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Dedication

In fondest memory of the mathematical genius, brilliant mind, warm soul, and quick wit of

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What is the Alliance?

• The Alliance of Automotive Manufacturers (OEMs who sell vehicles in North America) made a commitment to NHTSA that the automotive industry would develop voluntary guidelines for managing driver workload/distraction.

• The Driver Focus Telematics Working Group in the Alliance developed a set of guidelines that have been agreed to by the major OEMs:
  “Statement of Principles, Criteria and Verification Procedures on Driver Interactions with Advanced In-Vehicle Information and Communications Systems”

• Scope: Advanced information and telematics systems with visual-manual interfaces.

Benefits

• Use of a common method across vehicle manufacturers:
  - Ensures a level playing field
  - Improves mathematical correctness
  - Supports stability and accuracy in the solutions

• The Alliance method ensures that displays will be high enough, so that when directly looking at it for brief periods, that objects, vehicles, or events in the roadway ahead can still be seen (in peripheral vision) quickly and easily enough to stop the vehicle in a timely manner.
**Principle 1.4 - Downangle**

Principle 1.4 deals with the *downangle* for a display in a vehicle, or the angle that a driver looks down to see the information on a display:

*Visual displays that carry information relevant to the driving task and visually-intensive information should be positioned as close as practicable to the driver’s forward line of sight.*

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**Visual Downangle - Rationale**

- There is broad consensus that, apart from brief glances at mirrors or instrumentation, the driver’s gaze should be directed towards the roadway.
- Drivers make glances to a navigation or telematics display.
- The Alliance method ensures that a display will be high enough, so that when directly glancing at it for brief periods, that objects, vehicles, or events in the roadway ahead can still be seen (in peripheral vision) quickly and easily enough to stop the vehicle in a timely manner.
- Problem: How specify an industry criterion for maximum allowable downangle?
Two Criteria for Downangle

The Alliance of Automotive Manufacturers has developed two criteria to define the maximum allowable downward viewing angle for displayed information in North American vehicles:

- The first criterion is for use in two-dimensional Computer Aided Design (CAD) analyses
- The second criterion is for use in three-dimensional CAD analyses.
- The display can meet either of the two criteria; it does not have to meet both.

Criterion Angle Specification

The criterion angles are defined with respect to an Eye Point, and a Display Point.

The Display Point is defined as the geometric center of the display.
**Eye Point**
The Eye Point used is the Japanese Industrial Standard (JIS) eye point.
- The reason is that the downangle criteria were derived from research that underlies the JAMA guideline on downward viewing angle.

In order to apply these practices in North America in a way that is consistent with Japanese criteria, it is necessary to establish a corresponding point in terms of North American practice.
- In this Principle, therefore, the *Eye Point* is the SAE equivalent of the JIS Eye Point. The JIS point is located 8.4 mm up and 22.9 mm rearward of the mid-eye centroid of the SAE eyellipse.

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**Car Example**
Eye Point and Display Point, Car Example*

<table>
<thead>
<tr>
<th>Dimension Description</th>
<th>Dimen.</th>
<th>SAE Eyellipse Centroid</th>
<th>JIS Eye Point</th>
<th>Display Point</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance behind the front of vehicle</td>
<td>X</td>
<td>3011.31</td>
<td>3034.21</td>
<td>2506.00</td>
<td>mm</td>
</tr>
<tr>
<td>Side distance from car centerline</td>
<td>Y</td>
<td>-370.00</td>
<td>-370.00</td>
<td>12.00</td>
<td>mm</td>
</tr>
<tr>
<td>Height above SAE curb ground</td>
<td>Z</td>
<td>1327.28</td>
<td>1335.68</td>
<td>969.00</td>
<td>mm</td>
</tr>
</tbody>
</table>

* Assume grid coordinates for 2D angle, ground coordinates for 3-D angle.
2-D Criterion

*If head-down, the display shall be mounted in a position where the 2D downward viewing angle is less than or equal to 30 degrees at the geometric center of display.*

2-D Criterion Example

[Diagram showing JIS Eye Point and Display Point]
2-D Downangle: Side view

J.I.S. Eye Point E and display point T, projected into the side plane. \( \theta_{2D} \) is the two-dimensional downward viewing angle in grid coordinates. \( \theta_{2D} \) should be less than or equal to 30 degrees.

2-D Downangle
3-D Downangle

If information subject to this Principle is displayed at a head-down location, the displayed information must be located at or above the criterion 3-D downangle at the geometric center of the active display area.

- The 3-D downangle is the angle formed as if the driver had rotated their eye to the right, and then looked down at the center of the display.*
- The vehicle is now assumed to be oriented with respect to ground plane (not grid) coordinates.
  - The ground plane to be used is the SAE curb ground plane.**

* Center of display for the 3-D method is defined as the geometric center of the active display area, excluding unused display surface and physical switches
** SAE J1100 Revised JUL2002

3-D Downangle Criterion

$$\theta_{3D\text{max}} = 57.2958 \times \arctan[0.829722 \tan(0.263021 + 0.000227416 \max(1146, Z_{\text{ground}}))]$$

3-D downangle criterion as a function of eye height above SAE curb ground
**3-D Downangle Two-Point Method**

Rear view. JIS eye point E, projected eye point E’ and display point T” for car example 2, projected into the Y-Z plane.

The view in the oblique plane formed by EET” (not shown) will give the correct 3-D downangle, or it can be calculated numerically.

**Swept Line Method**

Another way to implement a 3-D downangle verification method in a Computer Aided Design (CAD) system is to create a swept line:

- Construct a single line that has a fixed angle down from the horizontal plane containing the eyepoint — that is, a fixed angle down from the driver’s forward line of sight to the roadway (assuming SAE curb ground plane).
- The down angle to the forward line of sight should be set at a value of $\theta_{3Dmax}$ -- the maximum allowable 3-D downward viewing angle.
- Once anchored and positioned this way, the line can be swept laterally, such that it makes a constant downangle with the horizontal plane containing the eyepoint.
- If the line falls below the center of the display, the display meets criterion.
**Cone Method**

This swept line also creates a cone. The cone that is generated by the swept line is illustrated in the following slide.

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**3-D Downangle Cone Method**

Rear view of downward viewing cone and instrument panel and the bottom picture is a solid view. The apex of the cone is at the eye point.

Wireframe rear view. If the display point is inside the boundary of the cone shown, the display placement does not meet the 3-D downangle criterion. If the display point is outside the boundary of the cone, it does meet the criterion.

Solid oblique view with the rear portion of the cone cut away so the interior of the cone can be seen.
2-D vs. 3-D Downangle Comparison

When the display point is closer to the driver than the intersection point \( I \) of the two constraint lines, the 3-D constraint line is higher (i.e., stricter) than the 2-D constraint line, whereas the opposite is true for display positions to the right of the intersection point \( I \). Hence the 3-D method is neither stricter nor more permissive than the 2-D method; it depends upon the cross-car location of the display relative to the driver.

The intersection of the swept cone with the vertical \( YZ \) plane containing the display point in the instrument panel traces a hyperbola.

Qualitative Examples

**Good:** Visual display positioned high on the instrument panel towards the driver’s side of the central console, but not being obstructed by the steering wheel or obstructing the forward vision.

**Bad:** Display positioned too low in the console area towards the front passenger’s side or within a glove compartment.
Overall Conclusions

- A simple 30-degree 2-D downangle criterion has been agreed to by major vehicle OEMs in the Alliance
  - The 2-D method is suitable for early design phases where the vehicle is in grid coordinates
- A more complicated 3-D criterion has also been developed and agreed to by the Alliance
  - More consistent with driver performance research data and the peripheral sensitivity of the human visual system to visual events
  - Suitable for later design phases where a ground plane has been defined for the vehicle
- Either method ensures that in-vehicle navigation and telematics displays will be placed high enough for a driver to use peripheral vision to monitor the roadway for major developments during quick glances to the display.

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