TECHNICAL RECONSTRUCTION GROUP CHAIRMAN'S FACTUAL REPORT

Palm Springs, CA

HWY17MH005

(53 pages)

NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF HIGHWAY SAFETY
WASHINGTON, D.C.

TECHNICAL RECONSTRUCTION GROUP CHAIRMAN'S FACTUAL REPORT

A. CRASH INFORMATION

Location: Westbound Interstate 10 (I-10) in the vicinity of post mile marker 32.5, near Palm Springs, Riverside County, California

Vehicle #1: 1996 MCI Motorcoach

Operator #1: USA Holiday Inc.

Vehicle #2: 2015 International Prostar Truck in combination with a 2013 Utility 3000 R Semi-trailer

Operator #2: TSC, Tri-State Collision, LLC

Date: October 23, 2016

Time: Approximately 05:16 a.m. Pacific Daylight Time (PDT)

Fatalities: 12 Bus Passengers, 1 Bus Driver

Transported: 30 Bus Passengers, 1 Truck Driver

NTSB #: **HWY17MH005**

B. TECHNICAL RECONSTRUCTION GROUP

Robert Squire - Accident Investigator, Group Chairman
NTSB Office of Highway Safety
490 L'Enfant Plaza East, S.W., Washington, DC 20594

C. CRASH SUMMARY

For a summary of the crash, refer to the *Crash Summary Report* in the docket for this investigation.

D. DETAILS OF THE TECHNICAL RECONSTRUCTION GROUP INVESTIGATION

The Technical Reconstruction Group provided investigative support through the examination and documentation of the collision scene and the two involved vehicles. Factual data was also acquired through the review of documentation provided by the California Department of Transportation (Caltrans), California Highway Patrol (CHP), and other NTSB investigative groups.

Primary documentation involved photography and 3D laser scanning techniques. Photographs were taken in digital format, while scanning was accomplished using the FARO Focus^{3D} x330 laser scanner.[1] Multiple scans of a subject were processed into three-dimensional point clouds for further analysis. Two scan projects that featured the involved vehicles were completed. Three-dimensional scan projects completed by CHP investigators featuring the two vehicles and the crash site were also utilized for factual and analytical purposes. Video documentation of the immediate approach to, and through the area of the crash was also conducted following the route of the motorcoach.

Factual reports prepared by other NTSB investigative groups should be consulted for additional information.

1. Collision Site Location and Documentation

The crash involved a 1996 Motor Coach Industries (MCI) 102D3 motorcoach that collided with the rear of a 2013 Utility VS2RA model 3000R refrigerated semitrailer that was being towed by a 2015 International Prostar 3-axle truck tractor.[2] The collision occurred when the MCI, traveling westbound on Interstate-10 (I-10) collided with the tractor-semitrailer combination as it sat stationary in a highway travel lane. The collision occurred within the jurisdiction of Palm Springs, CA with the onset of roadway evidence about 220 feet west of postmile marker 32.5. The nearest intersecting highways were N. Indian Canyon Drive, approximately 3,600 feet to the east and State Route 62, approximately 14,500 feet to the west.

The NTSB Technical Reconstruction Group examined the collision site on October 25, 2016. The site and other relevant features were documented through photographs, video and geographic coordinate (GPS) acquisition. As part of their on-scene investigation, CHP investigators three-dimensionally scanned the crash site, effectively documenting the roadway evidence. The CHP scan included portions of the westbound roadway that extended about 1,370 feet to the east, and 600 feet to the west of the area of the impact.

Preceding, and through the area of the collision, I-10 is an eight-lane, limited access highway with four lanes of travel in the west- and eastbound directions. The area of the collision was located on the westbound roadway in a sweeping 6,000-foot radius curve that transitioned

[1] The FARO Focus^{3D} is a high-speed terrestrial laser scanner for 3D documentation. The scanner produces dense point cloud scans that are combined or linked from multiple positions to create a cohesive three-dimensional point cloud rendering of the subject target. The laser will only capture features within the direct line of sight to the scanner. Areas obstructed to the laser or where surfaces fail to provide a reflection will appear as a hole in the image. The point cloud data can be imported into a CAD application for additional analysis.

[2] The semitrailer was manufactured by Utility Trailer Manufacturing Company. International Trucks is a subsidiary of Navistar International Corporation.

from a westerly heading of about 270 degrees to a west-northwesterly heading of 284 degrees. The east- and westbound roadways are divided by an earthen median that measured about 21 feet in width between the left shoulder guardrails for the two roadways. Amber colored retroreflective markers are positioned above the top edge of the left shoulder guardrail at regular intervals. The onset of roadway evidence appeared approximately 651 feet west of the beginning of the curve. Additional information regarding the highway is available in the NTSB Highway Factors Group factual report.

Roadway evidence from the collision was mostly confined to the right-center lane of the westbound roadway. Excluding displaced debris, such as vehicle components and cargo, roadway scene evidence consisted of tire friction marks, roadway surface metal scars, and fluid debris stains that extended over a linear distance of about 110.6 feet. Some tire and metal scar marks exhibited a leftward movement partially entering the left-center travel lane. The leftward movement represented the movement of the vehicles as they came to rest. At final rest, the International truck tractor and the MCI partially occupied the left-center lane. Fluid debris stained the roadway pavement beneath the front of the MCI at its position of final rest. **Figure 1** is a scaled two-dimensional diagram that was created from the CHP 3D scan.

While there was overlap of the tire friction marks during the vehicle post-impact travel, the source of the marks could be distinguished. All the roadway marks were created post-impact; there was no evidence of pre-collision tire friction marks (such to indicate an evasive maneuver). The tire marks, as interpreted through the scan data, indicated that the MCI collided with the semitrailer at a slight angle and was offset toward the left (driver's) side. Post-impact, the tractor, which was undamaged, moved approximately 70-72 feet in a westerly direction.

Figure 2 is a scaled two-dimensional diagram depicting the post-collision positions of rest for the vehicles. Vehicle placement was based on vehicle dimensions and scene evidence markings applied by CHP investigators.

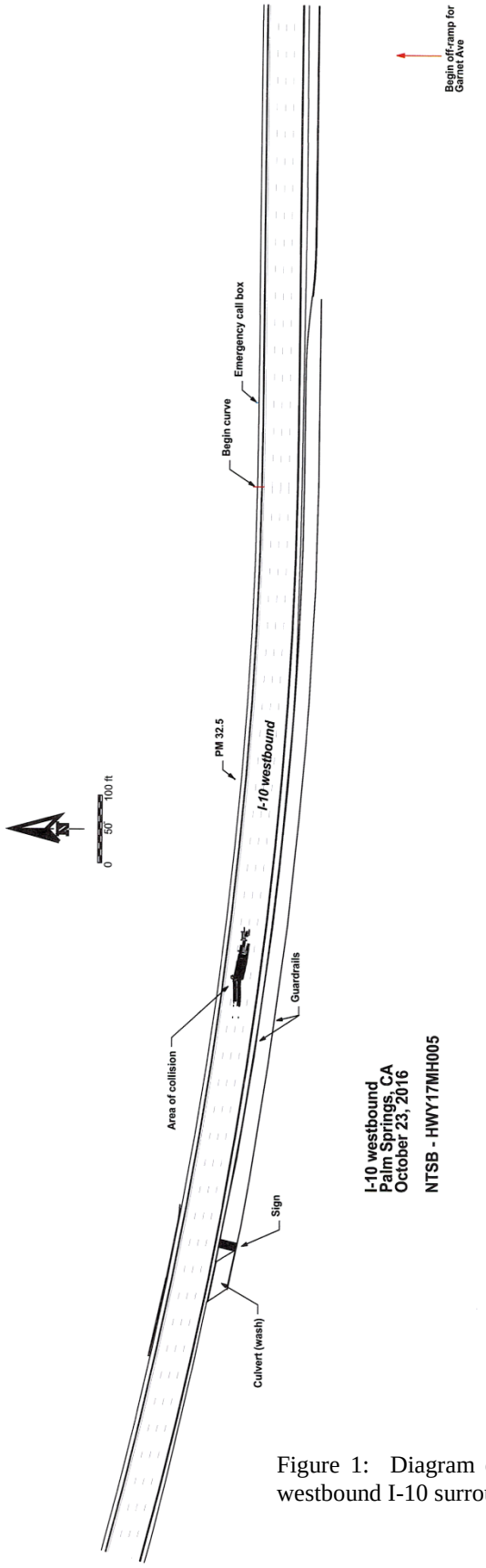

Figure 1: Diagram depicting approximately 2,000 feet of westbound I-10 surrounding the collision.

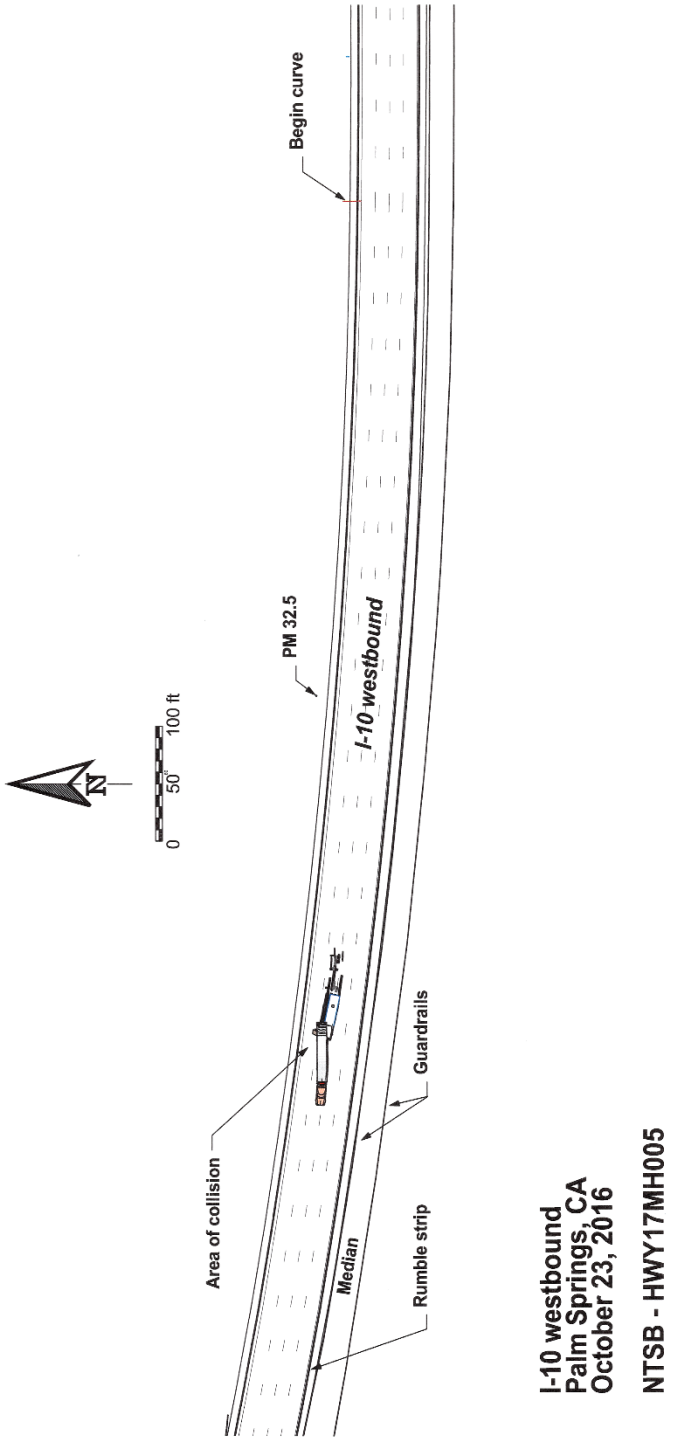

Figure 2: Diagram depicting positions of rest for International combination and the MCI motorcoach.

Figure 3 depicts a closer view of the diagram illustrating the vehicles at final rest.

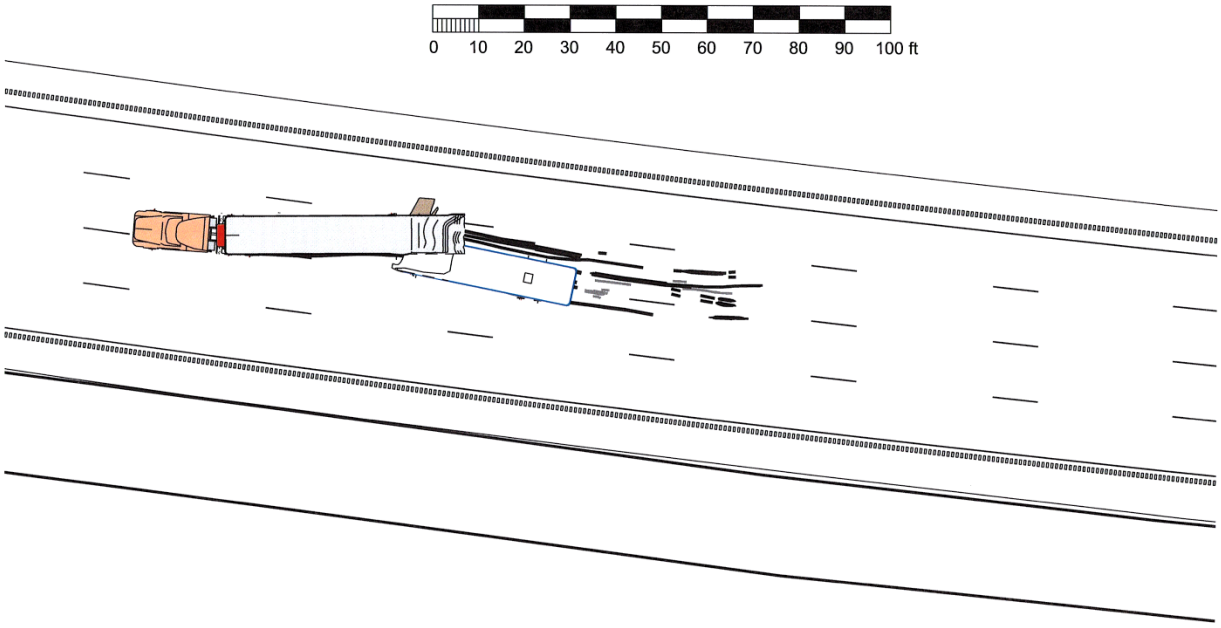

Figure 3: Diagram depicting post-collision positions of rest for the International combination and MCI motorcoach. Note – the depiction of vehicle damage is approximated and does not represent the full structural displacement.

1.1. Highway sight line

The collision occurred during the hours of darkness in an area with no additional lighting sources. The nearest luminaire on the westbound roadway was located approximately 1,595 feet east of the collision at the end of the highway on-ramp from N. Indian Canyon Drive.[3] On the eastbound roadway, the nearest luminaire was located about 1,450 feet from the collision at the beginning of the off-ramp to Garnet Avenue. The lighting was erected along the respective right roadsides.

Visual observations through the area during hours of darkness revealed no sight line obstructions or potential issues with pavement striping. While the daylight line of sight exceeded 2,800 feet (upon entering the tangent segment that preceded the curve), nighttime visibility or the ability to recognize roadway hazards would be a function of the hazard conspicuity, which would be affected by contrast through background illumination (silhouetting), self-illumination (having its own lighting), or direct (headlight) illumination. **Figure 4** is a video frame capture depicting

[3] Additional information concerning the luminaire is available in the NTSB Highway Factors Group Factual Report.

an example of certain qualities of conspicuity when approaching the rear of a various semitrailers along an unlit portion of I-10.

Figure 4: Video image capture depicting the approach to several semitrailers along an unlit portion of the highway. The separation distance is approximately 550-600 feet with low beam headlights in use. Both semitrailers exhibited rearward facing retroreflective sheeting, while the semitrailer occupying the right lane also featured stainless-steel rear door skin. (Video recorded in high definition, 1080p, at 30 frames per second with a 14mm equivalent lens focal length.)

2. Vehicle Documentation

2.1. MCI motorcoach

The vehicle was identified as a 1996 MCI model 102D3 motorcoach. The vehicle was examined on October 28, 2016 while stored at a local towing facility where the exterior and interior were documented with the 3D scanner from nine positions. Additionally, CHP investigators completed a separate 3D scan of the vehicle and provided that data to NTSB investigators.

The motorcoach sustained a frontal impact that resulted in substantial damage. Impact damage was offset toward the right (passenger) side of the vehicle. Based on the manufacturer specified maximum overall length, structural displacement at the right front extended rearward by about 3.4 feet.[4] Toward the left (driver's) side, rearward structural displacement diminished with the base structure at left front corner of the motorcoach remaining intact. Evidence of underride with the semitrailer was observed above the frontal damage resulting in additional intrusion into the vehicle cabin. Approximately 13.7 feet of the roof panel separated along the left side, inboard

[4] Manufacturer specified maximum overall length was 40.53 feet, less some rearward tapering toward the sidewalls.

of the sidewall.[5] On-scene photographs taken by CHP investigators revealed that the left sidewall of the semitrailer had intruded into the motorcoach and sheared the roof. The trailer sidewall subsequently intruded longitudinally atop the passenger seating in this area. The right steer axle wheel was also displaced reward resulting in a decrease in the wheelbase on that side of the vehicle by about 1.7 feet relative to the manufacturer specifications.[6]

The left front corner of the motorcoach exhibited no evidence of direct contact damage, although cosmetic body panels were displaced. Although displaced from the vehicle, the outer left side of the front bumper cover exhibited no evidence of contact with the trailer - unlike the right side which was substantially damaged and exhibited impressions from contact with the trailer.

Figure 5 depicts an image of the 3D point cloud rendered from the scan data provided by CHP investigators. The image depicts the right (passenger) side of the vehicle.

Figure 5: Depiction of 3D point cloud of the motorcoach right side. (Scan data provided by CHP)

[5] Measured aftward from front bumper of motorcoach.

[6] Manufacturer specified wheelbase was 23.25 feet as measured from the steer axle hub to the center of the drive axle. Measurements were based on scan data provided by CHP before the vehicle was elevated for inspection as depicted in Figure 7.

Figure 6 is a 3D point cloud image depicting an overhead view of the MCI and the forward roof breach. The left side (bottom in the image) was sheared by the semitrailer sidewall. Following separation of the vehicles for recovery, the roof panel folded inward toward the right side (top in the image).

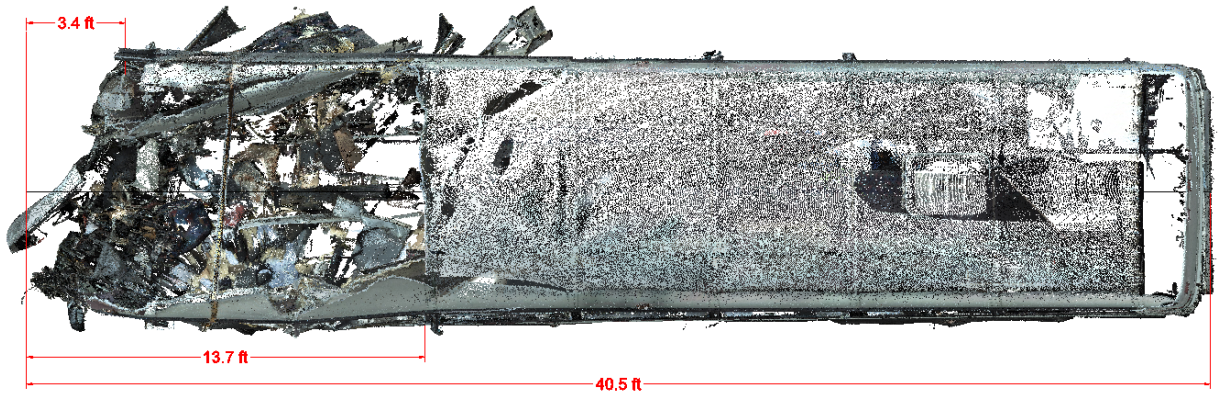

Figure 6: 3D point cloud image of motorcoach depicting frontal displacement and rood intrusion relative to original overall length. (Scan data provided by CHP)

Figure 7 is a 3D point cloud image depicting a slice of the scan at about the level of the interior floor of the motorcoach approximating the area of greatest structural damage. The image depicts the rightward offset and rearward displacement of the damage. The wheelbase measurements depicted in the scan represent some shifting as the vehicle was elevated for inspection and subsequent scanning. Scan data provided by CHP investigators where the vehicle was positioned at ground level indicated wheelbase measurements of approximately 23.5 feet and 21.6 feet on the left and right sides respectively.

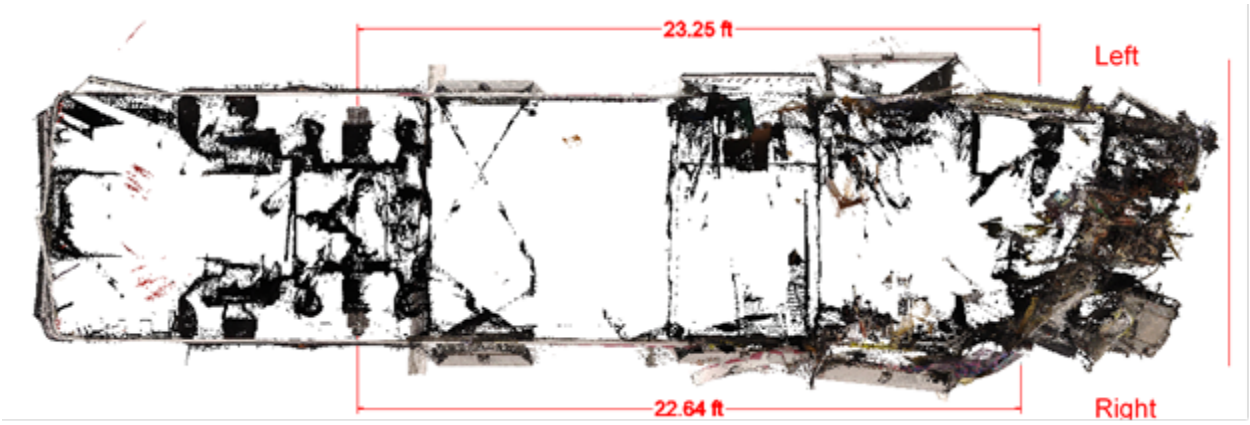

Figure 7: Image of 3D point cloud sliced at approximate floor level for motorcoach depicting structural displacement relative to overall vehicle length. The vehicle's undamaged overall length is depicted by the red vertical line. (Note: vehicle was elevated for inspection, which resulted in some alteration of the wheelbase dimensions as compared with the vehicle resting on the ground.)

The headlighting system on the motorcoach consisted of four sealed beam halogen lamps, with two lamps – one dual filament low/high beam and one high beam – on each side of the vehicle.[7] The low beam lamps occupied the outer-most position. Following the crash, the left dual filament low/high beam headlamp was found intact and was recovered for analysis. Although the housing, lens and reflector for left high beam lamp were destroyed, the bulb envelope and filament, with some exception, remained intact. As depicted in **Figure 8**, while the filament exhibited no distinct indication of deformation consistent with having been incandescent (lit) at the time of impact (i.e., hot shock) it did, however, exhibit a clean separation within the coil. The age of the separation could not be discerned and the lamp would otherwise be nonfunctional at the time of examination. See the NTSB Vehicle Factors Group Factual Report for additional information.

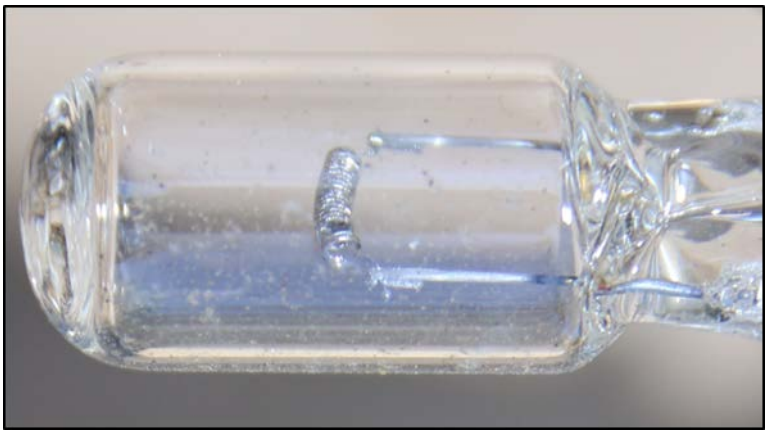

Figure 8: Photograph depicting post-collision condition of the left (inboard) high beam bulb filament and glass envelope located on the MCI.

2.2. Semitrailer

The towed vehicle in the combination was identified as a 2013 Utility model VS2RA/3000R refrigerated semitrailer, that had an undamaged overall length of 53 feet. The vehicle was examined on October 25, 2016 while stored at a local towing facility where it was documented with the 3D scanner from 12 exterior positions. Additionally, CHP investigators completed a separate 3D scan of the vehicle and provided that data to NTSB investigators.

The semitrailer sustained a rear impact that resulted in substantial damage and displacement of the deck (floor) and tandem axles. The aft portion of both sidewalls and roof likewise exhibited damage. Incidental bowing of the sidewalls was also observed near the front of the vehicle, rearward of the upper 5th wheel plate. Upon impact, the motorcoach intruded into the semitrailer displacing the deck and tandem axles forward. The motorcoach intruded inboard

[7] The outboard lamp (Type 2A1) consisted of a dual filament bulb that functioned as the low beam headlamp, and when engaged, also functioned as a high beam headlamp in combination with the inboard, single filament, high beam lamp.

of the right sidewall of the trailer, while the left sidewall penetrated the motorcoach. The semitrailer tandems exhibited greater forward displacement on the left (driver's) side where the wheel on the rear-most axle was displaced forward and above the forward (axle) wheel. Because the entire tandem axle assembly had shifted, the pre-crash wheelbase of the semitrailer (position of the axles relative to the king pin) could not be determined. Based on manufacturer dimensions, the floor was displaced forward approximately 4.6 feet.

Figure 9 depicts the colorized linked 3D scans of the Utility trailer as viewed from the left side.

Figure 9: Image of linked 3D scans depicting left side of Utility semitrailer. Note that the aft portion of the left (driver side) sidewall had been removed during recovery of the vehicle. The right sidewall remained intact, although the image above is incomplete.

Figure 10 is a 3D point cloud image depicting a slice of the scan at about the level of the interior floor of the semitrailer approximating the area of greatest structural damage. The image depicts the leftward offset and forward displacement of the damage, as well as displacement of the axles. The displacement of the undercarriage components was consistent with a potential heading offset of less than 5 degrees between the motorcoach and semitrailer.

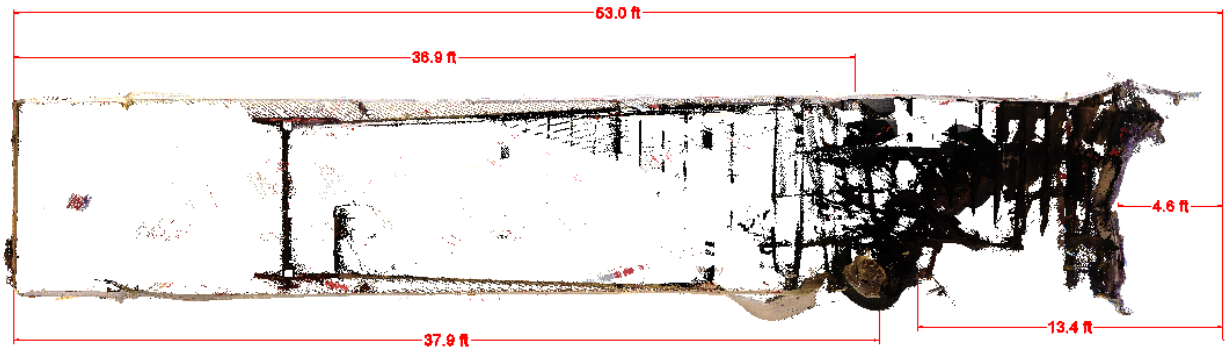

Figure 10: Image of 3D point cloud sliced at approximate floor level for semitrailer depicting structural displacement relative to overall vehicle length.

2.2.1. Rearward lighting and retroreflective sheeting treatment

Rearward lighting on the semitrailer was configured to be consistent with the requirements of applicable federal regulations.[8] The trailer exhibited a group of three (3), four-inch circular, grommet-mount, lamps on both sides of the vehicle.[9] The lamps were combination stop-turn-tail assemblies with the light source being light-emitting diodes (LED) behind a red colored filter. The tail lamps extended laterally inboard over a distance of about 13.2 inches at a nominal vertical height above ground of 41 inches, as measured at their centers. The outboard lamp was centered about 9.5 inches inboard of the respective sidewall. **Figure 11** is a photograph that depicts the stop-turn-tail lamp configuration on the right side of the semitrailer. The assembly is depicted in its post-collision condition after the rear-end structure had been displaced by the impact.

Figure 11: Photograph of rear stop-tail-turn signal lamp placement on rear of Utility semitrailer. Photograph depicts the post-collision condition of the right (passenger) side lamps after folding under the trailer floor deck.

Additional rearward lighting included clearance and identification (ID) lamps, all of which were LED type mounted along the top rail of the trailer just below the roof line at a vertical height of about 13 feet. Clearance and ID lamps are steady-burning, which serve to mark the outboard edges and midline of the vehicle respectively.

[8] See Federal Motor Vehicle Safety Standards (FMVSS) 49 CFR Part §108 and Federal Motor Carrier Safety Regulations (FMCSR) 49 CFR Part §393.11.
[9] Overall diameter is approximately 4.3 inches.

Inspection of the lamps by NTSB and CHP vehicle investigators established that each of the lamps was capable of functioning properly and would luminate when energized despite some compromise of wiring due to collision damage. As specified in FMVSS 108, each lamp was required to meet minimum photometric intensity thresholds based upon its application (intended use). The relevant requirements from FMVSS 108 for tail, clearance and identification lamps is provided in **Appendix 1.** The NTSB Vehicle Factors Group factual report should also be consulted for additional details.

As required by FMVSS 108, retroreflective sheeting was installed on vertical surfaces along the rear and both sides of the semitrailer. The sheeting applied to sides of trailer was comprised of individual alternating red and white panels measuring slightly less than 18 inches in length. The approximate length of each red and white segment was 11 and 7 inches respectively. The panels were about 2 inches wide and marked as the meeting "DOT-C2" standard. Additionally, each red and white segment exhibited the Utility Trailer Manufacturing logo. The panels were applied along the entire length of the trailer with separation gaps of about 15 inches between the panels. The striping was installed just above the lower sidewall frame.

The alternating red and white sheeting applied to the rear of trailer was comprised of a continuous length material. The color segment lengths were approximately 11 inches for the red and 7 inches for the white. The sheeting was about 2 inches wide and marked "DOT-C2" at two locations on each white segment. The sheeting was applied horizontally across the rearward face of the underride guard and along the bottom edge of both rear doors. As permitted by regulation, breaks in the striping appeared at the left and rear inboard vertical supports for the underride guard and at the edge frames and openings on the rear doors. With the trailer static, the vertical height of the striping was approximately 21 inches along the underride guard and 52-52 inches along the bottom door edge.

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. The two strips on each side were configured as to designate the shape of the corner (with a gap between the two for door hardware). Each segment measured about 12 inches long by 2 inches wide and were indelibly stamped "DOT-C2" at two locations.

Visual examination of the semitrailer's conspicuity treatment concluded that the material complied with applicable installation standards (see FMVSS 108, S8.2). While photometric standards for the conspicuity sheeting specific by FMVSS 108 are applicable at the time the vehicle is manufactured, samples were acquired from the vehicle for evaluation. Although the sheeting applied to the underride guard and bottom door edges exhibited significant collision damage, samples were acquired for examination, including a segment of sheeting approximately 16 inches in length that had been applied to the right side of underride guard. That strip contained a full red segment and partial white segments on both sides of the red. The sample exhibited collision damage, but less than other areas of the underride guard. A sample of the white sheeting applied to the upper corners of the rear doors was also collected with an approximately 12-inch-long segment was removed from the horizontal position on the right door. For comparison, three samples strips, each consisting of a single red and white segment were acquired from the left sidewall, forward of the area damaged by the collision.

The samples were mounted and forwarded to staff at the Texas A&M Transportation Institute (TTI) for photometric measurement. TTI employed a calibrated Gamma Scientific Model 932 retroreflectometer to measure 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 from at least two positions on each color segment of each sample. Measurements were made "as received" by TTI, and again after cleaning, which involved the wiping of the sheeting surface with a mild soap and water solution. TTI provided tabular results of the average photometric values and reported whether the sample area examined met the threshold value conveyed in FMVSS 108 Table XVI–c.[10] **Appendix 2** provides addition reference to FMVSS 108 requirements for retroreflective sheeting.

Figure 12 is a photograph of the sheeting samples after mounting and as presented to TTI for measurement.

Figure 12: Retoreflective sheeting samples acquired from the semitrailer for photometric measurement.

[10] TTI provided NTSB staff with measurement results in a tabular format. No additional report or evaluation was provided.

Tables 1a and **1b** represents the photometric values reported by TTI and the status of compliance with FMVSS 108.

Table 1a: TTI photometric measurements and compliance threshold for all white colored segments of retroreflective sheeting samples.

		.2° / -4° White					.2° / 30° White					.2° / 45° White				
		Standard	As is	Cleaned	Compliance	Change	Standard	As is	Cleaned	Compliance	Change	Standard	As is	Cleaned	Compliance	Change
Sample 1	Top rear door-Horizontal	250	6	23	No	283.3%	250	5	16	No	220.0%	60	7	11	No	57.1%
Sample 2	Rear underride guard	250					250					60				
Sample 3	Side	250	408	684	Both	67.6%	250	181	262	After	44.8%	60	55	78	After	41.8%
Sample 4	Side	250	369	552	Both	49.6%	250	167	225	No	34.7%	60	74	69	Both	-6.8%
Sample 5	Side	250	243	442	Both	81.9%	250	136	206	No	51.5%	60	60	62	Both	3.3%
		.5° / -4° White					.5° / 30° White					.5° / 45° White				
		Standard	As is	Cleaned	Compliance	Change	Standard	As is	Cleaned	Compliance	Change	Standard	As is	Cleaned	Compliance	Change
Sample 1	Top rear door-Horizontal	65	6	20	No	233.3%	65	5	13	No	160.0%	15	5	30	After	500.0%
Sample 2	Rear underride guard	65					65					15				
Sample 3	Side	65	136	158	Both	16.2%	65	65	102	Both	56.9%	15	47	48	Both	2.1%
Sample 4	Side	65	121	172	Both	42.1%	65	60	95	After	58.3%	15	74	69	Both	-6.8%
Sample 5	Side	65	106	174	Both	64.2%	65	55	94	After	70.9%	15	60	62	Both	3.3%

Table 1b: TTI photometric measurements and compliance threshold for all red colored segments of retroreflective sheeting samples.

		.2° / -4° Red					.2° / 30° Red					.2° / 45° Red				
		Standard	As is	Cleaned	Compliance	Change	Standard	As is	Cleaned	Compliance	Change	Standard	As is	Cleaned	Compliance	Change
Sample 1	Top rear door-Horizontal	60					60					15				
Sample 2	Rear underride guard	60	17	84	After	394.1%	60	13	69	After	430.8%	15	7	20	After	185.7%
Sample 3	Side	60	190	225	Both	18.4%	60	77	104	Both	35.1%	15	31	37	Both	19.4%
Sample 4	Side	60	194	320	Both	64.9%	60	71	117	Both	64.8%	15	33	38	Both	15.2%
Sample 5	Side	60	150	333	Both	122.0%	60	64	116	Both	81.3%	15	27	34	Both	25.9%
		.5° / -4° Red					.5° / 30° Red					.5° / 45° Red				
		Standard	As is	Cleaned	Compliance	Change	Standard	As is	Cleaned	Compliance	Change	Standard	As is	Cleaned	Compliance	Change
Sample 1	Top rear door-Horizontal	15					15					4				
Sample 2	Rear underride guard	15	12	45	After	275.0%	15	8	35	After	337.5%	4	7	20	Both	185.7%
Sample 3	Side	15	66	73	Both	10.6%	15	24	29	Both	20.8%	4	20	16	Both	-20.0%
Sample 4	Side	15	63	76	Both	20.6%	15	23	32	Both	39.1%	4	19	18	Both	-5.3%
Sample 5	Side	15	93	64	Both	-31.2%	15	24	41	Both	70.8%	4	16	19	Both	18.8%

As exhibited in Tables 1a and 1b, the majority of samples met FMVSS 108 standards in an "*as recovered*" condition. Prior to cleaning certain samples of white sheeting on both the side and rear failed to meet the standard. Likewise, the red sheeting acquired from the rear underride guard failed to the meet the standard except for one combination of entrance/observation angles. After cleaning, only a few white colored samples failed to meet the specifications, and then not under all entrance and observation angle combinations. The white sample that exhibited the poorest compliance was acquired from the upper rear door. Closer examination of the sample revealed damage to the microprismatic surfaces, which may have occurred during the collision and post-collision recovery. The doors were heavily damaged in the collision and deposited to a debris pile when recovered. **Figure 13** depicts a photographic comparison of the sheeting surface illustrating the damage.

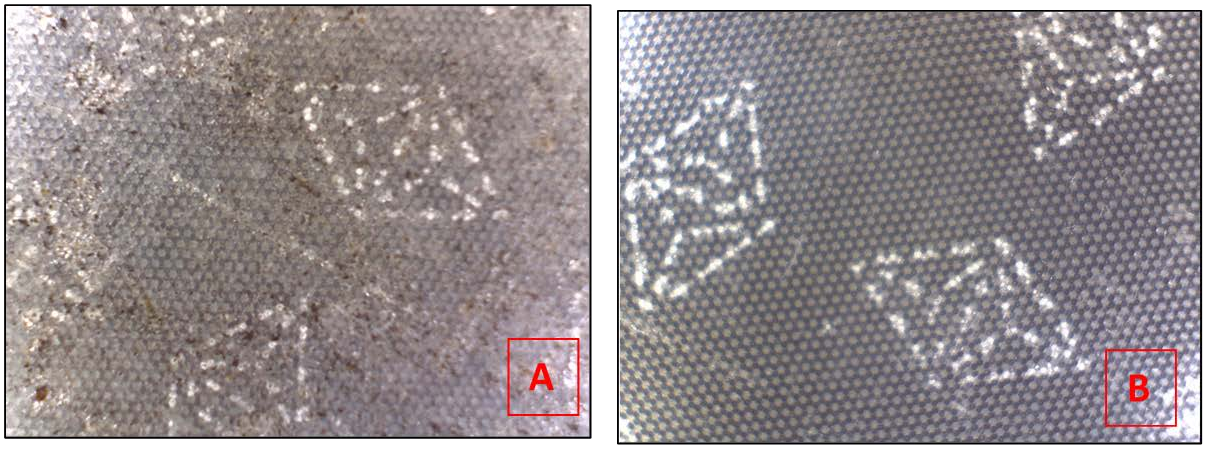

Figure 13: Photographic comparison of the white retroreflective sheeting acquired from semitrailer rear door (A) and sidewall (B). Sample A exhibited clear surface damage and failed to meet photometric requirements post-collision.

The overall conspicuity of the rear of the trailer was further enhanced by the stainless-steel door skin that featured a diamond-shaped (quilted) pattern. The door surface was highly reflective, but non-glaring. **Figure 14** is a manufacturer promotional image that depicts the rear-facing appearance of the semitrailer. Likewise, **Figure 4** in Section 1.1 depicts a leading semitrailer that had similar stainless-steel door surfaces.

Figure 14: Utility Trailer Manufacturing promotional image depicting the rear of the 3000R refrigerated semitrailer.

The combination of rearward lighting, retroreflective treatment and stainless-steel door surfaces would contribute to the identification task by creating a distinguishable and easily discernible pattern for drivers following the semitrailer.

2.3. Truck tractor

The power unit for the combination vehicle was identified as a 2015 International Prostar 3-axle truck tractor. The vehicle was examined on October 26, 2016 while stored at a local towing facility where it was documented with the 3D scanner from nine exterior positions. The truck tractor exhibited no evidence of collision-related damage. **Figure 15** depicts an image of the colorized linked 3D scans taken of the vehicle.

Figure 15: Image of linked 3D scans depicting left side of International truck tractor.

Figure 16 depicts the 3D scans rendered as a point cloud with certain dimensional data. When coupled with the semitrailer, the overall length of the combination vehicle was calculated to be about 73 feet.

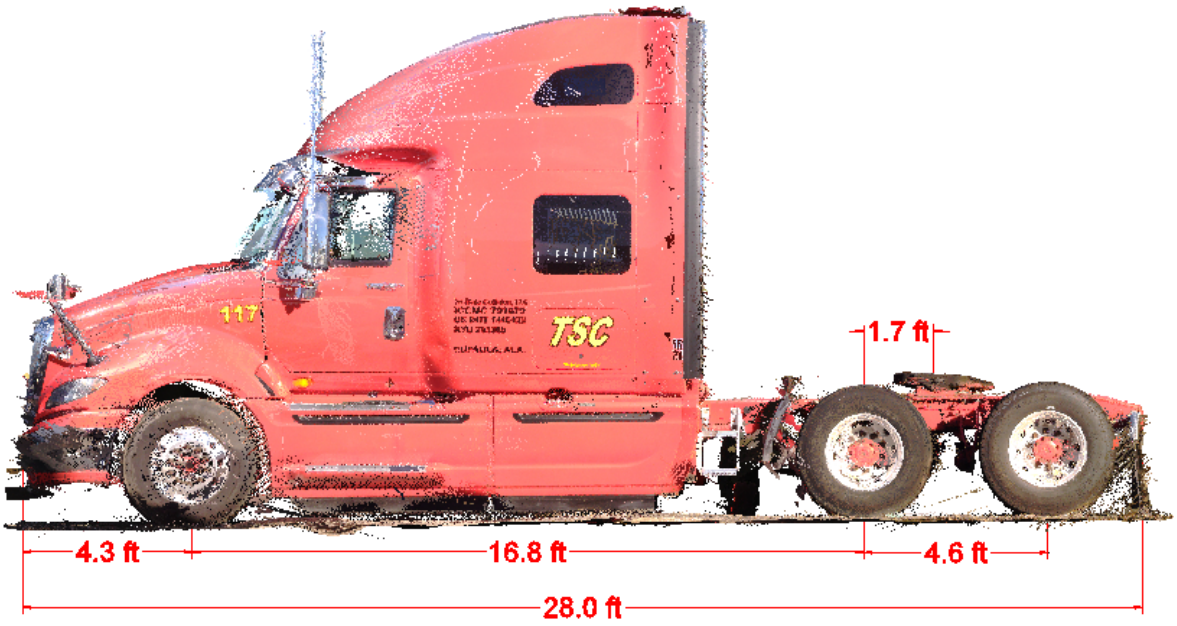

Figure 16: 3D point cloud image of the International truck tractor depicting certain dimensional information.

Post-collision examination of the highway surface at the crash scene revealed the presence of tire friction marks that terminated at the International's drive axle tires (also referenced as axle 2 and 3) and extended eastward from this point. The post-collision examination of the International revealed longitudinal scuffing and abrasions to the tread block on the eight tires of the two drive axles. The abrasions represented a patch on each tire that covered the full width of the tread and extended longitudinally over a distance of 10-14 inches. The scuffing was consistent across all the tires and was indicative of the wheels having been locked and then sliding on the pavement. **Figure 17** is a photograph of the right side aft drive axle dual tires exhibiting the scuffing. The physical appearance depicted in the photograph is consistent the three other sets of dual tires.

Figure 17: Post-collision photograph of longitudinal scuffing observed on the tires of both truck tractor drive axles. While the right side aft drive axle is depicted, the appearance is consistent with that observed on the remaining tires for both drive axles.

3. CHP MVARS – Traffic operations chronology

CHP investigators provided copies of MVARS (Mobile Video/Audio Recording System) digital media (video) from the two patrol units that participated in the traffic control operation that preceded the crash. For reference the two patrol units are identified by the initial highway direction over which they exercised the first traffic break – westbound and eastbound.[11] The two units were further distinguished by unit number as displayed on their respective MVARS videos – Unit 5259 for westbound and Unit 5260 for eastbound.

The videos were reviewed using the WatchGuard Video DVD Utility Manager. During playback of the video certain information including date, time and officer ID are displayed on the screen. CHP advised that some of the information displayed is subject to imprecision as it requires manual setting. CHP commented that the display of the officer ID was incorrect and the time display may not have reflected true synchronization with the actual time. The time was displayed as an "hours: minutes: seconds" format. In addition, the player software included a runtime

[11] "Traffic break" is the term used to identified a short-duration traffic control operation where traffic is slowed and potentially briefly halted to provide a gap in the traffic flow for a short duration event.

counter that likewise displayed as “hours: minutes: seconds.” The two videos reviewed for the west- and eastbound units included approximately 1:14:59 (h:mm:ss) of footage.

CHP successfully synchronized the MVARS videos to local time and determined that the video display was fast (ahead of local time) for both units. The clock offset time for the westbound unit 5259 was 56 seconds and 50 seconds for the eastbound unit 5260. The corrected time is provided in the tables below where video clock time is referenced.

Traffic break operations were conducted by a single police unit on both the west- and eastbound roadways. The operation involved the officer starting from a staging position and then conducting a serpentine maneuver across all travel lanes while decreasing forward speed to slow following traffic. At one point, each officer conducted a full stop of all traffic. Upon conclusion of the stop, traffic was released to normal flow and the officers proceeded to their next staging position, from which they would assume responsibility for the opposite roadway for the next scheduled traffic break. **Table 2** provides an overview of the individual and total times each officer engaged in the traffic slowing (serpentine) maneuver and was then stopped.

Table 2: Traffic break times as indicated by the corrected video clock associated with each patrol unit. Time reflects observable movement to slow traffic to the complete cessation of patrol vehicle movement, followed by observable forward movement (release of traffic).

Unit	Time for Traffic Slowing Maneuver	Time Stopped (Stationary)	Total Time Until Traffic Release
Westbound 5259	2:51 (mm:ss)	7:13 (mm:ss)	10:04 (mm:ss)
Eastbound 5260	4:12 (mm:ss)	6:01 (mm:ss)	10:13 (mm:ss)

The video data was also useful with determining the staging and stop locations for each officer. After identifying the location, geographic coordinates were identified from Google Earth and then compared with data collected during the on-scene investigation. The linear distance between locations of interest were then calculated. The calculated linear distance between the stopped position of the two units, the overhead wires and area of impact are summarized in **Table 3**. From their staging to stop positions, the westbound and eastbound patrol vehicles were estimated to have traveled approximately 4,375 and 6,200 feet respectively. The separation distance between the two patrol units was calculated at about 12,539 feet or 2.37 miles.

Table 3: Calculated linear distances between patrol units, the area of impact and overhead utility line work.

Reference Object	Westbound Unit 5259 (33.905431 / -116.559326)	Eastbound Unit 5260 (33.91331 / -116.599639)
Approximate area of impact	653 ft West	13,191 ft (~2.5 mi) West
Overhead utility wires above highway	6,544 ft (1.2 mi) East	5,997 ft (1.1 mi) West

The SCE work crew, for whom the traffic break was provided, was located on 20th Avenue, a service road that ran parallel to the westbound roadway, and adjacent the overhead of utility wires that crossed the highway. As such, the calculated distance separating the patrol units from the overhead wire crossing would also be representative of the distance separating those units from the SCE crew. The respective positions of the patrol units, area of impact and utility work area are depicted on the Google Earth images in **Figures 18 and 19**.

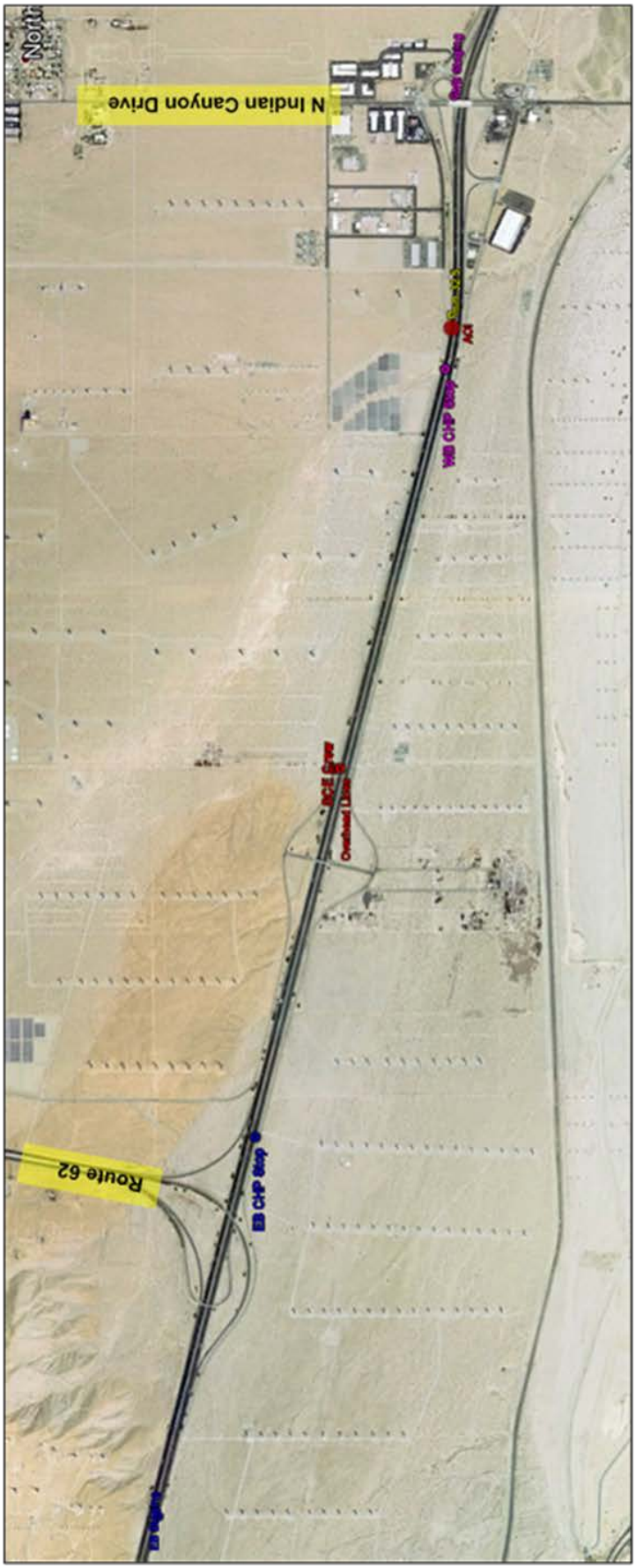

Figure 18: Illustration of the staging and traffic stop positions of the CHP patrol vehicles based on MVARS video data and geographic coordinate data for other relevant features including the location of the SCE work crew, overhead power transmission lines, area of impact and nearest postmile marker (32.5). Data was plotted on a Google Earth image.

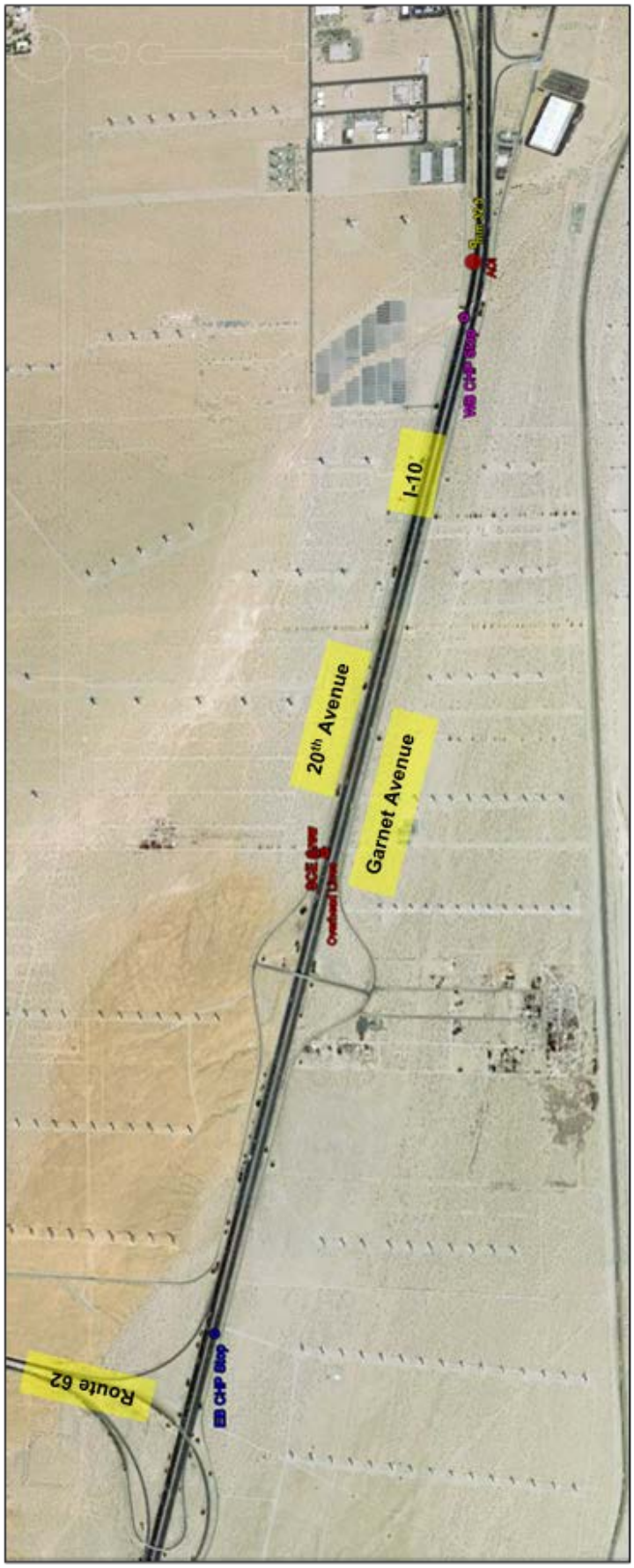

Figure 19: Enlargened illustration of Figure 18 depicting the traffic stop positions of the CHP patrol vehicles based on MVARS video data and geographic coordinate data for other relevant features including the location of the SCE work crew, overhead power transmission lines, area of impact and nearest postmile marker. CHP patrol vehicle staging areas are excluded. Data was plotted on a Google Earth image.

As depicted in the videos, the SCE work crew was vaguely visible from the respective stopped positions for the two patrol units. **Figure 20** depicts video frame image captured from the westbound patrol vehicle MVARS video. The eastbound patrol vehicle was stopped facing away from the work area and as such no video recorded the work area while the unit was stationary.

Figure 20: Forward video image from Westbound unit 5259 at time of full traffic stop. Lights from the SCE work crew are somewhat visible toward the right side of the image, while stopped eastbound traffic can be seen slightly to the left. Using the time correction provided by CHP investigators, the local time would have been 05:07:15 am.

As exhibited in **Figures 21 and 22**, the SCE work crew was visible as their location was passed by both units after release of the traffic following the break.

Figure 21: Westbound unit 5259 traveling west approaching SCE work site after release of traffic. Some westbound traffic from the preceding queue can be seen passing the patrol unit. The local time was 05:15:54 am.

Figure 22: Eastbound unit 5260 traveling east, approaching SCE work site after release of traffic. The local time would have been 05:14:43 am.

After releasing traffic, Eastbound Unit 5260 continued east toward N. Indian Canyon Drive. Approximately 1.36 (01:22) minutes after releasing eastbound traffic, the patrol unit began to pass westbound traffic that had also been released. After approximately five (5) seconds, the patrol unit had passed the released queue of vehicles and a large gap in the westbound traffic can be seen. Approximately 1.72 (01:43) minutes after releasing traffic and as the patrol unit neared the area of the collision, the involved International combination entered the patrol vehicle camera's field-of-view and can be seen sitting stationary in the westbound roadway. By this time the traffic queue had cleared from the area around the International and there was an unobstructed view of that vehicle for about four (4) seconds until the patrol vehicle passed. While the International's headlights appear to be extinguished, other running lights including those on the trailer were lit.[12] Although the intensity of the side marker lamps appears diminished in the image, they are lit. The activation of 4-way emergency flashers on the International could not be discerned.

After passing the stationary truck, Eastbound Unit 5260 passed three additional westbound vehicles, all of which appeared to be passenger-type vehicles before exiting the highway near N. Indian Canyon Drive (note that the highway exits onto Garnet Avenue to intersect with N. Indian

[12] See NTSB Vehicle Factors Group Factual Report regarding the operation of the headlighting system on the International truck tractor. Investigators identified that the headlamps would turn "off" when the tractor parking brake was engaged.

Canyon Drive). Headlights from other westbound vehicles can be seen further in the distance behind the International.

Figures 23 and 24 depict video image captures of the stationary International combination as the patrol vehicle passed on the opposing roadway.

Figure 23: Eastbound Unit 5260 approaching International truck occupying westbound roadway. The westbound traffic queue has already cleared. The corrected local time would be 05:15:41 am.

Figure 24: Eastbound Unit 5260 approaching International truck occupying westbound roadway and highway exit to Garnet Avenue. The westbound traffic queue has cleared and approaching westbound traffic can be seen in the distance. The corrected local time would have been 05:15:42 am.

Table 4 provides respective times for certain events for the two patrol officers engaged in the traffic break operation.

Table 4: Timing of relative events for the two CHP units participating in the traffic break operation. Timing is based on the unit's respective MVARS video after being adjusted for clock drift.

Event	Westbound Unit 5259 Video Time Stamp	Eastbound Unit 5260 Video Time Stamp
Begin traffic slowing	05:04:22	05:03:41
Stop	05:07:13	05:07:54
Release of traffic	05:14:26	05:13:55
Officer passing International truck	N/A	05:15:42
Begin last travel toward crash scene	05:22:50	05:19:31
Stop at crash scene	05:27:05	05:22:09
Arrival of fire truck	05:33:12	05:33:12

Tables 5 and 6 provide additional detail for specific events interpreted from the MVARS data.

Table 5: Events interpreted from MVARS data for CHP westbound unit 5259.

Video Time Stamp	Adjusted Time	Video Counter	Event
4:29:58	4:29:02	0:00:00	Begin video
4:36:00	4:35:04		SCE work crew visible - Work lights adjacent access road illuminating pole at officer travels westbound on I-10
4:36:44	4:35:48	0:06:44	Officer stops beside 2nd officer on shoulder of highway near sign "Joshua Tree National Park" (Next Right). SCE work crew visible
4:38:13	4:37:17	0:08:16	Officer begins traveling westbound
			Officer exits highway onto US 62 for U-turn - Travels eastbound I-10
4:43:51	4:42:55	0:13:54	Officer exits I-10 onto Garnet Ave to Indian Canyon Drive
4:45:28	4:44:32	0:15:30	Officer stops under Indian Canyon Drive overpass on westbound I-10 ramp
5:04:42	5:03:46	0:34:44	Officer begins moving westbound from stopped position
5:05:18	**5:04:22**	0:35:19	Overhead emergency lights activated, Officer begins slow S-maneuver to slow traffic
5:08:09	**5:07:13**	0:38:10	Officer stops on I-10 between left- and right-center lanes, near end of concrete railing above wash. SCE crew not visible.
5:15:22	**5:14:26**	0:45:23	Officer begins moving westbound from stopped position.
5:16:32	5:15:36	0:46:33	SCE work crew visible in distance
5:16:56	5:16:00	0:46:56	SCE work crew out of frame (passing)
5:20:36	5:19:40	0:50:37	Officer stops on eastbound ramp to I-10 following U-turn using US 62
5:20:54	5:19:58	0:50:55	Officer proceeds further down ramp to I-10
5:21:32	5:20:36	0:51:32	Officer stops on eastbound I-10 east of overpass
5:23:46	5:22:50	0:53:46	Officer begins traveling eastbound.
			Exits highway at Garnet, then to Indian Canyon and reenters westbound roadway
5:27:32	5:26:36	0:57:32	Encounters slow moving traffic queue
5:27:35	5:26:39	0:57:35	Enters right shoulder to pass traffic queue
5:28:01	5:27:05	0:58:01	Stops at crash scene - other CHP unit on scene
5:34:08	5:33:12	1:04:07	Fire truck stops on right side of unit
5:45:00	5:44:04	1:14:59	Video end

Table 6: Events interpreted from MVARS data for CHP eastbound unit 5260.

Video Time Stamp	Adjusted Time	Video Counter	Event
4:29:57	4:29:07	0:00:00	Begin video
4:33:52	4:33:02	0:03:55	Officer stops at highway sign adjacent work area "Joshua Tree National Park"
4:36:37	4:35:47	0:06:39	2nd officer pulls alongside on shoulder of highway near sign "Joshua Tree National Park" (Next Right). SCE work crew visible
4:38:08	4:37:18	0:08:11	2nd Officer departs
			Officer exits highway onto US 62 for U-turn for return to I-10. Continues WB on I-10 to crossover.
4:43:09	4:42:19	0:13:11	Officer stages on right shoulder of EB I-10
5:04:31	**5:03:41**	0:34:33	Officer activates overhead lights, begins traveling eastbound with slow S-maneuver across all travel lanes
5:08:44	**5:07:54**	0:38:45	Officer stops in highway, facing south across travel lanes
5:14:45	**5:13:55**	0:44:46	Officer begins moving eastbound from stopped position.
5:15:37	5:14:47	0:45:37	Work site to north passed
5:16:07	5:15:17	0:46:07	Begins passing first vehicles from westbound traffic queue - westbound traffic released
5:16:28	**5:15:38**	0:46:28	Accident truck entering camera field-of-view (~40 ± vehicles passed in westbound direction)
5:16:32	**5:15:42**	0:46:33	Accident truck passed - running lights on, no headlights
5:16:46	5:15:56	0:46:46	Officer exits at Garnet Ave - 3 additional westbound passenger vehicles pass after passing accident truck. No commercial vehicles visible
5:18:08	5:17:18	0:48:08	Officer stops on Indian Canyon Drive atop ramp to I-10
5:20:21	5:19:31	0:50:22	Officer begins traveling on ramp to westbound I-10
5:22:59	5:22:09	0:52:59	Officer stops at crash scene. First unit on scene. Had used slow S-maneuver to slow and stop traffic on approach.
5:34:02	5:33:12	1:04:02	Fire truck stops on right side of unit
5:45:00	5:44:10	1:14:59	Video end

4. Traffic movement chronology – Area surveillance video imagery interpretation

Surveillance video recorded from two outdoor cameras located at a FedEx facility adjacent the south side of the highway was acquired by CHP investigators and forwarded to NTSB investigators. The images from both cameras were examined to identify certain pre-collision movements of both the International combination and the MCI motorcoach.

The two cameras, identified as "NE Mid Yard" and "West Yard South" were positioned on the northern and western facing sides of the building and incidentally captured portions of I-10 east of the crash site. CHP investigators were able to provide the camera locations on the exterior of the building. Although no camera specifications were available, the respective fields-of-view for the cameras were reasonably estimated using physical features visible in the video footage. The NE Mid Yard and West Yard South cameras were estimated to be approximately 1,900 and 1,500 feet southeast of the area of impact, respectively. There is some overlap in their respective fields-of-view, although the NE Mid Yard camera extends further west, almost to the area of impact. At their nearest point to the highway, the cameras were about 700 feet from the westbound roadway. The combined camera fields-of-view were estimated to cover about 1,500 feet of the highway, although portions were obscured by other buildings in the foreground. The run time of the videos was approximately one hour, 23 minutes for the NE Mid Yard footage and one hour for the West Yard South footage.

Figure 25 provides an overhead view of the area relative to the FedEx facility, while **Figure 26** illustrates the locations and estimated fields-of-view for the two cameras. The locations marked as "AOI" (area of impact), and "patrol vehicle" were based on previous scene, and CHP MVARS video data and were plotted on the Google Earth image using geographic (GPS) coordinates. The location marked "patrol vehicle" indicates the approximate location where the officer initiating the westbound traffic break had stopped his vehicle to hold traffic. The areas

Figure 25: Google Earth image depicting location of FedEx facility relative to crash site and location of westbound CHP patrol vehicle during traffic break operation.

where the respective camera fields-of-view were obstructed by other buildings are highlighted by yellow and red colored hatch patterns.

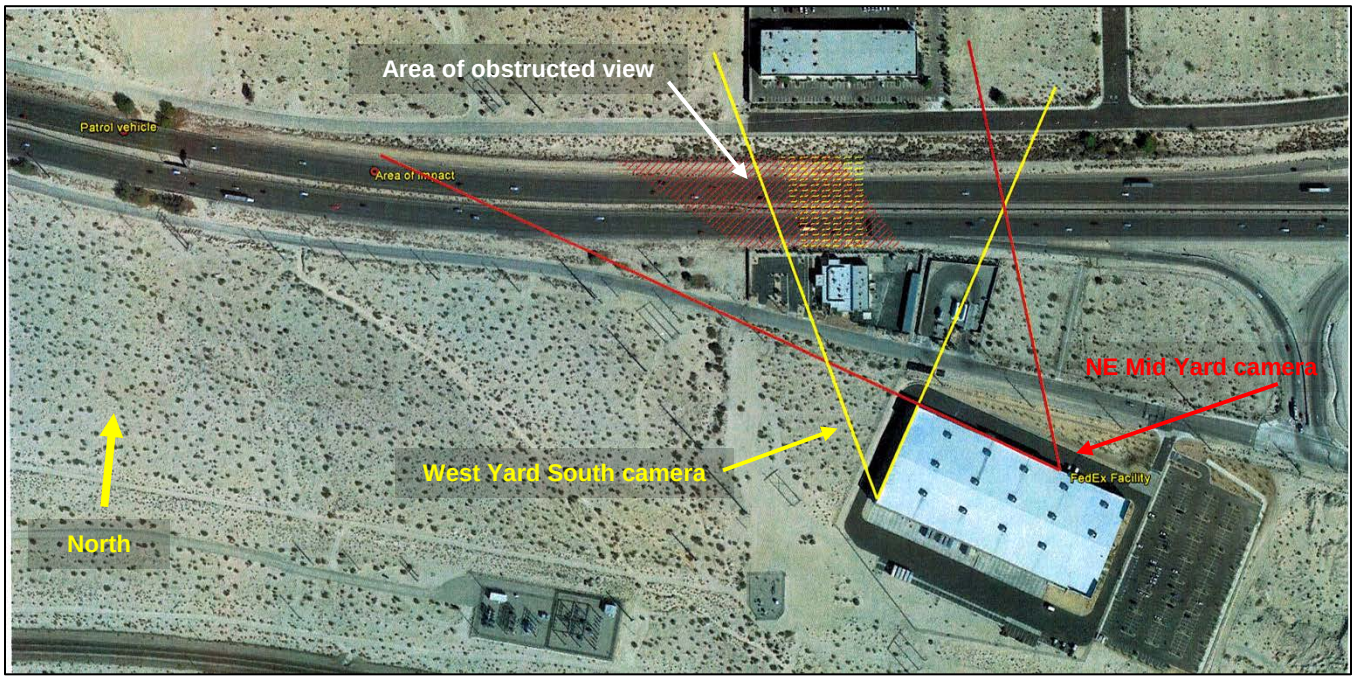

Figure 26: Google Earth image depicting location of FedEx facility relative to crash site and location of westbound CHP patrol vehicle during traffic break operation in relation to the estimated camera fields-of-view from the FedEx facility.

The videos were reviewed using the Genetec Security Center Portable Video Player. During playback of the video certain information including camera identification, date, and time of day (expressed as hours, minutes, and seconds to three decimal places) was displayed. The video images were in color, and while the images were slightly grainy, the resolution was consistent with nighttime video imagery. Despite the distance between the cameras and highway, and the partial field-of-view obstructions due to buildings in the foreground, vehicles could be easily observed traveling east- and westbound on I-10. Commercial vehicles were easily identified and could be identified separately from light vehicles. CHP investigators were able to corroborate that the camera images were recorded through a shared system and that the time displayed accurately represented local time.

CHP MVARS data indicated that the westbound traffic was halted by CHP at 05:07:13 hours and then released at 05:14:26 hours. During this time, westbound vehicles could be seen slowing in the NE Mid Yard footage. At an indicated time of 05:05:21 hours, a slow-moving police vehicle with overhead flashing emergency lights had completely entered the NE Mid Yard camera field-of-view. At an indicated time of about 05:06:31 hours the police unit exits the camera field-of-view. Eventually, a stationary traffic queue formed and could be seen in the video image. At about 05:11:55 hours the International combination is observed entering the NE Mid Yard camera field-of-view. The vehicle comes to a near stop just before exiting the camera field-of-

view at 05:12:24 hours. The Fleetmatics data (addressed in Section 5) indicated the International as stopped (speed = 0) at about 05:13 (05:12:29) hours. It is important to note that the individual highway lanes occupied by each of the vehicles cannot be discerned. While the sequence of the vehicles entering the video can be identified, it cannot be determined whether the vehicles are traveling in the same lane.

Figure 27 depicts the International combination shortly after entering the field-of-view for the NE Mid Yard camera.

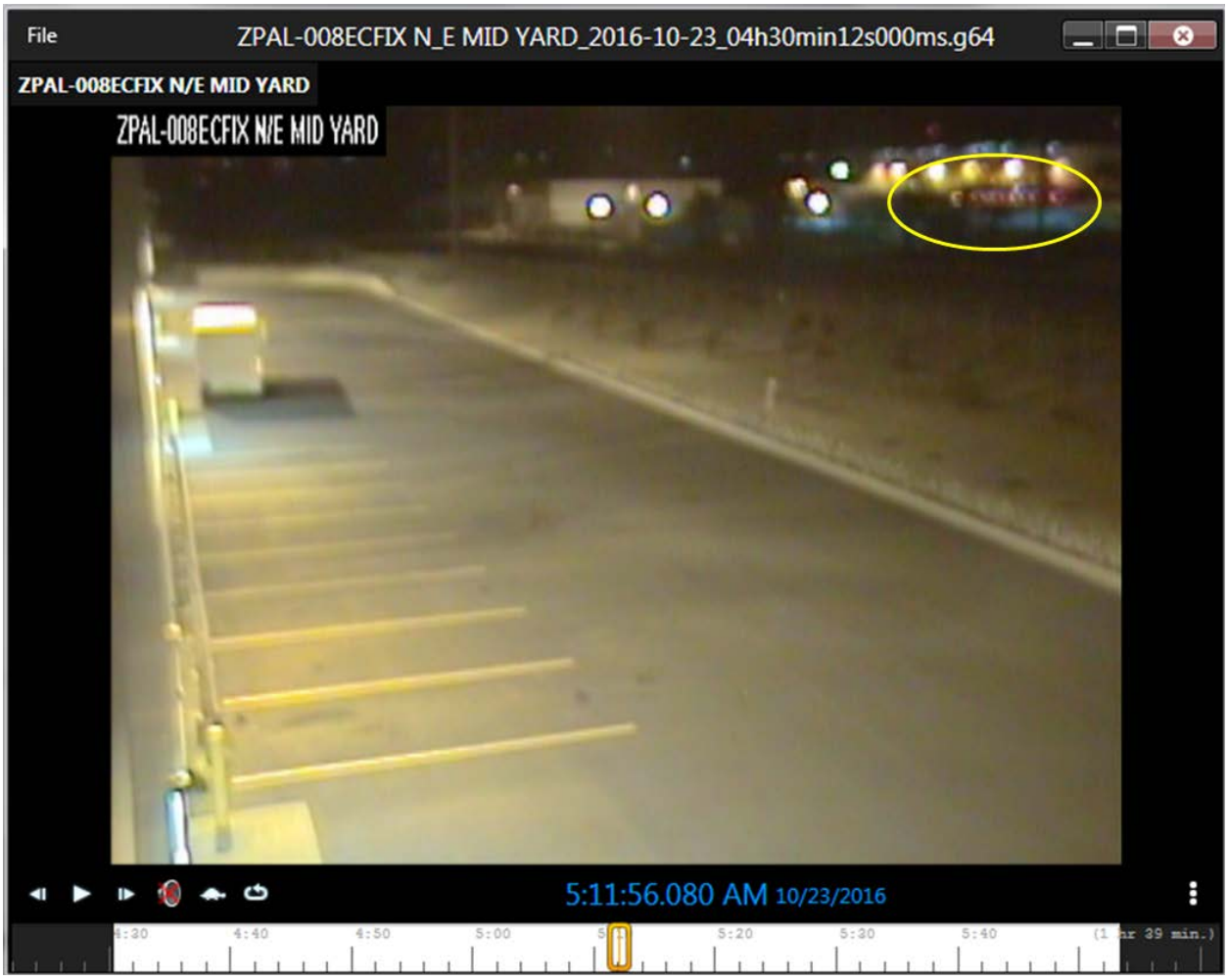

Figure 27: Video frame capture depicting the International combination (yellow circle) shortly after entering the field-of-view for the NE Mid Yard camera.

Figure 28 is an image from the NE Mid Yard camera that depicts a second combination vehicle (right side of image) that was trailing the International combination (left side of image) by about 11 seconds. In the video, the International combination can be seen slowing, and its brake lights activated. Activation of hazard flashers is not apparent before the International departs the camera field-of-view. As the trailing combination vehicle came to a stop within the traffic queue it remained partially within the camera field-of-view.

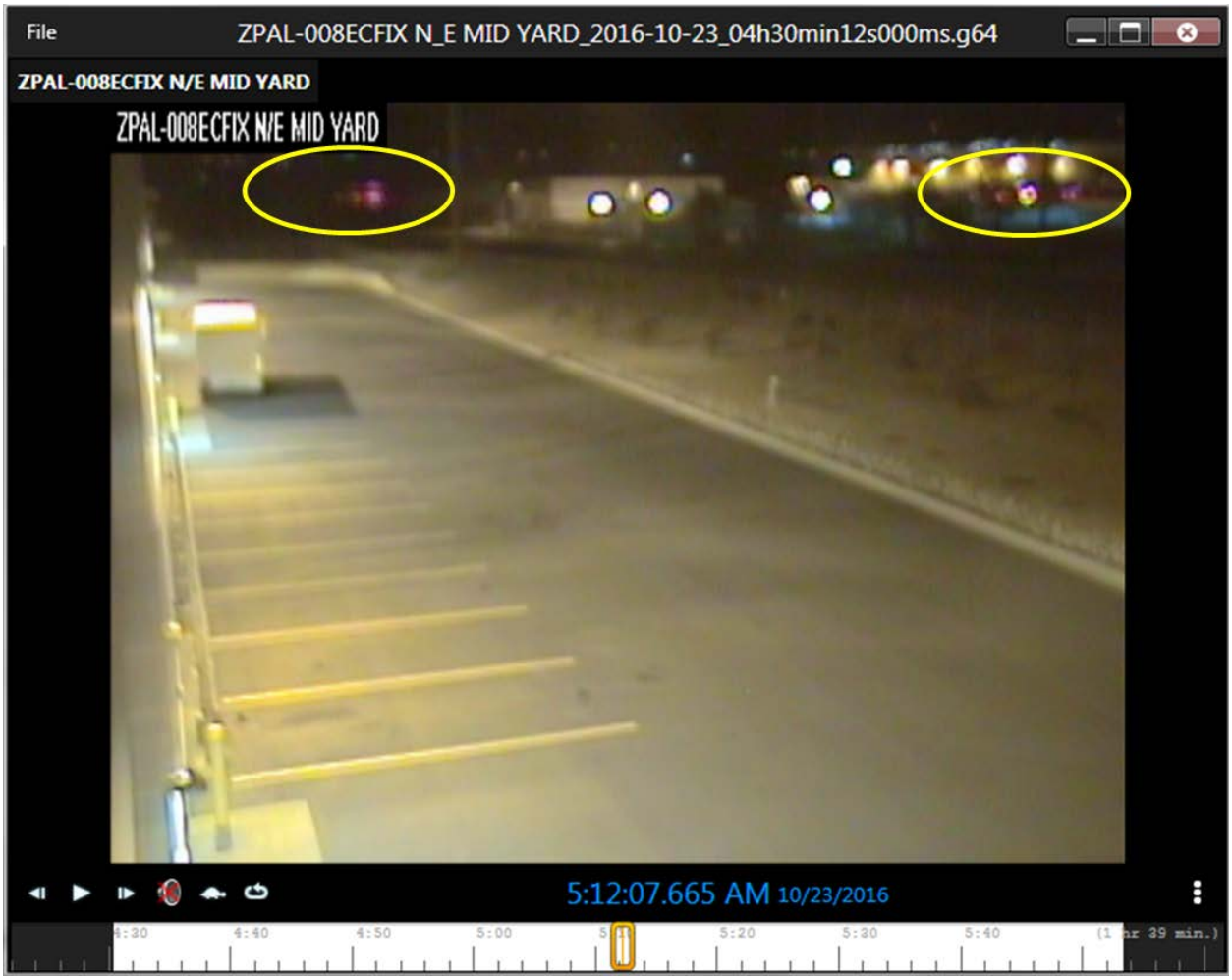

Figure 28: Video frame capture from the NE Mid Yard camera that depicts the combination vehicle (right side of image in yellow circle) that was trailing the International combination (left side of image in yellow circle). In the video, the International combination can be seen slowing, and its brake lights activated.

By 05:15:30 hours the stationary queue had cleared and was no longer visible in the NE Mid Yard camera video. Review of the MVARS video data from the eastbound CHP officer, depicted him passing the stopped the International combination and exiting I-10 onto Garnet Avenue at 05:15:56 hours.

At about 05:16:28 hours the MCI motorcoach had entered the NE Mid Yard camera field-of-view. The motorcoach could be clearly identified in the West Yard South camera using a similar indicated time. **Figure 29** depicts the motorcoach after entering the NE Mid Yard camera field-of-view and **Figure 30** depicts the MCI within the West Yard South camera field-of-view.

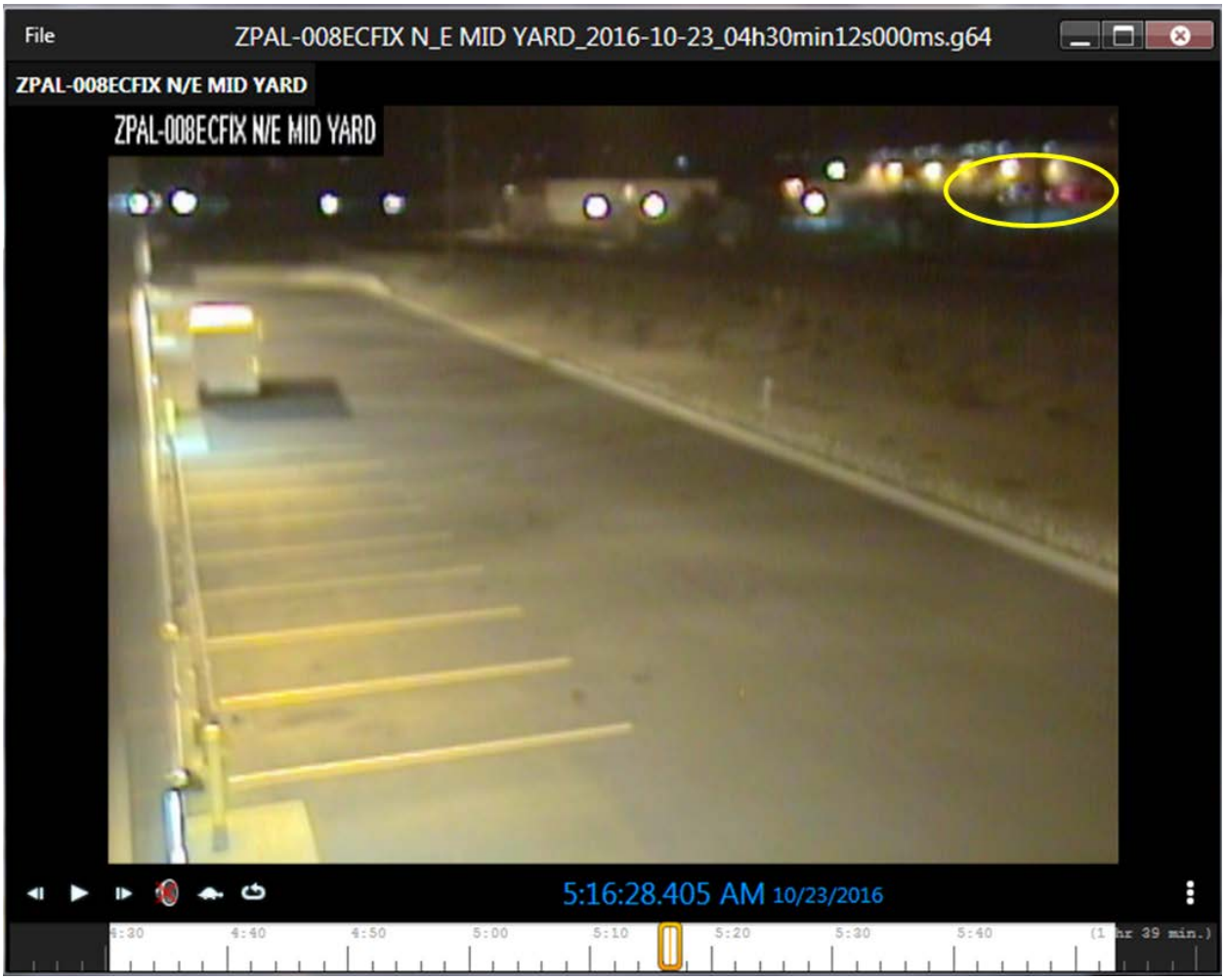

Figure 29: Video frame capture depicting the MCI motorcoach after it entered the NE Mid Yard camera field-of-view.

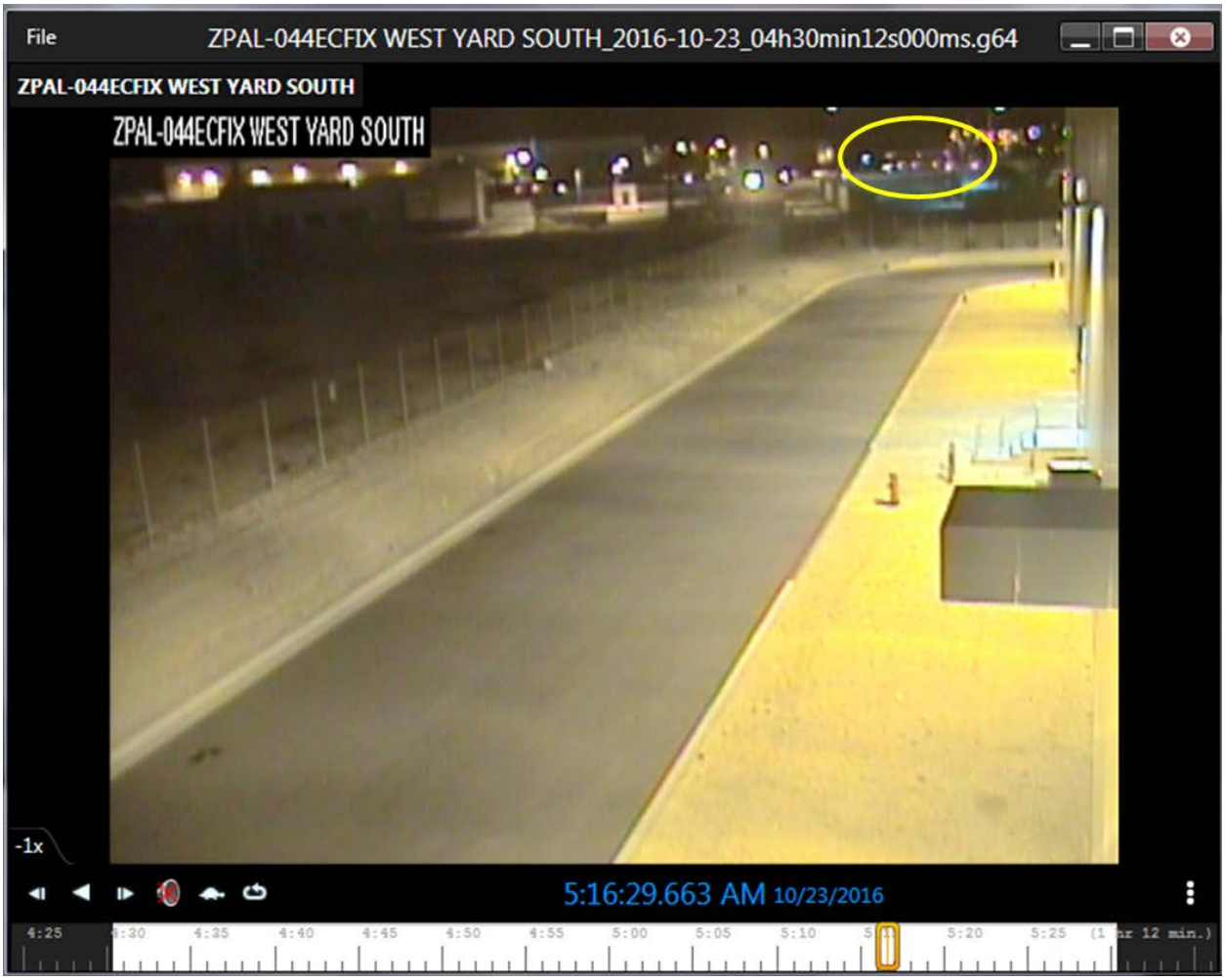

Figure 30: Video frame capture depicting MCI motorcoach after it had entered the West Yard South camera field-of-view.

At about 05:16:40 hours the MCI departs the video – the collision cannot be seen. No activation of the vehicle's brake lamps was observed before the motorcoach departed the camera view.

After the visible traffic queue cleared by about 05:15:30 hours, five (5) other vehicles had entered the video ahead of the MCI and by 05:16:07 hours eastbound traffic was observed entering the NE Mid Yard camera field-of-view.[13] Activation of brake lamps could be seen on each of those vehicles. The nearest vehicle ahead of the MCI was a passenger vehicle, and while its lane position could not be determined, time displayed on the video indicated that the vehicle led the motorcoach by about two (2) seconds. The brake lamps on this vehicle did activate as it departed

[13] Although visual observation of vehicle tail lights within the traffic queue had disappeared from the video image by 05:15:23, another vehicle entered the scene by 05:15:24 and discernibly slowed as it exited the scene by 05:15:36. This vehicle was likely influenced by the clearing traffic queue. The five subsequent vehicles referenced began entering the camera field of view beginning about 05:15:44 and are not believed to have been influenced by the previous traffic queue. Reference to eastbound traffic observation concerns the apparent resumption of regular traffic and not the appearance (most likely) of the eastbound patrol unit at 05:15:47 traveling to the next staging point.

the camera field-of-view. The video data indicates that the approximate time of the crash would have been within a few seconds after 05:16:40 hours.

After the MCI departs the camera field-of-view, the next westbound vehicle that entered the field-of-view for the NE Mid Yard camera was a light vehicle at about 05:16:46 hours, or approximately 18 seconds behind the motorcoach. Each vehicle following the motorcoach was observed to have their brake lamps activate and noticeably reduced speed as they neared the end of the camera field-of-view. By 05:18:40 hours a traffic queue could be seen in the video.

The first westbound CHP unit that appeared in the video following the crash is depicted in **Figure 31**. The first responding officer had originally managed the eastbound traffic break. MVARS data depicted the officer's response began at about 05:19:31 hours from atop the Indian Canyon Drive overpass with an arrival on site around 05:22:09 hours (after executing a series of serpentine maneuvers to slow traffic approaching the crash).

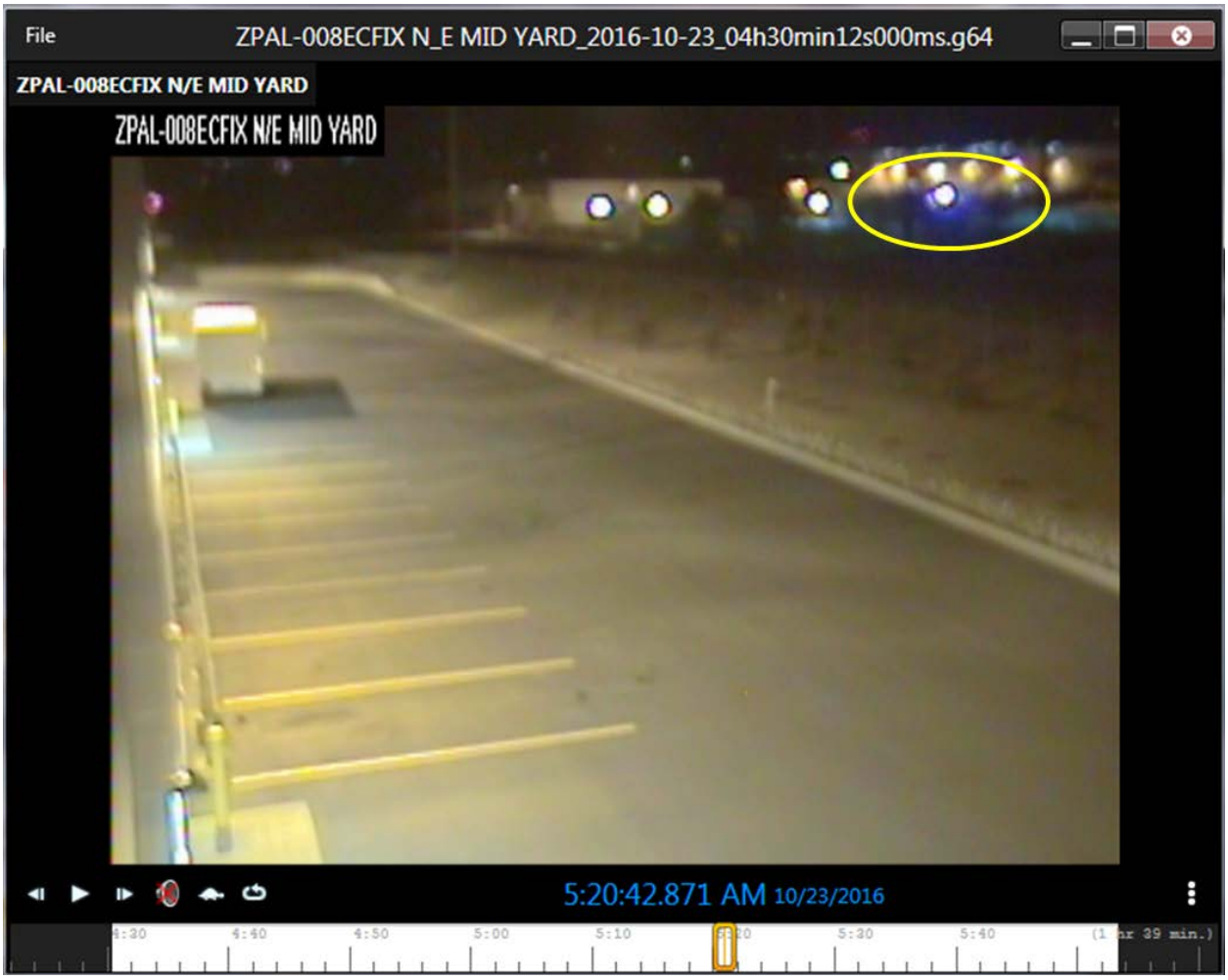

Figure 31: CHP patrol vehicle – previously eastbound unit participating in traffic break operation – traveling to crash site.

5. International electronic data

Certain data in an electronic format were acquired from the International truck tractor. That data included vehicle position and speed tracking through a vehicle-based telematics system that reported certain data to a central server accessible by the carrier. The second source of data were acquired from the vehicle's electronic engine control module (ECM). For additional information regarding the data acquisition, content and format see the Electronic Devices Factual Report prepared by NTSB staff with the Vehicle Recorders Division in the Office of Research and Engineering.

5.1. Vehicle tracking - Fleetmatics

The onboard vehicle tracking data involved a web-based fleet management system provided by Fleetmatics Group PLC. While the service and system is scalable with the capacity to monitor numerous vehicle systems and operations, the carrier reportedly used the system to monitor vehicle location without reference to events. The service and data is provided to the carrier based on a subscription to features. The carrier provided approximately 30 days of data to NTSB investigators beginning with September 24, 2016 and continuing through the date of the crash.

As noted in the NTSB Electronic Devices report, the Fleetmatics system uses a Sierra Wireless GNX-5P unit to record the GPS position of the vehicle. The GNX-5P has internal cellular and GPS antennas and a three-axis accelerometer to collect GPS data. Additional information from Fleetmatics states that vehicle locations and times are pinpointed from the Global Position System satellites and relayed to their data center over the general packet radio service (GPRS) network in real time. The GPRS network allows 2G, 3G and WCDMA mobile networks to transmit IP packets to external networks such as the Internet.

System specifications indicate that vehicle data can be reported as frequently as every 90 seconds in real time. The data provided to NTSB investigators was in a spreadsheet format with time stamps reported every 60 to 120 seconds in whole minutes. The time format suggest that reporting times are rounded to the nearest whole minute.

The data provided to NTSB investigators reported vehicle location as a function of latitude and longitude, relative location such as highway and nearest city, and vehicle speed all relative to a time stamp. After adjusting the reported time to Pacific Daylight Time, the movement of the International immediately preceding the crash was interpreted.[14]

The International combination began its travel on October 23 at 02:58 am (PDT) after having been stationary at the Flying J Travel Center located on I-10 in Ehrenberg, AZ located at the Arizona/California state line for about 11 hours, 9 minutes. The vehicle then traveled westbound on I-10 at an average speed of 57.4 mph until it began to slow as it approached the area of the collision at an indicated time of 05:12 am. The International traveled just over 123 miles (data indicates 123.27) between the travel plaza and the crash site.

At 05:13 am the vehicle speed is reported as zero and at 05:16 am the data indicates vehicle shutdown. There was a total of three data entries at 05:16 am including the shutdown record.

[14] Time is logged as Central Daylight Time (CDT).

While all three entries indicated a ground speed of zero, the position data indicated a movement of about 58 feet westward between the first and second entries at 05:16 am.[15] This westward movement would be consistent with the post-impact movement of the International.[16]

The data indicate three subsequent startup and shutdown cycles following the crash. The first occurs at 05:18 am and continues for 32 minutes with no movement of the vehicle. This cycle is followed by another at 11:18 am for one minute, again with no movement. The last cycle begins at 12:01 pm and lasts for two minutes during which vehicle movement within the crash scene is observed.

According to the carrier, the Fleetmatics data was not configured to record or report event data, and no events were reflected in the data.

Figure 32 depicts the route of the International combination on October 23, 2016 as indicated by the data and plotted on Google Earth. **Figure 33** depicts the data as the vehicle came to a stop at the crash scene and its relative position to other features.

[15] A total westward movement of about 63 feet was observed between the first record of zero speed at 05:13 am and the second position entry at 05:16 am.

[16] While the coordinate data recorded until the second shutdown at 05:50 am is not constant, the positions are random and are within typical GPS positional accuracy. The movement observed at the 05:16 am time stamp exhibits clear westward movement within the travel lane.

Figure 32: Depiction of the route taken by the International combination on October 23, 2016 as indicated by the Fleetmatics data.

Figure 33: Depiction of the vehicle came to a stop at the crash scene and its relative position to other features.

5.2. Electronic Engine Control Module (ECM)

The International was powered by a Navistar N13 diesel engine that was managed by an electronic engine control module (ECM). The primary role of the ECM is management and operation of the vehicle engine. Subsequent to managing the operation of the engine the module features the ability to record engine fault codes and certain vehicle operation events. As conveyed in the NTSB Electronic Devices report, the event data retained in the ECM included *last stop* and *hard acceleration/deceleration* events in addition to engine system fault codes. The module had the capacity to record up to two last stop and hard acceleration/deceleration events. As summarized in the NTSB Electronic Devices report *last stop* events are recorded when the vehicle wheel speed equals zero and the truck then idles for two minutes or is powered down. *Hard acceleration/deceleration* events are set when this vehicle increases or decreases speed at a rate of 7.4 miles mph/sec (10.85 feet/sec^2 or about .34g). Recorded data could cover up to 105 seconds before the event and 15 seconds following the event.

Of the two last stop records, one was identified as having been set immediately before the crash and one following the crash. The data summarized 28 parameters and reported on another 20 that were time stamped in one second intervals. Included with the summarized data was the date and time of the event. During the data download process NTSB Vehicle Recorders staff determined that the ECM clock trailed actual time by 58 seconds. In reporting the data as Pacific Daylight Time, the date and time reported by the ECM was converted from Coordinated Universal Time (UTC) and updated by 58 seconds.

The *last stop* record that preceded the crash was logged as Last Stop #2 (subsequent the most recent) and date/time stamped at 05:12:29 hours PDT on October 23, 2016. Beginning 105 seconds before the stop (wheel speed zero) the International had been traveling at a reported steady speed of 59 mph.[17] Eighty-two (82) seconds before the stop, the vehicle speed began decreasing followed by the indication of the service brake pedal being applied 53 seconds before the stop.[18] While the brake pedal application is not indicated as having been continuous following the initial trigger, beginning 23 seconds before the stop and for the reported 15 seconds following the stop the pedal application is constant.[19] While the parking brake status is another parameter recorded by time stamp, there was no record that the parking brake was applied during the 15 seconds after the stop.

The *last stop* #1 record was set approximately 6 hours, 48 minutes after the first, although the vehicle only accelerated to a speed of about 4 mph. This record is consistent with a two-minute operation that was reflected in the Fleetmatics data where the vehicle was moved while at the crash scene.

No recorded fault data related to the crash was recovered.

[17] While reported speed is not an issue with this vehicle, factors that affect the recorded speed include tire size, drive axle gear ratio and vehicle speed sensor setting. Examination of the ECM configuration data and tire manufacturer data indicated that the reported speed was at least 99.2% or at most ½ mph lower than reported.
[18] Pedal application record is triggered by activation of the brake lamp switch.
[19] Exception is at the 1 second time at which the brake pedal is recorded as not activated.

6. MCI electronic data

The motorcoach was powered by a Detroit Diesel Corporation Series-60 engine that was managed by a DDEC-IV electronic engine control module.[20] In addition to engine configuration settings related to engine management, the module has the capability to record certain engine performance and operation activity. The module can record up to two *hard brake* events and one *last stop* event, as well as fault events. Since the motorcoach had sustained severe damage, the ECM was removed for data imaging.

As referenced in NTSB Electronic Devices report, data was recovered from the module using a bench-top simulator in mid-December 2016. Recovered data consisted of configuration information, a life-to-date trip activity summary, monthly activity summary covering September through November 2016, and a 30-day, daily engine use summary.[21]

While the end date on the data is indicated as November 28, 2016, during the data imaging NTSB Vehicle Recorders staff determined that the ECM clock, as indicated by the data records, was trailing by 15 days, 13 hours, 1 minute and 45 seconds (i.e., ECM clock drift). When the report date was adjusted, the final date was determined to be December 13, 2016, the date of the ECM imaging. This date would be set as the ECM was powered for the collection of data.

The recovered data identified the last two days reported in the daily engine as October 6 and 7, 2016. After the ECM clock drift was adjusted, those dates were identified as October 21 and 22, 2016. Although the reported hourly segments were likewise adjusted for the clock drift and time zone in which the collision occurred (PDT), there was insufficient information to compare that data with the limited known operation of the motorcoach on those days. Other than an increase is recorded mileage, the reported data provided no useful trip data for analysis on the day of the crash.[22]

Although two *hard brake* and one *last stop* records were recovered, those events apparently occurred on October 22, 2016. According to ECM reported mileage, the most recent *hard brake* event occurred 222 miles prior to final recorded mileage. The other *hard brake* event occurred at 376 miles and the *last* stop record was set 36 miles before the final recorded mileage.[23] The lack of a last stop record preceding the crash, as well as the difference in the final reported mileage may have been due to sudden power failure from the collision.[24] Configuration data indicated that the vehicle was governed to a maximum speed of 79 mph.

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[20] DDEC – Detroit Diesel Electronic Control system

[21] Life-to-date summaries are presented in tables and histograms and include vehicle speed/RPM range; engine load/RPM range, and engine overspeed/over rev data. The 30-day engine use is presented in tables and graphs by hourly segments during a 24-hour period. Data parameters include "key off", "driving", and "idle" operations.

[22] Research has concluded that the ECM clock drift may not be consistent over time. See Baade, Ronald, Electronic Control Module Internal Clock Accuracy. National Association of Professional Accident Reconstruction Specialists, *NAPARS News*, December 2016.

[23] The trip departure point for the MCI motorcoach was approximately 54 miles from the crash site.

[24] The preservation of data, such as a *hard brake* and *last stop* events, require 20-25 of power to the ECM following the event to write to memory. In addition to the power requirement, a *last stop* record requires a "key off" of the power. *Hard brake* events were triggered at a deceleration rate of 7 mph/sec and cover 60 seconds pre- and 15 seconds

7. Event timeline summary

Based video and vehicle electronic data an approximate timeline of events was established.[25] **Table 7** conveys the event, indicated local time and data source.

Table 7: Overall event timeline.

Time	Event	Source
05:03:41	Eastbound CHP unit begins traffic slowing maneuver	CHP MVARS
05:04:22	Westbound CHP unit begins traffic slowing maneuver	CHP MVARS
05:05:21	Westbound CHP unit enters surveillance video with overhead emergency lights activated	FedEx Surveillance video
05:06:31	Police vehicle exits camera field-of-view	Surveillance video
05:07:13	Westbound CHP unit halts traffic	CHP MVARS
05:07:54	Eastbound CHP unit halts traffic	CHP MVARS
05:11:55	International combination (westbound) enters surveillance camera field-of-view	Fed FedEx Surveillance video
05:12:24	International combination (westbound) departs surveillance camera field-of-view. Vehicle at near stop.	FedEx Surveillance video
05:12:29	International combination stops	Vehicle ECM
05:13:55	Eastbound CHP unit releases traffic	CHP MVARS
05:14:26	Westbound CHP unit releases traffic	CHP MVARS
05:15:30	Westbound traffic queue clears from video field-of-view	FedEx Surveillance video
05:15:38	International combination seen in MVARS video from eastbound CHP unit	CHP MVARS
05:15:42	Eastbound CHP unit about to pass International combination	CHP MVARS
05:15:56	Eastbound CHP unit exits I-10	CHP MVARS
05:16[26]	*International data indicates engine shutdown (05:16-05:17)*	*Fleetmatics*
05:16:07	Eastbound traffic moving into surveillance camera field-of-view	FedEx Surveillance video
05:16:28	MCI motorcoach (westbound) enters surveillance video field-of-view	FedEx Surveillance video
05:16:40	MCI motorcoach departs surveillance video field-of-view	FedEx Surveillance video
05:16:46	Westbound vehicle behind MCI enters surveillance camera field-of-view	FedEx Surveillance video
05:18:40	Westbound traffic queue develops	FedEx Surveillance video
05:19:31	Eastbound CHP unit begins moving along on-ramp to westbound I-10 to respond to crash	CHP MVARS
05:22:09	Eastbound CHP unit arrives at crash scene	CHP MVARS

The timeline data suggests that the International combination came to a stop about 1.95 minutes before the traffic break was released and about 4.18 minutes before the crash. The traffic that was halted by the traffic break had been released about 2.23 minutes before the crash. Video imagery from both the FedEx surveillance and CHP MVARS cameras depict the traffic queue from the stop as having cleared before the crash.

post-event while the *last stop* record covers 105 seconds pre- and 15 seconds post-event after the wheel speed reaches zero.

[25] While each source was reportedly adjusted to "local time", various sources were used to establish local and could not be compared.

[26] The time stamp reported by Fleetmatics is presented in hours and whole minutes. This data was not synchronized with local time. Data reported to the whole minute could be between 05:16:00 and 05:16:59 a.m.

E. REPORT APPENDICES

Appendix 1 – FMVSS 108 (49 CFR 571.108) reference for photometric values for tail, clearance, and identification lamps.

Appendix 2 – FMVSS 108 reference for retroreflective sheeting

Appendix 3 – Geographic coordinate (GPS) data for select crash site features

F. REFERENCES

1. NTSB Vehicle Factors Group factual report
2. NTSB Electronic Devices factual report
3. NTSB Highway Factors Group factual report
4. 49 CFR part 571.108 (2015 edition)

G. DOCKET MATERIAL

The following attachments and photographs are included in the docket for this investigation:

LIST OF ATTACHMENTS

None

LIST OF PHOTOGRAPHS

None

END OF REPORT

Robert Squire
Highway Accident Investigator

Appendix 1 – FMVSS 108 References
Photometric tablets for lamps including tail, clearance and identification lighting

TABLE V–c—VISIBILITY REQUIREMENTS OF INSTALLED LIGHTING DEVICES—LUMINOUS INTENSITY VISIBILITY OPTION

Lighting device	Corner points[1] [2]				Required visibility Minimum luminous intensity in any direction throughout the pattern defined by the specified corner points.
	Motorcycle		All Other		Candela
Turn signal lamp.	15° UP–20° IB	15° UP–80° OB	15° UP–45° IB	15° UP–80° OB ..	0.3
	15° DOWN–20° IB	15° DOWN–80° OB	15° DOWN–45° IB.	15° DOWN–80° OB.	
Stop lamp	15° UP–45° RIGHT[4] ..	15° UP–45° LEFT[4]	15° UP–45° IB	15° UP–45° OB ..	0.3
	15° DOWN–45° RIGHT[4].	15° DOWN–45° LEFT[4].	15° DOWN–45° IB.	15° DOWN–45° OB.	
Taillamp[3]	15° UP–80° RIGHT[5] ..	15° UP–80° LEFT[5]	15° UP–45° IB	15° UP–80° OB ..	0.05
	15° DOWN–80° RIGHT[5].	15° DOWN–80° LEFT[5].	15° DOWN–45° IB.	15° DOWN–80° OB.	
Parking lamp	No Requirement	No Requirement	15° UP–45° IB	15° UP–80° OB ..	0.05
	No Requirement	No Requirement	15° DOWN–45° IB.	15° DOWN–80° OB.	

[1] IB indicates an inboard direction (toward the vehicle's longitudinal centerline) and OB indicates an outboard direction.
[2] Where a lamp is mounted with its axis of reference less than 750 mm above the road surface, the vertical test point angles located below the horizontal plane subject to visibility requirements may be reduced to 5° down.
[3] Inboard and outboard corner points are 80° for a single taillamp installed on a motorcycle.
[4] If a multiple lamp arrangement is used for a motorcycle stop lamp, the inboard angle for each lamp shall be 10 degrees.
[5] If a multiple lamp arrangement is used for a motorcycle tail lamp, the inboard angle for each lamp shall be 45 degrees.

Figure A1-1: Copy of FMVSS 108 Table V-c depicting photometric requirements for tail lamps. (2015)

TABLE VIII: TAILLAMP PHOTOMETRY REQUIREMENTS

GROUP NUMBER	TEST POINT (degrees)		PHOTOMETRIC INTENSITY[1][2][4] (cd)						GROUP MINIMUM PHOTOMETRIC INTENSITY[1][2] (cd)		
			Lighted Sections						Lighted Sections		
			1		2		3		1	2	3
			MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM			
1	20L	5U	0.3	18	0.5	20	0.7	25	1.4	2.4	3.5
		5D	0.3	-	0.5	-	0.7	-			
	5L	10U	0.4	18	0.7	20	1.0	25			
		10D[3]	0.4	-	0.7	-	1.0	-			
2	10L	5U	0.8	18	1.4	20	2.0	25	2.4	4.2	6.0
		H	0.8	18	1.4	20	2.0	25			
		5D	0.8	-	1.4	-	2.0	-			
3	V	5U	1.8	18	3.1	20	4.5	25	9.6	16.8	24.0
	5L	H	2.0	18	3.5	20	5.0	25			
	V		2.0	18	3.5	20	5.0	25			
	5R		2.0	18	3.5	20	5.0	25			
	V	5D	1.8	-	3.1	-	4.5	-			
4	10R	5U	0.8	18	1.4	20	2.0	25	2.4	4.2	6.0
		H	0.8	18	1.4	20	2.0	25			
		5D	0.8	-	1.4	-	2.0	-			
5	5R	10U	0.4	18	0.7	20	1.0	25	1.4	2.4	3.5
		10D[3]	0.4	-	0.7	-	1.0	-			
	20R	5U	0.3	18	0.5	20	0.7	25			
		5D	0.3	-	0.5	-	0.7	-			

(1) The photometric intensity values between test points must not be less than the lower specified minimum value of the two closest adjacent test points on a horizontal or vertical line.

(2) If the sum of intensity values for all points in the group is not less than the specified total value for the group, the measured intensity value for each individual test point is not required to meet the minimum value.

(3) Where taillamps are mounted with their axis of reference less than 750 mm above the road surface, photometry requirements below 5º down may be met at 5º down rather than at the specified required downward angle.

(4) A taillamp shall not exceed the maximum intensity at H or above.

Figure A1-2: Copy of FMVSS 108 Table VIII depicting photometric requirements for tail lamps. (2015)

TABLE XI—CLEARANCE AND IDENTIFICATION LAMPS PHOTOMETRY REQUIREMENTS

Test point (degrees)	Minimum photometric intensity (cd) [2] red lamps	Minimum photometric intensity (cd) [2] amber lamps
10U:		
45L [4]	0.25	0.62
V	0.25	0.62
45R [4]	0.25	0.62
H:		
45L [4]	0.25	0.62
V	0.25	0.62
45R [4]	0.25	0.62
10D: [1]		
45L [4]	0.25	0.62
V	0.25	0.62
45R [4]	0.25	0.62
Maximum photometric intensity [3] (cd) red lamps	15	

[1] Where clearance lamps or identification lamps are mounted with their axis of reference less than 750mm above the road surface, photometry requirements below 5° down may be met at 5° down rather than at the specified required downward angle.

[2] The photometric intensity values between test points must not be less than the lower specified minimum value of the two closest adjacent test points on a horizontal or vertical line.

[3] When optically combined with a stop lamp or turn signal lamp, this maximum applies on or above the horizontal.

[4] Where clearance lamps are installed at locations other than on the front and rear due to the necessity to indicate the overall width of the vehicle, or for protection from damage during normal operation of the vehicle, they need not meet the photometric intensity requirement at any test point that is 45° inboard.

Figure A1-3: Copy of FMVSS 108 Table XI depicting photometric requirements for clearance and identification lamps. (2015)

Appendix 2: FMVSS 108 References for Retroreflective Sheeting

S8.2.1 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 Application pattern.

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	Red	White	Red	White	Red
		(cd/lux/sq m)	(cd/lux/sq m)	(cd/lux/sq m)	(cd/lux/sq m)	(cd/lux/sq m)	(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

Figure A2-1: Copy of FMVSS 108 Table XVI-c depicting photometric requirements for retroreflective sheeting. (2015)

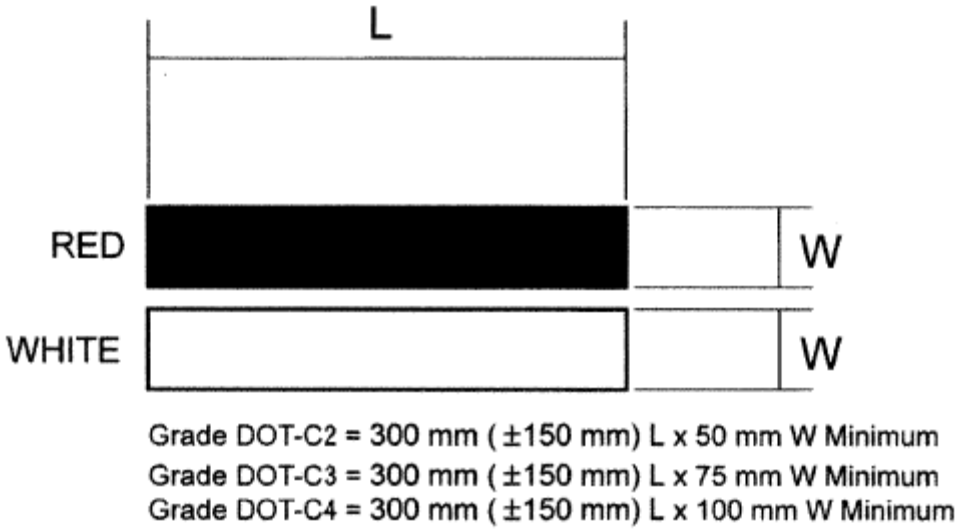

Figure A2-2: Partial copy of FMVSS 108 Figure 12-1 depicting minimum size requirements for retroreflective sheeting panels.

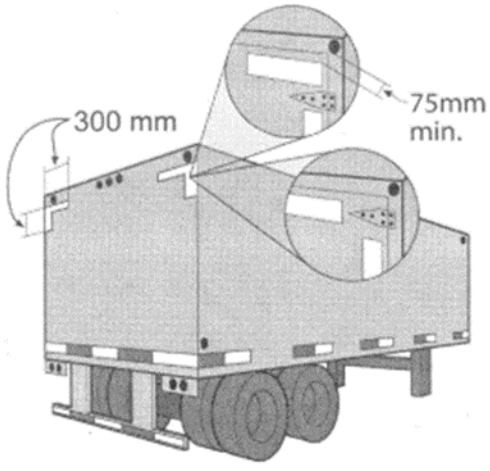

Figure A2-3: Partial copy of FMVSS 108 Figure 11 depicting requirement for placement of retroreflective sheeting panels on van body semitrailers.

Appendix 3: Geographic coordinate (GPS) data for select crash site features

latitude	longitude	Name
33.90517	-116.55649	Postmile marker 32.5
33.90521	-116.557277	AOI
33.90979	-116.58029	Power lines
33.91068	-116.58514	Bridge - Wall Road
33.90483	-116.54556	Bridge - N. Indian Canyon Dr
33.905431	-116.559326	WB Unit Stop
33.91331	-116.599639	EB Unit Stop
33.90559	-116.54608	Ramp light 1 (top of ramp)
33.90507	-116.55141	Ramp light 2 (near bottom of ramp)
33.90506	-116.55202	Ramp light 3 (bottom of ramp)
33.9052	-116.55878	Sign - Route 62 median (lighted)