Economic and Social Council

Economic Commission for Europe

Inland Transport Committee

World Forum for Harmonization of Vehicle Regulations

Working Party on Passive Safety

Seventy-third session
Geneva, 15–19 May 2023
Item 19 of the provisional agenda
Mutual Resolution No. 1

Proposal for Amendment 4 of the Mutual Resolution No. 1 (M.R.1) of the 1958 and the 1998 Agreements *

Submitted by the Chair (Republic of Korea) of the Informal Working Group on the Deployable Pedestrian Protection Systems of UN Global Technical Regulation No. 9.

The text reproduced below was prepared by the experts of the Informal Working Group (IWG) of the Deployable Pedestrian Protection Systems (IWG-DPPS) on UN Global Technical Regulation No. 9 to propose a new Addendum 5 on provisions for the DPPS Generic Vehicle (GV) Models. The modification to the existing text of the Mutual Resolution No. 1 are marked in bold for new or strikethrough for deleted characters.

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* In accordance with the programme of work of the Inland Transport Committee for 2023 as outlined in proposed programme budget for 2023 (A/77/6 (Sect. 20), table 20.6), the World Forum will develop, harmonize and update UN Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

I. Proposal

Contents, amend to read:

"Contents

Section II,

Paragraphs 3. and 3.1., Specific provisions, amend to read:

3. Specific Provisions

3.1. The table below details the individual addenda to this Mutual Resolution in which details of the design, construction, maintenance and preparation of the test devices or equipment can be found.

ECE/TRANS/WP.29/1101	*Generic name of the Test Tool*	*Regulation(s) requiring the test Tool Device*	*Global technical regulation(s) requiring the Test Tool or Device*	*Date of adoption of the Addendum*
Amend.3 - Addendum 1 to M.R.1	BioRID Dummy	No. 17	No. 7	**24 Nov. 2021**
Amend.1 - Addendum 2 to M.R.1	WorldSID 50th male Dummy	No. 135	No. 14	12 Nov. 2014
Amend.2 - Addendum 3 to M.R.1	FlexPLI	No. 127	No. 9	
- Addendum 4 to M.R.1	(Reserved) Q Dummy	…	…	**…**
Amend.4 - Addendum 5 to M.R.1	**General Vehicle models**	**No. 127**	**No. 9**	**[ ]**

"

Appendix, amend to read:

"Addendum 1 – Bio Rear Impact Dummy (BioRID) specifications

…

Addendum 2 – Specifications for the Construction, Preparation and Certification of the World Side Impact 50th percentile adult male anthropomorphic test device (WorldSID 50th male)

…

Addendum 3 – Specifications for the Construction, Preparation and Certification of the flexible Pedestrian Legform Impactor (FlexPLI)

…

Addendum 4 – [Reserved for Q Dummies]

Addendum 5 – Generic Vehicle (GV) Models for Qualification of Human Body Models (HBMs) for Head Impact Time (HIT) Determination Simulations

Contents

1. General Provisions

1.1. This Addendum provides the specifications for the generic vehicle models to be used for the qualification of pedestrian models for HIT determination according to [UN GTR No. 9, amendment [3], Annex 2]. This document specifies the models and their usage.

1.2. The generic vehicle models as such are available. In this Amendment, general usage is explained and their structure and properties documented.

2. User Manual

3.1. Types of generic vehicle models

3.1.1. The generic vehicle models are available in the three different Finite Element codes used by car manufacturers for DPPS simulations:

(a) LS-Dyna (Ansys);

(b) RADIOSS (Altair);

(c) VPS (ESI).

A consistent approach for all codes was pursued. Download the package in the FE code, which is intended to be used.

3.1.2. The generic vehicles are available in three different shapes (shown in Figure 1), whereby all three are required for the procedure to qualify the HBMs in [UN GTR No. 9, amendment [3], Annex 2]:

(a) Family Car (FCR);

(b) Roadster (RDS);

(c) Sport Utility Vehicle (SUV).

Figure 1
Shapes of Generic Vehicle Models

Roadster   Family car   SUV
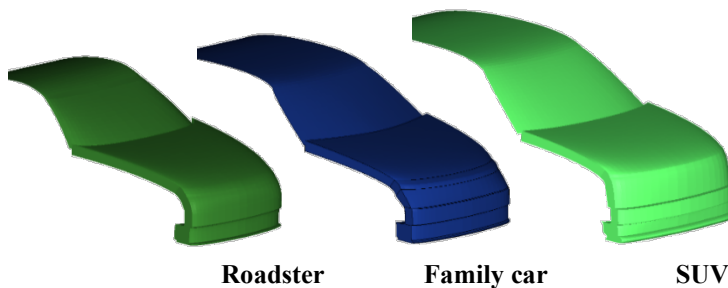
3.1.2. The generic vehicles are available in three different unit systems and shall be used in the unit system used throughout the procedure:

(a) Millimetre, kilogram, milliseconds (mm_kg_ms);

(b) Millimetre, tons, seconds (mm_to_s).

3.4. Auxiliary files for the utilisation of the generic vehicle models are available together with the models, which are further explained in Annex 2. These files are templates only and therefore have to be adjusted by the user.

3.   General Design

3.1.   The generic vehicle models are finite element simulation models, which were designed to represent three different shapes and stiffnesses representative for the European fleet at the time of development of the models. The geometry of the cross-section at the vehicle centreline of the three different vehicle shapes is shown below:

Figure 2
Components of the Generic Vehicle Models to Represent Generic Structure
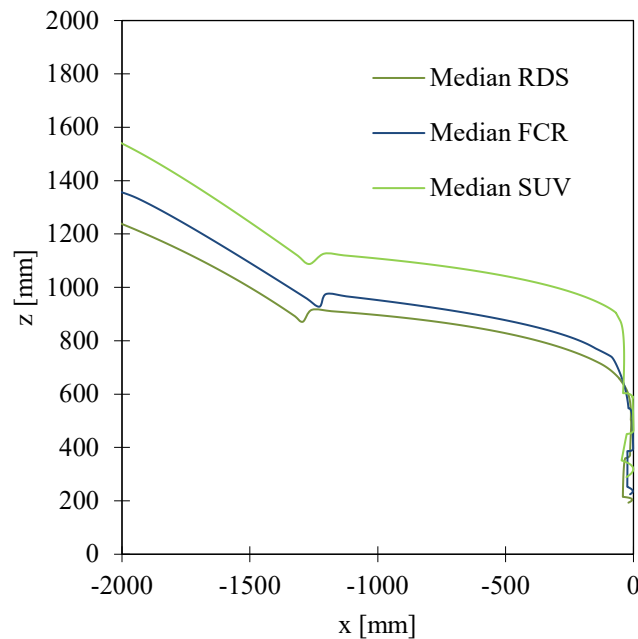
3.2.   **Physical properties**

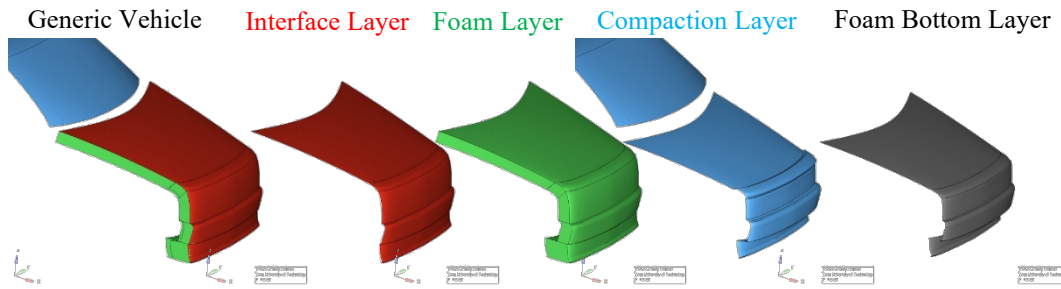**3.2.1.**   The generic vehicle model consists of the components shown in Figure 1. The structural response is modelled through an outer shell surface, an interface layer, (for modelling the vehicles fascia), a generic foam (to model energy absorbing structures like rips), resting on the bottom layer (a rigid skeletal vehicle structure) and the compaction layer which works a hard stop.

3.2.3.   The generic vehicle models have only one degree of freedom, which is the x-direction in the vehicle coordinate system. An initial velocity is applied to the generic vehicle models at the start of the simulation. Further motion in x are not prescribed. The mass of the generic vehicle modes are shown in Table 1. The vehicle's moments of inertia remain unconsidered, though.

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Figure 3
Components of the Generic Vehicle Models to Represent Generic Structure

Generic Vehicle   Interface Layer   Foam Layer   Compaction Layer   Foam Bottom Layer

Table 1
Mass of the Generic Vehicle Models

Vehicle Category	Total Mass [kg]
SUV	1 775.0
Family Car	1 690.0
Roadster	1 462.5

4. Certification

4.1. The certification of the generic vehicle models may be performed if the user has any doubt that the generic vehicle models work properly with the solver version and control cards used. If issues (i.e. significant deviations to the reference curves provided) are identified, the user shall switch to another solver version, review the control settings and report the issue to gv.vsi@tugraz.at.

4.2. To perform the comparison, the files specified in Annex 2 for the respective FE code, vehicle shape and impactor location shall be used. Impacts shall be performed with the rigid cylindrical impactor (density= 7.89 E-6 kg/mm³, diameter= 120 mm, height= 400 mm and wall thickness= 5 mm) at the vehicle centreline on the spoiler (ID=1), Bumper (ID=3), Bonnet Leading Edge (ID=5) and bonnet (ID=7), as shown in the figure below.

Figure 4
Impact Locations for Generic Vehicle Certification
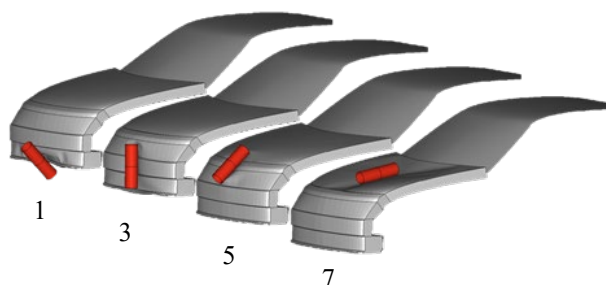
4.3.   **The outputs of the impactor node shall be utilised to compare the simulation results with the references shown in Table 2. The impactor acceleration has to be multiplied with 5.95kg to receive the force and the resultant displacement is used as displacement. The black and grey lines shown in the figures show the responses of the generic vehicle models in the three different FE codes and should be used as reference. The focus in the development of the generic vehicle models was consistency between the different FE codes using the shown corridors and median responses as reference.**

4.4.   **The GV Models have been validated with the following solver versions:**

(a)   **RADIOSS 2019:**

(b)   **LS-Dyna R12:**

(c)   **VPS 2019, 2020, 2021, 2022.**

Other solver versions can be used, but users shall verify the behaviour of the GV models by performing the impactor simulations.

[**Table 2**
Reference Curves for Impactor Simulations with Generic Vehicle models

FCR	RDS	SUV

Spoiler CL

Bumper CL

Bonnet Leading Edge CL

Bonnet CL

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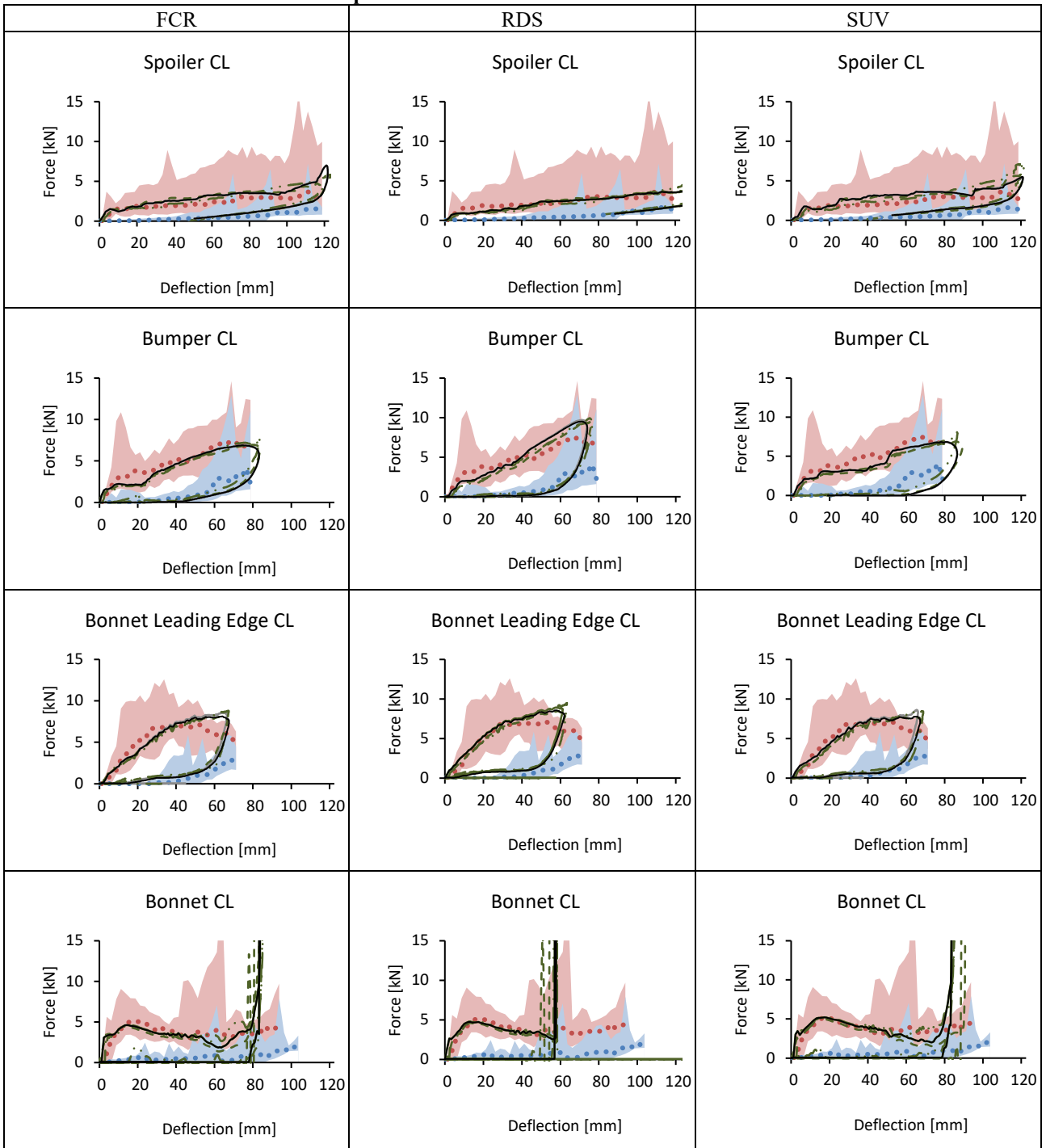
Annex 1

File List of Generic Vehicle Models[1]

Table A-1
File Structure and Names of the Generic Vehicle Models
The models are provided "as is". The users are responsible to verify the behaviour of the models according to chapter 4.

FE Code	Unit System	Master files	File ID
LS-Dyna	**mm, kg, ms**	GV_FCR_R3_1_mm_kg_ms.key	**D-GV-1**
		GV_RDS_R3_1_mm_kg_ms.key	**D-GV-2**
		GV_SUV_R3_1_mm_kg_ms.key	**D-GV-3**
	mm, to, s	GV_FCR_R3_1_mm_to_s.key	**D-GV-4**
		GV_RDS_R3_1_mm_to_s.key	**D-GV-5**
		GV_SUV_R3_1_mm_to_s.key	**D-GV-6**
RADIOSS		GV_FCR_R3_1_mm_kg_ms.0000.rad	**R-GV-1**
	mm, kg, ms	GV_FCR_R3_1_mm_kg_ms.0001.rad	**R-GV-10**
		GV_RDS_R3_1_mm_kg_ms.0000.rad	**R-GV-2**
		GV_RDS_R3_1_mm_kg_ms.0001.rad	**R-GV-20**
		GV_SUV_R3_1_mm_kg_ms.0000.rad	**R-GV-3**
		GV_SUB_R3_1_mm_kg_ms.0001.rad	**R-GV-30**
	mm, to, s	GV_FCR_R3_1_mm_to_s.0000.rad	**R-GV-4**
		GV_FCR_R3_1_mm_to_s.0001.rad	**R-GV-40**
		GV_RDS_R3_1_mm_to_s.0000.rad	**R-GV-5**
		GV_RDS_R3_1_mm_to_s.0001.rad	**R-GV-50**
		GV_SUV_R3_1_mm_to_s.0000.rad	**R-GV-6**
		GV_SUV_R3_1_mm_to_s.0001.rad	**R-GV-60**
VPS	**mm, kg, ms**	GV_FCR_R3_1_mm_kg_ms_VPS.inc	**V-GV-1**
		GV_RDS_R3_1_mm_kg_ms_VPS.inc	**V-GV-2**
		GV_SUV_R3_1_mm_kg_ms_VPS.inc	**V-GV-3**
	mm, to, s	GV_FCR_R3_1_ mm_to_s_VPS.inc	**V-GV-4**
		GV_RDS_R3_1_ mm_to_s_VPS.inc	**V-GV-5**
		GV_SUV_R3_1_ mm_to_s_VPS.inc	**V-GV-6**

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[1] [The generic vehicles are available on the website of the Mutual Resolution No. 1 (M.R.1) of the 1958 and the 1998 Agreements:
www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29resolutions.html]

Annex 2

Auxiliary Files[1]

Table A-2
Auxiliary Files to Facilitate the Use of the Generic Vehicle Models
All master files listed in this table have to be adjusted by the user to create the specific simulation setup to perform the impactor simulations specified in Chapter 4. They are available in both unit systems.

LS-Dyna

Template for Impactor Simulations	**\Auxiliary_files_Impactor_Sim\00__GV_Main_ IMP_Template.dyn**	**D-I-1**
referring to include files: **Cyclindrical impactor**	**\IMP_FILES\11a_IMP_NodEle_Cyl.inc**	**D-I-2**
Parameters for impact on FCR	**\IMP_FILES\ 10__IMP_Parameters_FCR.inc**	**D-I-3**
Parameters for impact on RDS	**\ IMP_FILES\ 10__IMP_Parameters_RDS.inc**	**D-I-4**
Paramters for impact on SUV	**\ IMP_FILES\ 10__IMP_Parameters_SUV.inc**	**D-I-5**
Exemplary control file	**\ CONTROL_EXAMPLE\ 00__Controls_example.inc**	**D-I-6**

RADIOSS		
Template for Impactor Simulations	**\Auxiliary_files_Impactor_Sim\00__GV_Main_ IMP_Template_0001.rad**	**R-I-1**
	\Auxiliary_files_Impactor_Sim\00__GV_Main_ IMP_Template_0000.rad	
referring to include files: **Cyclindrical impactor**	**\IMP_FILES\IMPACTOR.inc**	**R-I-2**
Parameters for impact on FCR	**\IMP_FILES\IMP_Parameters_FCR_01.inc**	**R-I-3**
	\IMP_FILES\IMP_Parameters_FCR_03.inc	**R-I-4**
	\IMP_FILES\IMP_Parameters_FCR_05.inc	**R-I-5**
	\IMP_FILES\IMP_Parameters_FCR_07.inc	**R-I-6**
	\IMP_FILES\IMP_Parameters_RDS_01.inc	**R-I-7**
Parameters for impact on RDS	**\IMP_FILES\IMP_Parameters_RDS_03.inc**	**R-I-8**
	\IMP_FILES\IMP_Parameters_RDS_05.inc	**R-I-9**
	\IMP_FILES\IMP_Parameters_RDS_07.inc	**R-I-10**

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[1] **[The auxiliary files are available on the website of the Mutual Resolution No. 1 (M.R.1) of the 1958 and the 1998 Agreements:**
www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29resolutions.html]

LS-Dyna

Paramters for impact on SUV	**\IMP_FILES\IMP_Parameters_SUV_01.inc**	**R-I-11**
	\IMP_FILES\IMP_Parameters_SUV_03.inc	**R-I-12**
	\IMP_FILES\IMP_Parameters_SUV_05.inc	**R-I-13**
	\IMP_FILES\IMP_Parameters_SUV_07.inc	**R-I-14**
VPS		
Template for Impactor Simulations	**\Auxiliary_files_Impactor_Sim\fcr-impactor-template.pc**	**V-I-1**
	\Auxiliary_files_Impactor_Sim\rds-impactor-template.pc	**V-I-2**
	\Auxiliary_files_Impactor_Sim\suv-impactor-template.pc	**V-I-3**
referring to include files: **Cyclindrical impactor**	**\Auxiliary_files_Impactor_Sim\impactor.inc**	**V-I-4**

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The reference curves shown in Table 2 are included in the file "Impactor_Simulation_Results.csv"."