

### **Status report and a drafted proposal as a basis to discuss the next step**

- Annex 1. Summary of study/data presentations from the meetings held to date in DEOP
- Annex 2. Draft ToR for an IWG on Equitable Occupant Protection

GRSP agreed in December 2021 that the ad hoc group of experts could continue to review existing research/share ongoing research and if GRSP determines that there is enough evidence to address this issue, an IWG may be established.

There have been 5 meetings in this ad hoc group between December 2021 and December 2022.

The group has collected and reviewed data to determine whether there is a difference when it comes to gender, but indirectly also the full diversity issue, i.e., stature, mass, and age of occupants in crash safety.

The presented data indicate that the injury risk is higher for women than for men regarding all types of injuries and all types of crashes. The specific difference in fatality risk between female and male occupants has decreased with newer vehicle types but is still visible. Non-fatal injuries, which may lead to long-term consequences, e.g., neck injuries and injuries to extremities, remain a concern. The group has had a particular focus on neck injuries, including permanent disability, because there is evidence of significant differences in risk of injury between male and female occupants. The presented data give reason to assume that similar differences in risk occur for other significant diversity aspects, such as age, weight, and height. In conclusion, there is a larger equity issue.

Since the presented data indicate differences, it is time to start a discussion about what the GRSP can do to enhance the equitability when it comes to crash safety for all occupants. The DEOP group would like to invite interested parties/stakeholders to discuss possible ways forward. As a basis to start the discussion the DEOP group has drafted a proposal of an Informal Working Group on Equitable Occupant Protection. Focus is on two perspectives,

- one on short to midterm perspective to find possible solutions with tools already existing, and reviewing current regulations and
- one long term perspective considering the potential of virtual crash testing as one way to improve equitable occupant protection.

## **Annex 1. Summary of study/data presentations from the meetings held to date in DEOP**

### First meeting <https://wiki.unece.org/display/trans/DEOP+1st+session>

1. Results from one comprehensive literature review, which covers most relevant publications on the subject of equitable occupant protection regarding sex for the last decades through 2020, are presented and discussed. In summary, the review indicates that the injury risk is higher for women than for men regarding all types of injuries and all types of crashes, and that the greatest difference between female and male fatality risks is in the age of 18-35. (CHALMERS)
2. An IRCOBI paper from 2020, though included in the literature review, is presented here separately, and discussed. Risk for injuries of various types in crashes occurring 2000-2019 is studied, adjustments are made for crash year and car mass. There is a clear risk reduction in cars launched 2010–2019 compared to 1980–1989. The analysis is separated for sex and age groups, but not height or size. The study shows that the trend of risk reduction for newer cars is equal for male and female occupants. The risk for any injury as well as permanent medical impairment remains significantly higher for female occupants compared to male. Young females were found to be at higher risk for cervical spine injuries compared with both males and older females. (FOLKSAM)
3. The study “Restraint Systems - for all occupants?” is presented and discussed. This is a study of severe frontal impact crashes in Germany. The crash data do not indicate an increased risk of injury for women or men, but different injury patterns can be identified. Older car occupants have a higher risk of injury than younger ones. Injuries to the head, abdomen and pelvis are more common for elderly. (ADAC)

### Second meeting <https://wiki.unece.org/display/trans/DEOP+2nd+session>

1. In this meeting, we have a presentation of one study from late 2021 that is not included in the literature review that had been completed earlier and presented in the first meeting. The objective of the study is to evaluate the effect of occupant sex on injury risk in front and side crashes while controlling for vehicle and crash difference between men and women. Previous research indicates that women are more likely than men to suffer severe injuries in motor vehicle crashes, on a per-crash basis. In this study, after controlling for crash and vehicle differences, women and men have similar risk of serious non-extremity injuries in front crashes, but women remained at a higher risk of less severe injuries and especially extremity injury. Women are more likely than men to be driving the struck vehicle in side-impact and front-into-rear crashes. According to the study, there is a need for further studies on the increased risk to females due to sex-based differences in crash exposure, also more on the finding that females are at higher risk of extremity injuries, and finally more data is needed to understand injury risk in side impact crashes. (IIHS)
2. The second study presented is about a difference between the Saab 9-3 and Saab 9-5 passenger cars. The seats look similar, but the protection performance is different in a field analysis. Both seats protect men well, but the 9-3 seat results in a significantly higher risk for women. A 50th percentile female dummy for rear-end impact testing is developed in addition to the existing BioRID 50th percentile male, and this female dummy is now used for evaluation of the 9-3 and 9-5 seats to better understand the difference. It turns out that the interior seat structures are somewhat geometrically different although the same protective mechanism is used. (CHALMERS)

3. Standards should reflect typical needs of both men and women, whether about instructions, grip strength, geometry, or voice recognition, but until now the standardization work has in many aspects focused attention on the needs of men and failed to account for women. The starting point should be that there are differences between the female and male population regarding physiological aspects. For this reason, the UNECE WP6 on Regulatory Cooperation and Standardization Policies has drafted the “Guidelines on Developing Gender-Responsive Standards”, which provides practical advice for standards developers on how they can improve the gender-responsiveness of their standards. This approach and draft are presented in the second DEOP meeting. (UNECEWP6)

Third meeting <https://wiki.unece.org/display/trans/DEOP+3rd+session>

1. A review regarding current regulations and evaluation tools is presented. Among other things, we currently see that the male ATD’s (50th percentiles) are used in 18 different regulatory tests (plus 2 “pending”), whereas the female ATD’s (5th percentiles) are used in 9 different regulatory tests. Another finding comes from a comparison of selected US Anthropomorphic Data and corresponding ATD metrics. The metrics Standing Height, Weight, Upper Leg Length for both male and female ATD’s are all compared to corresponding anthropomorphic data. As an example, the standing heights and weights for the female 5<sup>th</sup> percentile ATD’s correspond relatively well with anthropometric data, whereas the upper leg length of the same ATD’s were much longer than anthropometrics. Similar trend is seen for the male ATD’s. The review does also discuss Thorax Certification – Samples of Injury Risk Curves (for HIII5F, HIII50M, SIDII and WorldSID50M) in relation to discrepancies between required criteria and corresponding dummy thorax certification test corridors. (AUTOLIV)
2. A thorough presentation of Anthropometric Test Devices (test dummies) is given. The presentation provides an overview of available ATD’s and focus specific attention on the new advanced test dummies THOR, both the THOR 50M and the THOR 5F. Related aspects are discussed, such as the context with crash regulations and rating standards, as well as CAE models of dummies (digital twins of the dummies) and digital Human Body Models. (HUMANETICS)
3. Whiplash protection for female occupants was presented and discussed. Findings ADSEAT the EU research project has been provided in previous DEOP meetings and this time some important observations were shared. Whiplash protection of 3 typical serial seats were compared through virtual testing with the following two virtual dummies (1. The BioRID simulation model, representing a 50th male and 2. The EvaRID simulation model, representing a 50th female). Recommendation for regulatory development is to assure that no geometric mismatch occurs. There is no need to wait for a new female dummy, such as the EvaRID; a geometric check is feasible and might suffice, according to the presenter, and a preliminary proposal for correctly adjusted Head Restraints for height for a 50th female (lowest or head restraint aligned with the head, whichever is higher). (FORVIA)

Fourth meeting <https://wiki.unece.org/display/trans/DEOP+4th+session>

1. One additional study with focus on head restraints and protection against whiplash associated disorders in rear impacts is presented (“Whiplash improvements for females”) in this meeting. The presentation shows the result from dynamic whiplash tests with the standard BioRID 50th and the experimental BioRID 50th Female (BioRID 50F) in a base seat and a seat with improved head restraint design. The improvement consists of additional head rest insert adapted to 50%-ile male and female occupants. The head restraint with the insert

adapted to BioRID 50M and 50F show the same tendency of whiplash improvements for both 50th male and 50th female. A significant decrease of shear-force (+FX upper) for both BioRID 50M and BioRID 50F is seen, but the absolute value remains higher for the BioRID 50F. The recent changes to R17 and the importance to follow up the results of that are discussed. (FORVIA)

2. The IIHS Crashworthiness evaluations for the protection of occupants in low-severity rear impacts are presented. The presentation includes both a historical review of whiplash injuries, evaluation methods and countermeasures, as well as ongoing and future activities. From 1999 to 2016 the reported injuries (any) in rear-impact crashes have dropped with over 50%. Females are still at a higher risk. Drivers in vehicles with good-rated head restraint are 24% less likely to suffer neck injury than those in poor rated vehicles. The improvement is present for all occupant categories, but females have a greater benefit from good-rated head restraints. Active head restraints show an overall 44% reduction of neck injuries. Key takeaways from the presentation are that a) the current evaluation tools have reduced injuries in rear impacts for both men and women, b) women are still at a higher risk for whiplash injuries than men, and c) virtual testing provides opportunities to address equity and robustness in crashworthiness evaluations.

Fifth meeting <https://wiki.unece.org/display/trans/DEOP+5th+session>

1. The EU research project VIRTUAL is presented. The project addresses the needs of models of both the female and the male part of the population in the assessment of road user safety. The use cases are seated occupants (adults and children) in vehicles, pedestrians, cyclists, and in addition, standing occupants in public transport. All models and tools developed in the project are open source. The virtual human body models (the VIVA+ 50F and 50M) are presented and their use as pedestrians being hit by a vehicle is shown. In addition, the outline of the Seat Evaluation Tools (SET) 50F and 50M for the low severity rear impact case is briefly described.

Relevant available/published study which has not been presented

1. *NHTSA Female Crash Fatality Risk Relative to Males for Similar Physical Impacts; NHTSA, August 2022 (follow up of Kahane's study from 2013). Incremental female fatality risk estimates versus males are reduced in newer MY vehicles. In this study, incremental risks for female front-row occupants (average of drivers and right-front passengers) age 16 to 96 are found to be 19.9 ( $\pm 1.3$ ) percent in fatal crashes in MY 1960-1999 vehicles, and 9.4 ( $\pm 2.2$ ) percent in MY 2000-2020 vehicles. The difference in fatality risk between females and males is further reduced when looking at MY 2010-2020 vehicles (6.3  $\pm$  5.4%) compared to MY 1960-2009 vehicles (18.3  $\pm$  1.2%). Note that this study focus attention on fatality risk, not non-fatal injuries. (NHTSA)*
2. *Nutbeam T, Weekes L, Heidari S, et al. Sexdisaggregated analysis of the injury patterns, outcome data and trapped status of major trauma patients injured in motor vehicle collisions: a prespecified analysis of the UK trauma registry (TARN). BMJ Open 2022;12:e061076. doi:10.1136/bmjopen-2022-061076. The result of this study is that male patients are more severely injured and more likely to die as a result of MVC than female patients. Female patients under 80 are more frequently trapped than male patients. Female patients are more likely to have spinal and pelvic injuries and male patients are more likely to have head, face, thoracic and limb injuries. Future work should include appropriate sex-based and gender-*

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*based analyses designed to shed light on the biological and sociocultural factors that create differential experience and outcomes for women and men involved in MVCs.*

## **Annex 2 Draft ToR for an IWG on Equitable Occupant Protection**

This document is the result of the discussion in the DEOP ad hoc group (formed under the GRSP) where experts representing both contracting parties and industries have participated.

### **Informal Working Group on Equitable Occupant Protection**

#### **Terms of Reference – Proposal**

##### **A. Introduction**

An ad-hoc group on equitable occupant protection (founded by Canada, France, Germany, Japan, the Netherlands, Spain, and Sweden after the 70<sup>th</sup> session of the GRSP) started to review relevant data regarding equity of men and women in occupant protection, in early 2022.

Today, crash tests are carried out with dummies that represent a man who is 176cm tall and weighs 70kg and in frontal crashed additionally with a dummy that is a 5<sup>th</sup> percentile female is a downscaled man who is 151cm tall weighing 48kg. Both of them sit very straight in their cars with their seats perfectly adjusted.

The presented data indicate that the injury risk is higher for women than for men regarding several types of injuries and all types of crashes. The specific difference in fatality risk between female and male occupants has decreased with newer vehicle types but is still visible. Non-fatal injuries, which may lead to long-term consequences, e.g., neck injuries and injuries to extremities, remain a concern. The group has had a particular focus on neck injuries, including permanent disability, because there is evidence of significant differences in risk of injury between male and female occupants. Furthermore, the presented data give reason to assume that similar differences in risk occur for other significant diversity aspects, such as age, weight, and height. In conclusion, there is a larger equity issue. Further review is needed to be able to explain the injury differences that can be seen in crash statistics, (such as more likely to have lower leg injuries, abdomen, arms and necks), and it will be required to review other relevant data, in particular data from both physical and virtual crash tests, with the view to better understand equitability. Nonetheless, the visible inequitable outcomes so far underscore a need to start reviewing the current regulatory requirements.

The potential of virtual crash testing as one way to improve equitable occupant protection has also been considered. Virtual crash testing will make it possible to test vehicles for a wider range of occupants in different crash scenarios, including both the pre-crash event (including emergency braking and evasive steering) and the in-crash event (including occupants of different size and sex, different seating positions, impact severities and impact angles, etc.). Virtual testing will most likely become the most cost-effective procedure for society to evaluate crash safety; and also

reviewing possibilities to implement advanced crash test dummies existing today but there will be a need for a regulatory framework, standards and guidelines.

When numerical models (of vehicles, safety systems and humans) are developed and considered for regulation, it is crucial to ensure that they meet certain standards to ensure comparable and reliable results, for instance that a particular virtual testing leads to a similar level of safety performance regardless of which numerical human body model a vehicle has been assessed with.

In this regard, the ad-hoc group on equitable occupant protection has identified the following points to follow up on:

- Continue to collect and review relevant field accident data to further understand the reasons for the varying injury risks of different occupants. For the same reason, collect and review other relevant and available data, in particular data from the virtual testing performed today in research. The reason is to be able to separate the issues which current concerned regulations under GRSP could address directly (if upgraded) from the gaps where more research is needed.
- Explore and advance the current state-of-the-art of virtual crash testing to determine and increase its capability as a tool and process to evaluate equity, including a specific assessment of the state-of-the-art virtual human body models, i.e., virtual models of humans, particularly the possibilities for a safety performance evaluation at a higher level of detail.
- Review the concerned UNECE regulations under the 1958 agreement for crashworthiness and occupant protection (passive safety), and related regulations, with a view to identify opportunities for improvement of concerned UNECE regulations regarding equity; NB, equity in its expanded definition.
- Assess whether existing regulations are sufficiently flexible to allow new technical developments regarding occupant safety resulting from new assessment possibilities of particularly virtual crash testing.

## **B. Objective of the informal working group**

The informal working group shall

1. Identify and present a map of issues which should be addressed by regulatory upgrades directly vs gaps where more research is needed regarding equitable occupant protection. Review previous work done in wp.29 regarding a female 50<sup>th</sup> percentile crash test dummy.
2. Determine how greater diversity in terms of representation of crashes and occupants should be implemented in concerned crash safety regulations, and if needed, propose well defined changes to those regulations and further activities in GRSP.
3. Assess virtual crash testing as a method in concerned regulations to improve equity in occupant protection further, through
  - a. mapping the gaps in terms of equity in the concerned regulations that virtual crash testing could potentially fill,
  - b. assessing the current state-of-the-art of virtual crash testing tools and processes, e.g., understand the readiness of virtual human body models regarding their validation level of occupant kinematic and potential to predict injury,

- c. Review existing ATD:s and other tools (incl. injury risk curves and test conditions) and the possibilities they provide to more diverse crash testing.
  - d. drafting preliminary global guidelines for virtual models to ensure that they are inclusive,
  - e. reaching a common understanding of basic requirements that virtual crash testing models should fulfill, particularly regarding car occupants of different sex and size,
  - f. reviewing whether current regulations are sufficiently flexible to allow the new technical developments resulting from the new assessment possibilities created by virtual crash testing, for example for advanced adaptive protective systems,
  - g. assessing the possibilities, and shortcomings, of virtual crash testing when it comes to
    - i. different kind of injuries for example:
      - 1. neck injuries, including the soft tissues of the head, neck, and spine,
      - 2. thoracic injuries,
      - 3. injuries to the extremities
    - ii. the value of new types of crash test, e.g., low-speed rear impact sled tests,
    - iii. increased protection of vulnerable road users (if identified as an equity issue),
    - iv. preventing misapplication of crash test protocols,
    - v. advanced human body models that enable the assessment of all types of crashes in greater detail (omni-directional crash impacts; different seat configurations and seat positions; all types of occupants from child to senior, from short to tall, women and men, etc.)
  - h. Definition of requirements for simulation models and procedures to enable virtual testing
    - i. Requirements to ensure comparability of simulation results (by standardizing requirements for human models, which can be used for virtual assessments)
    - ii. Definition of Anthropometry Catalogues for future safety assessments
    - iii. Definition of validation procedures for virtual models of relevant vehicle parts
    - iv. Definition of procedures to ensure integrity of virtual assessments
4. Identify any shortcomings of existing regulations and related standards, such as whether the current test protocols can be misapplied to optimise crash performance for the specific test conditions and test dummies in a narrow way that is detrimental to the protection of a diverse population.

### **C. Operating principles**

1. The informal working group on developing equitable occupant protection is open to all Contracting Parties and Non-Governmental Organisations to the 1958 and 1998 agreements.
2. A Chair, a Vice Chair and a Secretary, will manage the informal working group.
3. The working language of the informal working group will be English.
4. An agenda and related documents shall be made available on the website of WP.29 by the Secretary of the group in advance of all scheduled meetings.
5. All documents and/or proposals shall be submitted to the Secretary of the group in a suitable electronic format in advance of the meetings. The group may postpone discussion on any

item or proposal which has not been circulated 5 working days in advance of the scheduled meeting.

6. The Secretary of the group will distribute the meeting minutes to the informal group members within 15 working days after the meeting of the group.
7. Decisions and proposals of the group shall be reached by consensus within the participating contracting parties. When consensus cannot be reached, the Chairman of the group shall present the different points of view to GRSP. The Chairman may seek guidance from GRSP as appropriate.
8. Sessions shall be held in agreement with a majority of the participants after the group has been established in a constitutional meeting. Sessions may be in person or virtual using web-based technology.
9. A provisional agenda shall be drawn up by the Secretariat in accordance with the participants of the group. The first item upon the provisional agenda for each session shall be the adoption of the agenda.
10. The second item on the provisional agenda will be discussion, matters arising and adoption of the minutes of the previous session.
11. The Chair of the group or his/her representative will report back to GRSP on the progress of work on regular basis.

#### **D. Work plan and time schedule**

- Task 1 – Identify and present a map of issues which should be addressed by regulatory upgrades directly vs gaps where more research is needed regarding equitable protection – Report to GRSP in December 2023.
- Task 2 – Determine how greater diversity in terms of representation of crashes and occupants should be implemented in concerned crash safety regulations, and if needed, propose well defined changes to those regulations and further activities in GRSP. Report to GRSP in May 2025. Report out in two phases:
  - In order to benefit female populations as soon as possible with available tools, the IWG should first provide a recommendation on the usage of existing ATDs (together with options for related injury assessment and test conditions) - by dec 2023.
  - Full report on attaining equity in crash safety regulations to GRSP in May 2025.
- Task 3 – Assess virtual crash testing as a method in concerned regulations to improve equity in occupant protection further and define related requirements for the models and procedures, including how virtual testing can be validated with existing ATDs. Report to GRSP in December 2027.
- Task 4 – Identify any shortcomings of existing regulations and related standards, such as whether the current test protocols can be misapplied to optimise crash performance for the specific test conditions and test dummies in a narrow way that is detrimental to the protection of a diverse population. Report to GRSP in December 2027.
- The IWG will report to the GRSP continuously until December 2027 in the following task:

- Continue to collect and review relevant field accident data to further understand the reasons for the varying injury risks of different occupants. For the same reason, collect and review other relevant and available data, in particular data from virtual testing. The reason is to be able to separate the issues which current concerned regulations under GRSP could address directly (if upgraded) from the gaps where more research is needed.
- Explore and advance the current state-of-the-art of virtual crash testing to determine and increase its capability as a tool and process to evaluate equitability, including a specific assessment of the state-of-the-art virtual human body models, i.e., virtual models of humans, particularly the possibilities for a safety performance evaluation at a higher level of detail considering diversity.
- Review the concerned UNECE regulations under the 1958 agreement for crashworthiness and occupant protection (passive safety), and related regulations, with a view to identify opportunities for improvement of concerned UNECE regulations regarding equity; NB, equity in its expanded definition.
- Assess whether existing regulations are sufficiently flexible to allow new technical developments regarding occupant safety resulting from new assessment possibilities of particularly virtual crash testing.