

**TFGP-06-02**

# HWT “Literature” Final Status Report

GRE/TF-GP 6<sup>th</sup> session

*3 February 2026*

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- 2 – Factors influencing Glare
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# Disability Glare

It refers to the actual reduction in a driver's visual performance and their ability to detect objects.

**Cause**: light scattering within the eye, which creates a "luminous veil" or "veiling luminance" over the retina, and reduces the contrast.

**Key Factors**: illuminance reaching the driver's eye. Largely unaffected by the color spectrum and size of the light source.

**Safety Implications**: measurable reduction in visual performance, directly shortening the detection distance for objects and pedestrians.

# Discomfort Glare

Subjective sensation of annoyance, irritation, or pain.

**Cause**: a bright light source in the field of view. It is associated with cognitive processing and physical responses, such as the uncomfortable contraction of the iris and muscles surrounding the eye.

**Key Factors**: peak illuminance produced by the source at the eye. Sensitive to the light spectrum; higher color temperatures (bluer light) are perceived as more uncomfortable.

**Safety Implications**: Distracting. Over time, it leads to visual fatigue and eyestrain, which reduces driver attention and increases crash risk.

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# Vehicle Factors



## Aim and Condition

### Headlamp misaim

*This is one of the most prominent factors influencing glare. An open point for investigation is that we should understand what happens to the vehicle in the first part of its life-cycle (10.000 Km or 3 months).*

### Soiling of the headlamp

*Soiling negatively influences the precision of lighting systems. It is particularly impacting on ADB systems. Even if a headlamp is perfectly aimed, dirt acts as a scattering medium that redistributes light unevenly. A soiled headlamp can produce 6 to 7 times more illuminance for oncoming traffic than a clean one.*

### Headlamp adjustment at garage and PTI level

*It is generally noticed that PTI services and garages are achieving less precise aiming setup than the one performed at factory level.*

## Light Source Technology

### Increased Light Intensity and Luminous Flux

#### Size of the Light Source

*Light source size does not significantly impact disability glare provided eye illuminance remains constant. While smaller lamps can increase discomfort, this effect is negligible or limited in correctly adjusted, legally compliant systems.*

#### About the color spectrum influence

*While "blue" or short-wavelength light from HIDs and LEDs can increase discomfort glare, its impact on actual vision loss (disability glare) is minimal to non-existent. These sources are perceived as brighter and more dazzling than "warmer" halogen lamps, even when producing the same photometric intensity.*

## Mounting Height

### Height mismatch

*Headlamps can be positioned higher than the eye level of drivers in smaller passenger cars.*

*For the mounting heights of 950 mm (to top), 850 mm (to center), and 660 mm, if the luminous intensity was reduced to or below the 50% of initial intensity, the glare became acceptable.*

*Glare from the highest allowed mounting positions only becomes tolerable if lamp intensity is reduced to 10% of its original setting.*

### Rearview mirror glare

*Rear view mirrors can be hit by high intensity light from below the cut-off line, which has significantly increased over time. Higher-mounted headlamps on trucks and SUVs can cause an increase in the light intensity reaching a preceding driver's rearview mirror.*

# Environmental Factors

A dark, atmospheric landscape featuring a road that curves through a valley. The road is illuminated by a bright, glowing yellow line that runs down its center, creating a strong contrast with the dark surroundings. The landscape is dominated by dark, rugged mountains and hills, with some green patches of vegetation visible. The sky is a deep, dark grey, suggesting a night or twilight setting. The overall mood is mysterious and dramatic.

## Road Geometry

*Road geometry is frequently identified as the dominant factor in strong glare situations and the primary cause of moderate glare events. Consequently, the intensity of glare experienced by drivers is dictated more by their location and the vehicle's pitch and roll than by the specific type of vehicle encountered.*

### **Vertical crests and dips (hills and hollows)**

*This pitching movement generated by the road inclination is one of the main cause of glare in dynamic traffic, as it directs light beams upward. Glare events are particularly intense during uphill travel or when a vehicle arrives at a crest, as these features shift the beam pattern directly into the line of sight of other road users.*

### **Curvature and beam asymmetry**

*The "asymmetry sector" of a low beam can be directed into the eyes of oncoming drivers during turns. Right-hand bends are specifically associated with an increased risk of glaring other cars.*

*If these factors combine, the risk of being glared increases directly.*

## Weather conditions

### **Wet road reflection**

*Maximum illuminance experienced by oncoming drivers on wet roads can be 5 times greater than on dry roads. This phenomenon is driven by increased forward reflection and reduced backward reflection on saturated surfaces, effectively turning the road into a mirror-like environment.*

### **Indirect glare**

*Glare by indirect light reflected from a wet surface is frequently perceived by drivers as being at least as intense as the direct light emitted by an oncoming headlamp.*

A pair of round, dark-rimmed glasses with thin temples is resting on a stack of several sheets of white paper. The papers are covered in handwritten text in blue ink, which is mostly illegible due to a shallow depth of field. The entire scene is set on a dark, textured wooden surface. The lighting is soft and directional, coming from the upper left, creating subtle shadows and highlights on the glasses and the wood. The overall mood is one of quiet study or intellectual work.

# Human Factors

## Ageing Population

### Increased light sensitivity

*Drivers over the age of 40 or 50 are more susceptible to disability glare due to increased intraocular scatter, which creates a "veiling luminance" over the visual scene and reduces the contrast of objects. While older drivers experience more severe vision loss from glare, some research indicates that younger observers may be more sensitive specifically to the luminance (surface brightness) component of discomfort glare.*

### Longer Dark re-adaptation time

*"Re-adaptation time" refers to the period required for a driver's visibility to return after being glared by a bright light source. This recovery period increases significantly from the age of 40 onwards, leading to a substantial loss of visual performance following a glare event.*

*The duration of this impairment is directly linked to the intensity of the light encountered: as glare illuminance increases, the time needed for the eyes to re-adapt to the dark also increases, an effect that becomes increasingly pronounced with age.*

## Driver Behavior

### Direct glance at light source

*Eye-tracking data reveals that drivers frequently look directly at oncoming headlights, particularly at close distances, contradicting previous assumptions that assumed they would naturally avoid bright light sources.*

*These direct glances significantly worsen disability glare, leading to increased visual impairment and a reduced ability to detect objects on the road. While the specific luminance of the lamp does not further impair vision if legal illuminance limits are maintained, the act of looking into the light remains a primary cause of temporary dazzle and reduced contrast.*

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**UN Regulations**

**Enforcement**



## UN Regulations

- Due to the rapid evolution of lighting technology, the existing Regulations require revision to **reflect the current technological developments.**
- Current Regulations lack a definition of an **upper limit for luminous flux.** As of today, manufacturers are only required to declare the flux value: whenever this value exceeds certain thresholds, a headlamp cleaning system becomes mandatory.
- Without defined maximum values, **excessive light can occur near the cut-off line,** a situation enable particularly by LED technology.
- **There are no maximum values for illuminance** in the Regulations in the low-beam measure points like 50R, 75R and 50L.



## Enforcement

**PTI checks:** there appears to be a gap between the initial aiming of the headlamps carried out by the manufacturer, and how it is assessed and readjusted at garage and PTI level.

**Driver awareness of on-board technology:** more often than not, drivers are unaware about the onboard systems to manually adjust the aiming of the headlamps. Even if they are aware of these systems, they do not intervene to adjust the aiming.

*General opinion of the HWT Literature experts: For the same reason, most drivers equipped with advanced systems such as ADB are not aware that they could (and should, in some cases) override them.*





**Proposed solutions**

## Technology

### **Adaptive Driving Beam**

*These systems are particularly effective in challenging scenarios like curves, as they can automatically switch to a lower or adaptive beam pattern before the most intense portion of the light hits an oncoming driver.*

### **Dynamic Headlamp Levelling**

*These systems are particularly effective in case of vehicle pitching due to acceleration and braking.*

### **Dynamic adaptation of low beam intensity**

*These systems provide effective mitigation of glare on wet roads by adjusting intensity based on mounting height and environment. This dynamic adaptation (for example: light reduction in the forefield) can effectively mitigate indirect glare on wet roads without compromising the driver's own visibility.*

### **Dimming in urban context**

*Light dimming in urban contexts can help mitigate glare to compensate the effect of traffic calming measures and undulations on the road surface, and improve recognition of road users such as pedestrians.*

*General opinion of the HWT Literature experts: Some of these systems will be equipped on higher-end vehicles, which do not consist in the majority of vehicles on the road. Therefore, the overall benefit of mitigating glare in road traffic could be much less widespread than expected. The extension to all vehicles may require a considerable amount of time, and may cause an increase in price for the end customer.*

## Infrastructure

### **Improve Lane dividers / Guardrails**

*Current lane dividers may cause the headlamps of oncoming vehicles to be hidden or intermittently visible, potentially resulting in glare and flicker from ADB systems.*

### **Improve driver awareness on regular headlamp cleaning**

*While manufacturers provide the technology and Periodic Technical Inspections (PTI) verify its function, the driver's role in basic maintenance is essential. Consider public awareness campaigns to encourage drivers to clean their headlamps more frequently, especially during winter or in adverse weather when road spray is common.*

### **Improve driver awareness on onboard aiming adjustment systems**

*Consider public awareness campaigns to raise the drivers awareness about the basic functionality of onboard aiming adjustment systems, as well as on how and in which scenarios overriding automatic systems is required. Last but not least, drivers should periodically check the aiming of their headlamps.*