability and simplicity.

[12] HPC is calculated in the same manner as the Head Injury Criterion (HIC).

creating an informal group to draft the gtr. The formal proposal to develop a gtr (WP.29/AC.3/7) was considered and adopted by the AC.3 at its tenth session, in March 2004. It is based on document TRANS/WP.29/2004/26, which had been submitted by the European Commission, which is the technical sponsor of the project.

Informal document 10 of the thirty-first session of GRSP lays down the terms of reference of the group and the document was adopted by GRSP (INF GR/PS/2).

Informal document 7 of the thirty-second session of GRSP reported on the result of the first meeting of the informal group (INF GR/PS/9).

Informal document 2 of the thirty-third session of GRSP (INF GR/PS/47 Rev1) was the first preliminary report of the informal group and responds to paragraph 5 of documents TRANS/WP.29/2002/24 and TRANS/WP.29/2002/49 as adopted by AC.3 and endorsed during the one-hundred-and-twenty-seventh session of WP.29. The documents were consolidated in the final document TRANS/WP.29/882. The preliminary report was adopted as WP.29/2003/99 by AC.3 in November 2003.

Informal document 2 of the thirty-fourth session of GRSP reported on the action plan of the informal group (INF GR/PS/62).

Informal document 5 of the thirty-fifth session of GRSP was the second preliminary report of the informal group (INF GR/PS/86 Rev2 and PS/88). This report was considered by AC.3 in June 2004 as informal document WP.29-133-7.

Informal document 1 of the thirty-sixth session of GRSP was the first draft gtr of the informal group (INF GR/PS/116).

TRANS/WP.29/GRSP/2005/3 was proposed at the thirty-seventh session of GRSP and was a revised draft gtr including the preamble, of the informal group (INF GR/PS/117).

The group has held the following meetings:

- 4-5 September, 2002, Paris
- 10 December, 2002, Geneva
- 15-16 January, 2003, Santa Oliva
- 15-16 May, 2003, Tokyo
- 10-12 September, 2003, Ottawa
- 24-26 February, 2004, Paris
- 28-30 September, 2004, Paris
- 11-13 July, 2005, Brussels
- 5-6 December, 2005, Geneva
- 16-19 January, 2006, Washington DC

The meetings were attended by representatives of:

The Netherlands, France, Germany, Canada, European Community (EC), Spain, Japan, United States of America (USA), Korea, Italy, Turkey, EEVC, CI, CLEPA and OICA. Spell out these abbreviations

The meetings were chaired by Mr. Mizuno (Japan) and Mr. Friedel/Mr. Cesari (EC), while the secretariat was provided by Mr. Van der Plas (OICA).

IV. EXISTING REGULATIONS, DIRECTIVES, AND INTERNATIONAL VOLUNTARY STANDARDS

At the present time, there are no regulations concerning the provision of improved protection for pedestrians and other vulnerable road users in the Compendium of Candidates.

The following is a summary of national and regional legislation and of work in international fora:

The Japanese Government has established a regulation on pedestrian protection. The regulation addresses the issues of providing protection for the child and adult heads. It applies to passenger cars with up to 10 seats and to small trucks of up to 2500 kg gross vehicle weight with application from 2005 for new vehicle types and from 2010 for existing vehicle types (certain other vehicles have a timetable which is postponed by two years). The regulation requires compliance with test requirements using representative head impactors.

The European Parliament and Council adopted the Directive 2003/102/EC which provides for the introduction of requirements for leg injuries, upper leg injuries and adult and child head injuries. The Directive and its requirements are incorporated into Community legislation under the European Union whole vehicle type approval system set up by EU Framework Directive 70/156/EEC. It applies to passenger cars of category M_1 and to light commercial vehicles derived from passenger cars of M_1 category, both up to 2500 kg gross vehicle weight, with application dates in two phases starting in 2005 and 2010. The requirements and the tests are based on the research results that were published by EEVC in the 1990's and that were introduced in a less severe form for the first phase and in the originally proposed form for the second phase. However, since EEVC results never have been fully accepted by all involved parties, the Directive provided for a review of the feasibility of the requirements of the second phase in 2004. This feasibility review has taken place and will result in amendments to the European requirements in its second phase, starting in 2010.

Canada is currently reviewing their bumper regulation. The Canadian bumper regulation is one of the most stringent in the world (all the safety features of the vehicle have to be functional after an 8 km/h impact). In addition, Canada is investigating the effect of bumper design on different leg test devices (TRL legform impactor; Polar dummy and flexible pedestrian legform impactor (Flex-PLI)).

The United States has had pedestrian protection programmes for pedestrian leg and pedestrian head and upper body impacts. A rulemaking proposal for improved pedestrian leg protection was terminated in 1991 when potential countermeasures were not shown to be effective. The National Highway Traffic Safety Administration (NHTSA) focused research on pedestrian head protection, developing test procedures, similar to this gtr, for simulating pedestrian head impacts on vehicle surfaces. Research was also conducted to understand how vehicles could be modified to reduce the severity of head impacts [13/] [14/]. The current US pedestrian protection research

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[13/] Saul, R.A., Edlefson, J.F., Jarrett, K.L., Marcus, J.R.; "Vehicle Interactions with Pedestrians," Accidental Injury: Biomechanics and Prevention, New York: Springer-Verlag, 2002.

programme supports the IHRA objectives. Current activities include (1) pedestrian field data analysis to develop test conditions, (2) evaluation of pedestrian head and leg test tools, (3) experimental impact testing of vehicle structures to assess aggressivity, (4) pedestrian case reconstructions using a combination of field data, computer simulation, and testing to better understand injury mechanisms, (5) computer model development using available biomechanical literature, and (6) completion of other IHRA Pedestrian Safety Working Group action items.

IHRA has developed test procedures for head protection and is considering, as a new step, leg protection requirements. The informal group has requested that IHRA research and report their recommendations on an improved tool and test procedure for the upper legform to high bumper vehicle test. Additionally, the informal group requests IHRA to further research the upper legform impactor to bonnet leading edge test. This is discussed in detail in later sections of this preamble.

The International Organization for Standardization created the pedestrian protection working group (ISO/TC22/SC10/WG2) in 1987 to develop test methods for the reduction of serious injuries and fatalities for pedestrian to car accidents. The mandate for ISO/WG2 was to produce test methods, covering crash speeds up to 40 km/h, which will contribute to make cars pedestrian friendly. Since then, the WG2 has developed pedestrian test procedures and has described the necessary test tools. The study results were fully used in the IHRA/PS group, when IHRA/PS developed the adult and child impactors.

The ISO standards and draft standards are:

- ISO 11096: 2002 Road vehicles—Pedestrian protection—Impact test method for pedestrian thigh, leg and knee,
- ISO/DIS 14514 Road vehicles—Pedestrian protection—Head impact test method,
- ISO/DIS 16850 Road vehicles—Pedestrian protection—Child head impact test method.

The ISO group is now starting the development of a new adult leg test method and its test tool.

V. GENERAL ISSUES

a. Scope

From the review of pedestrian fatality and injury statistics from several countries, as discussed previously, it was shown that the head and the legs are the most frequently injured body regions in pedestrian accidents. It was agreed that the gtr would encompass tests for the adult head and leg, and the child head. It was also shown by these studies that the majority of pedestrian injuries are occurring in urban environments; therefore the gtr should test those vehicles found in this environment, including passenger vehicles, vans, and light trucks.

As suggested by the terms of reference of the informal group, consideration was given to the use of the best available technology and improvements in technology that will provide significant steps in developing methods and in achieving and improving benefits, including both active and passive safety measures. (TRANS/WP.29/GRSP/30). There was discussion on whether the proposed pedestrian gtr should regulate passive and/or active safety systems. Active safety

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[14]/ "Report to Congress: Pedestrian Injury Reduction Research," NHTSA Report DOT HS 808 026, June 1993.

systems such as brake assist, anti-lock brakes and day-light running lights were suggested as solutions for the reduction of pedestrian injuries, but it was ultimately counselled by GRSP and WP.29 to concentrate on passive systems for this gtr as this is the main domain of expertise of the GRSP experts, and only to provide advice on the use of active systems.

The group agreed that active safety and infrastructure measures were not within the remit of the group, but agreed that it could be useful and efficient to inform WP.29/AC.3 as well as other authorities of the need to take these issues into account for real world safety improvements. The group also noted the importance of educational measures as well as the need to enforce existing road traffic legislation.

Some experts noted that consideration of other safety measures, if properly balanced with the passive safety requirements, might help in ensuring that the vehicle passive safety requirements are kept at a realistic and feasible level. OICA, in particular, mentioned brake assist systems which can, in emergency situations, substantially improve the braking performance and consequently reduce the impact speed when the impact is unavoidable. A study on the effectiveness of such a system was presented by OICA using the German In-Depth Accident Studies (GIDAS) database (INF GR/PS/25). This showed that if the vehicle speed is 50 km/h at the start of braking, the collision speed (car versus pedestrian) would be reduced to 40 km/h in general, to 35 km/h for an experienced driver and to 25 km/h for cars equipped with brake assist systems. Another study performed by the Technical University of Dresden on behalf of ACEA was presented by OICA (INF GR/PS/92). This study confirmed the positive effect of brake assist systems on pedestrian fatalities and injuries.

OICA also pointed to the importance of the infrastructure and presented the results of a 1998 study conducted on behalf of ACEA by the consultants ORIENTATIONS (F) and TMS Consultancy (UK) (INF GR/PS/29). This study, which evaluated the effect of infrastructural measures based on real data evaluations, concluded that such measures could dramatically reduce the number of pedestrian victims (fatalities/injuries) at low cost.

b. Applicability

The application of the requirements of this gtr refers, to the extent possible, to the revised vehicle classification and definitions outlined in the 1998 Global Agreement Special Resolution 1 (SR 1).

Difficulties, due to differing existing regulations and divergent vehicle fleets, were encountered in determining which vehicles would be included in the scope. The Japanese regulation applies to passenger cars for up to 10 passengers and commercial vehicles up to a Gross Vehicle Mass (GVM) of 2.5 tonnes. The IHRA recommends tests and procedures for passenger vehicles of GVM 2.5 tonnes or less. The European Union Directive applies to M_1 vehicles up to 2.5 tonnes and N_1 vehicles up to 2.5 tonnes, which are derived from M_1. The ISO recommendations are for M_1 and N_1 vehicles that have a GVM of 3.5 tonnes or less. In addition, some countries, taking into account their current fleet composition, considered that care should be taken not to exclude from the requirements too large a number of vehicles, such as light trucks and sport utility vehicles.

The group originally reviewed in detail the IHRA recommendation to take into account the shape of the front of the vehicle, as an important parameter when discussing the types of pedestrian injuries to be mitigated. IHRA specifies 3 groups of vehicle shape: sedan, SUV, and 1-box. For the adult and head impacts, IHRA foresees different impact test speeds and different impact angles. The EU requirements, on the contrary, do not differentiate between the various test speeds and impact angles.

The group compared these various considerations and, on the basis of simulations (INF GR/PS/129), concluded that the EU requirements in effect are more severe than the IHRA proposals. For safety reasons, the group therefore uses the EU approach, not taking into account the shape of the vehicle front in defining the requirements. Furthermore, the group also determined that the IHRA recommendations would be difficult to put in place in the context of a regulatory and certification approach.

There was considerable discussion over the mass of the vehicles to which this gtr should apply. Using the categories described in SR1, there were several options examined. It was agreed that as a minimum the gtr should apply to all vehicles in Category 1-1 with a vehicle mass of less than 2.5 tonnes GVM. An argument for the 2.5 tonnes GVM maximum limit is that all existing tests were only validated for (previously conducted on) vehicles up to 2.5 tonnes GVM. However, since some Category 1-1 vehicles weigh more than 2.5 tonnes GVM, some delegates argued that the gtr should be applicable to vehicles that weigh up to 3 or 3.5 tonnes GVM. These delegates argued that the front-end structure of these heavier vehicles usually is similar to lighter vehicles; therefore the application of the requirements should be the same.

The group confirmed its intention to include a maximum of vehicles representative of the current vehicle fleets worldwide, taking however into account their involvement in pedestrian accidents, the technical feasibility and cost/benefit considerations. In particular, it was recognised that the proposed tests are only validated up to a gross vehicle mass of 2500 kg. The group also recognised that a large proportion of current light trucks and sport utility vehicles would fall in the proposed category 1-1 below 2.5 tonnes; heavier vehicles of categories 1-1 only constitute a small portion of the vehicle fleet.

It was therefore agreed that the gtr would apply to all Category 1-1 vehicles with a gross vehicle mass not exceeding 2.5 tonnes and if a jurisdiction determines that its domestic regulatory scheme is such that limited applicability is inappropriate, it may extend domestic regulation to other Category 1-1 vehicles, provided that justification regarding the applicability is offered.

Many vehicles in Category 2 are manufactured on the same platform as vehicles in Category 1-1 and have the same or similar front-end shapes. The group considered that these vehicles should be included in the proposed gtr, but noted the difficulty in defining this group of vehicles. The group agreed to use the term "derived from" as in the EU requirements, whereby "derived from" means that forward of the A-pillars, the general structure and the shape are the same. This would, as an example, be the case of a light truck built on the same platform and with the same front-end shape as a passenger car or SUV.

As for vehicles of Category 1-1, the group agreed to limit the application to those Category 2 vehicles with a Gross Vehicle Mass below 2.5 tonnes, yet if a jurisdiction determines that its domestic regulatory scheme is such that limited applicability is inappropriate, it may extend domestic regulation to other Category 2 vehicles provided that justification regarding the applicability of the requirements is offered.

The tests in this proposed gtr are all considered to be technically and economically feasible as outlined in this preamble. However, it will be the decision of each jurisdiction to determine whether the benefits achieved by requiring these tests justify the costs. Based on this determination, a jurisdiction can choose to further limit the application in their own regulation to specific vehicle categories and/or it may decide to phase in the regulations over time.

c. Future Consideration

During the discussions, it became clear that some issues could not be fully resolved within the timeframe of the terms of reference for the informal group. The group recommended that the following issues should be resolved in the future.

1) Lower legform impactor

As the FlexPLI is considered by some to have high biofidelity and excellent injury assessment ability, the FlexPLI should be considered to replace the TRL lower legform impactor in the future. However, because of the lack of experience in using the FlexPLI as a certification tool, a further confirmation process is needed. Therefore, WP.29/GRSP was requested [is this something that was already done, or something we will request to have done?] to set up a Technical Evaluation Group (TEG). This TEG will, based on independent studies and relevant information provided by its members, monitor the reliability of the FlexPLI as a certification tool. The TEG will advise GRSP, by a date to be agreed, whether the FlexPLI can be used for testing and compliance verification purposes. The TEG should also propose the effective date of entry into force and the date at which the FlexPLI could supersede the rigid lower legform impactor. TEG will also propose a transitional period, during which the FlexPLI and the rigid lower legform impactor can be used as alternatives.

2) Upper legform impactor to high bumper test

The group requests IHRA/PS to research and report their recommendations on the possibility of an improved upper legform impactor for possible future use.

3) Upper legform impactor to bonnet leading edge test

Test results using the proposed upper legform to bonnet leading edge prescriptions are contradictory to the actual situation encountered in many real world accidents. This is shown in several accident studies comparing modern "streamline" vehicle fronts registered in or after 1990 and old vehicles from the eighties or seventies. The accident studies were performed using French data by the LAB (INF GR/PS/30) or by the University of Dresden using the German GIDAS data (INF GR/PS/92). In addition, EEVC WG17 summarized in their 1998 report that no serious (AIS2+) upper leg or pelvis injuries caused by the bonnet leading edge were found for post-1990 car models impacting a pedestrian at a speed up to 40km/h.

This fact, together with the existing concerns on the impact energy, the test tool biofidelity and the injury acceptance levels, caused the group to exclude the test at this stage. However, the group recognizes that this test may have potential value and requests IHRA/PS to carry out further research into the needs and methods for this test.

VI. PEDESTRIAN HEAD PROTECTION.

The proposed gtr would specify minimum performance requirements for bonnet tops and windscreens in providing pedestrian head protection. The performance of a bonnet would be evaluated by impacting a child headform and an adult headform into the bonnet top and windscreen at 35 km/h. As discussed below, within those impacted test areas, portions of the bonnet top and windscreen must limit the Head Performance Criterion to 1000, while other portions of those areas must limit HPC to 1700.

a. Area of the Vehicle to be Tested

1) Bonnet Top

The bonnet top is an area bounded by reference lines corresponding to the bonnet leading edge, the sides of the vehicle, and the rear of the bonnet (all terms are objectively defined in this proposed gtr). The proposed gtr divides the bonnet top into a "child headform test area" and an "adult headform test area" based on a "wrap around distance" (WAD) parameter. The WAD is the distance from a point on the ground directly below the bumper's leading edge to a designated point on the bonnet, as measured with a flexible device, such as a cloth tape measure. A WAD of a specified distance, measured as described in the gtr, defines points on the vehicle's bonnet from which boundaries can be determined.

The informal group believes that the WAD is a good indicator of where head impacts are likely to occur on the bonnet. Head impact locations on the bonnet are largely explained by the standing height of the pedestrian and the frontal geometry of the striking vehicle. The WAD measurement is based on both pedestrian height and vehicle configuration. By use of the WAD, it can reasonably be estimated where on a vehicle a child or adult pedestrian's head may impact.

Accordingly, based on the data of actual accidents, the WAD is used to define the test area on the bonnet top. The bonnet top is separated into a child headform test area and an adult headform test area, based on wraparound distances of pedestrian head impacts to a vehicle. The child headform test area is bounded in the front by a boundary determined by a WAD of 1000 mm, and at the rear by a WAD 1700 mm line. [Why 1000 mm? Why 1700 mm? Please explain bases for those values.] The adult headform test area is bounded in the front by a wraparound distance of 1700 mm, and at the rear, by a boundary determined by a WAD of 2100 mm. [Why 2100 mm?.]

Although an overlap area was also considered with a WAD of 1400 mm to 1700 mm where both adults and children have received head injuries in actual accidents, a defined boundary was determined to be more suitable because little difference in the life-saving rate was perceived between the two approaches and the boundary method provided a clearer approach. The WAD 1700 line should be the boundary between the test areas for adult head injuries and child head injuries from a standpoint of maximizing the life-saving rate. [Again, why at 1700 mm?]

2) Windscreen Area

The proposed gtr specifies the borders of the windscreen test area. Generally, the borders are lines 82.5 mm from a rear reference line (corresponding to the windscreen header), 82.5 mm from side reference lines (associated with the A-pillars); and 82.5 mm from a lower reference line (all terms are defined in the gtr). [Insert explanation of basis for 82.5 mm]

Feasibility studies have shown that some areas within the head test area, including the windscreen, will not be able to comply with an HPS 1000 limit. For the windscreen area, documents INF GR / PS / 72, 94, 102, 103 indicate the need to exclude the A-pillars and the edges of the windshield. For the present time, there are no countermeasures that could reduce the HPC levels in areas of the A-pillars, roof and cowl.

b. Points Tested

As head injuries to both adults and children occur throughout a wide range of areas at the front of the vehicle, subsystem tests using the adult and child headform impactors are appropriate to evaluate the bonnet top and windscreen.

The informal group considered whether to specify both the number of test points and the minimum spacing of such test points. On consideration, the group determined that the specification of such points did not have a place within this proposed gtr for the following reasons:

1) For governments that used a self-certification regulatory framework, it was not considered necessary to mention the number of tests required for head impact testing or their spacing, as would be incumbent on vehicle manufacturers to ensure that vehicles comply with all the impact zone requirements defined within this proposed gtr when tested by the regulating authority.

2) For type approval, the number of tests that need to be carried out to satisfy the relevant authority that vehicles meet the requirements is an issue for that authority, which may specify the number of tests and the spacing between the test points.

3) The mention of a minimum number of tests or a minimum distance apart between tests could result in manufacturers being burdened with unnecessary tests and/or authorities being unnecessarily restricted in test programs, as it would be difficult to set a target that would encompass both the largest and smallest test zones, and the situation could arise where test zones could be smaller than the minimum number of test required that could be fitted into that zone.

c. Head Performance Criterion

The majority of pedestrian fatalities in road accidents are caused by head injuries. The informal group determined that the head protection performance should be based on the "head performance criterion" (HPC),[15] given the ability of HPC (HIC) to estimate the risk of serious to

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[15] HPC is calculated in the same manner as the Head Injury Criterion (HIC). The resultant acceleration at the location of the accelerometer mounted in the headform will be limited such that, for any two points in time, t_1 and t_2, during the event which are separated by not more than a 15 millisecond time interval and where t_1 is less than t_2, the maximum calculated head injury criterion (HIC) shall not exceed 1,000, determined using the resultant head acceleration at the center of gravity of the headform, a_r, expressed as a multiple of g (the acceleration of gravity), calculated using the expression:

$$HIC = \left[\frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} a dt \right]^{2.5} (t_2 - t_1)$$

fatal head injury in motor vehicle crashes. An HPC value of 1000 is equivalent to approximately a 15 per cent risk of AIS 4+ head injury. The proposed gtr specifies that:

1) For the bonnet top, the HPC must not exceed 1,000 over 1/2 of the child headform test area and must not exceed 1,000 over 2/3 of the combined child and adult headform test areas. The HPC for the remaining areas must not exceed 1,700 for both headforms. [Insert explanation of why the relaxed HPC value is 1700. Why not a higher or lower value? What is the 1700 based on?] (The need for "relaxation zones," in which the HPC limit is 1,700, is discussed below in this preamble.) Clarify: suppose there is no adult zone. Is the requirement HPC 1000 over ½ or 2/3 of the bonnet?

2) For the windscreen area, the HPC must not exceed 1700 for one third of the windscreen test area, and not exceed 1000 in the remaining windscreen test zone, irrespective of which of the headforms is used. [Insert explanation of why the relaxed HPC value is 1700. Why not a higher or lower value? What is the 1700 based on?] [Verify that the child headform is used in this test.]

HPC would be calculated within a 15 ms interval. The main reason that a longer interval was not used was that head impacts to external car structures are very short, occurring within a few milliseconds of contact. As the pulse itself is so short in time, there is no risk to lose part of the pulse during the HPC calculation--and no risk of a lower calculated HPC value--if a 15 ms interval were used rather than a longer interval. Accordingly, using either a 15 ms or a 36 ms pulse window provides the same HPC value. Moreover, the test is not intended to record more than one impact. A short time duration avoids the risk that a second impact could be recorded after rebound. A longer duration for the time interval could result in distortions in the data recorded by the headform, which may lead to inaccurate HPC values.

d. Relaxation zones

1) Bonnet Top

The reason for providing relaxation zones is based on determinations of the informal group as to design changes that would or would not be technically feasible to meet an across-the-board HPC 1000 limit. Virtually all bonnets have hard substructures beneath them (e.g., shock struts) that prevent attainment of the HPC 1000 performance criterion at all areas in the test area. The feasibility study detailed in INF GR/PS/91 and 101 showed the problem areas on the bonnet. Also the feasibility study conducted on behalf of the European Commission (INF GR/PS/89) acknowledged the need to define an area on the bonnet for which a higher HIC limit is needed. As the problems on the bonnet are not the same for every car model, it was felt necessary to set a maximum area with relaxed requirements that could be defined for every car by the manufacturer.

The informal group considered the feasibility of applying the relaxation zone separately for the child and adult headform test areas, i.e., applying an HPC 1700 limit to a maximum of 1/3 of the child test zone. It was determined that, because the location of necessary under-bonnet components, such as locks and suspension towers, cannot be fundamentally changed, they need to be located in the child headform test area. As a result, the relaxation zone for the child headform test area must be greater than 1/3 of the zone (see illustrations 1 and 2 of INF GR/PS/158). [There needs to be more support for the finding that ½ of the zone needs to be relaxed. How many vehicles are represented by PS 158's illustrations? Why ½ and not a smaller area?]

2) Windscreen Area

In specifying the HPC limit for the windscreen area, the informal group considered the conflicting functional needs that could affect vehicle performance. In the lower windscreen area, the required deformation space to meet a head impact requirement is restricted by the instrument panel. Some components that are required to meet governmental safety standards, such as defrost/demist etc., make it impossible to lower the dashboard significantly. In addition, the structural components of the dashboard are important load paths in front or side crashes.

In addition, most manufacturers are currently developing systems aimed at accident avoidance or injury risk mitigation. Such devices mainly support the driver in the driving task (windscreen rain sensors, head up displays, night vision systems, etc.). Some of these features need to be located on or directly behind the windscreen. This can significantly influence the HPC in this area by reducing the available deformation space or by increasing the effective mass. Considering that such systems have a positive influence on the safety of both motorists and pedestrians, installation of the systems should not be prevented.

Finally, vehicle manufacturers have found problems related to scatter of HPC when performing tests in the windscreen in accordance with the European Directive Phase 1 (INF GR/PS/134). The reasons for the scatter are still not fully known and the breaking behaviour of the windscreen is still under investigation (e.g. EU funded research project APROSYS).

Because of these considerations, the proposed gtr specifies an HPC value of maximum 1700 for one third of the windscreen test area, while maintaining an HPC limit of 1000 in the remaining windscreen test zone.

e. Headform

The child headform (impactor mass is 2.5 kilograms)(kg) is used to test the bonnet in the child headform test area, and the adult headform (impactor mass of 4.8 kg) is used in the adult headform test area.

The appropriate headform impactor size and mass, determined based on the characteristics of the human body, are explained below (INF GR/PS/46, 74 and 93).

1) Headform diameter

The diameter of the child headform is 165 mm. Due to the fact that the majority of child pedestrian victims are 5 or 6 years old, this value was determined based on the average head diameter of a 6-year-old child (by averaging the diameter obtained from the circumference of the head and the longitudinal and lateral measurements of the head).

The diameter of the adult headform is 165 mm. Although the average diameter of an adult head was also considered [what is the average diameter of an adult head?], this value was determined based on the diameter of an existing adult headform specified in another regulation. [Specify which regulation. We also need to explain why we chose the diameter of an existing adult headform of another regulation.]

2) Headform mass and moment of inertia

Computer simulations conducted in the IHRA study show that the effective mass of the head in an impact with vehicles is identical to the actual mass of the head. Accordingly, the headform mass was therefore determined as follows:

The mass of the child headform is 3.5 kg, which is the mass of the head of a 6-year-old child.

The mass of the adult headform is 4.5 kg, which is the mass of the head of a 50^{th} percentile adult male. This proposed gtr specifies the moment of inertia analyzed by EEVC as reported in INF GR/PS/148. That document specifies a value of adult head moment of inertia of: 0.0110 kgm^2, allowing a variation of ± 0.001 kgm^2 (adult headform Moment of Inertia comprised between 0.0100 and 0.0120 kgm^2).

f. Headform Accelerometer

This proposed gtr specifies a damped accelerometer (as specified in INF GR/PS/133) in the adult and child headform impactors. As explained in INF GR/PS/96, in a research program in 2002 using the Japanese New Car Assessment Program (J-NCAP) headform test with undamped accelerometers, abnormal acceleration signals with high HIC values were recorded frequently in windshield impacts, and also in bonnet impacts. It was determined that this was due to the resonance vibration of the undamped accelerometer, which would occur if the spectrum of the impact waveform was near to the resonance frequency of the accelerometer. Once a high resonance, over the CAC setting level, occurs, it has a high chance to deform the acceleration waveform, i.e. one cannot obtain a correct acceleration waveform from the undamped accelerometer.

g. Headform Test Speed and Angle

The head impact conditions (speed and angle) were considered together. The head impact test replicates a vehicle-to-pedestrian impact at 40 km/h.

1) Bonnet Top

The proposed gtr specifies that the child headform impacts the bonnet top at 35 km/h at an angle of 50 degrees to the horizontal. The adult headform impacts the bonnet at 35 km/h at a 65 degree angle.

In determining test speeds and angles of impact, the informal group considered the findings of IHRA and the EEVC. IHRA had explored whether various vehicle shapes influenced the angle at which a pedestrian's head impacted the bonnet top. Computer simulations were conducted, as part of the IHRA study, by the Japan Automobile Research Institute (JARI), the National Highway Traffic Safety Administration, and the Road Accident Research Unit of Adelaide University (RARU). The simulations used a 50^{th} percentile adult male model and a 6-year-old child model. The distribution of headform impact speeds and angles in various impacts was obtained by simulating head impacts using three types of walking position, three types of vehicle frontal shapes and two types of bonnet stiffness as parameters. The studies showed that the same headform impact speed could be used for any type of vehicle frontal shape. Further, the interpretation of the results indicated a speed of 32 km/h, which is 0.8 times the vehicle impact speed of 40 km/h. In addition, various angles for adult and child impact conditions and for the three different shapes were defined as well.

In contrast, EEVC had concluded that one set of angles (50 degrees for the child headform test and 65 degrees for the adult headform test) for all vehicles is reasonable, simplifying any head test procedure dramatically. EEVC's decisions concerning head impact angles for child and adult tests were based on two reports used as working documents: Glaeser K.P. (1991), "Development of a Head Impact Test Procedure for Pedestrian Protection," BASt Report under contract N° ETD/89/7750/M1/28 to the E.C. (INF GR/PS/150); and Janssen E.G., Nieboer J.J. (1990), "Protection of vulnerable road users in the event of a collision with a passenger car, part1 – computer simulations," TNO Report N° 75405002/1 (INF GR / PS / ???).

The EEVC values were based on post-mortem human subject (PMHS) tests and simulation results. The PMHS tests indicated a peak of the distribution of adult head impact angles to be 60 degrees, with all the results falling between 50° and 80°. Simulations gave a result around 67 degrees for adults, and indicated that vehicle shape had little influence on the angle of impact. EEVC chose a value of 65 degrees, which was close to the 67 degree angle resulting from the simulation and to the average of the PMHS results.

For child head impacts, EEVC considered simulations of a small adult female (close in anthropometry to a 12-year-old child) and of a 6-year-old child. Results of the small adult female simulations were very close to the results of the simulations for the 50th percentile male adult, while the simulations involving the 6-year-old child suggested a value around 50°. EEVC picked the value of 50°, believing that the simulations of a 6-year-old child were more relevant than those of a 12-year-old child for child pedestrian protection.

The informal group noted that the one set of angles from EEVC involves a different (higher) impact speed than that specified by IHRA. The group considered which of the two approaches of EEVC and IHRA was most stringent and thus offering of the most protection to pedestrians. INF GR/PS/129 showed, by both numerical calculation and by simulation, that the set of requirements defined by EEVC is more severe than the requirements defined by IHRA. The group thus decided to use the EEVC 50° and 65° impact angle for child and adult head testing while maintaining the higher EEVC impact speed to the bonnet of 35 km/h (compared to the IHRA speed of 32km/h).

2) Windscreen Area

In the current Phase 1 of the EU Directive, windscreen tests are performed with an impact angle of 35° to the horizontal. This is currently the only legal requirement on windscreen testing. The angle is similar to the findings of IHRA studies of 2002, where an impact angle of 40° was proposed based on simulation of pedestrian-to-vehicle impacts with different front shapes (INF GR/PS/156). For these reasons, an impact angle of 35° is specified for windscreen headform tests for both the child and adult headform impactor.

h. Other Issues

1) Systems or components that change position such as pop-up headlamps or headlamp cleaners

Any vehicle system or component which could change shape or position, such as pop-up headlights or headlamp cleaners, other than active devices to protect pedestrians, shall be set to a shape or position that is considered to be the position of normal use. If there is more than one position of normal use, the system or component need to satisfy the requirements of the gtr in all positions.

2) Active devices to protect pedestrians

If active devices, such as deployable bonnets, are used to provide protection to the pedestrians, the devices must not create a higher risk of injuries for the pedestrians. The devices are considered to meet this if they satisfy the requirements of the gtr and in addition comply with a certification procedure as defined in [Annex I] as an example.

VII. PEDESTRIAN LEG PROTECTION

a. General

This proposed gtr would specify minimum performance requirements for vehicle bumpers to provide leg protection by subjecting pedestrians to lower impact forces. As the majority of victims of leg injuries are adults, this proposed gtr specifies use of a legform impactor that simulates an adult leg. The performance of the bumper would be evaluated by impacting the bumper with either of two legforms, a lower legform impactor or an upper legform, depending on the height of the bumper.

The lower legform impactor is used to test vehicles with low bumpers, i.e., bumpers of heights less than 425 mm to a reference line on the lower surface of the bumper. Upper legform to bumper tests shall be carried out if the lower bumper height is more than 500 mm. For vehicles that have a lower bumper height between 425 mm and 500 mm, the vehicle manufacturer can elect to perform either a lower legform test or an upper legform test.

The reason there are two impactors is because the lower leg impactor test has some limitations depending on the bumper height. The contact point between impactor and bumper should be below the knee, due to the impactor's structure and characteristics.[16] The EEVC WG17 states in its report, paragraph 7.2.1: "Some vehicles, like off-road vehicles, have high bumpers for certain functional reasons. These high bumpers will impact the femur part of the legform impactor, where no acceleration is measured to assess the risk of fractures. Moreover, there is often no structure below the bumper to restrain the tibia part of the legform, for instance because an off-road vehicle needs a certain ramp angle and ground clearance. Therefore WG17 decided to include an optional, alternative horizontal upper legform test with an impact speed of 40 km/h, when the lower bumper height is more than 500 mm above the ground."

The proposed gtr provides an option of using the alternative upper legform test for vehicles with a lower bumper height of 425 mm to 500 mm. Although the WG17 states that the alternative

[16] There is also a concern that the lower leg test could readily be met by simply allowing the lower legform to slide and/or rotate beneath the high bumper. This could have an unintended consequence of encouraging high bumpers as a way to meet the requirements, and lead to more pedestrian injury due to run-over.

legform test should be available for vehicles with a lower bumper height of more than 500 mm, WG17 had referenced a value that WG10 associated with the upper (rather than lower) bumper reference line. The informal group believes that the appropriate value is 425 mm, measured to the lower bumper reference line, rather than 500 mm.[17] Investigations conducted with vehicles with off-road capabilities have shown that some of these vehicles have lower bumper heights as low as 400 mm. For these off-road vehicles, it is technically not feasible to have a countermeasure that will enable the vehicle to restrain the tibia part of the lower legform. How many vehicles in the fleet will be tested with the TRL lower legform, and how many will be tested with the upper legform? How many have a bumper height in the 425-500 mm range?

The impact speed for both legform tests is the same as that of the vehicle and thus determined to be 40 km/h.

b. Lower Legform Test

1) Impactor

It was agreed to use the legform impactor developed by TRL, for the time being, in evaluation of the leg protection performance. However, it was also agreed to consider the possible future use of the Flex-PLI, which is considered by some to be more biofidelic and expected to be highly usable and repeatable, following the evaluation to be conducted by the Technical Evaluation Group (INF GR/PS/106).[18]

Insert discussion of the relationship between TRL leg biofidelity, injury parameters, and injury risk. Show that the legform produces repeatable and reproducible results. Show that the legform can reliably distinguish between good and poor performers.

2) Injury Criteria

Knee injuries, which are typical leg injuries in car-to-pedestrian collisions, most frequently involve the elongation or rupture of knee ligaments, and/or crush of knee articulation surfaces (tibia plateau and/or femur condyle). The most common mechanism causing pedestrian knee injury is a lateral bending between the thigh and the leg, sometimes associated with shearing motion (horizontal displacement between the tibia top and the femur lower extremity in the direction of impact).

Several experimental research works were conducted in Europe, Japan and the United States using PMHS components during the last decade. There were also numerical simulations to better understand what happens inside the knee joint during the loading process.

These studies propose a bending limit in the range of 15 to 21° for knee protection. The informal

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[17] Since pedestrians are usually wearing shoes, the bottom of the legform impactor was determined to be 25 mm above the ground, the same height as the sole of a shoe (INF GR/PS/98).

[18] The size and mass of both the present rigid lower legform and the Flex-PLI were determined to be equivalent to those of a 50th percentile adult male (INF GR/PS/79). The results of computer simulation analyses and experimental data indicate that the mass of the upper body need not be taken into consideration for those impacts where the bumper strikes the legs below knee level (INF GR/PS/105).

group determined that a value close to the upper limit (21°) of this range should be considered, and not the average. The absence of muscle tone in the PMHS tests dropped the knee stiffness, and the high rigidity of the impactor bones transferred to the knee joint a part of the impact energy normally absorbed by the deformation of human long bones. For these reasons, a bending limit of 19º was selected for this gtr.

There is less research dealing with knee shearing limits. It is acknowledged that it is almost impossible to precisely determine knee shearing motion during PMHS tests, as the values are low (a few millimeters), and the knee is covered with flesh and skin. A value of 6 mm seems to correspond to the knowledge available concerning knee shearing biomechanics, even if some other biomechanical researches have proposed higher values.

Results of a series of pedestrian PMHS tests performed with modern cars suggests an average value of 222 g for tibia injury tests, and of 202 g for non tibia injury tests. A value of 200 g's would correspond to a 50 percent injury risk. To protect a higher proportion of the population at risk, a lower value of tibia acceleration has to be selected. For these reasons, a maximum lateral tibia acceleration limit of 170 g was selected.

In summary, it was concluded that the acceptance levels for the legform test should be set at:

Maximum lateral knee bending angle ≤ 19.0°;
Maximum lateral knee shearing displacement ≤ 6.0 mm;
Maximum lateral tibia acceleration ≤ 170 g.

[Is there a provision whereby a manufacturer may nominate bumper test widths up to 264 mm in total where the acceleration measured at the upper end of the tibia shall not exceed 200g? That needs to be highlighted here, with reasons given explaining the need for it.]

c. Upper Legform Test for High Bumpers

1) Impactor

The informal group discussed the appropriate impactor to use in the testing of vehicles whose bumpers strike the legs above knee level. As the majority of victims of upper leg injuries are adults, subsystem tests using legform impactors that simulate to upper adult leg should be performed. The impactor specifications in this proposed gtr are those used in the EU Directive 2003/102/EC for the upper legform impactor. [Explain that the informal group made an independent analysis of the EU upper legform and found it to be biofidelic and acceptable. Provide bases for those conclusions.]

2) Injury Criteria

For high bumper, the car impact occurs above the knee, and then, the thigh is directly impacted by the car front. Biomechanical research works conclude in a upper leg tolerance in bending in the range of 4 to 7 kN peak force, and 300 to 600 Nm bending moment. [Need citation to these reports.] These values are based on PMHS test results, for a three-point bending in the middle of the femur. The absence of muscle tone in the PMHS tests and the difference in the impact point between the PMHS tests and the car impact would support a higher tolerance, especially for the peak force value.

The informal group decided to adopt the requirements from the EU Directive. [Why did the information group accept the EU limits? There needs to be a discussion showing that the group independently concluded that the values were appropriate.] When tested in accordance with the upper legform to bumper test, the instantaneous sum of the impact forces with respect to time shall not exceed 6.25 kN and the bending moment on the test impactor shall not exceed 375 Nm.

[Is there a provision whereby a manufacturer may nominate bumper test widths up to 264 mm in total where the instantaneous sum of the impact forces with respect to time shall not exceed 7.5 kN and the bending moment on the test impactor shall not exceed 510 Nm? That needs to be highlighted here, with reasons given justifying the need for it.]

Section 3.3.3.4 of PS 89 (pg. 50) describes accident reconstructions with the upper leg to determine that a 50% probability of AIS 2+ femur or pelvis injury corresponded to 7.5 kN and 510 Nm; and 20% probability at 6.3 kN and 417 Nm. However, it goes on to say that EEVC WG 17 had concerns with this and then conducted further reconstructions leading to injury risk curves and a transfer function for the test device.

- Where are these further EEVC reconstructions and analysis described?
- How do the femur/pelvis injury probability curves relate to knee injury probability?
- Can we demonstrate that meeting the high bumper upper leg test will lead to a reduction in pedestrian knee joint injuries?

If I correctly understand the argument for requiring the high bumper test, it is out of concern that the lower leg test could readily be met by simply allowing the leg to slide and/or rotate beneath the high bumper. This could have an unintended consequence of encouraging high bumpers as a way to meet the requirements, and lead to more pedestrian injury due to run-over.

- If the upper leg bumper test were incorporated, how would this encourage protection of pedestrian knees, which are more important to protect?
- How would it discourage production of high bumper vehicles, particularly if the upper leg test requirements were easier to meet than the lower leg test?

VIII. REGULATORY IMPACT AND ECONOMIC EFFECTIVENESS

<u>Costs/benefits</u>

- Section 9 of PS 89 has cost estimates. Is a correct interpretation that the added cost per vehicle to meet the pedestrian requirements would be an average of about € 45? What costs are associated with each of the test requirements, i.e., leg-to-bumper, upper leg-to-bonnet leading edge, and head-to-bonnet?
- MEL (PS 89, section 8, pg. 18 of 1st MEL insert) suggests that the theory of the cost estimates be substantiated by OEMs and that there could be negative impact on emissions, fuel economy, and performance that should be considered. Has that been done? Do we have studies showing that the pedestrian gtr requirements can be met without conflict to existing regulations as listed in PS 35?
- In section 10 of PS 89, it is not clear how estimated reductions in pedestrian fatal & serious injuries were obtained without knowing the underlying baseline fleet performance relative to the proposed gtr requirements. Can further explanation be provided to clarify? What is the benefit derived for each of the impact requirements (i.e., child head, adult head, adult knee)? As per above, do we have either EuroNCAP, JNCAP, or KNCAP baseline performance information of the current fleet?
- PS 89 notes that "the estimates of injuries saved are sensitive to some of the assumptions

made about how well cars that are designed to meet the test procedures will protect vulnerable road users from injury," (pg. 198) and that "benefits from preventing head injuries will be over-stated as the injury risk curve used [was] for AIS 4+ injuries rather than AIS 2+" (pg. 199). Do we have a way to estimate these effects, such as knowing the baseline fleet performance?

- o The preamble will need to reflect cost, benefit, and feasibility for all regions. Do we have studies from Japan and Korea that we'll be able to cite?

The group already took note of the feasibility study performed in IHRA (INF GR/PS/5) on the EEVC WG17 proposed head tests. The main conclusions are:

- No vehicle fulfils EEVC/WG17 requirements completely
- No traditional solution currently exists to comply with EEVC/WG17 requirements (not possible with padding only)
- No sensor techniques are available yet to offer other active solutions

The group also checked with various NCAP (New Car Assessment Programme) programmes around the world to see if data from their tests could give an insight into the feasibility of certain pedestrian tests. Spain presented a study using data from cars tested in EURO-NCAP and compared these with the requirements set out in the first phase of the EU Directive 2003/102/EC on pedestrian protection (INF GR/PS/45). It concluded that, for child headform testing, current vehicles are still far away from being able to meet the proposed requirements. However, simple design changes on the best scoring vehicles will put them in a situation very close to meet the proposed requirements for the first phase of the EU Directive. For the lower legform testing the conclusion was that the majority of vehicles are performing well below the proposed requirements.

Another study was performed by Adelaide University (Australia) (INF GR/PS/66). The study reviewed 50 cars tested by AUS-NCAP and gave the detailed results of all pedestrian tests carried out. What were the results?

Both ACEA and JAMA have performed their own feasibility studies on the content of the second phase of the EU Directive 2003/102/EC. The ACEA study (INF GR/PS/91) looked at various car types (super mini car, executive car, sport utility vehicle, sports car). They used FE modelling to adapt these models to the Phase 2 requirements and check what the remaining problems are. The results include for each of the types a list of remaining solvable problems and remaining unsolvable problems. What were the results?

The JAMA study (INF GR/PS/101) looked at the technical feasibility study on EEVC/WG17 pedestrian headform to bonnet top test and on the EEVC/WG17 pedestrian upper legform to bonnet leading edge test. The study concluded, with respect to the headform tests, that a bonnet hinge complying with the EEVC/WG17 child headform to bonnet top test requirement could be developed but only under the unrealistic condition of removing the fender, and that such a hinge could not satisfy various required performances apart from pedestrian protection performance. As for the upper leg test the study concluded that the test poses serious problems in terms of the impact energy, the test tool in relation to biofidelity, and the injury acceptance levels. Additionally the test is apparently contradictory to the actual situation in a real-world car-pedestrian accident and it is not recommended to use this test in its present form.

In addition, the European Commission made its own feasibility study which was contracted out by TRL (United Kingdom). This feasibility study was required under EU Directive 2003/102/EC (INF GR/PS/89 and 120). The study concluded that, although meeting phase two of the Directive might be feasible for some types of vehicles, overall it would be unduly restrictive and is therefore not feasible without some modifications. A number of improvements to the test methods have been identified, the most significant of which are a heavier child headform impactor, revised upper legform test energies and new or reduced tolerances on test conditions. These changes will mean that the protection required will be more appropriate and it is thought that all the changes will make it easier for car manufacturers to achieve compliance. The study also evaluated the manufacturing cost and the estimated annual fatality reduction in the European Union (EU-25). The manufacturing cost to make cars compliant to the proposed amendments was assessed for all car categories and ranges from € 32.68 for a small family car up to € 406.61 for a roadster. The estimated annual fatality reduction in the European Union (EU-25) that would be obtained by implementing the suggested amendments was estimated at 1359 pedestrian and pedal cyclists lives saved and 34,305 serious injuries avoided. This would result in an estimated cost benefit ratio of 1 : 5.4 for the introduction of the revised requirements. Does the group agree?

APPENDIX – REFERENCE DOCUMENTS USED BY THE WORKING GROUP

A list of informal documents used by this Informal group is listed and available on the UNECE WP.29 website (http://www.unece.org/trans/main/welcwp29.htm).

Number of informal document	**Title of informal document**
INF GR/PS/1*	Agenda 1st meeting
INF GR/PS/2	Terms of reference
INF GR/PS/3	IHRA accident study presentation
INF GR/PS/4*	JMLIT proposed legislation
INF GR/PS/5	IHRA feasibility study
INF GR/PS/6	J information on possible scope
INF GR/PS/7	Attendance list 1st meeting
INF GR/PS/8*	Draft Meeting Minutes 1st meeting
INF GR/PS/9*	Report to GRSP 32 inf doc
INF GR/PS/10	Draft action plan
INF GR/PS/11	Agenda 2nd meeting
INF GR/PS/12	GIDAS accident data
INF GR/PS/13	GIDAS accident data graphs
INF GR/PS/14	Italian accident data
INF GR/PS/15	UN accident data
INF GR/PS/16	Spanish accident data
INF GR/PS/17	ACEA accident data
INF GR/PS/18	Draft Meeting Minutes 2nd meeting
INF GR/PS/19	Agenda 3rd meeting
INF GR/PS/20	Canadian accident data
INF GR/PS/21	Netherlands accident data
INF GR/PS/22	Scope overview
INF GR/PS/23	Draft content table preliminary report
INF GR/PS/24	Attendance list 3rd meeting
INF GR/PS/25	GIDAS presentation
INF GR/PS/26	Leg injuries ITARDA
INF GR/PS/27*	Draft Meeting Minutes 3rd meeting
INF GR/PS/28	Technical feasibility general
INF GR/PS/29	Infrastructure effectiveness
INF GR/PS/30	Pelvis / Femur fracture
INF GR/PS/31	IHRA/PS-WG Pedestrian accident data
INF GR/PS/32	ESV summary paper on IHRA/PS-WG report
INF GR/PS/33	Introduction of the regulation of pedestrian head protection in Japan; Nishimoto, Toshiyuki
INF GR/PS/34	Proposal for a directive of the European Parliament and the Council relating to the protection of pedestrians and other vulnerable road users in the event of a collision with a motor vehicle and amending Directive 70/156/EEC; Commission of the European Communities, Brussels, February 2003

INF GR/PS/35	List of conflicts with existing legislation / requirements
INF GR/PS/36	Draft preliminary report
INF GR/PS/37	Agenda 4th meeting
INF GR/PS/38	Technical prescriptions concerning test provisions for pedestrian safety
INF GR/PS/39*	Vehicle safety standards report 1
INF GR/PS/40	US Cumulative 2002 Fleet GVMR
INF GR/PS/41	Swedish accident data
INF GR/PS/42	TRANS/WP.29/GRSG/2003/10 proposal for common definitions
INF GR/PS/43	Category 1-1 GVM
INF GR/PS/44	Light duty truck
INF GR/PS/45	EURO-NCAP results and what they mean in relation to EU Phase 1
INF GR/PS/46	JAMA / JARI child and adult head impactors
INF GR/PS/47*	Preliminary report to GRSP 33
INF GR/PS/48*	Draft meeting minutes 4th meeting
INF GR/PS/49	IHRA child head test method
INF GR/PS/50	IHRA adult head test method
INF GR/PS/51	Attendance list 4th meeting
INF GR/PS/52	Provisional agenda for the 5th meeting
INF GR/PS/53	Draft gtr format
INF GR/PS/54	gtr proposal to WP29
INF GR/PS/55	Draft gtr
INF GR/PS/56*	Comparison table
INF GR/PS/57	Proposed schedule of the group
INF GR/PS/58	Presentation on veh shape, bound line, ...
INF GR/PS/59	A-pillar IHRA OICA presentation
INF GR/PS/60	ISO/TC22/SC10/WG2 N613
INF GR/PS/61	IHRA PS 237
INF GR/PS/62	Action plan from 5 meeting
INF GR/PS/63	Attendance list 5th meeting
INF GR/PS/64*	Draft meeting minutes 5th meeting
INF GR/PS/65*	Provisional agenda for the 6th meeting
INF GR/PS/66	AUS-NCAP pedestrian data
INF GR/PS/67	Test-method - active hood / bonnet systems
INF GR/PS/68	Target population head injuries - US
INF GR/PS/69	Working paper draft gtr
INF GR/PS/70	Korean information
INF GR/PS/71	Head test area windscreen + A-pillar
INF GR/PS/72	Head test data on windscreen
INF GR/PS/73	Head impact angle / speed re-assessment based on vehicle geometry
INF GR/PS/74	IHRA/PS/270 headform impactor specification
INF GR/PS/75	Powerpoint explanation of PS/67
INF GR/PS/76	IHRA legform discussions
INF GR/PS/77	Corridors proposed by UVA (lower legform)
INF GR/PS/78	Bio rating method: Maltese
INF GR/PS/79	IHRA antropometric proposal
INF GR/PS/80	IHRA/PS/278
INF GR/PS/81	Schedule for legform impactor for gtr

INF GR/PS/82	Injury threshold for ped legform test
INF GR/PS/83	Decided items and action items of the 6th meeting
INF GR/PS/84	Draft meeting minutes of the 6th meeting
INF GR/PS/85	Attendance list of the 6th meeting
INF GR/PS/86	Draft gtr EU working document
INF GR/PS/87	IHRA PS 273 Development of FlexPLI2003
INF GR/PS/88	Second interim report to GRSP 35
INF GR/PS/89	EU Feasibility Study Phase 2
INF GR/PS/90	Provisional agenda for the 7th meeting
INF GR/PS/91	ACEA feasibility study Phase 2
INF GR/PS/92	ACEA equal effectiveness study Phase 2
INF GR/PS/93	Design of head impactor
INF GR/PS/94	Front windshield
INF GR/PS/95	JPN comment on PS 86 Rev 2 + English text of Japanese technical standard
INF GR/PS/96	Problem of undamped accelerometer
INF GR/PS/97	Durability and repeatability of headform skin
INF GR/PS/98	IHRA PS 310 decision for legform test
INF GR/PS/99	Skin aging of head impactor
INF GR/PS/100	OICA proposed amendments to PS/95
INF GR/PS/101	JAMA feasibility study Phase 2
INF GR/PS/102	OICA windscreen testing according to EURO-NCAP protocol
INF GR/PS/103	CLEPA windscreen testing on one car model
INF GR/PS/104	Draft CLEPA / OICA document on active bonnet testing
INF GR/PS/105	Lower leg research for developing corridors
INF GR/PS/106	J-MLIT proposal for FlexPLI answering item 9 of PS/83
INF GR/PS/107	NHTSA proposal for guidelines of preamble
INF GR/PS/108	JAMA information on high bumper definition
INF GR/PS/109	Chairman proposal for FlexPLI and rigid impactor use in gtr
INF GR/PS/110	OICA proposal for side and rear windscreen reference line
INF GR/PS/111	Guideline for preamble
INF GR/PS/112	Action plan
INF GR/PS/113	Revision of draft gtr
INF GR/PS/114	Attendance list
INF GR/PS/115*	Draft meeting minutes of the 7th meeting
INF GR/PS/116	Cleaned up version of draft gtr
INF GR/PS/117	Preamble and draft gtr off doc for GRSP 37
INF GR/PS/118	Provisional agenda for the 8th meeting
INF GR/PS/119	ISO Activities for Pedestrian Safety
INF GR/PS/120	EC final feasibility study
INF GR/PS/121	GRSP/2005/3 as amended during GRSP/37
INF GR/PS/122	GRSP-37-18
INF GR/PS/123	GRSP-37-15
INF GR/PS/124	GRSP-37-16
INF GR/PS/125	Short report on comments received during GRSP-37
INF GR/PS/126	July meeting task list
INF GR/PS/127	Presentation on EU Phase 2

INF GR/PS/128	The need for harmonised legislation on pedestrian protection
INF GR/PS/129	Comparison between the J standard and the EU Phase 2 proposal for head testing
INF GR/PS/130	List of references for EU / EEVC on head impact angles
INF GR/PS/131	Analysis of pedestrian accident situation and portion addressed by this gtr
INF GR/PS/132	gtr testing and what it means for the US situation
INF GR/PS/133*	Proposal to solve the undamped accelerometer problem
INF GR/PS/134	Concerns on §7.4 with testing on the centre of the windscreen
INF GR/PS/135	OICA proposal for §3.33
INF GR/PS/136	OICA proposal for a mass for the upper leg impactor
INF GR/PS/137	OICA proposal on definition of high bumper vehicles
INF GR/PS/138	Economic effectiveness study from Korea
INF GR/PS/139	Action list of 8th meeting
INF GR/PS/140	IHRA Injury breakdown background document for PS/131
INF GR/PS/141	Update of PS67 on certification standard for deployable systems
INF GR/PS/142	Relative humidity of Korea
INF GR/PS/143*	Draft gtr based on INF GR / PS / 121 as amended during the 8th meeting
INF GR/PS/144	Draft meeting minutes of the 8th meeting
INF GR/PS/145	Attendance list 8th meeting
INF GR/PS/146	Flex-TEG Activities updating PS 124
INF GR/PS/147	Actions 1 3 4 6 9 of 8th meeting
INF GR/PS/148	Action 9 of 8th meeting doc FTSS_4[1].5kg_headform
INF GR/PS/149	Adult headform moment of inertia
INF GR/PS/150	Development of a head impact test, Glaeser
INF GR/PS/151	gtr preamble for accelerometer
INF GR/PS/152	Provisional agenda for the 9th meeting
INF GR/PS/153	Explanation of amendments from PS143 to PS143 Rev1
INF GR/PS/154	Handling guide for the TRL leg
INF GR/PS/155	LWRL definition
INF GR/PS/156	Impact angles for headform to windscreen tests
INF GR/PS/157	HIC limits for headform to windscreen tests
INF GR/PS/158	Headform to bonnet tests
INF GR/PS/159	Definition high bumper vehicles
INF GR/PS/160	Revised preamble replacing the preamble in PS/143 Rev 1