



SURFACE VEHICLE RECOMMENDED PRACTICE

J1750™

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(R) Describing and Evaluating the Truck Driver's Viewing Environment

RATIONALE

The 1995 version of this SAE Recommended Practice presented only two methods of evaluation: the Polar Plot and the Horizontal Planar Projection. Each of these methods is insufficient to adequately describe both direct and indirect fields of view around the entirety of the vehicle. However, the document referenced additional “experimental and graphical methods” that were defined at the time as beyond the scope of the document. This release is intended not to replace methods originally presented, and rather adds the preferred Target Evaluation, which allows for utilization of available tools that complete the original purpose of this Recommended Practice.

The Target Evaluation Method may be utilized for alternative vision systems as well (i.e., cameras and monitors), but additional work is necessary to specify system requirements that appropriately consider valid image representation (clarity, acuity, distortion, size, etc.).

A minimum mirror radius of 300 mm for a spherical convex mirror is recommended based on a consensus of the committee. Appendix D describes the rationale for this limit which is derived from considerations of visual acuity and typical vehicle layout.

In establishing a Target Evaluation Procedure, care was taken to ensure that the evaluation could be conducted in a simulated environment with appropriate CAD utilization, or equivalently with manual methods. This procedure details target cylinders and spacing, which were selected to be similar to the concept established in the Federal Regulation FMVSS 111, as required for school buses, with notable improvements.

Within the Target Evaluation Method, it is acknowledged that the extrapolation of the solid angles to form a vision cone, are not fully detailed in this Procedure with consideration of ergonomic limitations (i.e., head and eye movement). These limitations should be considered, but as with the previous 1995 version, are beyond the scope of this document.

It is recognized that the Target Evaluation Procedure counts the cylinder targets on the boundary between zones twice but it was judged by the Task Force to be preferable over a more complicated procedure that attempted to resolve the double count. This resolution of boundary target cylinders also allows each zone to be assessed independently, as well as in summary, to achieve a field of view volume evaluation.

The Target Evaluation Procedure requires a setup with the mirrors in the nominal adjustment position. The Task Force intended to require that both the top and bottom corners of the extremities of the vehicle would be visible, but it was determined that in most situations these extremities could not be viewed simultaneously without adjusting the mirror surface from nominal. Therefore, the bottom extremities of the vehicle were chosen as required view points.

SAE J1750 has been reaffirmed to comply with the SAE Five-Year Review policy.

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1. SCOPE & PURPOSE

This SAE Recommended Practice establishes three alternate methods for describing and evaluating the truck driver's viewing environment: the Target Evaluation, the Polar Plot and the Horizontal Planar Projection. The Target Evaluation describes the field of view volume around a vehicle, allowing for ray projections, or other geometrically accurate simulations, that demonstrate areas visible or non-visible to the driver. The Target Evaluation method may also be conducted manually, with appropriate physical layouts, in lieu of CAD methods. The Polar Plot presents the entire available field of view in an angular format, onto which items of interest may be plotted, whereas the Horizontal Planar Projection presents the field of view at a given elevation chosen for evaluation.

These methods are based on the Three Dimensional Reference System described in SAE J182a. This document relates to the driver's exterior visibility environment and was developed for the heavy truck industry (Class B vehicles, class 6, 7, 8 vehicles) although the projection principles presented in this document can be applied to any class of motor vehicles.

This document is intended to complement SAE J1050a and provides a visual format that can describe the driver's entire viewing environment. This environment can then be analyzed to determine what the driver is capable of seeing. It should be noted that one of the most important factors affecting the driver's field of view and the ability to make valid vehicle/design comparisons is the location of the driver's eyepoint. SAE J941 defines the Eyellipse which forms the basis for eyepoints chosen as the origin for Polar Plots and Horizontal Planar Projections. The Target Evaluation, Horizontal Planar Projection and Polar Plot create monocular evaluations. Projections/plots of multiple eyepoints must be overlaid to create binocular or ambinoocular evaluations.

Analytical methods for creating Target Evaluations, Polar Plots and Horizontal Planar Projections for direct and indirect vision (planar and spherical convex mirrors) are presented. Note that it is possible to create plots and projections for other mirror surfaces and vision devices if the equations for determining reflection points are provided.

2. REFERENCES

2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.2 SAE Publications

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J182a Motor Vehicle Fiducial Marks and Three-dimensional Reference System

SAE J264 Vision Glossary

SAE J941 Motor Vehicle Drivers' Eye Locations

SAE J1050a Describing and Measuring the Driver's Field of View

SAE J1100 Motor Vehicle Dimensions

2.3 Other Publications

TNO 01.OR.NT.011.1/JvdH Research Paper published by TNO Institute regarding Object Acuity in Vision Limitations.

3. SAE J1516 ACCOMMODATION TOOL REFERENCE POINT DEFINITIONS

3.1 Driver's Viewing Environment

The environment surrounding the driver as described relative to the driver and his/her vision abilities.

3.2 Polar Plot

A two-dimensional plot that represents the angle of sight lines tangent to items of interest within the driver's viewing environment relative to the horizontal and vertical plane passing through the origin of the sight line.

3.3 Horizontal Planar Projection

A two-dimensional plot which represents the intersection of sight lines with a ground plane or a specified plane parallel to the ground plane. The sight lines are tangent to items of interest within the driver's viewing environment. The Horizontal Planar Projection maps only the limits of items of interest (in contrast to the Polar Plot). The effect is as if a lamp at the driver's eyes casts a shadow of a window, mirror or other item onto the plane.

3.4 Eyellipse

The contraction of the words "Eye" and "Ellipse" and is so named because of the elliptical shape of the driver's eye range. "Eyellipse" is the statistical model defined in SAE J941.

3.5 Monocular Field of View

The field of view that can be seen by one eye. (Reference SAE J1050a)

3.6 Binocular Field of View

The total field of view that can be seen by both eyes simultaneously. (Reference SAE J1050a)

3.7 Ambinocular Field of View

The total field of view that can be seen by both eyes separately. This includes the binocular field as well as the monocular field visible to the right eye but not the left eye and vice versa. (Reference SAE J1050a)

3.8 Sight Line

A line representing the driver's line of sight from an eye point or a V point to a target point or at a given angle.

3.9 Vision Reference Points

Points from which sight planes/lines may be constructed. (V point)

3.10 Vision Opening Line

What the driver actually perceives as the D.L.O. (day light opening). It is the intersection of a surface of interest and a sight line from a vision reference point, tangent to the first body component obstructing these sight lines (i.e., window moldings, seals, ceramic paint, concealed wipers, front end surface, etc.)

3.11 Polar Plot/Horizontal Planar Projection Origin Point

Selected by the plot originator. It can be the eyellipse centroid, left or right eyellipse centroid, or a vision reference point.

3.12 Item of Interest

An item which the plot originator chooses to define as part of the driver's viewing environment. It can be vehicle vision opening lines, other vehicles, field of view targets, lane markers, etc. Note that items of interest may be unique to a specific eye point. For example, an item of interest such as the top edge of the dash may disappear as the eye point moves upward. The new item of interest might be the hood.

3.13 Variable/Coordinate System Definitions

The three-dimensional vehicle coordinate system is that established in J182. The positive X axis is to the rear, the positive Y axis to the driver's right and the positive Z axis is up. A second coordinate system is used in the Polar Plot and Horizontal Planar Projection calculations. In this system the axis directions remain the same, but the origin is moved to the eye point. Table 1 is presented to assist in the definition of the variables in both systems:

TABLE 1 - COORDINATE SYSTEM NOTATION

	Vehicle Coordinate System	Eye Coordinate System	Conversion
Point on Item of Interest	Tx, Ty, Tz	tx, ty, tz	$tx = Tx - Ex$ $ty = Ty - Ey$ $tz = Tz - Ez$
Point on Mirror	Mx, My, Mz	mx, my, mz	$mx = Mx - Ex$ $my = My - Ey$ $mz = Mz - Ez$
Intercept Point on Horizontal Plane	Nx, Ny	nx, ny	$nx = Nx - Ex$ $ny = Ny - Ey$

3.14 Class B Vehicles

Those vehicles having an H point height (H30) between 405 and 520 mm and steering wheel diameters (W9) between 450 and 560 mm. This class of vehicles includes heavy trucks and some buses and multipurpose vehicles. (Reference SAE J1516)

3.15 Accommodation Heel Reference Point

Refer to SAE J1516.

3.16 Accommodation Tool Reference Point

A point on the Accommodation Tool Reference Line at height H30 (as specified by the vehicle manufacturer). (Reference SAE J1516)

3.17 Accommodation Tool Reference Line

Refer to SAE J1516.

3.18 Seat Back Angle (A40)

Refer to SAE J1100.

4. TARGET EVALUATION PROCEDURE

4.1 The target evaluation procedure is intended to represent positions of objects around a vehicle in 3-D, typically on a ground plane projection. The exercise described may be conducted with a geometrically accurate 3-D software, or manually with appropriate physical layouts around an actual vehicle.

4.2 Standard Target Description

The standard target is described as a cylinder with three stacked sections, each 04 m (1.312 ft) in diameter and in height. Each section is color-coded from top to bottom as red, yellow and green, resulting in a total cylinder height of 1.2 m (3.937 ft). See Figure 1.

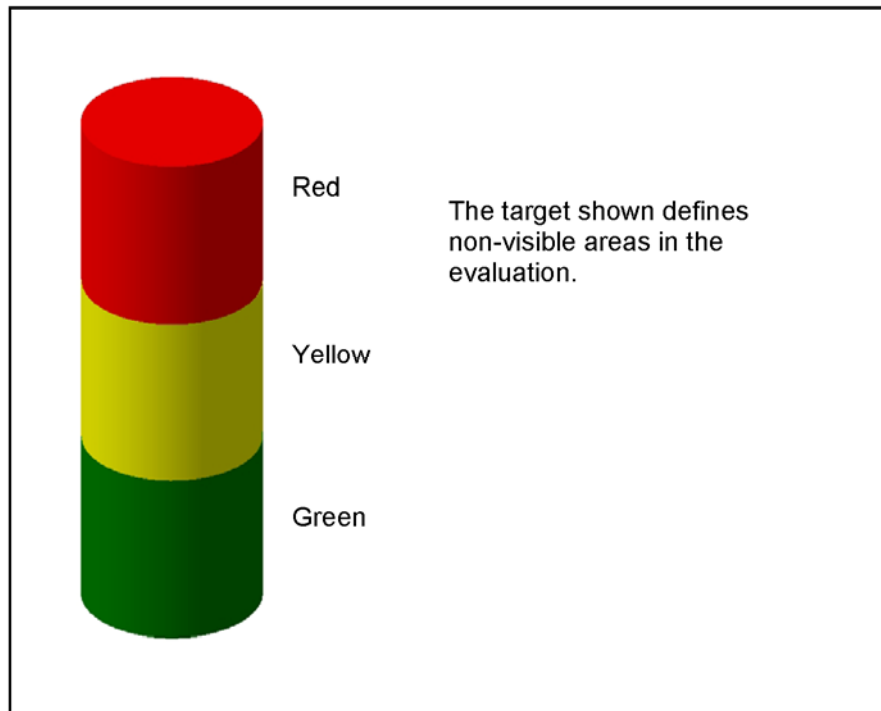


FIGURE 1 - VISION EVALUATION TARGET

4.3 Target Displacement Pattern and Coordinate Identification

The target evaluation procedure is to be conducted specific to a study vehicle. Therefore, coordinates of each cylinder position are defined in relation to a given vehicle (Figure 2). Each cylinder point should be located on a 0.485 m x 0.485 m grid pattern (1.5 ft x 1.5 ft). The front grid should be established starting with the cylinder at position F (0,0) touching the front center of the vehicle bumper. The front grid should extend to the rear extreme of the vehicle. To account for varying vehicle lengths, a secondary grid should be established starting with the cylinder R (0,0) touching the rear center of the vehicle extremity.

This grid layout may result in a narrow spacing between the beginning of the rear grid starting at R (0,0), and the truncation of the front grid, which extends to the back of the trailer. This is judged acceptable because it is more conservative to have closer spacing and it is essential that the rear zones begin at the rear bumper.

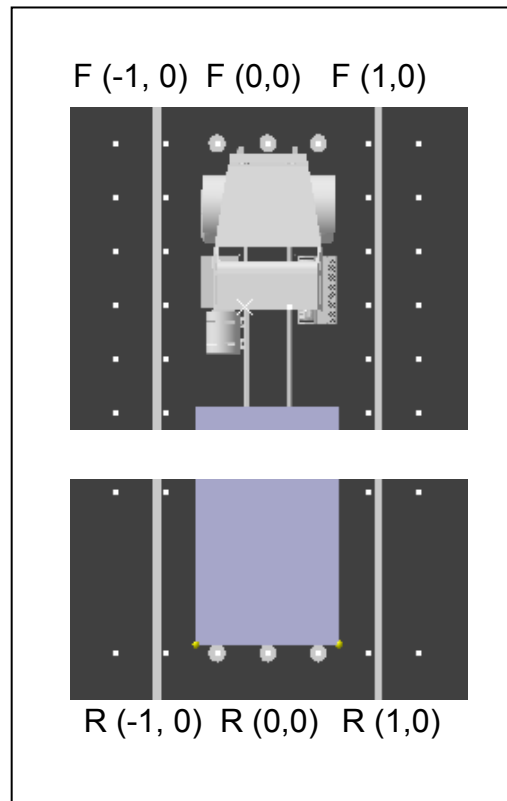


FIGURE 2 - GRID LOCATION NUMBERING

4.4 Field of View Zone Identification

The near field zones around the vehicle are defined as follows (see Figures 3 and 4):

NOTE: While SAE procedures require metric units, the standard U.S. road lane width is 12 ft (3.658 m). The zones dimensions are defined using multiples of "L" ("L" equals 3.658 m).

Front Left (FL) – Left adjacent lane (1 L wide) from a line touching the front bumper forward $2.5 \times L$, and extending to the back of the cab.

Front Forward (FF) – Vehicle lane (1 L wide) from a line touching the front bumper forward $2.5 \times L$

Front Right (FR) – Right adjacent lane (1 L wide) from a line touching the front bumper forward $2.5 \times L$ and extending to the back of the cab.

Adjacent Left (AL) – Left adjacent lane (1 L wide) from a line touching the rear of the cab and extending to a line touching the rear bumper of the trailer or truck body (i.e. the overall length of the vehicle OAL)

Adjacent Right (AR) – Right adjacent lane (one L wide) from a line touching the rear of the cab and extending to a line touching the rear bumper of the trailer or truck body (i.e. the overall length of the vehicle OAL)

Rear Left (RL) – Left adjacent lane (1 L wide) from a line touching the rear bumper rearward $2.5 \times L$

Rear Aft (RA) – Vehicle lane immediately behind the tractor trailer unit or truck (1 L wide) from a line touching the rear bumper rearward $2.5 \times L$

Rear Right (RR) – Right adjacent lane (1 L wide) from a line touching the rear bumper rearward $2.5 \times L$

The far or extended field zones beyond the near field zones are defined as follows (see Figure 4):

Far Forward Front (FFF) – The vehicle lane and two lanes to the left and right (5 x L wide) from 2.5 x L forward of the front bumper to 5 x L forward.

Far Adjacent Left (FAL) – The second adjacent lane (1 L to the left of the vehicle lane and 1 L wide) by the overall length (OAL) of the vehicle.

Far Adjacent Right (FAR) – The second adjacent lane (1 L to the right of the vehicle lane and 1 L wide) by the overall length (OAL) of the vehicle.

Far Rearward Aft (FRA) – The vehicle lane and two lanes (L) to the left and right (five total lanes or 5 x L wide) from 2.5 x L feet rearward of the rear bumper to 5 x L rearward.

4.5 Target Evaluation Method

4.5.1 Evaluation Setup

The evaluation procedure should be conducted with the mirror surfaces in the nominal adjustment position. In the nominal adjustment position, specific points should be visible from the driver eye-point position. These include the rear bottom vehicle extremities (i.e., bottom corners of the trailer). For specialty applications with a non-standard rear section, an appropriate bottom extremity should be utilized. (Figure 5)

4.5.2 Target Evaluation of Field of View

Using the vehicle geometry and established target locations, the driver's field of view should be geometrically projected as a solid angle originating at the driver's eyepoint. Sight lines should be extended from a single fixed cyclopean eyepoint (documented by user), and projected until blocked by an obstruction, or continuing to the ground plane if unobstructed. The expansion of the derived solid angle, or field of view cone, is limited in range by the Vision Opening Line. The resultant field of view is truncated at a horizontal surface, typically the ground plane. Figure 6 demonstrates the graphic portrayal of visible and nonvisible areas.

As a simplified model for representative purposes, the Target Evaluation Method uses a single fixed cyclopean eyepoint.

If a specific study requires a more refined eyepoint location including head movement, care should be taken to ensure that ergonomic factors are properly considered in these specific applications. Reference: SAE J1050a.

The resultant field of view, which identifies viewable and non-viewable areas, should be extrapolated to include both direct and indirect images. In order to accurately portray areas not visible to the driver, the cylinder targets, or cross-sectional portion of the targets, may be shown graphically if using CAD methods. An open green circle may be used to represent a target location completely visible from the static eye point. An example illustration using this Recommended Practice is shown in Figure 7.

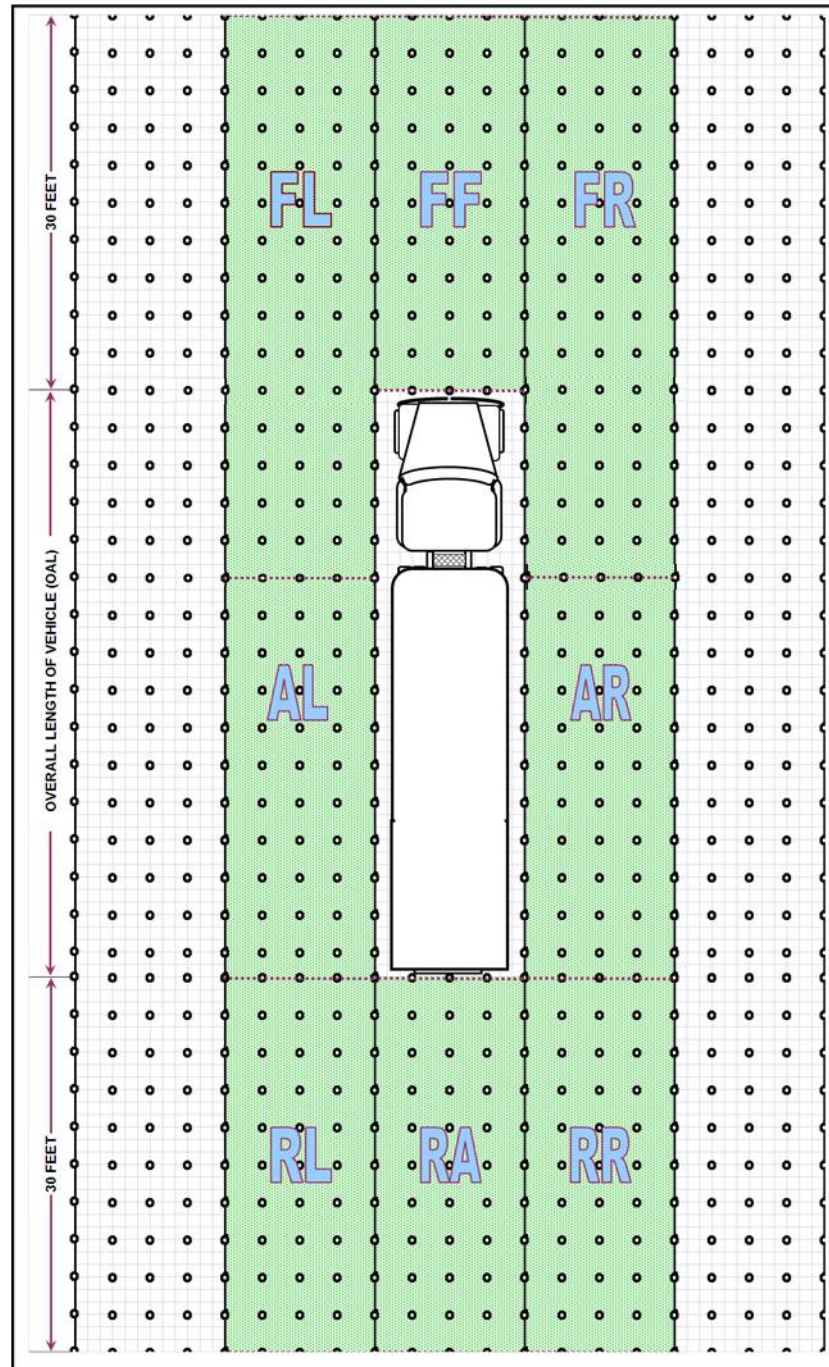


FIGURE 3 - NEAR ZONES

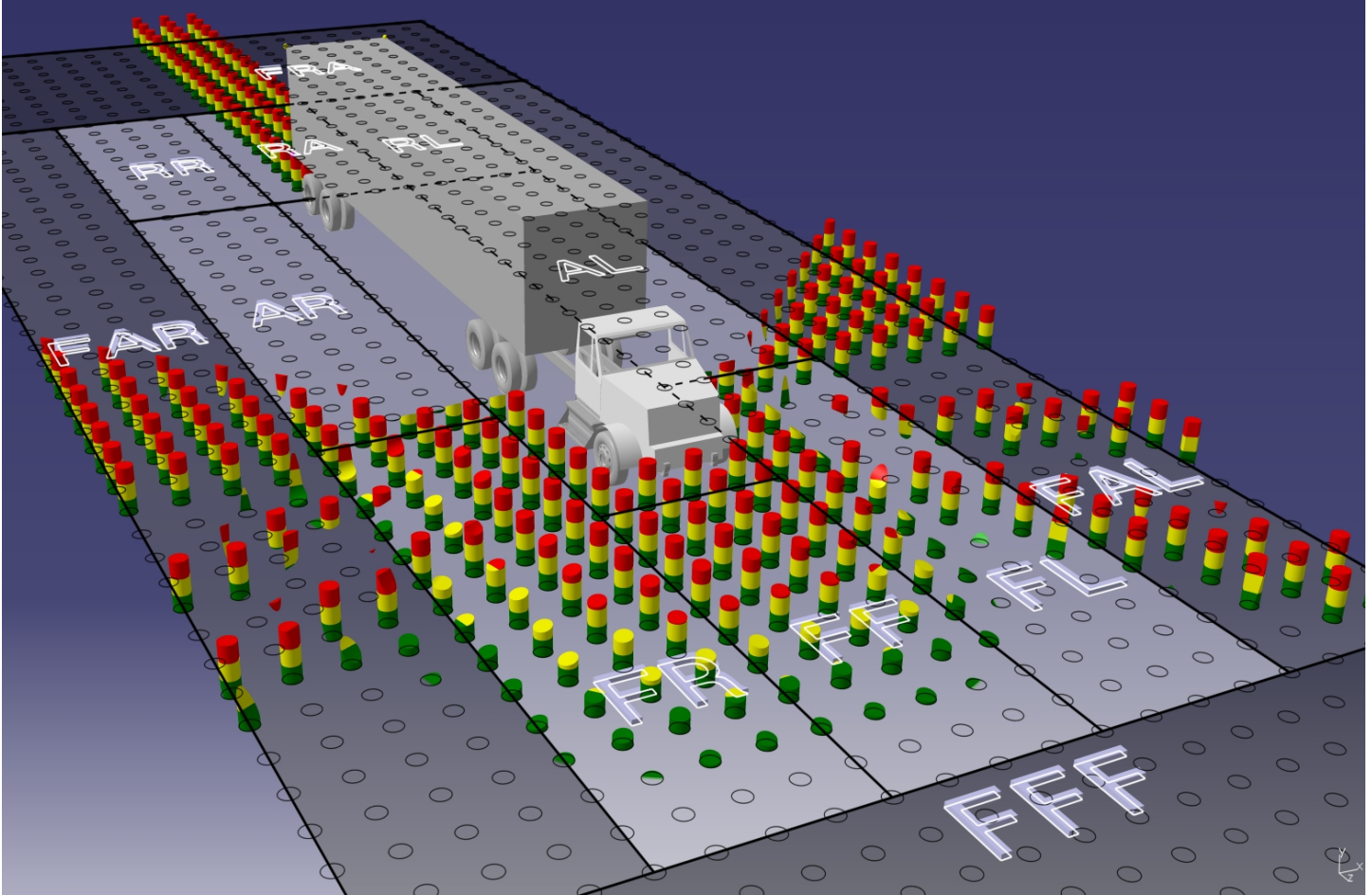


FIGURE 4 - FAR ZONES