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Headlamp Performance Ratings: A Comparative Analysis of HSPR and VLPS

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1. Abstract

The Headlight Safety Performance Rating (HSPR) and CIE 188:2010 provide comprehensive and physics-based evaluation frameworks for vehicle lighting systems for the UNECE Region, ensuring objective and repeatable assessments based on real headlight measurements according to the ANSI/IES LM-63-XX standard. These methodologies define measurement zones for various driving scenarios, viewing distance calculations, and opposing glare calculations, enabling detailed assessments of headlight performance. The China New Car Assessment Program (C-NCAP) follows a similar approach through its Vehicle Lighting Performance Score (VLPS), applying structured evaluation criteria to assess headlight effectiveness in real-world driving conditions while integrating simulation-based testing methods. Both HSPR and C-NCAP VLPS evaluate headlight performance based on key parameters, including straight and curved lane illumination, pedestrian visibility, intersection lighting, and glare calculation. Additionally, both frameworks evaluate adaptive driving beam (ADB) performance to preceding and oncoming vehicles at 50m, 100m, and 200m. While HSPR derives its rating from headlight benchmarks and considers the activation time of high beam, low beam and ADB, C-NCAP integrates its assessment within the broader NCAP vehicle safety rating system, ensuring that headlight performance is considered alongside other vehicle safety features. In addition, the HSPR directly correlates with real-world human perception of headlight performance. A key difference between the two methodologies is that while HSPR primarily uses a simulation-based approach, while C-NCAP complements this with real-world driving tests. The Road Function Verification serves as a live test track experiment, that evaluates ADB system responses under dynamic conditions by directly measuring vehicle speeds, distances, and sensor interactions with actual preceding and oncoming traffic. The HSPR and the C-NCAP VLPS are both valuable approaches to

evaluating headlight performance. However, the VLPS scoring system does not differentiate between performance after the maximum score is reached, although real differences in performance may occur. In the future, the HSPR could be supplemented by real-world tests and the VLPS could adjust its scoring system

Keywords: HSPR, Headlight Safety Performance Rating; China N-Cap; Vehicle Lighting Performance Score; VLPS, Automotive Lighting, Headlight Performance

2. Introduction

Vehicle lighting plays a major role in ensuring safety on the road, particularly during nighttime driving, when the risk of accidents is significantly elevated. Studies have shown that nighttime crashes account for a disproportionate share of traffic fatalities compared to daytime, often by a factor of two to four [1]. Headlamps are the primary source of visibility under these conditions, enabling the driver to detect lane markings, pedestrians, road edges, and potential hazards, while also controlling glare to avoid impairing the vision of other road users [2].

As a result, headlamp rating systems have emerged as powerful drivers for innovation. They influence OEM development goals by putting lighting performance into the spotlight. When vehicle lighting is objectively tested and published through such systems, OEMs are incentivized to improve headlamp scores to achieve better overall safety ratings, which has a measurable impact on consumer safety and product competitiveness [1,4].

In the European context, however, no lighting rating system has been fully integrated into an overarching NCAP-like evaluation structure. This lack of regulatory pressure leaves lighting performance less emphasized compared to other vehicle safety features.

Until 2023, no official rating system had objectively integrated the Adaptive Driving Beam (ADB) functionality into its scoring methodology. In 2019, Langhammer et al. demonstrated how ADB functionality could be integrated into the standardized evaluation methods of the CIE Technical Committee TC4-45 and the CIE 188:2010 photometric assessment method for low and high beam systems [3].

This research led to the development of the Headlight Safety Performance Rating (HSPR), initiated under the leadership of the Groupe de Travail “Bruxelles 1952” (GTB), in cooperation with TU Darmstadt and members of the former Light Sight Safety Group. HSPR evaluates low beam, high beam, and ADB performance based on detailed laboratory photometric measurements and correlates these results with subjective real-world driver perception. It offers a rating system that reflects actual user experience in terms of range, brightness, homogeneity, and perceived glare [4,5].

Recently, the China New Car Assessment Program (C-NCAP) introduced the Vehicle Lighting Performance Score (VLPS), which shares key methodological principles with

HSPR, including simulative assessment of lane illumination, pedestrian visibility, and glare control—while extending the evaluation to cover ADB functionality in real test cases [7,8]. The significant distinction is C-NCAP's inclusion of real-world driving tests known as Road Function Verification, wherein the dynamic ADB response is evaluated using real oncoming and preceding vehicles under defined conditions. This hybrid approach allows China NCAP to embed headlamp testing into a comprehensive full-vehicle safety rating structure [7,8].

This paper compares the HSPR and C-NCAP VLPS systems, outlining their methodological overlaps and differences, analyzing their scoring systems, and discussing their respective roles in influencing the development of automotive lighting systems.

3. Methodology

As mentioned earlier, both HSPR and VLPS are primarily simulation-based headlight rating systems. To carry out the simulations, the luminous intensity distribution for each defined use case must first be measured or provided by the OEM. In addition, the installation height and width of the headlamps need to be specified.

For low beam and high beam, each system only uses one case. In contrast, for adaptive driving beam (ADB) systems, there are six different use cases: oncoming traffic and preceding traffic scenarios at distances of 50 m, 100 m, and 200 m.

To enable a systematic comparison of HSPR and VLPS, the paper is structured into separate sections covering low beam, high beam, and ADB. Since both systems follow the classical separation between low and high beam, as described in CIE 188:2010, this structural framework is maintained [2,5,8]. Vehicles without an ADB system are evaluated solely based on low and high beam performance in both HSPR and VLPS. If an ADB system is present, additional evaluations are conducted, applying different weighting factors to the corresponding results.

The analysis combines photometric measurements (based on IES files) and real-world testing, with particular attention to methodological differences and resulting scores. Further aspects such as glare, luminous flux, and headlamp alignment are also included in the assessment. After comparing the systems theoretically, an example scoring for one test point is calculated and discussed.

4. Results

4.1 Lowbeam

Both the VLPS and the HSPR are rated in 5 different Zones. **Zone A** evaluates straight-ahead lane guidance by measuring how far the road is visible for the driver; **Zone B** assesses lane guidance on curved roads to determine a headlamp's ability to support curve negotiation; **Zone C** focuses on pedestrian detection on the offside (typically the left side for right-hand traffic), capturing visibility of roadside pedestrians or obstacles; **Zone D** quantifies the width of illumination in curves, which is essential for lateral perception; and **Zone E** evaluates illumination width at intersections, ensuring drivers have adequate visibility for turning maneuvers and detecting cross traffic. The Zones A-C are depicted in Fig. 1 (left) and the Zones D-E in Fig. 1 (right.) [2,5,8]

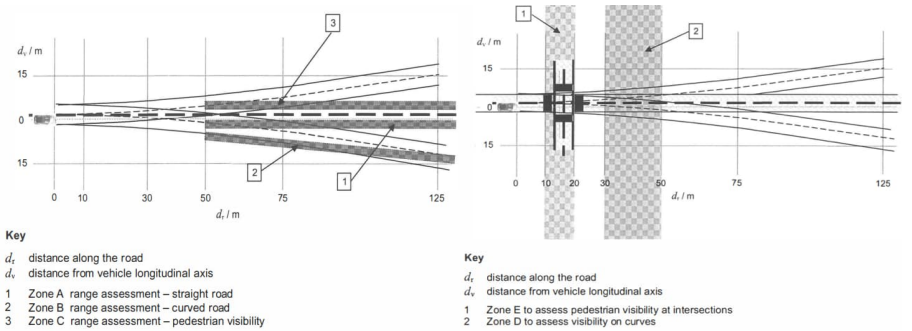


Figure 1: On the left, the figure shows Zones A, b and C according to **CIE 188:2010 [2]. On the right,** the figure shows Zones D and E according to CIE 188:2010 [2].

4.1.1 Zone A (Straight Road Visibility)

In HSPR, the distance is calculated by determining the intersection of the 1 lx, 3 lx, and 5 lx Isolux with the three parallel lines at 0 m, 1.5 m, and 3.0 m to the right of the vehicle's centerline at 250mm height. The average of these values determines the score. In VLPS, the method is similar, but with offsets at 0 m, 1.75 m, and 3.5 m, adapted to Chinese lane geometries. VLPS also includes all three Isolux levels and uses the average to determine the range. In HSPR, 2.0 points are awarded, with 95.1 m. In VLPS, up to 1.5 points can be earned, with full points awarded at 114.59 m. [2,5,8]. The main difference is that in HSPR the points are extrapolated after 2 points and VLPS caps the points at 1.5.

4.1.2 Zone B (Curved Lane Guiding Distance):

HSPR evaluates the beam pattern on a 5°-angled path, simulating a curved road. Distances are calculated again on the three lines and averaged. VLPS uses the same principle but shifts the lateral lines to 1.75 m and 3.5 m from the centerline. The HSPR awards up to 2.0 points (full score at 138.4 m). The VLPS awards up to 1.2 points, with 134.61 m required for full scoring. [2,5,8]

4.1.3 Zone C (Left-Side Pedestrian Visibility):

HSPR uses vertical illuminance values measured at 3.0 m, 4.5 m, and 6.0 m to the left of the vehicle and at 250 mm height, representing pedestrian leg visibility.
VLPS extends the distances to 3.5 m, 5.25 m, and 7.0 m, using the same illuminance thresholds and height. The HSPR provides up to 2.0 points (full score at 48.4 m). The VLPS gives up to 1.5 points, with a full score at 63.24 m. [2,5,8]

4.1.4 Zone D (Curve Lane Illumination Width):

HSPR assesses illumination width by evaluating the spread of light when the 3lx lines of the lowbeam is intersecting the plane from 30m to 50m. The width of the 3 lx isolux at 30m, 40m, 50m determines the scoring, reflecting the lateral reach of the beam on curves. VLPS does the same. The scoring is capped at 1.2 points (30.99m) in VLPS, compared to HSPR's more continuous scoring, scaled to 2.0 points (16.3 nearside, 12.5m offside). [2,5,8].

4.1.5 Zone E (Intersection Illumination Width):

To assess intersection lighting, both **HSPR** and **VLPS** measure the **3 lx beam width** at **10 m and 20 m** in front of the vehicle. The average width at these points reflects the ability to safely detect cross traffic and make turning decisions. The **HSPR** awards **2.0 points**, for **10.5 m (offside)** and **9.6 m (nearside)** beam width. The **VLPS** awards up to **1.5 points**, with full points reached at an average width of **20.62 m. [2,5,8].**

4.1.6 Low Beam Glare and Flux Assessment

Both systems include a **glare assessment** but handle it differently. **HSPR** incorporates glare into the performance score, while **VLPS** treats it as a **penalty item [2,5,8].**

Both HSPR and VLPS define the glare area as a rectangular region at **50 m in front of the vehicle**, spanning **+1.3 m to −7.9 m,** horizontally, and **0.18 m to 0.87 m vertically.**

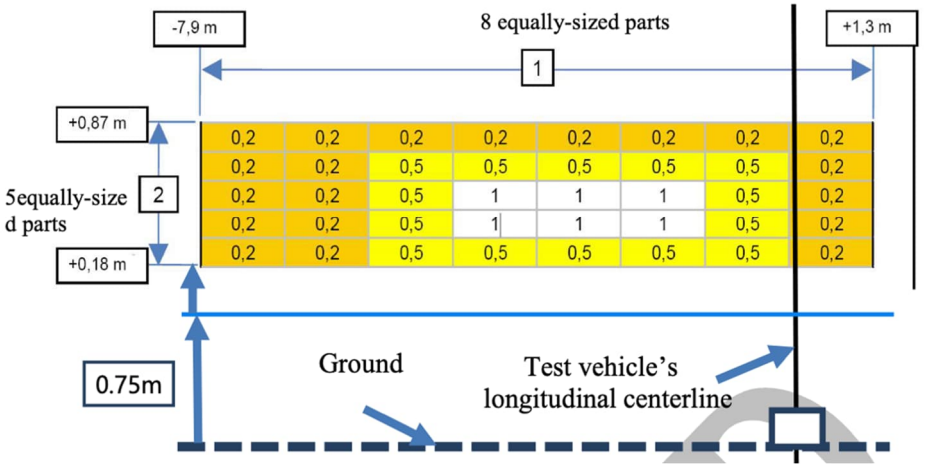


Figure 2: The Fig. shows the glare assessment area in HSPR and VLPS [8]. The numbers inside the subareas correspond to the weighing of the calculated flux. The plane is in 50m distance.

Within this zone, the luminous flux is measured and analyzed. Each sub-area within this region is weighted based on the probability of glare perception (see Fig. 3). In HSPR, glare is part of the zone-weighted performance score. Full points **(**2.0**)** are awarded for glare flux below 0.27 lm**.** [2,5,8]**.** In VLPS, glare triggers penalties instead of adding points:

No penalty if glare flux is between 0.26 lm and 0.63 lm, and all weighted zones remain under 0.38 lm**.**

- −0.5 points if total flux is 0.63–0.77 lm**,** still under zone limits.
- −1.0 point if flux exceeds 0.77 lm**,** or any zone exceeds 0.38 lm**.** [2,8]

4.1.7 Cutoff Line

The VLPS imposes several penalties to ensure headlamp systems meet essential safety criteria. If the low beam cutoff line position deviates by more than ±0.4% vertically or ±1.0% horizontally from the target, a penalty of −0.25 points per side is applied. Additionally, if the cutoff line sharpness is insufficient—indicating a blurred light-dark transition—another −0.25 points per side may be deducted [8]. This is tested after readjusting the headlamps cutoffline.

The sharpness factor is defined by the following formula [7]:

$$G = \log(E_\beta) - \log(E_{\beta+0.1}) \quad (1)$$

Where, E_β is the Illuminance at a vertical angle β (in degrees) and $E_{\beta+0.1}$, the Illuminance at β+0.1°. The scan is performed vertically across the horizontal part of the cutoff line, typically at 2.5° to the left of the vertical centerline (V-V line).

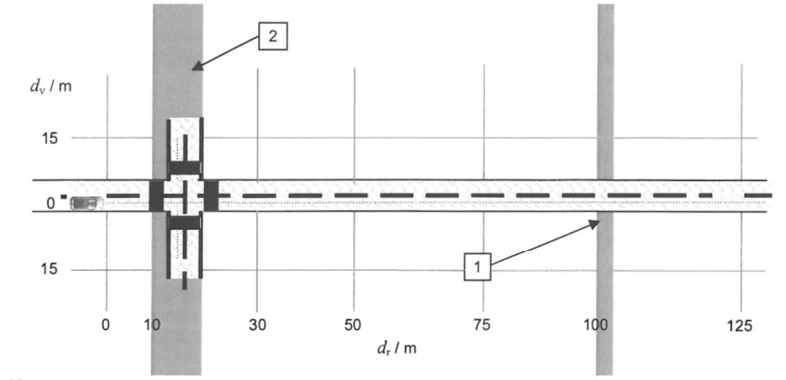
4.2 HIGHBEAM ASSESSMENT

Both systems evaluate the luminous intensity at five specific points located 100 m in front of the vehicle, see Fig 4**.** These points simulate key locations in the field of vision for high-speed driving [2,5].

The positions are:

- Point A**:** (0 m, 0 m) — directly ahead
- Point B**:** (−20 m, 0 m) — left roadside
- Point C**:** (0 m, 9 m) — upper part of the field of view
- Point D**:** (20 m, 0 m) — right roadside
- Point E**:** (0 m, −2 m) — near road surface

Each point represents a direction in which headlight intensity is measured, and the effective viewing distance is then calculated using the photometric inverse square law**,** assuming a 3 lx detection threshold.



Key

d_r distance along the road
d_v distance from vehicle longitudinal axis
1 range assessment - based on measurements on a vertical screen located at 100 m from the vehicle
2 width for pedestrian visibility at intersections

Figure 3: The figure shows the plane where the highbeam assessment points are located (1) and zone (2) to assess the pedestrian visibility at intersections [2]

In VLPS**,** each point contributes a fixed portion of the total high beam score, up to a combined maximum of 2.5 points**.** Full score distances are defined per point [8]:

- Point A: 223.91 m
- Points B & D: 75.09 m
- Point C: 63.17 m
- Point E: 218.86 m

In HSPR, the same point configuration is used and the scoring is also based on statistical benchmarks derived from evaluated systems. Points are awarded continuously, with [2,5]:

- Point A: 235.0 m
- Point B: 61.0 m
- Point C: 63.3 m
- Point D: 81.4 m
- Point E: 207.7 m

Each point-score is scaled to 2.0 points**,** but HSPR allowes for extrapolation, making the score continuous rather than capped [5].

For the evaluation of the width in Zone 2, Fig. 3, the same evaluation is used as in Zone E for the lowbeam. In HSPR. Again 2 points are archived at a width of 10.5 metres offside and 10.9 metres nearside [5].

In HSPR the flux is also evaluated from -45° to 45° horizontally and -5° to +10° vertically. Two points are archived for 3126.1lm [5].

4.3 THE ADB ASSESSMENT:

For The ADB Range Assessment in both cases the IES Files for six cases must be provided/measured. The use cases consist of an 50m, 100m, 200m oncoming and preceding car, where the ADB System is generating a light tunnel (6 Use cases = 6 Files for each headlamp). The use cases are shown in Fig. 4.

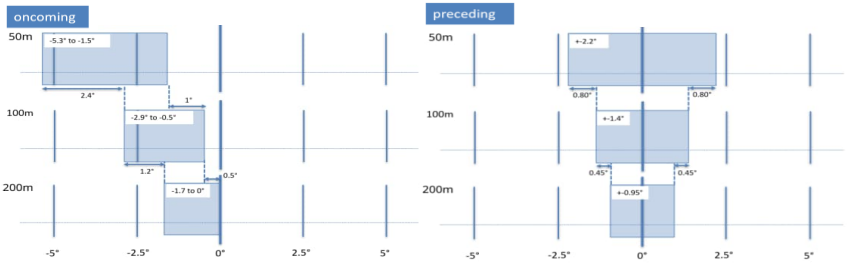


Figure 4: The figure shows the areas in the 6 test scenarios where the generated light tunnel should be for the preceding and following use cases.

For each test case, HSPR defines 'test lines' in the light tunnel where a certain light intensity must not be exceeded. This is necessary for the generation of light distributions [5].

In HSPR, the ADB assessments use Zones A′, B′, and C′, which correspond to straight lane visibility, curved guidance, and offside pedestrian detection—mirroring the lowbeam zones but the intersection plane is located 1500 mm above the ground, adapted to the ADB use case. Each zone is evaluated at all six distances, and the same methodology from the low beam is applied (average of 1 lx, 3 lx, 5 lx Isolux intersections). The resulting performance is again compared against a statistical database and weighted into the total ADB score. See “The Recommended Practice” for the limits and scoring points [5].

In VLPS, a similar approach is taken, but instead of just three zones, VLPS evaluates all five zones (1–5) used in the low and high beam assessment. Each of the six use cases has its own scoring structure and lower scores are given for missing performance at farther distances. Importantly, in VLPS, the base low beam score is reduced if ADB is available, so the ADB evaluation significantly influences the total lighting performance. For a system without ADB, the maximum archivable low beam score is 6.9 in the VLPS. When

an ADB system is evaluated, this reduces to 2.76 and the maximum archivable ADB score is 4.14 (without bonus/penalties). See [8] for the detailed limits and scoring points.

In order to assess the potential glare for ADB systems, the VLPS and HSPR only test two of the above cases, the 50 m oncoming and the 50 m preceding case. The 50 m oncoming case is shown in Fig. 5. On the right you can see the light tunnel created and the area where the glare potential is tested and on the left side, the plane where the glare is measured, in 75 cm height. This is the same for both rating systems. For the preceding case, the glare assessment area changes, see Fig. 6. For each sub-area, the average luminous flux is calculated and then the weighting factor (shown within the sub-area) is used to calculate an overall glare flux. This in turn is used to determine a glare score of up to 2 points in the HSPR [5,7].

HSPR requires that ADB distributions adhere to upper intensity thresholds along "testing lines" within the light tunnel to prevent overspill into the masked area. This ensures the cutoff behavior of ADB is controlled and consistent [5]. VLPS currently does not require this validation step. Although the resulting light distributions are measured, there's no check that the intensity in the masking area adheres to a specific maximum [7,8].

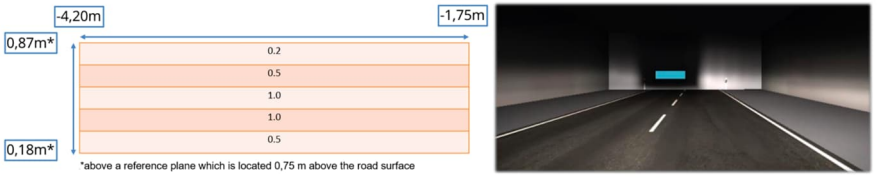


Figure 5: On the left side the evaluation grid for the 50m oncoming test case is shown and on the right side, the grid is shown in cyan, simultaneously with the created light tunnel [5].

For the 50m preceding case the evaluation Area changes slightly, see Fig. 6.

The further ADB functionality for VLPS is tested during real world driving tests, where bonus points can be archived for the VLPS. The HSPR does not further takes Function activation, Response time into account.

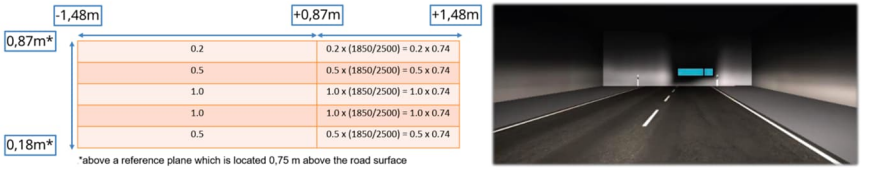


Figure 6: On the left side the evaluation grid for the 50m preceding test case is shown and on the right side, the grid is shown in cyan, simultainiously with the created light tunnel [5].

ADB Function Road Validation - Function Activation, Response Time and Masking Width

The **VLPS** assesses ADB performance through real-world scenarios with bonus and penalty scoring. ADB must activate when detecting an **oncoming vehicle ≥400 m** or a **preceding vehicle ≤100 m**; if successful, **0.25 bonus points** are awarded per case. If activation is late, no bonus is given, and masking width isn't tested. Additionally, the system must respond within **2 seconds**, or a **0.1-point penalty** is applied. For **masking width,** a narrow light tunnel earns up to **0.2 bonus points: < 1 lane = 0.2, 1–2 lanes = 0.1, ≥ 2 lanes = 0.** [8]

Currently the HSPR is lacking such tests. Response time is not tested. Masking Width is indirectly tested because a better masking will lead to better scores in range Assessment for the 6 use cases for Zone A, B and C. The detection distance is also not tested for HSPR [5]. The VLPS defined easy implementable measurements using a **combination of distance-triggering sensors and synchronized light sensors** to detect when the ADB system responds. The Car under Test must at least travel 60km/h [8].

ADB - Further Bonus and Penalty items.

In the VLPS scoring system, additional bonus points are awarded for the presence of advanced headlighting features that enhance safety and comfort in various driving situations. Vehicles equipped with AFS functions—such as city, motorway, or adverse weather lighting modes—can receive up to 0.3 bonus points, provided that at least two sub-functions are available. A further 0.2 points are awarded for an automatic high beam assist system, which automatically switches between low and high beam based on traffic conditions. Additionally, if the vehicle is fitted with an automatic headlamp levelling system (ALWR), which adjusts the vertical aim of the beam depending on load or pitch angle, an extra 0.1 point is granted. [8]

In contrast, the HSPR rating system does not award separate function-based bonuses. Automatic Highbeam Assist is inherently reflected in the measured effective performance scores because the weighing changes based on activation time, based on results of different studies, who showed that cars with highbeam assist leading to an increased highbeam activation [5,6].

4.4 THE SCORING

For both HSPR and VLPS, a set of benchmark light distributions is evaluated across the test cases. From these results, the mean and standard deviation (std) can be calculated for parameters such as glare, flux, width, or range estimation for each test case. Based on these statistics, points are assigned by interpolating between mean − std and mean + std. In HSPR, this range is scaled to 2 points (see Equation 2) [5]. However, the HSPR scoring formula also allows for extrapolation beyond this range.

$$P = \frac{1}{V_2 - V_1} \cdot (V - V_1) + 1 \qquad (2)$$

Here, V_2 represents the mean + std for the test case, and V_1 represents the mean − std for the use case.

In VLPS, the scoring is then calculated by interpolation using the following formula [8]:

$$F(x) = \mathrm{I}_{\mathrm{weight}} * \int_{-\infty}^{x} \frac{1}{\sqrt{2\pi}\sigma} \exp\left(-\frac{(x-u)^2}{2\sigma^2}\right) dx / 0.9 \qquad (3)$$

Based on the weight, the maximum attainable points are determined. Unlike HSPR, The VLPS is capped at the maximum points.

4.4.1 THE HSPR FINAL SCORE

For HSPR and VLPS, different scores are given for the specific test cases. In the case of HSPR, the points are given relative to the performance of 16 evaluated lighting systems for LB and HB. In the case of ADB, 20 systems were evaluated. The exact scores and weighting factors are given in the “Recommended Practice” [5].

$$\Sigma = \Sigma(w_i \cdot P_i) \qquad (4)$$

Then the weighted sum of criterion points is calculated for LB, HB and ADB. For the ADB it’s the average for all three distances [5].

$$\Sigma_{\mathrm{ADB}} = \frac{\Sigma_{50\,\mathrm{m}} + \Sigma_{100\,\mathrm{m}} + \Sigma_{200\,\mathrm{m}}}{3} \qquad (5)$$

The criterion points can then be converted to a five-star rating by scaling between a standard halogen system and a state of the system and then normalizing the result between 1 and 5 points [5].

However, if an evaluation is to be archived that reflects the actual performance of the system, the following can be done to calculate the actual Effective Performance [5]:

$$EP_{\text{passing}} = 5.80 \cdot \text{Score}_{\text{passing}} + 64.17 \tag{6}$$

$$EP_{\text{driving}} = 11.71 \cdot \text{Score}_{\text{driving}} + 141.27 \tag{7}$$

$$EP_{\text{ADB}} = 10.87 \cdot \text{Score}_{\text{ADB}} + 94.13 \tag{8}$$

The Effective Performance is then used to calculate the Mean Effective Performance (according to activation times) [5]:

$$MEP_{\text{manual}} = 0.95 \cdot EP_{\text{passing}} + 0.05 \cdot EP_{\text{driving}} \tag{9}$$

$$MEP_{\text{auto}} = 0.80 \cdot EP_{\text{passing}} + 0.20 \cdot EP_{\text{driving}} \tag{10}$$

$$MEP_{\text{ADB}} = 0.30 \cdot EP_{\text{passing}} + 0.20 \cdot EP_{\text{driving}} + 0.50 \cdot EP_{\text{ADB}} \tag{11}$$

The final score can then be calculated as a continuous scale with [5]:

$$\text{System Score} = 0.626 \cdot \text{MEP} - 36.42 \tag{12}$$

4.4.2 THE VLPS FINAL SCORE

The VLPS is relatively easy to calculate compared to the HSPR. The points for each function are simply added together to give a final score, which is limited to a maximum of 10 points for a low beam and high beam system or an ADB system. So, 10 points can be archived even if no ADB system is implemented. If a system is good enough to archive 10 points, no further improvement in lighting performance is recognized [8].

4.5 Example calculation

To illustrate the difference in the point distribution between HSPR and VLPS, the estimated range and the corresponding score at Point A for the high beam were calculated using four light distributions. In VLPS, the maximum score is achieved at a range of 224 m; beyond this point, the curve asymptotically approaches 1.0 points. In contrast, HSPR uses a continuous scoring system that allows scores greater than 2.0, as shown in Figure 7.

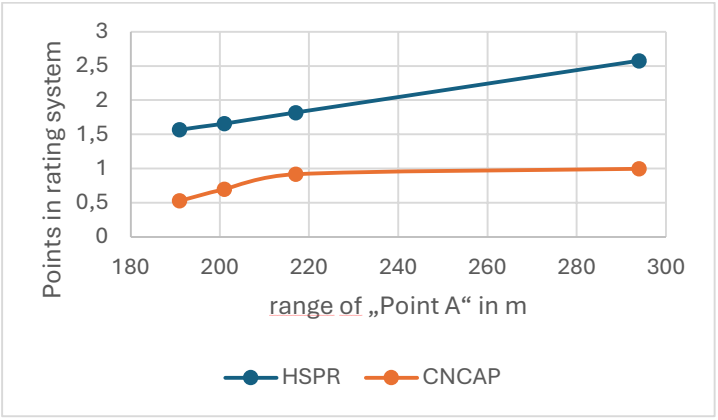


Figure 7: The figure shows the estimated range and the corresponding scores at Point A for the high beam evaluation, based on four different light distributions.

5. Discussion

The previous comparison shows that the HSPR and the VLPS are quite similar in their assessment of the lighting functions. The main difference in the low beam evaluation is the road width, which is considered wider in the VLPS for Chinese roads [7,8]. The HSPR and the VLPS also rate glare in exactly the same way. Unlike the VLPS, the HSPR evaluates the flux for the low beam area. High beam is evaluated at the same points for HSPR and VLPS [5,7,8]. However, HSPR evaluates the high beam again at the intersection and calculates the total flux in a specific high beam area, which VLPS currently lacks [5].

In the evaluation of ADB systems, one of the key differences between HSPR and VLPS is that HSPR does not currently implement real-world driving tests, whereas VLPS integrates dynamic vehicle testing. Both HSPR and VLPS assess range performance in oncoming and preceding traffic scenarios [5,7,8]. However, HSPR evaluates only Zones A to C, while VLPS extends the evaluation to Zones D and E [5].

HSPR also imposes strict threshold controls on luminous intensity within the light tunnel during IES file generation, ensuring that maximum permissible intensities are not exceeded [5]. VLPS, in contrast, does not enforce such tunnel intensity limits during its ADB simulation tests [7,8].

For glare assessment, both systems focus primarily on 50 m oncoming and preceding scenarios [5,7,8].

Another major distinction is that HSPR currently does not assess ADB system response time [5], whereas VLPS includes a penalty if the ADB system fails to respond within two

seconds. However, a major criticism of the VLPS real-world test protocol is the lack of a precisely defined vehicle speed. Vehicle speed has a significant influence on ADB performance testing: higher speeds introduce more motion blur for camera sensors and affect the calculated activation distances due to increased traveled distance during reaction time. Therefore, a fixed, clearly defined test speed would be essential for ensuring consistent and comparable results. [7,8]

In terms of automatic high beam activation, HSPR reflects the real-world usage by adjusting the weighting factors between low beam and high beam operation based on activation studies. This ensures that increased high beam usage due to automatic systems is naturally reflected in the Effective Performance (EP) score [5,6]. In contrast, VLPS simply awards bonus points for the presence of automatic high beam assist, without verifying its actual impact on lighting usage [7].

VLPS also awards bonus points for the presence of an automatic levelling system (ALWR) and evaluates the initial cutoff line position. This cutoff position is compared against a theoretical reference point. However, slight misalignments can occur during transport or over time despite initial factory adjustments. Thus, manufacturers might be penalized for factors they cannot fully control, even when initial factory settings were correct [7,8].

Furthermore, VLPS awards extra points for the presence of AFS functions (e.g., country light, city light, fog light), regardless of their actual performance. Ideally, dedicated performance-based test cases should be developed for these features to ensure meaningful evaluation [7].

Overall, the scoring philosophies of HSPR and VLPS differ significantly. Even though both systems rely on a relative comparison to a benchmark database (HSPR: 16 systems for low and high beam; 20 systems for ADB), HSPR's scoring is based ensuring a continuous and performance-reflective scale without an upper bound [5]. In contrast, VLPS limits the maximum score: low beam and high beam systems are capped at 10 points, and ADB systems are also capped at 10 points [7,8].

This structure means that a very good low/high beam system without ADB can achieve the same maximum 10 points as an advanced ADB system. In HSPR, by comparison, a vehicle equipped with an ADB system would naturally score higher due to better illumination and dynamic adaptation, encouraging lighting innovation [5]. The capping of the scoring points is also demonstrated by calculating the score at Point A for the high beam assessment. Even if a system offers a greater viewing distance for the driver, its performance is no longer rewarded beyond a certain threshold.

The VLPS capping system risks discouraging the implementation of advanced ADB technologies in China. If manufacturers realize they can achieve maximum lighting scores without ADB, they may opt against installing such systems, which contradicts the goal of

promoting continuous innovation in vehicle lighting. Furthermore, since the VLPS is capped, any further improvements—such as offering an additional 50 meters of visibility distance—are not rewarded, whereas HSPR's continuous scaling would reflect and reward such improvements [5,8].

Although, from a Chinese market perspective, this approach is understandable: most drivers reside in urban areas where ADB usage is limited. Still, to promote global innovation and ensure future-proof vehicle safety standards, an adaptation of the VLPS scoring is recommended.

Nevertheless, VLPS is easier to implement, more straightforward to understand, and highly practical for integration into comprehensive vehicle ratings such as China NCAP. It successfully brings lighting into the vehicle assessment landscape.

6. Conclusion

To drive innovation and promote advanced lighting technologies, the scoring system of China NCAP should be adapted. Although VLPS marks an important first step by integrating lighting into full-vehicle safety assessment, its methodology should be expanded to reward systems offering real performance advantages.

Simultaneously, HSPR should work towards developing real-world driving test protocols, including functional validation of ADB activation response time, masking width, and dynamic glare behavior. This would enable HSPR to be integrated into larger evaluation frameworks like Euro NCAP.

In the future, ADB systems will play an increasing role not only in rural areas but also in urban and semi-urban environments. New scoring systems and real-world use cases must be developed to properly assess and incentivize the next generation of intelligent, adaptive lighting functions.

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