National Transportation Safety Board
Office of Highway Safety
Washington, DC 20594

HWY23MH015

TECHNICAL RECONSTRUCTION

Group Chair's Factual Report

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A. CRASH

Location: Highland, Madison County, Illinois
Date: July 12, 2023
Time: 01:48 a.m. CDT

B. TECHNICAL RECONSTRUCTION GROUP

Group Chair	Robert Squire National Transportation Safety Board Washington, DC
Group Member	Curtis Eggemeyer Illinois State Police
Group Member	Bradley Brachear Illinois State Police

C. CRASH SUMMARY

For a summary of the crash, refer to the *Crash Information and Summary Report*, which can be found in the NTSB docket for this investigation.

D. DETAILS OF THE INVESTIGATION

The Technical Reconstruction Group was convened for this investigation to assist with providing on-scene documentation of the crash location and the involved vehicles; and to facilitate an analysis of certain collision events and causation factors. In support of these tasks the group relied upon information, data and documentation provided by the Illinois State Police (ISP) and Illinois Department of Transportation (IDOT). Factual reports prepared by other NTSB investigative groups should be consulted for information related to other aspects of the investigation, including information referenced within this report.

The crash involved the collision of a 2014 Prevost motorcoach with three parked combination commercial motor vehicles, a 2019 Freightliner Cascadia truck tractor in combination with a 2024 Vanguard semitrailer (Freightliner combination), a 2000 Kenworth truck tractor coupled with a 2007 Benson semitrailer (Kenworth combination) and a 2023 Mack Anthem coupled with a 2019 Great Dane semitrailer (Mack combination).

The three combination vehicles were parked along the shoulder of a highway exit ramp and were subsequently struck in the rear by the Prevost motorcoach after it had departed the highway travel lane.

1.0 Introduction, Crash Location and Site Documentation

The crash events occurred on the exit ramp from westbound Interstate 70 leading into the Silver Lake rest area. The rest area is located just east of Silver Lake and Highland, Illinois. The ramp is located adjacent to the right travel lane along a sweeping, large radius, leftward curve that reversed a preceding sweeping, large radius, rightward curve. **Figure 1** is an area map depicting the approximate location of the rest area relative to Interstate 70 and Highland, IL.

Generally, Interstate 70 (I-70) is a major east–west Interstate Highway that runs from I-15 near Cove Fort, Utah, to I-695 in Woodlawn, Maryland. Approximately 155 miles of I-70 passes through the state of Illinois.

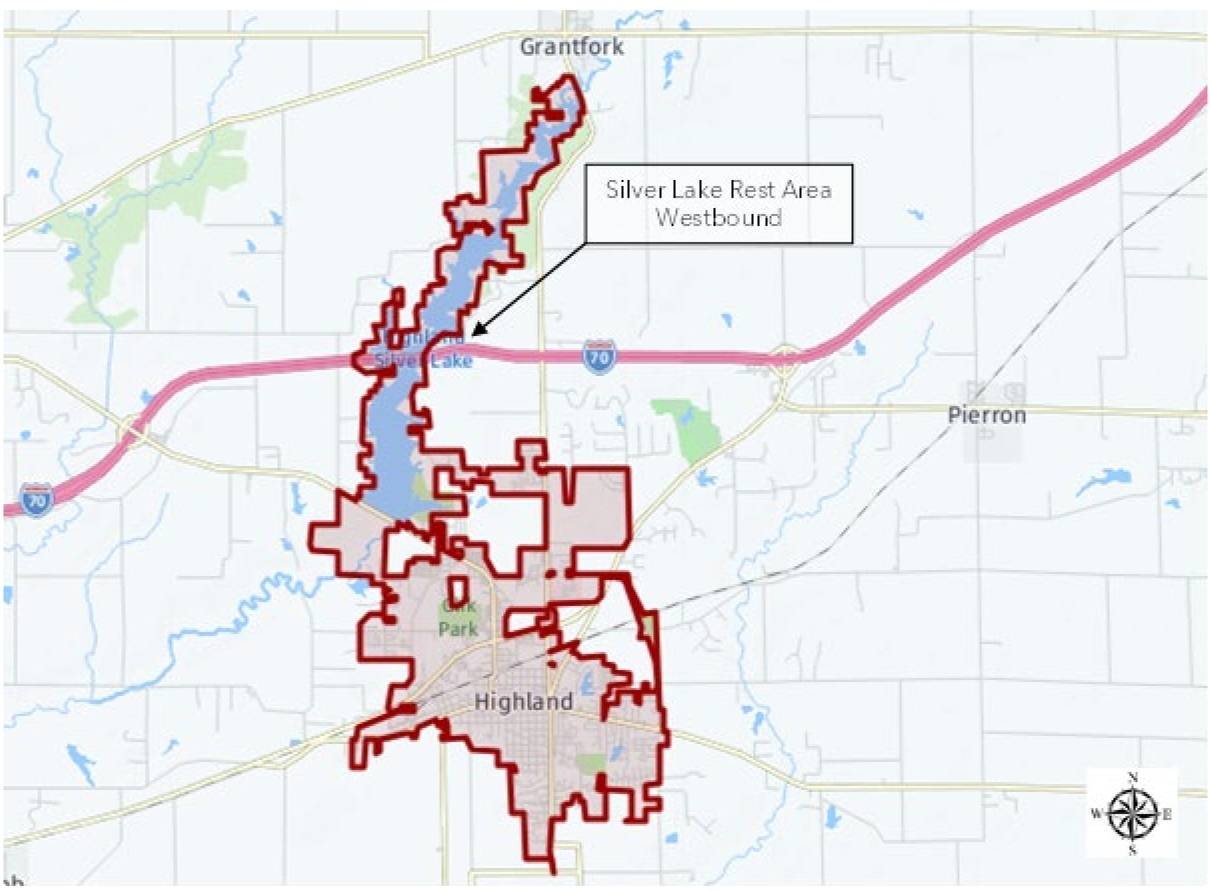

Figure 1: Area map depicting the rest area location relative to Silver Lake and the city of Highland, IL.

The westbound approach to the rest area and I-70 exit ramp exhibits a consistent (near tangent) west-east orientation for about 2.3 miles before the first sweeping curve (highway plans denote an actual tangent segment of about 1,204 feet before the point of curvature).[1] The first curve encountered is a 1,510-foot-long rightward horizontal having an approximate radius of 5,730 feet. A 272-foot tangent segment follows this curve after which the highway transitions into a 2,189-foot-long leftward horizontal curve having an approximate radius of 3,820 feet.[2] The rest area exit ramp begins about 10 feet before the onset of the leftward curve.[3] From a westbound travel heading perspective, the rest area exit ramp visually appears as a continuation of the short tangent segment between the two curves. **Figure 2** depicts a photograph of the approach to the exit ramp. Furthermore, the exit ramp and roadway pavement striping were clear and well delineated.

Figure 2: Photograph depicting the westbound approach to the rest area exit ramp.

As the exit ramp diverges from the right travel lane it exhibits a leftward curvature albeit at a larger radius (~3,873 feet) than the travel lanes. This initial curve

[1] Point of curvature—The point where straight (tangent) alinement ends, and circular alinement begins.
[2] See the NTSB Highway Factors Group Chair Report for additional details.
[3] Onset of the ramp was derived from highway plans provided to the NTSB by IDOT and references the right pavement edge.

extends about 663 feet. As this curve ends, a 365-foot-long rightward curve begins. The exit ramp is approximately 1,063 feet in length with the rest area parking lot estimated to begin about 1,148 feet from the start of the ramp at the highway travel lanes.

The tangential separation and larger curve radius of the exit ramp, relative to the travel lanes, created a gore area that was delineated by pavement striping.[4] The striping transitioned into edge line striping for both the ramp and right travel lane. Generally, the highway and initial portion of the exit ramp appear horizontally level with some increase in elevation of the exit ramp as it nears the rest area parking lot.

Street lighting was present along portions of the exit ramp. As noted in IDOT documentation there were four cantilever luminaires erected along the right roadside of the ramp (the fourth luminaire was located at the onset of the parking lot). Site documentation placed the first luminaire about 311 feet west of the start of the ramp (~155 feet west of the ramp gore apex). The second and third luminaires exhibited separation distances of about 200 and 250 feet respectively (as measured from site documentation). At the time of the crash the Freightliner combination (first unit struck) was parked directly beneath the second luminaire (westward from ramp beginning). The light distribution pattern of the luminaires was not assessed, although moving westward, the fixtures were positioned closer to the pavement.

Additional and more specific highway data is referenced in the NTSB *Highway Factors Group Chair's Factual Report*.

1.1 Post-Collision Site Documentation and Roadway Evidence

The crash site was confined to the highway exit ramp leading to the rest area. The site was photographically documented by ISP investigators using terrestrial and small unmanned aerial system (sUAS, i.e., aerial drone) methodologies. NTSB investigators examined the scene after the crash and employed similar documentation methodologies. The intensity of some collision-created tire friction marks had diminished by the time NTSB investigators examined the scene. Some roadway evidence was further marked by ISP investigators using yellow paint. The sUAS images were processed using Pix4DMapper photogrammetry software from which three-dimensional point clouds and two-dimensional orthomosaic images were created for analysis.[5] Additionally, NTSB investigators also deployed terrestrial three-dimensional

[4] The apex of the gore or area of the pavement striping convergence will also be used as a distance datum as this point similarly defines the ramp travel lane width. The gore apex was approximately 156 feet west of the beginning of the ramp as defined at the right pavement edge.

[5] Pix4DMapper is a photogrammetry software package designed to use overlapping photographic images to generate 3D point clouds. Additional outputs from the generated point cloud include 3D

scanning about the identified area of impact for additional analytic reference.[6] Two-dimensional orthomosaic images of the scene are depicted in **Figures 3 and 4**.

The area of impact was established at a location where the Prevost made contact with the Freightliner combination – the first vehicle struck and the last of those stopped on the ramp shoulder. At this location, a prominent tire friction mark consistent with vertical tire loading (exhibiting edge and tread rib deflection) and pavement slip characteristics of an impact was identified. The mark was located on the shoulder and centered approximately 1.4 feet offset from the edge line and 465 feet west of the start of the ramp (~309 feet from the apex of the pavement striped gore). A near parallel mark is observable in terrestrial photographs positioned closer to the pavement edge (this mark was not discernible in sUAS photographs).

Preceding the area of impact (leading westward to the area of impact), a single linear tire friction mark measuring about 53 feet in length was observed.[7] This mark appeared to arc from the shoulder toward the ramp travel lane. ISP scene photographs depict the tire mark intensity as faint at the onset although the tire width can be seen further westward, and the right (looking west) edge exhibits a darker intensity. The mark appears relatively consistent until apparently overlapping the impact tire mark. At its onset, the mark was centered about 2.4 feet onto the shoulder. The mark was too faint to observe additional evidence of tire slip on the pavement surface.

Westward of the loading or impact tire mark, the mark continued although the dark edge exhibited a scalloped appearance consistent with a deflated or damaged tire. As it progressed westward, the intensity of the mark decreased and was no longer visible in the photographs as it intersected with the edge line about 34 feet west of the impact area.

Beginning approximately 50 feet west of the first area of impact a series of prominent tire friction marks angled from the shoulder toward the right roadside. These marks were most prominent from about the middle of the ramp shoulder extending to the pavement edge. Very light pavement surface scratches and other tire friction marks were observed on the shoulder between the area of impact and these angled marks. These angled marks were consistent with the off-pavement location of the Freightliner's drive axle wheels.

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models (textured mesh), digital surface and terrain models, and 2D orthomosaic maps. An orthomosaic is an image with high detail and resolution made by combining many smaller images and is corrected for lens distortion, camera tilt, perspective, and topographic relief.

[6] 3D scanning was completed using the FARO Focus Premium 350 laser scanner. Scans were rendered into three-dimensional (3D) point clouds using FARO Scene® software.

[7] Length was based on paint markings applied by ISP investigators.

Further westward surface scrapes and additional tire friction marks were observed with nearly all roadway evidence confined to the ramp shoulder. Additional, more prominent tire friction marks characteristic of vertical loading appeared about 86 and 220 feet west of the first area of impact. Examination of ISP on-scene photographs placed these loading marks in proximity to the Kenworth and Mack combination vehicles, respectively. The more prominent tire friction marks are highlighted in **Figure 5**.

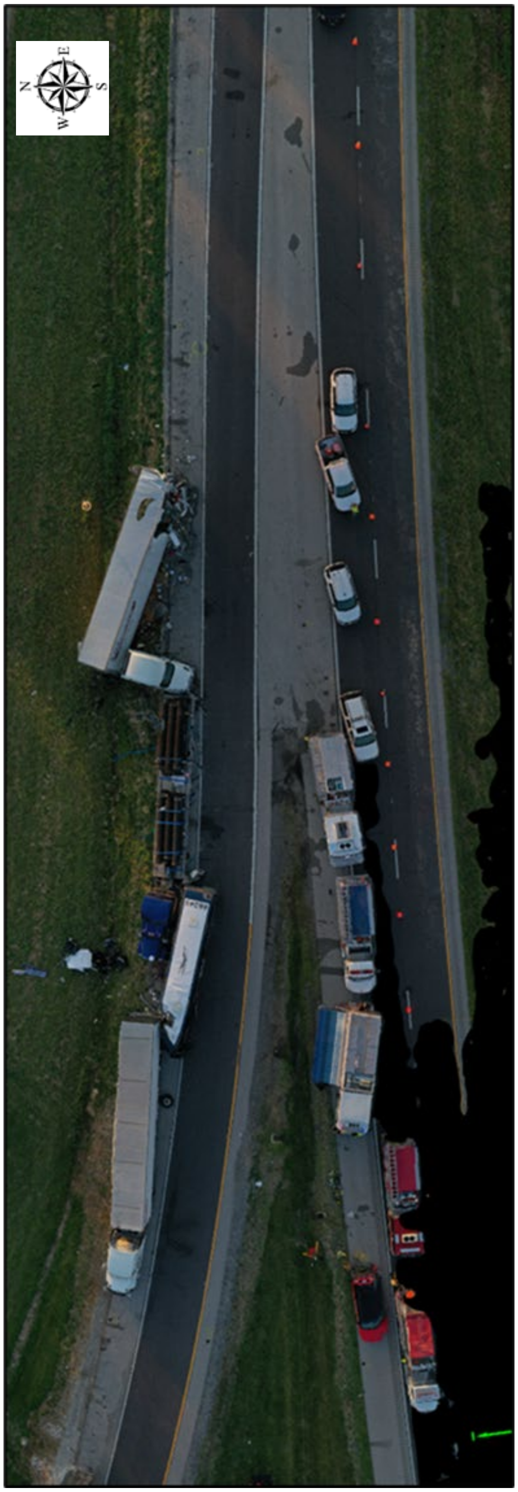


Figure 4: Selected portion of the orthomosaic image from ISP sUAS project.

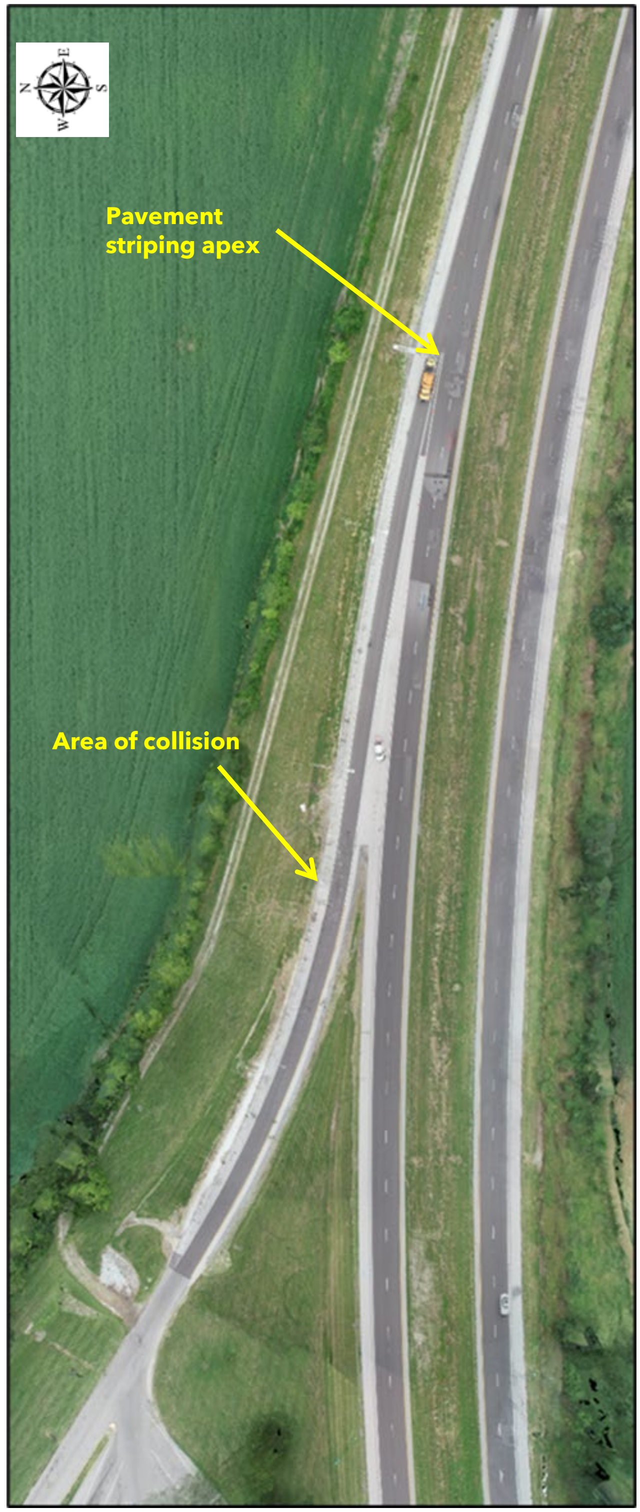


Figure 3: Selected portion of orthomosaic image from the NTSB sUAS project.

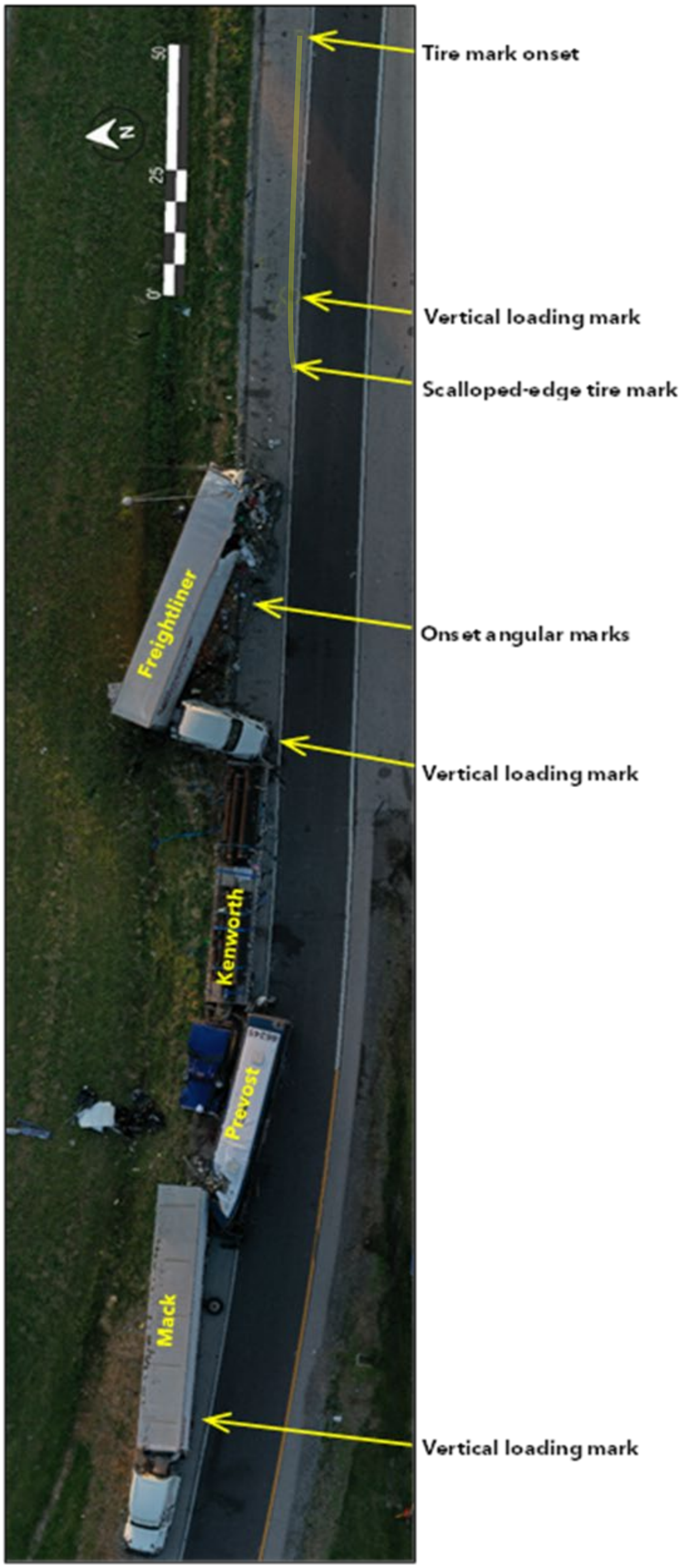


Figure 5: Image depicting vehicle post-collision positions of rest relative to certain roadway evidence (additional highlight added to tire mark).

2.0 Vehicles

Three commercial combination vehicles were involved in the collision with the Prevost motorcoach. At their positions of final rest, the three combination units were positioned on the ramp shoulder or right roadside adjacent the shoulder. Orientation of the trucks at the final rest positions corroborated that they had been moved as a result of contact with the motorcoach. The vehicle positions of final rest were documented by ISP investigators through sUAS photographs as depicted in **Figure 3**.

2.1 2014 Prevost x3-45 Motorcoach

The striking vehicle was identified as a 2014 Prevost x3-45 motorcoach. At final rest, the motorcoach exhibited a slight angular heading from the ramp travelway toward the right shoulder. The passenger side wheels were on the shoulder while the driver side front wheel was essentially atop the right edge line and the driver side rear overhung the ramp travelway by about six feet. The passenger side front was in contact with the driver side rear of the Great Dane semitrailer that was coupled with the Mack truck tractor (Mack combination). The front of the motorcoach was approximately 197 feet west of the area of impact.[8]

The passenger side of the motorcoach sustained extensive damage that exhibited evidence of overlapping areas of contact forward of the front axle. Intrusion and separation of the passenger side occupant compartment sidewall continued rearward from the frontal impact area. ISP scene photographs depict significant overlap of the contact area between impact with the Freightliner combination and Mack combination. Evidence of direct contact was observed at passenger side and extended inboard about 21-23 inches (indirect and recovery damage extended further inboard of the right side). The forward structure was displaced rearward into the passenger stairwell. As depicted in **Figure 6**, the passenger side A-pillar was displaced, and the roof panel disfigured rearward along the passenger side approximately 14 feet.

Substantial evidence of contact extended rearward along the passenger side including, but not limited to, the passenger compartment sidewall, steer axle tire and baggage compartment doors. A substantial segment of the passenger compartment sidewall (floor anchorage to lower windowsill) was displaced from the vehicle creating an opening that extended vertically from the vehicle floor to upper window frame. Displacement of the sidewall at floor level extended about 26 feet rearward from the

[8] Measured distances are truncated to neared foot and undamaged structures are considered.

front of the vehicle. Post-collision measurements placed the floor height of the motorcoach at about 45 inches above ground level.[9]

Figure 6: Photograph depicting damage to motorcoach roof.

Figure 7 depicts a screen capture of an oblique view of point clouds created from 3D scans of the involved motorcoach and an exemplar motorcoach provided by the carrier.

At final rest, the Prevost was engaged with the driver side rear of the semitrailer in the Mack combination. Post-collision damage examination indicated that the lateral intrusion from the trailer extended inboard from the passenger side of the motorcoach no further than about 21-23 inches and rearward no further than the rear of front tire fender, about 9.5 feet rearward from the vehicle front.

Reports prepared by NTSB Vehicle Factors and Survival Factors Groups should be consulted for additional vehicle information.

[9] This measurement likely approximates the pre-collision dimension due to overall collision damage.

Figure 7: Three-dimensional point cloud images of the involved motorcoach and an exemplar vehicle.

2.2 2019 Freightliner Cascadia truck tractor in combination with a 2024 Vanguard VXP semitrailer (Freightliner combination)

The first of the three parked combination vehicles struck by the Prevost motorcoach was identified as a 2019 Freightliner Cascadia truck tractor towing a 2024 Vanguard VXP, 53-foot-long semitrailer configured with a van body. At final rest, the Freightliner combination was partially off the ramp shoulder onto the roadside. The truck tractor was angled nearly 90-degrees relative to the pavement with the front wheels on the shoulder pavement and drive wheels furrowed into the right roadside soil depression. The semitrailer remained coupled with the tractor but was oriented at a near 90-degree angle. The semitrailer was angled from the pavement to the roadside wherein the left wheels were at the pavement edge and right wheels in the roadside soil. Post-impact the front of the truck tractor moved about 29 feet (linear) westward as it rotated counterclockwise. The semitrailer pivoted about the coupling and was moved about 48 feet.

The Freightliner truck tractor exhibited contact damage to the front that extended across the full width of the vehicle, although it appeared more significant at the passenger side.

The Vanguard semitrailer exhibited contact damage at the driver side rear with related damage continuing forward. At time of examination, the driver side rear loading door was missing, the left side rear vertical support and a portion of the left sidewall were missing. The missing sidewall extended forward about 12 feet from the rear of the vehicle. The driver side rear exhibited evidence of contact damage that extended inboard about 15 inches from the sidewall. The left rear corner of the semitrailer was displaced upward about 2.5 inches. Post-crash vertical measurements with the trailer parked on its landing gear, revealed a floor height of about 45 inches and a lower sidewall rail height of about 43 inches above the ground, respectively.

Contact damage was outboard of the driver side longitudinal frame rail. The exterior underside of the floor exhibited evidence of contact damage that extended forward about 15.2 feet while angled outboard to the left side. The damage area terminated just behind the leading axle. The driver side outer tire and wheel on the trailing axle also exhibited contact damage. **Figure 8** depicts a screen capture of an oblique view of the point cloud created from 3D scans of the semitrailer.

Figure 8: Three-dimensional point cloud image of the Vanguard semitrailer.

As required by FMVSS 108, retroreflective sheeting was installed on the sidewalls and rear doors of the semitrailer. The sheeting applied to sides of trailer was comprised of individual alternating red and white segments each measuring six inches in length. The segments were 2 inches wide and appropriately labeled as meeting

"DOT-C2" standard. Additionally, each red and white segment exhibited the Vanguard National Trailer Corporation. The alternating segments were installed along the sidewalls just above the lower sidewall frame rail and across the rear of trailer along the bottom edge of the doors and rear underride guard. With the trailer static, the vertical height of the sheeting was approximately 22-23 inches along the underride guard and 53-54 inches along the bottom door edge, notwithstanding vertical deformation at the driver side rear and the trailer supported by its landing gear. Additional sheeting was applied to the upper outboard corners of both rear doors and consisted of one horizontal strip and one vertical strip, both white in color.

Visual examination of the conspicuity sheeting concluded that the material complied with applicable installation standards (FMVSS 108, S8.2). While photometric standards for the conspicuity sheeting specified by FMVSS 108 are applicable at the time the vehicle is manufactured, samples were acquired from the rear of the vehicle for evaluation. Although the sheeting applied to the underride guard and bottom door edges exhibited significant collision damage, an 18.5-inch-long sample was acquired from the passenger side rear door for examination. That sample contained at least one complete red and white segment. The sample exhibited no direct damage other than wear.

A RoadVista model 932 retroreflectometer was used to measure the photometric value of the samples. The measurement protocol adhered to ASTM E1709 and ASTM E2540 to evaluate the requirements of FMVSS 108, S8.2.1.7 for both red and white segments of the sheeting. The measurements were reported for entrance angles of -4, 15, and 30 degrees in combination with observation angles at 0.2, and 0.5 degrees. Measurements were taken at several points on each color segment of each sample. Other than brushing off visible dirt, the surfaces were not altered. FMVSS 108 Table XVI–c cites the threshold values for new applications. Appendix 2 provides additional reference to FMVSS 108 requirements for retroreflective sheeting. **Figure 9** is a photograph of the sheeting samples. The photometric results are cited and graphically conveyed in **Figure 10**.

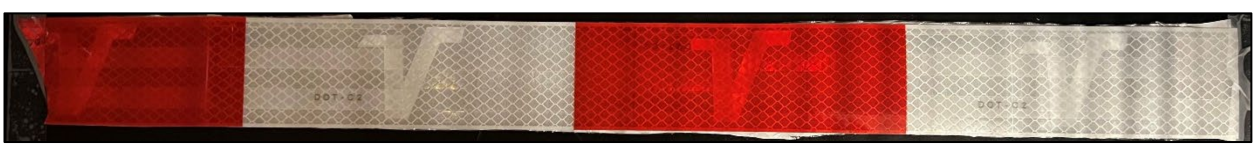
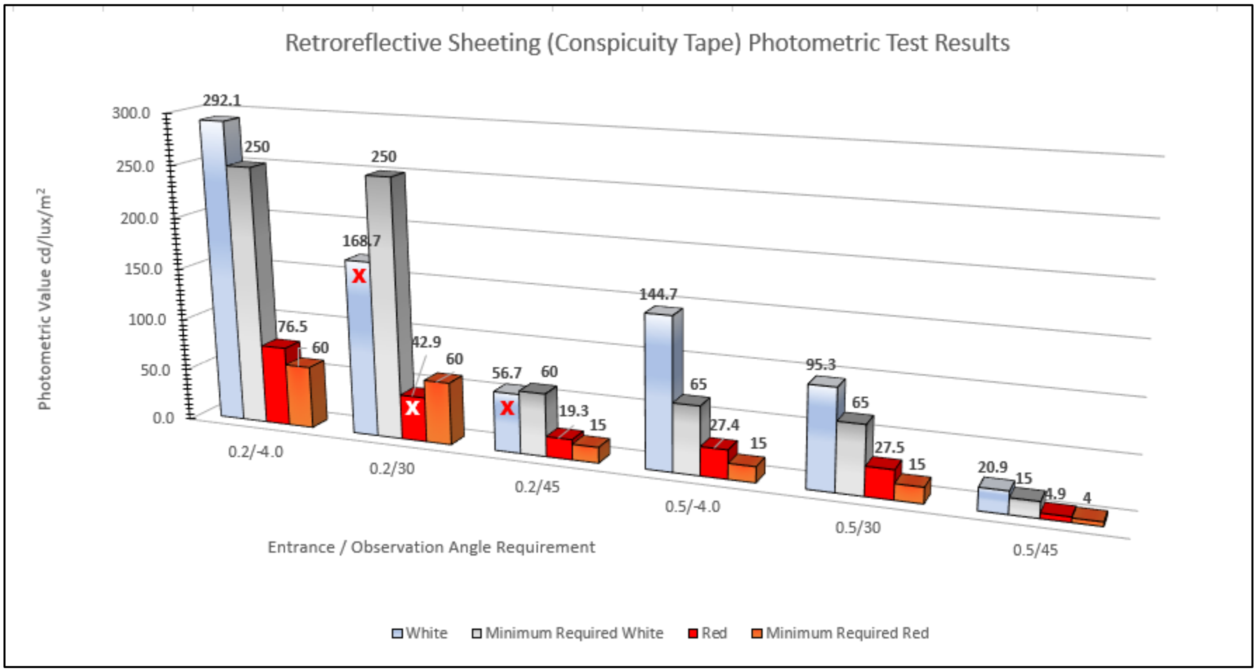


Figure 9: Photograph of retroreflective sheeting sample from rear of Vanguard semitrailer.



	Entrance /Observation Angle (degrees)											
	0.2/-4.0		0.2/30		0.2/45		0.5/-4.0		0.5/30		0.5/45	
	W	R	W	R	W	R	W	R	W	R	W	R
Results cd/lux/m^2	292.1	76.5	168.7	42.9	56.7	19.3	144.7	27.4	95.3	27.5	20.9	4.9
Minimum Required cd/lux/m^2	250	60	250	60	60	15	65	15	65	15	15	4

Figure 10: Photometric examination results from sample of Vanguard conspicuity sheeting on rear of vehicle.

2.3 2000 Kenworth W-900 truck tractor coupled with a 2007 Benson semitrailer (Kenworth combination)

The combination vehicle parked in front of the Freightliner combination was identified as a 2000 Kenworth W-900, three-axle, truck tractor coupled with a 2007 53-foot-long Benson aluminum flatbed semitrailer. Both the truck tractor and semitrailer exhibited contact damage along their respective drivers' sides. The vehicle was examined and photographed after the cargo had been removed and the vehicle was being made ready for travel with the replacement of some left side wheels and tires.

At the time of the crash the semitrailer had been loaded with 15, 24-inch diameter ductile iron pipes nominally weighing 34,650 pounds per the bill of lading. The pipes had been blocked and chocked and were secured to the trailer by nylon straps. Although at least three of the rear-most straps were displaced in the impact (as observed in scene photographs) the pipes remained on the trailer.

The driver-side rear corner of the semitrailer exhibited contact damage (**Figure 11**). A segment of the rub rail and the trailing axle outer wheel and tire at the end of the trailer were displaced or substantially damaged. The outer tires and wheels on the driver side of the semitrailer and truck tractor likewise exhibited contact damage as did the truck tractor's left-side fuel tank, entry step and front fender.

Figure 11: Photograph depicting area of first contact at the driver side rear of the Benson semitrailer (Kenworth combination).

The combination vehicle was moved forward about 10-12 feet due to the impact including slight clockwise articulation of the truck tractor.

2.4 2023 Mack Anthem coupled with a 2019 Great Dane semitrailer (Mack combination)

The third combination vehicle involved in the collision was identified as a 2023 Mack Anthem, 3-axle truck tractor, coupled with a 2019 Great Dane, 53-foot van body semitrailer. The combination vehicle was not retained by ISP investigators and was unavailable to NTSB investigators while on scene. ISP scene photographs depict the Prevost motorcoach in contact with the driver side rear of the semitrailer at final rest.

As depicted in ISP site photographs, the semitrailer exhibited contact damage at the driver side rear corner, outboard of the vertical support for the rear underride guard (**Figure 12**). Scene photographs depict the rear of the semitrailer as having intruded into the motorcoach and overlapped the area of initial contact with the Vanguard semitrailer. Photographs depict the semitrailer deck as having overridden the motorcoach front tire and come to rest around the trailing end of the wheel well, an overall distance of about 9.5 feet from the front of the motorcoach.

Figure 12: Photograph depicting impact damage to the driver side rear of the Great Dane semitrailer (Mack combination courtesy of ISP).

Scene evidence indicates that the combination moved forward about five feet while the semitrailer simultaneously moved slightly lateral toward the right roadside.

3.0 Electronic Data

3.1 Prevost Motorcoach Engine Control Module

As mentioned in the NTSB Vehicle Factors Group Chair report, imaging of the Prevost engine control module was conducted by a Volvo-approved forensic engineering firm contracted by the motor carrier.[10] The imaging process was observed by NTSB investigators and copies of the imaged data were provided.

Peripheral to engine management and operation, the engine control module (described as engine "ECM" in this context) processes certain data related to engine electronics programming, usage, fault codes and event data that may be stored and later retrieved. Event data consists of acceleration-triggered actions that can include hard braking and a last stop record. Such event data are reported in time-series format covering a specific period of time before and after the triggered event. In the case of a crash event where an acceleration event is triggered and recorded, that data may be useful for analysis of vehicle movement and driver action when the data can be tied to the crash.

Regarding the ECM on the Prevost Volvo engine, an acceleration-triggered event (e.g., hard brake) is typically set by a change in vehicle of ±10 mph/sec. When recorded, data is reported for 60 seconds before and 30 seconds after the trigger at ¼ second intervals (4 Hz). Last stop events are similarly reported as time-series data typically triggered when the vehicle speed decreases to zero followed by an ignition key "off" condition. Last stop data is reported at ¼ second intervals for a period of 90 seconds before the trigger. Parameters included with this data may include vehicle speed, accelerator pedal position (%), engine speed (revolutions/minute), service brake (i.e., brake switch actuation-on/off), parking brake (on/off), clutch pushed (on/off), engine brake low (on/off), engine brake high (on/off), cruise control (on/off), and key switch (on/off).

The data imaging revealed two records or "logged incidents," one titled "acceleration-triggered event' and the second "last stop". The event dates and times were recorded as 07/12/2023 at 05:48:32 and 05:48:52 UTC, (20 seconds apart) respectively. Although the crash occurred in the U.S. Central Time zone, these times would correlate with Eastern Standard Time for the approximate time of the crash if the ECM were initially set to EST as many are. Information provided by other investigators approximated the time of the crash 01:48 hours CDT. While typical time validation can be accomplished by comparing the current ECM time with the download computer time (i.e., identify ECM clock drift), a difference of more than 58 hours was observed.[11] Interpretation of a diagnostic trouble code (DTC) time stamp in the data indicated that the ECM clock apparently stopped at some point – potentially the crash incident – and then restarted when powered-up for the imaging.

The parameters in each of the data records were populated and the two records exhibited some overlap where the data could be aligned. While certain parameters exhibited consistency, others such as vehicle speed did not. The data did not indicate

[10] Delta-V Forensic Engineering, Charlotte, NC.
[11] Imaging of the ECM occurred on 07/14/2023 about 4:35 p.m.

a brake application. Graphs from the individual records produced from the imaged data and provided to NTSB investigators are provided in **Figure 13**.

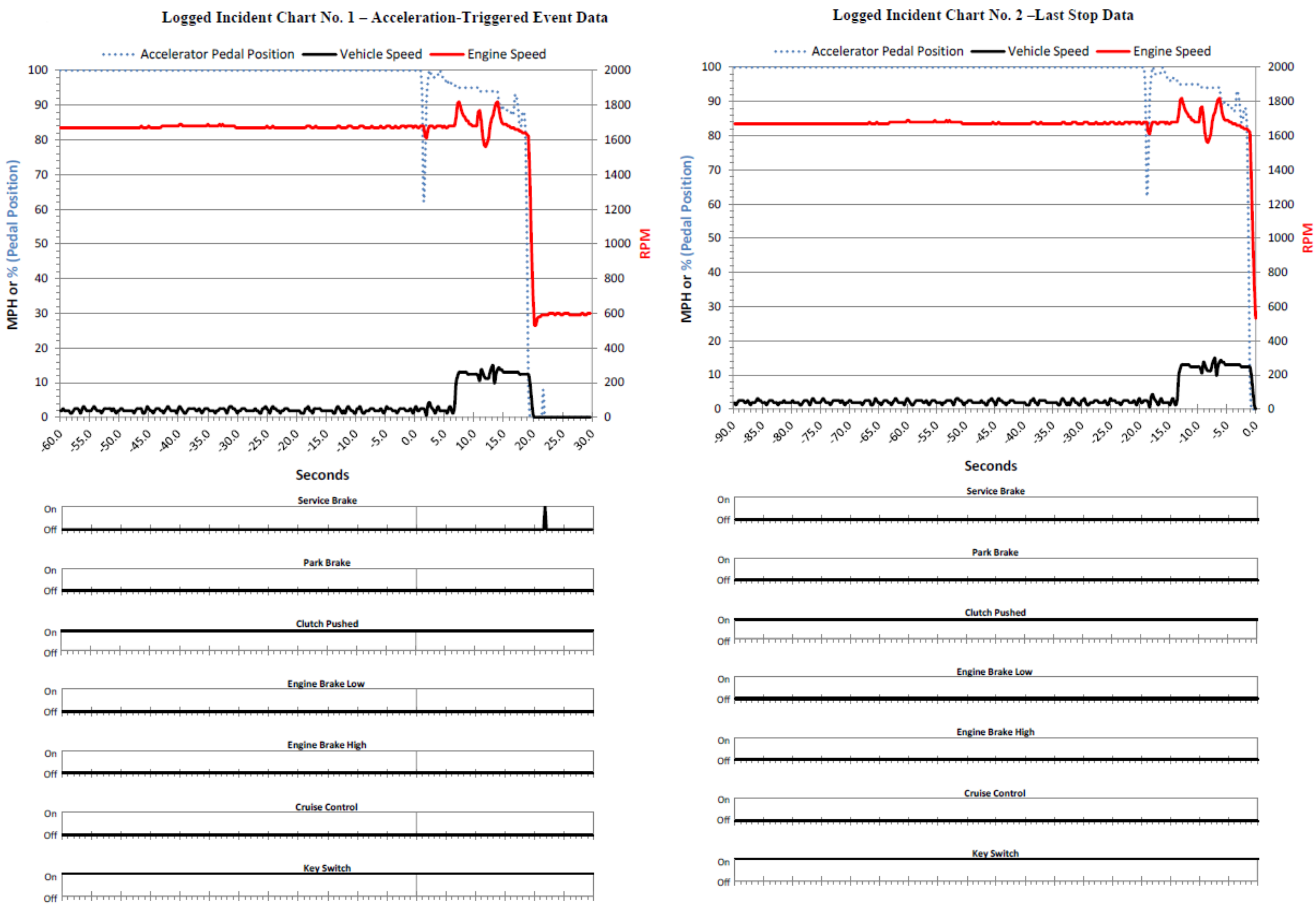


Figure 13: Graphs depicting data from the two logged events as provided to NTSB investigators following imaging of the Prevost engine ECM.

The imaged data included other programming attributes and DTC records. Other parameters considered useful for analysis included a governed road speed of 68 mph and a cruise control operational road speed range of 18 to 68 mph. The engine idle speed was programmed to 600 RPM (noted range of 550-700 RPMs) and a nominal top engine speed of 2200 RPM. Additional data analysis was undertaken by the NTSB Vehicle Factors Group.

3.2 Other Vehicle Position and Velocity Data

3.2.1 Icomera Mobile Wi-Fi System

Information provided by the motorcoach carrier included data images related to the motorcoach mobile wi-fi/internet system manufactured by Icomera AB. In addition to providing passenger Internet access and documenting certain operational aspects, the system includes continuous geographic positioning (i.e., GPS) capability. When integrated with time, changes in position can be used to derive vehicle velocity. The carrier provided images of certain data from the system. The data images included position data or a vehicle track map (**Figure 14**) and graphs depicting wi-fi operating aspects and computed vehicle velocity (**Figure 15**).

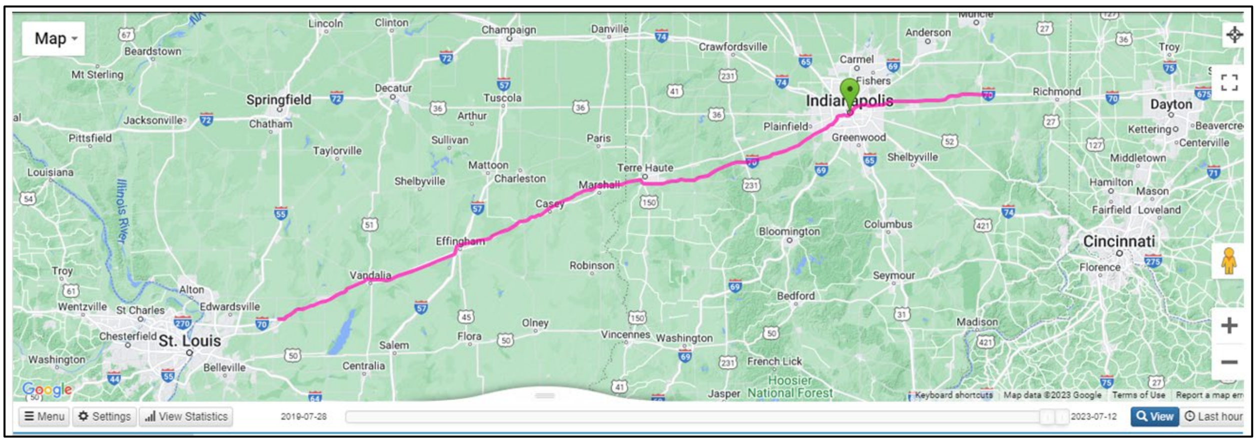


Figure 14: Map image provided by motorcoach carrier depicting vehicle position (route) as derived from the Icomera mobile wi-fi system.

Figure 15: Graphical data image provided by motorcoach carrier depicting certain data from the Icomera mobile wi-fi system.

The motor carrier described the data images as representing the last data feed from the motorcoach before the crash event. The time scale depicted runs from just before 21:00 (9:00 p.m.) to just after 02:45 (2:45 a.m.). While the time zone (likely a programmed aspect rather than a unit location aspect) is not indicated, it would be consistent with Eastern Daylight Time in the context of the crash. The underlying data for the velocity graph were not provided.

3.2.2 Lytx DriveCam and Fleet Management System

The motorcoach was outfitted with a Lytx DriveCam fleet management video system that was identified to include a forward external-facing video camera combined with a company subscription to the Lytx Driver Safety Program and Fleet Tracking Service. Discussion of the operational aspects of the video and fleet management system will be discussed in the factual report prepared by the NTSB Motor Carrier Factors Group.

Although no video imagery of the crash was recovered, the motor carrier did provide a hard copy data table from the Lytx system that depicted elements of vehicle position and time. The data covered the dates of July 11 and 12 beginning at midnight on July 11 and a final data point on July 12 at an indicated time of 06:46 (6:46 a.m.) – covering a total of 30 hours and 46 minutes. The table (multiple pages) reported Lytx unit serial number, latitude, longitude, date, and time expressed in hours and whole minutes. As such, the data was reported at one-minute intervals. While the time zone is not identified, in the context of the location data (relative to the crash site) the indicated time is consistent with CDT adjusted to UTC. Adjusted for CDT, the time stamps would be moved back five hours such that the first sample began on July 10 at 7:00 p.m. and the final at 1:46 a.m. on July 12. The final geographical coordinates depict a westward track on I-70 approaching the crash location. The last location data point was about 2.2 miles east of the crash location.

E. REFERENCES

NTSB Vehicle Factors Group Chair Factual Report
NTSB Motor Carrier Group Chair Factual Report
49 CFR Part 571.108 S8.2 Conspicuity Systems (FMVSS 108)

F. DOCKET MATERIAL

None

Submitted by:

Robert Squire
Highway Crash Investigator

APPENDIX A: SELECT FMVSS 108 REFERENCES FOR RETROREFLECTIVE SHEETING

S8.2.1.1 Retroreflective sheeting must consist of a smooth, flat, transparent exterior film with retroreflective elements embedded or suspended beneath the film so as to form a non-exposed retroreflective optical system.

S8.2.1.2 Retroreflective sheeting material. Retroreflective sheeting must meet the requirements, except photometry, of ASTM D 4956–90 (incorporated by reference, see § 571.5) for Type V Sheeting. Sheeting of Grade DOT–C2 of no less than 50 mm wide, Grade DOT–C3 of no less than 75 mm wide, or Grade DOT–C4 of no less than 100 mm wide may be used.

S8.2.1.3 Certification marking. The letters DOT–C2, DOT–C3, or DOT–C4, as appropriate, constituting a certification that the retroreflective sheeting conforms to the requirements of this standard, must appear at least once on the exposed surface of each white or red segment of retroreflective sheeting, and at least once every 300 mm on retroreflective sheeting that is white only. The characters must be not less than 3 mm high, and must be permanently stamped, etched, molded, or printed in indelible ink.

S8.2.1.4.1 Alternating red and white materials.

S8.2.1.4.1.1 As shown in Figures 12–1 and 12–2, where alternating material is installed, except for a segment that is trimmed to clear obstructions, or lengthened to provide red sheeting near red lamps, alternating material must be installed with each white and red segment having a length of 300 ±150 mm.

S8.2.1.4.1.2 Neither white nor red sheeting must represent more than two thirds the aggregate of any continuous strip marking the width of a trailer, or any continuous or broken strip marking its length.

S8.2.1.5 Application location. Conspicuity systems need not be installed, as illustrated in Figure 12–2, on discontinuous surfaces such as outside ribs, stake post pickets on platform trailers, and external protruding beams, or to items of equipment such as door hinges and lamp bodies on trailers and body joints, stiffening beads, drip rails, and rolled surfaces on truck tractors.

S8.2.1.6 Application spacing. As illustrated in Figure 12–2, the edge of any white sheeting must not be located closer than 75 mm to the edge of the luminous lens area of any red or amber lamp that is required by this standard. The edge of any red sheeting must not be located closer than 75 mm to the edge of the luminous lens area of any amber lamp that is required by this standard.

S8.2.1.7 Photometry. Each retroreflective sheeting must be designed to conform to the photometry requirements of Table XVI–c when tested according to the procedure of S14.2.3 for the color and grade as specified by this section.

S14.2.3.7 Procedure. Photometric measurements of reflex reflectors and retroreflective sheeting must be made at various observation and entrance angles as shown in Table XVI.

S14.2.3.7.1 The observation angle is the angle formed by a line from the observation point to the center of the reflector and a second line from the center of the reflector to the source of illumination.

S14.2.3.7.2 The entrance angle is the angle between the axis of the reflex reflector and a line from the center of the reflector to the source of illumination.

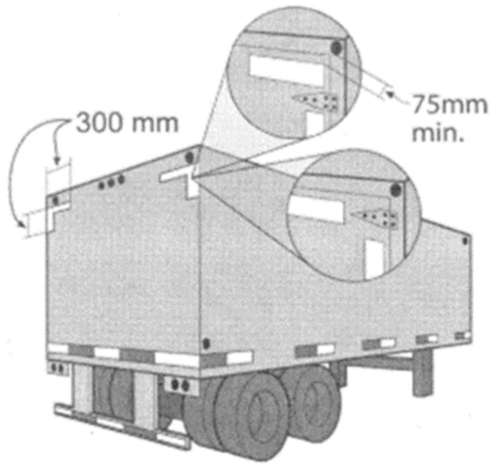
S14.2.3.7.3 The entrance angle is designated left, right, up, and down in accordance with the position of the source of illumination with respect to the axis of the reflex reflector as viewed from behind the reflector.

S14.2.3.7.4 Measurements are made of the luminous intensity which the reflex reflector is projecting toward the observation point and the illumination on the reflex reflector from the source of illumination.

S14.2.3.8.2 Retroreflective sheeting. The required measurement for retroreflective sheeting reflectors at each test point as shown in Table XVI is candela per lux per square meter of area.

TABLE XVI–c—RETROREFLECTIVE SHEETING PHOTOMETRY REQUIREMENTS

Observation angle (degrees)	Entrance angle (degrees)	Minimum performance					
		Grade dot-C2		Grade dot-C3		Grade dot-C4	
		White (cd/lux/sq m)	Red (cd/lux/sq m)	White (cd/lux/sq m)	Red (cd/lux/sq m)	White (cd/lux/sq m)	Red (cd/lux/sq m)
0.2	−4	250	60	165	40	125	30
	30	250	60	165	40	125	30
	45	60	15	40	10	30	8
0.5	−4	65	15	43	10	33	8
	30	65	15	43	10	33	8
	45	15	4	10	3	8	2


300 mm
75mm
min.