CRASHWORTHINESS FACTORS GROUP CHAIRMAN'S

FACTUAL REPORT

Oxnard, CA

HWY15MH006

(39 pages)

NATIONAL TRANSPORTATION SAFETY BOARD

OFFICE OF HIGHWAY SAFETY

WASHINGTON, D.C.

CRASHWORTHINESS GROUP CHAIRMAN'S FACTUAL REPORT[1]

A. CRASH INFORMATION

NTSB Accident Number:	HWY15MH006
Location:	Oxnard, CA
Date / Approximate Time:	February 24, 2015 / 5:44 a.m. (PST)[2]
Type of Accident Event:	Train collision with highway vehicle, and subsequent derailment and highway vehicle fire[3]
Train Owner / Operator:	SCRRA (Metrolink)
Railroad Property:	Union Pacific Railroad (UPRC)[4]

B. Summary Narrative

For a summary of the accident, please refer to the *Accident Summary* report in the NTSB docket of this investigation.

C. Crashworthiness – Technical Working Group Participants

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[1] This report exclusively addresses railroad vehicle crashworthiness elements of the investigation, in which emergency preparedness and emergency response, and injury causation elements of the investigation are addressed by the Survival Factors investigation

[2] Pacific Standard Time

[3] Collision occurred on railroad track bed (not at a highway-rail at-grade crossing)

[4] Host railroad

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[5] Representing Metrolink
[6] As designated, on-scene, by [and representing] the Federal Railroad Administration (FRA)

Note – Photographs compiled during the investigation by the Crashworthiness Technical
Working Group will be forthcoming as separate factual report documentation.

Select abbreviations and acronym nomenclature used in this report

~	approximate, or approximately
APTA	American Public Transportation Association (see [Internet] http://www.apta.com/)
CEM	crash energy management
CFR	Code of Federal Regulations
FRA	Federal Railroad Administration (see [Internet] http://www.fra.dot.gov/)
FRP	fiberglass reinforced plastic
lbs	pounds [weight; international avoirdupois]
MP	milepost [railroad track location reference]
mph	miles per hour [vehicle speed]
PEAM	principal energy absorption mechanism
PST	Pacific Standard Time
ref	reference
Rev	revision
UPRC	Union Pacific Railroad Company
SCRRA	Southern California Regional Rail Authority

D. Factual Details of the Investigation

1.0 Relevant Background Factors

1.1 Locality / Civil Jurisdiction

The accident occurred on track of the Union Pacific Railroad Company (UPRC) in the City of Oxnard, which is within Ventura County, California.[7] The accident site is located in an industrial/agricultural sector of the east side of the city, proximate to the intersection of South Rice Avenue and East Fifth Street (which is also designated California Route 34).

[7] ref, and for additional information, see [Internet] http://www.ci.oxnard.ca.us/

1.2 Railroad Property Owner (Host Railroad)[8]

Metrolink train #102 operated on UPRC track at this location under an "overhead trackage rights" agreement.[9] The UPRC is a standard gauge[10], common-carrier, Class I freight railroad[11], with corporate headquarters located in Omaha, NE. The UPRC operates approximately 32,000 route-miles of track covering 23 states across the western two-thirds of the United States. Dispatching of trains operating on the UPRC at this location, including Metrolink, is provided by the UPRC through the Harriman Dispatch Center, located in Omaha, NE.

See Railroad Operations Group Factual report for additional information detail.

1.3 Railroad Operator Overview[12]

Metrolink is a regional-based commuter railroad operation, which operates an average of 169 trains in its weekday schedule.[13] As described by the company,[14] "Metrolink is the Southern California commuter rail service that provides transportation to commuters throughout six counties. During fiscal year 2011-2012, the agency provided 11.9 million passenger trips. Metrolink's governing body, the Southern California Regional Rail Authority (SCRRA), was formed in 1991 as a Joint Powers Authority that was tasked with addressing the need for increased mobility and reducing traffic congestion in the region. The SCRRA is made up of five major transportation agencies that, together, govern Metrolink via an 11-member Board of Directors: Los Angeles County Metropolitan Transportation Authority (Metro), Orange County Transportation Authority (OCTA), Riverside County Transportation Commission (RCTC), San Bernardino Associated Governments (SANBAG) and Ventura County Transportation Commission (VCTC). In 1992, the SCRRA began operating Metrolink as a solution to the region's transportation needs. Over the years, Metrolink has served as a major link between the six counties it serves, providing seamless transportation connectivity options. During the past two decades, Metrolink has expanded from 112 route miles, three service lines spanning two counties, 11 stations and 2,300 daily boarding's to 512 route miles, seven service lines spanning six counties, 55 stations and more than 44,000 daily boarding's. As of 2012, Metrolink is the nation's third largest commuter rail agency based on directional miles and the seventh largest based on annual ridership.

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[8] ref, and for additional information, see [Internet] http://www.up.com/.

[9] A common agreement among railroads, where a railroad owning track allows another railroad the right to operate on that track. The railroad owning the track is referred to as the host railroad.

[10] U.S. "standard gauge" track is 56.5 inches (143.5 cm) between the rails, as measured on straight track.

[11] ref., as defined in, 49 CFR 1201.1-1 Classification of Carriers

[12] ref, and for additional information, see [Internet] http://www.metrolinktrains.com/agency/page/title/about/

[13] ref. [Internet; Metrolink Fact Sheet for Q1 (2015)] http://www.metrolinktrains.com/agency/page/title/facts

[14] ref: Metrolink 20th Anniversary Report; [Internet] http://www.metrolinktrains.com/pdfs/20thAnniversaryReport/.

Additional information on Metrolink is available in the Internet website of this organization.[15]

See Railroad Operations Group Factual report for additional information detail.

1.4 Accident Site Overview[16]

The accident involved a Metrolink commuter passenger train that collided with a highway vehicle that was located on the railroad track, in the path of the oncoming train, which occurred at a location that was not at a highway-railroad at-grade crossing.[17]

1.4.1 Railroad

The accident occurred in single-track territory, proximate to milepost (MP) 406.14, in the Santa Barbara Subdivision of the Los Angeles Division of the UPRC. The maximum track speed for passenger trains operating in this area is 79 mph. Review of public timetables indicates six Metrolink trains and 12 Amtrak trains navigate the site on weekday (Monday – Friday) schedules.

See Railroad Operations Group Factual report for additional information detail.

1.4.2 Trackage / Roadway Interface – General Configuration

The physical evidence supports that the accident occurred (i.e., the collision initiated) on the railroad track to the west of a highway-rail at-grade crossing[18] located at South Rice Avenue. The grade crossing is of a white Portland cement precast concrete grade crossing panels and asphalt pavement construction, and incorporates a signal warning system comprised of flashing lights and descending crossing gates that activate (i.e., illuminate / lower into position, respectively) upon approach of a train from either direction.

The railroad track intersects with the multi-lane roadway grade crossing at South Rice Avenue in a perpendicular orientation (i.e., measured at 90 degrees) at this location. The dimension of the grade crossing western-most pavement curb line, and the eastern-most pavement curb line, relative to the longitudinal [north/south] centerline of the grade crossing pavement, both correspondingly measured about 50 feet (i.e., the grade crossing pavement overall width is about 100 feet).

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[15] ref: [Internet] http://www.metrolinktrains.com/

[16] the longitudinal [west/east] trackage centerline datum, and the longitudinal [north/south] centerline of the highway-rail at-grade crossing, were arbitrarily selected as Cartesian reference coordinates to describe the accident site locations.

[17] the evidence of the investigation is consistent with, and supports an accident scenario in which the highway vehicle was driven from the roadway pavement (at the grade crossing) onto the railroad track, in which a collision with the train occurred a distance from the roadway pavement.

[18] 18 ref DOT Grade Crossing (inventory) number 745855

To the south of the grade crossing, South Rice Avenue extends for 70 feet between the centerline of the track and the north curb line of East Fifth Street. The intersection of the two roadways is configured in a perpendicular orientation (i.e., measured at 90 degrees), in which East Fifth Street was aligned in a west/east orientation, where the East Fifth Street roadway alignment was also approximately parallel to the railroad track [west/east] alignment. The distance between the railroad track centerline and the center of the South Rice Avenue / East Fifth Street intersection is about 100 feet. A crossing gate cantilever structure is located 15 feet north of the grade crossing; approximately 3 feet from the west curb line of South Rice Avenue, in the northwest quadrant of the grade crossing. A crossing gate signal mast is located 10 feet north of the grade crossing; approximately 3 feet from the west curb line of South Rice Avenue, in the northwest quadrant of the grade crossing.

A marker post ("warning" signage), indicating "High Pressure Gas Pipeline", was located along the western edge of the South Rice Avenue grade crossing pavement curb line (indicating a pipeline was buried in this area along the [north/south] alignment of South Rice Avenue). Marker posts ("warning" signage), indicating "Buried Fiber Optic Cable", were located in several places along the railroad right-of-way, in the area proximate to the accident site.

See Highway Factors Group Factual report for additional information detail.

1.4.3 Track Configuration

The track alignment approaching the accident site from either direction was tangent (had a straight alignment) and had a slight descending grade to the east. The railroad right-of-way, in the area proximate to the accident site, was about 100 feet in width (measured north/south), with the railroad track located on the approximate centerline of the railroad right-of-way.

Generally described, the railroad trackage was comprised of conventional, continuously welded, 136 lbs/yard, "T-section", steel running rails, as secured in place with cut spikes to preservative- treated, timber [wood] crossties, which was integrally anchored in place by rock ballast.

For the area to the east of the South Rice Avenue railroad grade crossing, proximate to where the derailed railroad equipment came to rest:

- the area was observed to be void of structures, trees, large rocks / boulders, or other large objects (i.e., the area was open land),
- the vertical height (distance) between the top of rail and the prevailing ground level elevation (approximate to where the railcars came to rest), in the areas immediately adjacent to (i.e., north / south of) the track bed, measured about 40 inches,[19] the East Fifth Street roadway pavement surface (proximate to where the railcars came to rest) was [visually estimated to be] about 1½ foot lower in elevation than the top of rail,

[19] when measured, the soil surfaces appeared to have been disturbed as a result of wreckage recovery / site cleanup activities (soil grading and leveling operations), and thus no determination could be made as to if the post-recovery ground level (elevation) closely corresponded to the pre-recovery ground level.

- the horizontal distance between the centerline of the railroad right-of-way, and the northern edge of the East Fifth Street roadway pavement, was about 70 feet,
- a metal balustrade fence, about six feet in height and secured to intermittently located concrete block columns (on about19 foot centers), initiated about 50 feet to the east of the South Rice Avenue pavement and extended eastward, which was aligned approximately parallel to the track, in which the alignment was about 50 feet to the north of the track (apparently positioned on / close to the northern boundary of the railroad right-of-way).

See Railroad Operations Group Factual report for additional information detail.

1.5 Highway Vehicles

Two highway vehicles were involved in the accident, as follows.

See Vehicle Factors Group Chairman's Factual Report for additional information detail.

1.5.1 Truck and Trailer Combination Vehicle

This highway vehicle, which was stopped on the railroad track a distance from the roadway pavement at the time of the collision, was a truck and trailer combination, consisting of a 2005 Ford F-450 Utility Truck that was towing a 2000 Wells Cargo model TW122 Tandem Axle Utility Trailer. The vehicle driver (and sole occupant of the vehicle) had abandoned the vehicle prior to the collision.

1.5.2 Automobile

This highway vehicle, which was stopped at the lowered gate-arm of the at-grade crossing at the time of the collision (awaiting passage of an approaching train), was a 1998 Toyota Camry. The vehicle driver (and sole occupant of the vehicle) was in the driver's seat of the vehicle at the time of the collision.

2.0 Details of the Accident Train

2.1 Overview of Train Number 102

2.1.1 Train Consist

The train involved in the accident:

- was assigned an operational designation of Train Number 102, which was an eastbound regional commuter train,
- initiated operation at the East Ventura station on the day of the accident, and had a destination of Los Angeles Union Station on that same day,

- was operated by crewmembers employed by Amtrak[20] under a contractual arrangement with
  Metrolink,
- normally operates in a 'Push-Pull' configuration, and was operating in a 'Push' mode configuration at the time of the accident (i.e., the locomotive was situated at the rear [west end] of the train).

The configuration of the train, which is referred to [in railroad vernacular] as the 'train consist', is as follows.

Train Position	Metrolink Road Number[21]	Railroad Equipment --- Type / Manufacturer – Model Designation	In-Service Date
1 (lead)	645	Cab car (coach) / Hyundai Rotem – Double-deck	Feb 2011
2	206	Coach / Bombardier – BiLevel	Apr 2002
3	211	Coach / Hyundai Rotem – Double-deck	Dec 2011
4	263	Coach / Hyundai Rotem – Double-deck	Apr 2012
5 (trailing)	870	Locomotive / EMD – F-59PH (unoccupied)	1993

The lead car of Train 102 was a "cab control car (abbreviated as "cab car" in this report), which is also formally referred to as a "locomotive, cab car"[22], which was a non-powered coach car that was available for occupancy by revenue passengers, which was also fitted with a train operator's compartment at the leading end of the car (as further described; see § 2.3.1). The remaining railcars of the train consist were conventional non-powered coach cars, that were available for occupancy by revenue passengers (as further described; see § 2.3.2 and § 2.3.3). The locomotive provided motive power for the train, which was located at the rear [trailing] end of the train consist (as further described; see § 2.4).

2.1.2 Train Occupants (Passengers / Crewmembers)

The investigation identified that there were 51 passengers and three Metrolink crewmembers (i.e., an engineer, an engineer trainee, and a conductor, respectively) on board Train # 102 at the time of the accident.

2.2 Design Overview of the Passenger Railcars

2.2.1 Railcar Manufacturers

The Metrolink fleet is comprised of passenger railcars manufactured by two vendors, as follows.

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[20] a passenger railroad operation formally known as the National Railroad Passenger Corporation (NRPC); ref, and for further information, see [Internet] http://www.amtrak.com/about-amtrak

[21] railroad industry reporting code (designation) for SCRRA/Metrolink railroad equipment is "SCAX" (as labeled on the equipment).

[22] as defined by the FRA; ref, 49 CFR 238.5 Definitions

[1] Bombardier[23], in which:

- one coach car supplied by this manufacturer was involved in the accident, and
- the manufacturer referred to the railcar (in the manufacturer's product-line literature[24]) as "Bi-level" coach equipment,[25] although as a technicality, the cars actually have three levels of seating (see further § 2.2.2), in which the railcars are also referred to by Metrolink as the "Sentinel Fleet"[26], and

[2] Hyundai Rotem[27], in which:

- three railcars supplied by this manufacturer were involved in the accident (i.e., the cab car, and two conventional coaches), and
- the manufacturer referred to the railcars (in the manufacturer's product-line literature[28]) as "Double-deck" coach equipment, although as a technicality, the cars actually have three levels of seating (see further § 2.2.2), in which the railcars are also referred to by Metrolink as the "Guardian Fleet"[29].

2.2.2 Carbody – General Description

The Metrolink passenger railcar fleet are all multi-level, non-powered railcars, which is comprised of both "cab cars" that operate at one end of a given "push-pull" train (i.e., the car is positioned at the opposite end of the train to the locomotive), as well as "coach cars" that operate between the cab car and the locomotive of a given train, which are also referred to as "trailer" cars by the railcar manufacturers.

Generally described, the interior features of the Metrolink passenger railcars fleet are all essentially similar in design to each other, with variants in design occurring between the individual "delivery series" railcars[30] as produced by the identified railcar manufacturer (e.g., "earlier" vs. "later" manufactured cars by Bombardier), as well as variants in design occurring between the two manufacturers that have supplied passenger railcars to Metrolink (e.g., cars manufactured by Bombardier vs. manufactured by Hyundai Rotem).

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[23] the company is formally identified as the Bombardier Transportation Corporation; ref, and for additional information, see [Internet] http://us.bombardier.com/us/contacts.htm#transport

[24] ref, and for additional information, see [Internet] http://www.bombardier.com/en/transportation/products-services/rail-vehicles/commuter-and-regional-trains/double-deck-coaches.html

[25] BiLevel was noted (in the Internet website of the company) as a Trademark of Bombardier Inc., or its subsidiaries.

[26] ref, Metrolink Matter newsletter; [article titled] "New Guardian Fleet Railcars Roll into Service!", dated Dec. 2010-Jan 2011; and for additional information, see [Internet] http://www.metrolinktrains.com/news/newsletters.

[27] the company is formally identified as the Hyundai Rotem Company; ref, and for additional information, see [Internet] http://www.rotem.co.kr/Eng/Company/HyundaiRotem.asp

[28] ref, and for additional information, see [Internet] https://www.hyundai- rotem.co.kr/Eng/Business/Rail/Business_Record_View.asp?brid=78

[29] ref, Metrolink Matter newsletter; [article titled] "Metrolink Unveils New Safety-Enhanced Rail Cars", dated Dec. 9, 2010; and for additional information, see [Internet] http://www.metrolinktrains.com/news/news_item/news_id/676.html.

[30] delivery series" refers to a procurement contract [documentation] reference, when the railcars were originally purchased from the identified manufacturer (Bombardier); e.g., "earlier manufactured" refers to "Contract 200" and "Contract 207" equipment as procured in 1992/93, and 1997/98, respectively, as compared to "later manufactured" refers to "Contract 214" equipment as procured in 2002.

Metrolink passenger cars have three levels (also referred to as "decks") of passenger seating, in which all levels are available for occupancy by revenue passengers. The individual levels are generically referred to as the 'lower level' deck, the 'intermediate level' (also referred to as the 'mezzanine level') located at opposite ends of the railcar, and the 'upper level' deck of the car. There are two stairwells provided in the multi-level railcar design[31], with the stairwells providing access between the individual deck levels. Four main (passenger ingress / egress) side-exits, pneumatically operated, two-leaf (panel) sliding pocket doors[32] are located on the 'lower level' deck of the railcar, with two sets of doors provided on each side of the railcar. A 'vestibule area' is provided between the main side-exit doors at each end of the 'lower level' deck. An 'emergency release handle' is provided adjacent to each main side-exit door, which (when activated) releases one of the (sliding pocket) door panels at each adjacent door location. A restroom is also located at one end of the 'lower level' deck. For coach cars, the 'intermediate level' of the railcar is provided with a door at each end bulkhead of the car, which allows passage (through a "diaphragm assembly"[33]) to an adjacent passenger car[34]. For cab cars, the 'intermediate level' of the railcar is provided with a door (and corresponding diaphragm assembly) at the B-end bulkhead of the car.

2.2.3 Passenger Seating

Generally described, passenger seating accommodations on board Metrolink coach cars consist of a combination of transverse and longitudinal mounted 'fixed seat' assemblies[35], with the seat assemblies provided on both sides of a longitudinally oriented center aisle passageway on all three deck levels. Almost all of the transverse mounted fixed seat assemblies are arranged in a (so-called) "2 + 2", paired / side-by-side configuration (also referred to as a 'paired seating sets' arrangement). Many of the paired seating sets are arranged in an opposing 'face-to-face' layout, with the balance of the paired seating sets arranged in a uni-directionally configuration (the paired seating sets are all facing in the same direction).

The 'fixed seat' assemblies fitted to the Bombardier supplied railcars are comprised of either a (molded) fiberglass seat-pan design or a (extruded) steel seat-pan design[36]. The seat assemblies employ an upholstered seat cushion insert and incorporate an upholstered headrest above the seatback, and also have either a 'rigid' (built-in) armrest between the seats, or have a movable armrest, which can be rotated, manually, to an upright location (between the two seatbacks).

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[31] The stairwells are located at approximately the ¼ point and the ¾ point along the length of the carbody.

[32] a 'pocket-door' is a door design wherein the door panel opens by sliding horizontally into a narrow compartment located within the wall adjacent to the doorway

[33] a diaphragm is a 'bellows-like' component, fitted to the exterior end bulkhead of a passenger railcar (around the perimeter of the bulkhead end-door) that, when mated against a similar 'diaphragm' assembly of an adjacent coupled railcar, forms a 'weather-seal', and provides an enclosure that allows passage between the two coupled railcars.

[34] except for coach cars at the aft-end of a train (in which case, the end door [which is facing the locomotive] is normally locked)

[35] a "fixed seat" is a passenger seat that is permanently configured in a given location, where it cannot otherwise be readily reconfigured (by operational or maintenance personnel) to face any other direction.

[36] the 'seat-pan' is essentially a one-piece component of the seat assembly, encompassing both the seat-back and the seat-bottom elements as a single unit, that functions essentially as the frame of the seat assembly, upon which the seat cushions, armrests, headrest, and (underside) leg assembly components are attached.

The 'fixed seat' assemblies fitted to the Hyundai Rotem supplied railcars are of either a "low back" design or a "high back" design, in which the high back design incorporates an "integrated headrest" that includes a "crash pad feature" that affords a degree of kinetic energy attenuation for the passenger's head in the event of a deceleration event. The technical specification[37] of the seats indicated that:

- "Seats in the cab car shall all be facing the B-end of the cab car, except for the Operator seat and work table locations[38]. Seats in trailer cars shall be distributed such that half the seats are facing the B-end of the trailer car."
- "[the design] shall comply with all aspects of 49 CFR 238 and APTA SS-C&S-016-99, Rev. 1.", and
- "[an] engineering design and ergonomic analysis shall be performed … on the proposed seat design arrangement and installation, [in which the] analysis shall demonstrate the application of compartmentalization concept for each seat type and orientation used."
- "Each seat within the passenger car that includes the transverse seat attachment to the side structure, seat boxes where used and all crew seating shall be constructed to comply with all aspects of 49 CFR 238.233 Interior Fittings and Surfaces and APTA SS-C&S-016-99, Rev.1."

2.2.4 Work-Station Tables Fitted to Passenger Cars

A number of Metrolink passenger railcars are fitted with "workstation" tables (also referred to in a manufacturer's technical manual as a "work table") that are located between certain paired seating sets of opposing passenger seats. The workstation tables are integrally configured with "energy absorbing" features to help ameliorate injury in the event of passenger impact (e.g., during a high-deceleration occurrence, such as a train-to-train collision).

For the Hyundai Rotem equipment procurement, the technical specification of the workstation table indicated that "[the design] shall comply with all aspects of 49 CFR 238.233 and be tested in conjunction with the seating per APTA SS-C&S-016-99, Rev. 1."[39]

A list of publications researched by the investigation, which address technical factors and considerations relative to kinetic energy attenuation attribute(s) of the energy absorbing feature(s) of the workstation tables, is provided in Exhibit 1.

[37] ref SCRRA Passenger Railcar Technical Specifications (for the Hyundai Rotem equipment procurement, dated 2005), Section 4 "Interior Arrangement, Features, And Appointments"; [specifically] § 4.7.4 Work Tables

[38] Although the technical specification was written for the cab cars to be fitted with work tables, SCRRA decided not to install the work tables in the cab cars, [which was] a decision based primarily on passenger safety in a collision/accident" (ref email from Metrolink Party to the Investigation representative, dated 8/11/2015)

[39] ref SCRRA Passenger Railcar Technical Specifications (for the Hyundai Rotem equipment procurement, dated 2005), Section 4 "Interior Arrangement, Features, And Appointments"; § 4.7.4 Work Tables

2.3 Passenger Railcar – General Arrangement and Specific Carbody Configurations

A brief technical description of the individual passenger railcars involved in the accident is as follows.

2.3.1 Cab Car / Coach - Number 645

a. Manufacturer / Procurement Transaction Data

The subject railcar was manufactured by Hyundai Rotem, as delivered under SCRRA "IFB NO. EP142-06" procurement transaction reference, which was executed in 2005, with railcar deliveries commencing in December 2010.

b. Configuration/Technical Specification

The Hyundai Rotem "cab car" is fitted with a "train operator's compartment" (also referred to in the manufacturer's technical manual as the "operator's control station"), located at the F-end of the car. The F-end end of the car is positioned at the lead-end of a train when the locomotive is placed at the aft (trailing) end of a train. Train control equipment located in the train operator's compartment is connected with the locomotive, which [when the train is operated with the cab car positioned at the leading end of the train] allows the train operator (Engineer) to control the operation of the train from the train operator's compartment. A cab car may also be utilized as a conventional coach car (in a situation where it's not being utilized as a cab car), in which the cab car could be placed in any location in the train consist between the locomotive and the operating cab car (as would be normally located at the lead-end of the train)[40].

Generally described, the overall carbody dimensions are 85.0 feet in length[41], about 9.54 feet in width, about 15.92 feet in height[42], and the car has a maximum empty weight of about 146,000 lbs, and a capacity of 128 passengers (fully seated, no standees). The railcar utilizes a pair of conventional passenger [service] truck-assemblies, each of which incorporate two pair of (33 inch wheel diameter) wheel-sets, and the car utilizes a pair of conventional AAR short shank Type H interlocking [railroad car] mechanical couplers.

As described in technical documentation of the equipment[43]:

- "The carbody structure:
  - is constructed as a welded structure, which includes the underframe, side structures, end structures, roof and skin sheathings …",

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[40] as a cab car does not have a door or a "diaphragm assembly" at the F-end bulkhead of the car, train occupants (in that cab car) would not be able to pass between the cab car and an adjacent railcar (coupled to that end of the car), and vice-versa.

[41] as measured between opposite [carbody] end 'coupler faces'.

[42] as measured from the top of rail to top of carbody roof.

[43] . ref [data source]: SCRRA, Cab Cars: 638 to 694 [and] Trailer Cars: 211 to 270, Maintenance and Overhaul Manual, (Rev 01, dated Sept. 2012), Chapter 2 – Carbody Structure And Exterior Appointments (©2012 SCRRA).

- "… is designed and configured to meet the design and performance requirements … within the SCRRA operating environment. The structure of each cab car and trailer car incorporates a crash energy management (CEM) system to dissipate kinetic energy during a collision. The CEM system provides a controlled deformation and collapse of designated carbody sections within unoccupied volumes of the car to absorb collision energy and to reduce the decelerations on passengers and crewmembers resulting from dynamic forces transmitted to occupied volumes." "The carbody is constructed as a welded structure, which includes the underframe, side structures, end structures, roof and skin sheathings …", and
- is constructed with LAHT ["low alloy high tensile" steel], AISI 301L [a grade of high tensile stainless steel], and SPA-H [Superior Atmospheric Corrosion Resistance Steel]."

▫ "The underframe structure is an integral unit that extends from one end of the car to the other", which:

- "consists of the "middle underframe" (comprised of side sills joined to the center sill by lateral cross beams and floor beams) and two "end underframes" (one at each end of the car), each comprised of a carbody bolster, fixed sill, sliding sill, and the end sill with the mechanical coupler support structure,
- the cab car end underframe also includes a transverse beam to facilitate collision and corner post bottom connections, in which the underframe at the non-cab end includes a transverse beam to connect and support the end partition wall and end beam, and
- is constructed primarily with LAHT, and SPA-H."

▫ "a fiberglass reinforced plastic (FRP) "mask" enclosure is fitted to the F-end of the cab car", which:

- "is secured to the carbody "end frame" structure, and covers the entire end of the car, including the CEM zones, except for the windshield [glass] panels, and
- the FRP sheathing material is equivalent (in strength) to a 0.5 inch thick steel plate with a 25,000 psi yield strength."

A 'general arrangement' illustration of the Hyundai Rotem - Double-deck, Cab car / coach car design is provided in Exhibit 2.

c. Crashworthiness Design – Technical Criteria

As described in technical documentation of the equipment[44]:

[44] ref [data source]: SCRRA, Cab Cars: 638 to 694 [and] Trailer Cars: 211 to 270, Maintenance and Overhaul Manual, (Rev 01, dated Sept. 2012), Chapter 2 – Carbody Structure And Exterior Appointments (©2012 SCRRA), and as cited otherwise.

- “Each cab car and trailer car is designed with a Crash Energy Management (CEM) system to dissipate kinetic energy during a collision, [which] provides a controlled deformation and collapse of designated carbody sections within unoccupied volumes of the car, to absorb energy and to reduce the deceleration of passengers and crewmembers resulting from dynamic forces transmitted to occupied volumes. Two crush zone designs are provided, [consisting of] a cab end crush zone (located at the F-end), and a non-cab end crush zone (located at cab car B-end, and [on] both ends of the trailer cars).”

  For the <u>cab end CEM structure</u>, “the principal energy absorption mechanism (PEAM) is provided by two “deformation tubes” and eight “PEAM tubes” which function as energy absorbers.”

  For the <u>non-cab end CEM structure</u>:

  - “the PEAM energy absorption is provided by eight energy absorbers, organized in three groups [comprised of] two pairs of deformation tubes, two collision post energy absorbers and two corner post energy absorbers.”,
  - “there are two collision post energy absorbers”, referred to also as “deformation tubes”, “located immediately behind the collision posts at the intermediate floor level.”, and
  - “there are two corner post energy absorbers located immediately behind the corner posts at the anti-telescoping plate/roof rail line … [which have] the same function as collision post energy absorbers.”

- “CEM [is defined as a] strategy for improved occupant survivability during a collision. Designs using this strategy include sacrificial crush zones at the ends of the cars and other unoccupied space.”[45]

- “The [carbody] end structure:
  - includes CEM structural elements and collision posts, as well as corner posts on the end of the carbody, in which the collision posts and corner posts on each end of the carbody are:
    - located at the end of the occupied volume, [in which the] CEM structural elements are housed between end partition wall and collision / corner post structure,
    - continuous from the bottom plate of the end underframe to their connection to the roof structure,
    - attached by welding to all structures through which they pass or contact, and
    - [constructed] of LAHT material.
  - connections of the [collision] posts, at their bottoms, develop the full shear value of the posts which they connect.”

[45] . ref [data source]: SCRRA … <u>Maintenance and Overhaul Manual</u>, Chapter 1 – Scope [of the Contract].

- "The [carbody] side structure:
  - incorporates side sheathings and side frames with side posts, door posts, longitudinal structural rails, longitudinal floor support members, doorframes, side sheet stiffeners and a cantrail,
  - … includes CEM interface structural elements at the non-cab end,
  - … is resistance spot-welded to form an integral part of the carbody structure, contributing to the strength and rigidity of the car,
  - [wherein the] … side frame members are required to provide adequate stiffness in carrying end compression loads, including principle energy absorption mechanism (PEAM) loads, and
  - is constructed completely of AISI 301L stainless steel."
- "push-back" mechanical couplers[46] are fitted to the car that provides kinetic energy attenuation, and [in the event of a derailment] facilitate keeping the cars upright and aligned with the track. An 'activation indicator' (informally referred to as a 'flag') is provided to the draft-gear to afford a visual indicator if the kinetic energy attenuation feature of the draft- gear had been engaged.

Research of the Hyundai Rotem passenger railcar CEM systems technology, identified that design attributes and technical considerations of the Hyundai Rotem CEM system was described in US Patent Number 7,900,565, [titled] "Passenger Rail Car".[47][48]

An illustration[49] describing the design configuration of the "Guardian fleet" type of Hyundai Rotem passenger railcar, which includes a description of the various CEM design elements employed in this car design, is provided in Exhibit 3.

A list of publications researched by the investigation, which address technical factors and considerations relative to CEM as applied to passenger railcar design, is provided in Exhibit 1.

d. Regulatory Compliance – Crashworthiness Design

Documentation of the SCRRA passenger railcar equipment procurement contract[50] for the Hyundai Rotem equipment indicated the following.

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[46] as a technicality, the kinetic energy attenuation mechanism of the "push-back" mechanical coupler is actually a feature that's incorporated into the "draft gear" element of the mechanical coupler system, as fitted to the railcar

[47] as issued to [inventor(s)] Raul V. Bravo, et al, assigned to Hyundai-Rotem Company, issue date: March 8, 2011

[48] ref (as sourced from), see [Internet] http://www.uspto.gov/

[49] 49. ref (as sourced from), see [Internet] http://www.metrolinktrains.com/agency/page/title/our_trains

[50] ref SCRRA [passenger railcar procurement contract #] "IFB NO. EP142-06", [dated] 2005

"3.1.2 Physical Requirements

The carbody shall be designed and constructed in full compliance with the Technical Specification along with any and all applicable FRA Regulations, AAR Standards and APTA Standards and Recommended Practices, including but not limited to: 49 CFR 238 Passenger Equipment Safety Standards; APTA SS-C&S-034-99, Rev. 1 Standard for the Design and Construction of Passenger Railroad Rolling Stock; 49 CFR 223 Safety Glazing Standards – Passenger Cars; 49 CFR 239 Passenger Train Emergency Preparedness.

In addition, cab cars and trailer cars shall incorporate CEM [Crash Energy Management] as required by Section 3.10 [of the contract specification]."

Review of "Section 3.10 Approach" of the contract specification indicated that it addresses the technical details of the CEM design criteria as employed in the Hyundai Rotem passenger railcars, which, in Section 3.10.3., further cited that the "CEM requirements for this Specification are based on the results of FRA research to date, and are consistent with CEM requirements and recommendations [of the voluntary standards] in APTA SS-C&S-034-99, Rev. 1 and [the applicable Regulation in] 49 CFR 238 … [and that] … [for] this procurement, cab cars and trailer cars shall be designed with the full set of required CEM functions".

2.3.2 Coach Car - Number 206[51]

a. Manufacturer/Procurement Transaction Data

The subject railcar was manufactured by Bombardier, as delivered under SCRRA "Contract 214" procurement transaction reference[52], which was executed in 1999, with railcar deliveries completed in 2002.

b. Configuration / Technical Specification[53]

Generally described, the overall carbody dimensions are 85.0 feet in length[54], about 9.83 feet in width, about 15.92 feet in height[55], and the car has an empty weight of about 115,777 lbs, and a capacity of 143 passengers. The railcar utilizes a pair of conventional passenger [service] truck- assemblies, each of which incorporate two pair of (33 inch wheel diameter) wheel-sets, and the car utilizes a pair of conventional AAR short shank Type H interlocking [railroad car] mechanical couplers, as fitted to conventional "single cushion" draft gear.

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[51] as this particular railcar type was researched during a prior NTSB investigation, as a replication of prior data supplied by Metrolink, data in this report section was sourced (reproduced) from the Crashworthiness Group Chairman's Factual Report of the NTSB Investigation, Chatsworth, California, Metrolink [SCRRA] Accident that occurred September 12, 2008, report dated Feb. 20, 2009 (as available in the NTSB public docket; ref, and for additional information, see [Internet] http://www.ntsb.gov/investigations/AccidentReports/Pages/RAR1001.aspx)

[52] . ref. [SCRRA] Contract Agreement No. EP100 for Trailer and Cab Control Commuter Rail Vehicles for Rail Passenger Service Between SCRRA and Bombardier Transit Corporation, Conformed Contract, Issued November 17, 1999, which is also referred to as the "Contract 214" by Bombardier.

[53] ref Crashworthiness Group Chairman's Factual Report of the NTSB Investigation, Chatsworth, CA (see above)

[54] as measured between opposite [carbody] end 'coupler faces'.

[55] as measured from the top of rail to top of carbody roof

The carbody is a "semi-monocoque construction" that is constructed principally of aluminum alloy extrusions and formed shapes, with welded steel sub-assembly components used for certain 'load-bearing' structural elements of the railcar. The carbody also incorporates a 'non-linear structural steel centersill element' as its principal longitudinal / load-bearing structural support component (as further described in this report; see § 2.3.2.c.), and an aluminum alloy superstructure, in which also the exterior 'skin' of the roof, sidewalls, and (exterior) end-structure panels are aluminum sheet metal. The end-structure assembly (also referred to as the 'end bulkhead' of the railcar) is fabricated principally of welded steel sub-assembly components, which also incorporates a pair of 'collision post' and 'corner post' elements.

A 'general arrangement' illustration of the Bombardier Bi-level coach car design is provided in Exhibit 4.

c. Crashworthiness Design – Technical Criteria[56]

Bombardier Bi-Level Coach railcars incorporate a 'non-linear structural steel centersill element' (under-frame weldment)[57] that is manufactured from a "low alloy high tensile" (LAHT) steel. The structural steel centersill element also bears a significant structural load-bearing function in the overall carbody structure. Coach cars manufactured by Bombardier under the SCRRA "Contract 214" procurement transaction reference employed a "welded" carbody side-panel assembly construction (as compared to a "riveted" [mechanical fastener] side-panel construction, as utilized in the railcar procurement previous to this welded design), and also incorporated steel corner post elements.

d. Industry Standard Compliance – Crashworthiness Design

As identified in a prior NTSB investigation involving Metrolink passenger railcar equipment of this particular design[58], review of SCRRA passenger railcar equipment procurement contract documentation identified language that indicated the subject railcar equipment was compliant with the pertinent industry standard[59] as applicable to the subject railcar [equipment] at the time of manufacture[60], the descriptive narrative (excerpt of which) is reproduced as follows.

[56] ref Crashworthiness Group Chairman's Factual Report of the NTSB Investigation, Chatsworth, CA (see above)
[57] the 'non-linear structural steel centersill element', in the area were the longitudinal-horizontal plane of the component changes elevation, is informally characterized as the 'gooseneck' feature of the centersill (as portrayed by its generalized shape in that area).
[58] ref Crashworthiness Group Chairman's Factual Report of the NTSB Investigation, Chatsworth, CA (see above)
[59] ref AAR Manual of Standards and Practices, Part C (revision date 1984), specific to the applicable subsection therein: AAR Standard S-034-69 "Specifications of the Construction of New Passenger Equipment Cars
[60] as cited in 49 CFR Part 238 Subpart C, regulatory requirements became effective for "… passenger equipment ordered on or after September 8, 2000 or placed in service for the first time on or after September 9, 2002".

Review of 1999 procurement documentation[61], as supplied to the investigation by SCRRA, for a group of Bi-Level railcars purchased, which was comprised of railcar equipment that incorporated the new 'welded' carbody side-panel assembly design (which succeeded the 'riveted' carbody side-panel design of prior [Contract 200 and Contract 207] purchases), indicates, in reference to the carbody structural framing requirements, "…The car structural design has been demonstrated to satisfy the requirements of the AAR Manual of Standards and Practices, Part C, for Passenger Cars, and for FRA 49 CFR 229.141(a), Non-M.U. control cab locomotives in a train of more than 600,000 lb. empty weight. The structure is assembled by welding and mechanical fastening using industry accepted techniques".

As a consideration, the above reference to the "…'welded' carbody side-panel assembly design" refers to the SCRRA "Contract 214" procurement transaction, which included the subject railcar.

2.3.3 Coach Cars - Number 211 and 263[62]

a. Manufacturer / Procurement Transaction Data

The subject railcars were manufactured by Hyundai Rotem, as delivered under SCRRA "IFB NO. EP142-06" procurement transaction reference, which was executed in 2005, with railcar deliveries commencing in December 2010.

b. Configuration / Technical Specification

The Hyundai Rotem coach railcar design is essentially identical to the cab car design (i.e., three separate 'passenger compartment' levels that are occupied by revenue passengers; see § 2.3.1.b), except that the coach car is not fitted with a train operator's compartment located at the lead-end of the car, in which the floor plan configuration of the lead-end of the car is symmetric to the opposite end ("B-end") of the car. The overall carbody dimensions (length/width/height), running gear (i.e., truck-assemblies, wheel-sets,) and mechanical couplers of the car are identical to the cab car design, in which this railcar [configuration] has a maximum empty weight of about 140,000 lbs, and a capacity of 132 passengers (fully seated, no standees).

A 'general arrangement' illustration of the Hyundai Rotem - Double-deck, Cab car / coach car design is provided in Exhibit 2.

c. Crashworthiness Design – Technical Criteria

The Hyundai Rotem coach railcar design is essentially identical to the cab car design, in which the coach railcar design commensurately incorporates the CEM design attributes / features as described for the "non-cab end" of the cab car design (see § 2.3.1.c).

d. Regulatory Compliance – Crashworthiness Design

[61] both these railcars were of an identical design and were built by the same manufacturer.

[62] ref. [SCRRA] Contract Agreement No. EP100 for Trailer and Cab Control Commuter Rail Vehicles for Rail Passenger Service Between SCRRA and Bombardier Transit Corporation, Conformed Contract, Issued November 17, 1999, which is also referred to as the "Contract 214" by Bombardier.

The regulatory compliance provisions of these railcars are the same as prescribed for the Hyundai Rotem cab cars (see § 2.3.1.d).

2.4 Locomotive Number 870 – General Arrangement/Configuration

Generally described, this is a four-axle, diesel-electric locomotive, having the model designation F-59PH, which was manufactured in 1993 by the Electro-Motive Division (EMD) of the General Motors Corporation[63]. The overall dimensions of the unit are 58.2 feet in length[64], about 10.5 feet in width, about 15.8 feet in height[65], has an operating weight of about 270,000 lbs. Operation of the unit can be controlled from the cab of this locomotive, or controlled remotely from the cab car of the train.

2.5 Passenger Railcar Crashworthiness Specifications

Passenger railcars operating in U.S. revenue service are generally manufactured in compliance with either regulatory requirements, or "Industry Standards", which are summarized as follows.

2.5.1 Regulation (49 CFR Part 238 Subpart C)[66]

Regulation prescribed in 49 CFR Part 238 Passenger Equipment Safety Standards, Subpart C - Specific Requirements for Tier I Passenger Equipment[67] was applicable to the passenger railcar equipment as operated in the Metrolink system, with the exception of one railcar (see § 2.3.2.d), which includes technical criteria of the railcar design that address the following.

49 CFR 238.203	Static end strength
49 CFR 238.205	Anti-climbing mechanism
49 CFR 238.207	Link between coupling mechanism and car body
49 CFR 238.209	Forward end structure of locomotives, including cab cars and MU Locomotives
49 CFR 238.211	Collision posts
49 CFR 238.213	Corner posts
49 CFR 238.215	Rollover strength
49 CFR 238.217	Side Structure
49 CFR 238.219	Truck-to-car-body attachment

The Part 238 Regulation includes a provision that passenger railcars may utilize an "Alternative compliance"[68] design, which prescribes that the equipment is deemed compliant with applicable sections of the Regulation, providing that an "engineering analysis" demonstrates that "… the equipment provides at least an equivalent level of safety in such environment with respect to the protection of its occupants from serious injury in the case of a derailment or collision.".

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[63] the company is now a Division of Caterpillar, Inc.

[64] as measured between opposite [carbody] end 'coupler faces'

[65] as measured from the top of rail to top of carbody roof.

[66] Final Rule [of the] "Passenger Equipment Safety Standards", published in the Federal Register on May 12, 1999.

[67] basically described, Tier I operation applies to passenger trains that operate "at speeds not exceeding 125 mph"

[68] ref 49 CFR 238.201(b) Alternative Compliance

2.5.2 Industry Standards (Voluntary)

A document entitled, “APTA Manual of Standards and Recommended Practices for Rail Passenger Equipment”, first published by the American Public Transportation Association (APTA) in 1998, and includes the standard that is utilized by commuter railroad operators, titled “APTA SS-C&S-034-99, Rev. 1 Standard for the Design and Construction of Passenger Railroad Rolling Stock”

2.6 Emergency Information and Safety Equipment / Features Fitted to the Railcars

As required under 49 CFR Part 239.101, the following emergency equipment / features, and passenger safety information was observed provided in the railcars.[69][70]

Item	Quantity	Location (normally situated)
Evacuation Instructions (placard)		one at each end of the car
Emergency Egress / Access (‘Pull’) Window		2 on each side of the car
Emergency Pull Window Instructions (decal)		1/each emergency pull window location; 2 on each side of the car
Manual Door Release, Interior	1 / door; 4 total / car	at each side door
Manual Door Release, Exterior	1 / door; 4 total / car	at each side door
Fire Department access decal	1 / door; 4 total / car	at each side door
Fire Extinguisher	1 / car	emergency tool compartment
Pry bar	1 / car	emergency tool compartment
First aid kit	1 / car	emergency tool compartment
Flashlight (handheld)	1 / car	emergency tool compartment

Supplementary to the above, additional equipment / features, specific to Metrolink operations, were provided in the cars, as follows.

Item	Quantity	Location (normally located)
Handsaw	1 / car	emergency tool compartment
Axe	1 / car	emergency tool compartment
8-pound sledge hammer	1 / car	emergency tool compartment

2.7 Other Factors / Considerations Reviewed in the Crashworthiness Investigation

[69] ref. MNR Emergency Preparedness Plan, dated [transmittal correspondence to FRA] May 2012.

[70] the investigation observed that the railcars maintained certain emergency equipment [cited in the list] that exceeded the requirement of the Regulation; e.g., fire extinguishers – 1 required, 4 provided, flashlight – 1 required per car, 1 carried by each crewmember.

2.7.1 Safety of 'Push-Pull' Passenger Rail Operations

A list of publications researched by the investigation, which address technical factors and considerations relative to safety of 'push-pull' passenger rail operations, is provided in Exhibit 1.

2.7.2 Seatbelt Usage in Passenger Rail Operations

A list of publications researched by the investigation, which address technical factors and considerations relative to seatbelt usage in passenger rail operations, is provided in Exhibit 1.

3.0 Pre-recovery – Site/Vehicle Examination

Pursuant to investigation on-scene evidentiary artifact characterization procedures, a detailed examination and documentation process normally is conducted of the trackage and railroad right- of-way, and railroad equipment involved in the accident, before it is disturbed by wreckage recovery/site cleanup operations.

In this investigation, Crashworthiness investigative staff arrived at the accident scene after the railroad equipment and track-bed surfaces were significantly disturbed (as a result of wreckage recovery/site cleanup operations)[71], which commensurately preempted conducting a first-hand, pre-recovery examination of the corresponding undisturbed accident site and/or railroad equipment evidentiary artifacts. However, the undisturbed accident site and railroad equipment was documented, to a reasonable degree of precision and accuracy, by other NTSB on-scene personnel, local law enforcement, Federal Railroad Administration (FRA) personnel, and the railroad operator, in which this data[72] was subsequently made available to the Crashworthiness investigation. This data transmittal subsequently accommodated a reasonably detailed reconstructive characterization of the undisturbed accident site and railroad equipment by the Crashworthiness investigation, which is summarized as follows.

Select images of pre-recovery photo-documentation, as made available to, and utilized by the investigation, may be forthcoming as separate Crashworthiness, and/or other Technical Working Group, factual report documentation.

3.1 Documentation Compiled of Wreckage Distribution (Site Survey Map)

An aerial photograph image, titled "Derailment of Metrolink Train, S. Rice Ave and Hwy 134 [see Note][73] (E. Fifth Street), Oxnard, California, February 24, 2015", dated "03/05/2015", was prepared by "Rail Surveyors & Engineers, Inc." (a technical contractor to the SCRRA), to document the accident site prior to wreckage removal. The document, prepared to a [horizontal] scale of 1 inch = 40 feet and labeled accordingly to describe the key elements of the overall accident site (including wreckage distribution), includes (as reference datum) the longitudinal [north/south] centerline of the grade crossing pavement and the longitudinal [west/east] railroad the track centerline. The document was made available by the SCRRA to

[71] The Crashworthiness Technical Working Group Chairperson arrived at the accident site ~ 13 hours after the accident occurred.

[72] Consisting of ground-based and aerial photographs, and a scaled aerial photographic image; see § 3.1.

[73] Note – although the document was titled "… Highway 134 …," review of local maps indicated that the identified roadway designation was Highway 34, and not Highway 134.

support the NTSB investigative effort[74], which effectively functioned as a "site survey map". A copy of the document is anticipated to be available in the NTSB public docket.

3.2 Site Characterization

Visual examination[75] of the rails and track structure, trackage right-of-way, grade crossing pavement, and ground (soil surface) areas adjacent to the track, identified the following evidentiary artifact characteristics.[76]

Utilization of the aerial photograph image (as made available to the investigation; see § 3.1)[77], which describes the locational coordinates of the various vehicle / topographical features and characteristics of the site, will facilitate an interpretation of the following site characterizations.

See Railroad Operations Group Factual report for additional information detail.

3.2.1 Point of Collision

Evidentiary artifacts were identified to the investigation (e.g., spilled vehicle fluids and vehicle component debris resting on the ground), which were consistent with the approximate point of collision, which were located about 130 feet to the west of the South Rice Avenue grade crossing centerline (which was also about 80 feet to the west of the grade crossing pavement curb line).

3.2.2 Point of Derailment

Evidentiary artifact markings, consistent with a derailment, comprised of railroad wheel flange marks that were located on the ball (top surface) of the running rail, were observed by NTSB field investigation personnel[78], about 105 feet to the west of the South Rice Avenue grade crossing centerline (which was also about 55 feet to the west of the grade crossing pavement curb line).

3.2.3 Disturbed Trackage Right-of-Way Infrastructure/Adjacent Ground Areas

- Between the identified point of derailment and the western edge of the South Rice Avenue grade crossing pavement curb line, striation indentation marks, which were consistent with contact markings of railroad wheel flanges, were visibly apparent on the top surfaces of the crossties.

- Commencing at the western edge, and extending to the eastern edge of the South Rice

[74] As utilized by the Crashworthiness investigation; see narrative in § 3.0.
[75] Note – the evidentiary observation cited is based upon a visual inspection only, and is not based upon any scientifically-sourced characterization (utilizing instrumentation or testing), or subject matter expert consultation.
[76] The longitudinal [west/east] trackage centerline datum, and the longitudinal [north/south] centerline of the highway-rail at-grade crossing, were arbitrarily selected as Cartesian reference coordinates to describe the locations of the railroad equipment
[77] Ref, the aerial photograph image supplied to the investigation, [titled] "Derailment of Metrolink Train, …, Oxnard, California, February 24, 2015", dated "03/05/2015", as prepared by "Rail Surveyors & Engineers, Inc."
[78] Observations made at the onset of the on-scene investigation, by the Chairperson of the Railroad Operations Group.

Avenue grade crossing pavement curb line, striation indentation marks, which were consistent with contact markings of railroad wheel flanges, were visibly apparent on the concrete surface of the grade crossing pavement, in an orientation that very closely paralleled the location of the running rails (that were imbedded in the grade crossing pavement surface).

- East of the South Rice Avenue grade crossing pavement, two distinctively characteristic sets of ground scaring / striation marks were observed, consisting of two parallel furrows that had "plowed" (i.e., that been pushed or dragged) through the soil[79], which measured about 4.7 feet between centers and about one foot or more in depth, in the following locations:

  a. Commencing at the eastern edge of the South Rice Avenue grade crossing pavement curb line, at a location that was centered substantially coincident with the track centerline, the soil surface exhibited a distinct set of parallel furrows, that:

     - progressed in an easterly direction, which also commensurately curved in a slightly northeasterly direction as the easterly progression as the furrows continued (i.e., the furrows were skewing, in a curved motion, away from the track centerline), where the furrows advanced through the soil surface to an area that was about 370 feet to the east of the South Rice Avenue grade crossing centerline, and about 65 feet to the north of railroad track centerline,

     - at which point the furrows then abruptly changed direction, and progressed in a slightly curving southeast direction, toward the track centerline, where the furrows advanced through the soil surface to an area that was about 350 feet to the east of the South Rice Avenue grade crossing centerline and about 50 feet to the north of the track centerline, at which point the furrows terminated at the western-most [cab] end of overturned cab car # 645.

  b. Commencing at an area about 250 feet to the east of South Rice Avenue grade crossing centerline (i.e., at a location that was about in the middle of the footprint where the locomotive was located), at a location that was centered substantially coincident with the track centerline, the soil surface exhibited a distinct set of parallel furrows, that:

     - progressed in an easterly direction, which also commensurately curved in a slightly southeasterly direction as the easterly progression of the furrows continued (i.e., the furrows were skewing, in a curved motion, away from the track centerline),

     - where the furrows advanced through the soil surface to an area that was about 450 feet to the east of the South Rice Avenue grade crossing centerline, and about 70 feet to the south of the track centerline, in which the furrows also extended onto the roadway pavement of East Fifth Street, at which point the furrows terminated at the western-most [A-] end of overturned coach car # 206.

[79] in the context of the accident environment, the identified furrows were characteristics that appeared consistent with the soil having been in contact with the wheels of a derailed railcar (which measure about 4.7 feet between flanges), as it moved forward through the soil, until coming to rest

- a segment of the metal balustrade fence, located to the east of the South Rice Avenue pavement (i.e., on / close to the northern boundary of the railroad right-of-way; see § 1.4.3), commencing at a point about 60 feet east of the South Rice Avenue pavement curb line, and measuring about 117 feet in length, was missing, in which the location of this missing fence segment coincided with the distinct set of parallel furrows that advanced through the soil surface (that commenced at the eastern edge of the South Rice Avenue grade crossing pavement curb line, as described above).

3.2.4 Railroad Wreckage Distribution (Debris Field)

The accident occurred (i.e., the evidence supports that the collision initiated) about 80 feet to the west of the pavement curb line of the South Rice Avenue grade crossing. The distance between the western-most pavement curb line and the [north/south] centerline of the grade crossing was about 50 feet. The eastern-most location where derailed railroad equipment came to rest was approximately 500 feet to the east of the centerline of the South Rice Avenue grade crossing. Accordingly, given the above dimensions, the accident site encompassed a total linear distance [as measured west to east] of approximately 630 feet.

The wreckage of the derailed train, upon coming to rest in what's referred to as a 'debris field', was distributed:

- longitudinally [as measured west to east], over a total distance of about 270 feet, which:
  - initiated at a point about 230 feet to the east of South Rice Avenue grade crossing centerline (i.e., the point where the western-most [cab] end of the locomotive came to rest), and
  - extended eastward to, and terminated at a point about 500 feet to the east of the grade crossing centerline (i.e., the point where the eastern-most end of coach car # 206 came to rest).

- laterally [as measured north to south], over a total distance of about 130 feet, which:
  - initiated at a point about 55 feet to the north of the track centerline (i.e., the point where the northern-most end of overturned coach car # 645 came to rest), and
  - extended southward to a point about 75 feet to the south of the track centerline (i.e., the point where the southern-most end of overturned coach car # 206 came to rest).

3.3 Railroad Vehicles

All truck assemblies remained secured to the respective railcar carbody/locomotive structures. Note – all directional references [left / right / front / rear] below are relative to the normal forward direction of travel of the identified railroad equipment.

3.3.1 Cab Car / Coach # 645

This was the lead railcar of the train, which was also configured as a Cab Car, in which:

- the car was operating in an F-end forward orientation,
- the car derailed, was disconnected (uncoupled) from the succeeding railcar, and came to rest on its right sidewall panel,

- the eastern-most end of the car was located about 440 feet to the east of the centerline of the highway-rail at-grade crossing, and about 30 feet to the north of the track centerline datum,
- the carbody had rotated counterclockwise (relative to its normal orientation, when viewed from above), in which the lead (F-end) of the carbody was oriented rearward, about 170 degrees, relative to the track centerline datum,
- the aft-end, lower side-sill of the carbody, came to rest in contact with the roof panel of the overturned 3rd railcar of the train consist (SCAX 211),
- a quantity of displaced soil was accumulated at the eastern-most end of the carbody, the location and characteristics of which were consistent with the carbody having slid along the ground at that location.
- the ground surface exhibited distinct impact scaring and contact striation marks, leading up to the western-most end of the carbody, the location and characteristics of which were consistent with the carbody having slid along the ground at that location.

3.3.2 Coach Car # 206

This was the second railcar of the train, in which:

- the car was operating in a A-end forward orientation,
- the car derailed, was disconnected (uncoupled) from the preceding and succeeding railcar, and came to rest on its left sidewall panel,
- the carbody had rotated clockwise (relative to its normal orientation, when viewed from above), in which the leading (A-) end of the carbody was oriented principally southward, where the carbody had rotated about 110 degrees, relative to the track centerline datum,
- the leading (A-) end of the car came to rest on the right side of the westbound lane of the roadway pavement (East Fifth Street), and the trailing (B-) end of the car came to rest on the track (top surface of the rails).
- the coupler heads of both the A-end, and the B-end, mechanical couplers that were fitted to the car, were observed to have fractured at the "head-to-shank transition", and had separated from the shanks of the respective couplers, wherein the subject coupler elements were removed (as prospective evidentiary artifacts) and transported to the secure railroad storage facility[80] for potential further examination (see § 4.3).

3.3.3 Coach Car # 211

This was the third railcar of the train, in which:

- the car was operating in a A-end forward orientation,
- the car derailed, was disconnected (uncoupled) from the preceding and succeeding railcar, and came to rest on its left sidewall panel,

[80] the Metrolink railcar storage yard, in Moorpark, CA.

- the carbody had rotated counterclockwise (relative to its normal orientation, when viewed from above), in which the lead (A-end) of the carbody was oriented principally eastward, where the carbody had rotated about 10 degrees, relative to the track centerline datum,

- the A-end mechanical coupler that was fitted to car #211 was observed to have sustained a broken coupler. This break was not in the shank. The coupler had separation at the vertical pin coupler boss, wherein the subject coupler elements were removed (as prospective evidentiary artifacts) and transported to the secure railroad storage facility[81] for potential further examination (see § 4.3).

3.3.4 Coach Car # 263

This was the fourth railcar of the train, in which:

- the car was operating in a A-end forward orientation,
- the car derailed, was disconnected (uncoupled) from the preceding railcar, but remained coupled to the locomotive (at its trailing end), and came to rest upright and substantially aligned with the track centerline datum.

3.3.5 Locomotive # 870

This was the locomotive [at the trailing-end] of the train, in which:

- the unit was operating in a F-end trailing orientation (cab facing to the rear),
- the unit derailed; it remained upright and closely aligned with the railroad track centerline
- the eastern-most end of the unit was located about 290 feet to the east of the grade crossing centerline,
- the leading end of this unit remained coupled to, and was wedged against the trailing end of the railcar preceding this unit (car # 263).

3.4 Highway Vehicles

See Vehicle Factors Group Chairman's Factual Report for additional information detail on the vehicles.

3.4.1 Truck and Trailer Combination

Both elements of this vehicle sustained catastrophic collision damage, in which the utility truck had separated from the utility trailer during the collision event. Wreckage of the utility truck came to rest about 130 feet to the east of grade crossing centerline, and about five feet to the south of the track centerline datum (i.e., utility truck wreckage was located immediately adjacent to the southern edge of the railroad track). Wreckage of the utility trailer came to rest in the northbound lanes of, and on the southern shoulder of, the grade crossing pavement, and about 20 feet to the south of the track centerline datum, which was also burning upon arrival of first responders [Police / Fire Department] at the accident scene. The vehicle driver was not in the vicinity of the vehicle at the time of the collision.

[81] Ibid

3.4.2 Automobile

This vehicle, which apparently did not move during the collision event, was apparently struck by wreckage debris that had separated from the Truck and Trailer Combination vehicle, and sustained minor damage. The vehicle driver was not reported as injured.

4.0 Post- recovery – Vehicle Examination

Pursuant to investigation evidentiary artifact characterization procedures, a detailed examination and documentation is normally conducted on the vehicles subsequent to recovery from the accident site, in which the collected data augments the on-scene (pre-recovery) evidentiary artifact characterization process.

Note – all directional references [left / right / front / rear] below are relative to the normal forward direction of travel of the identified railroad equipment.

4.1 Railroad Equipment

A detailed examination of the railcars of the accident train was conducted by the Crashworthiness Technical Working Group of the investigation[82], the damage of which was documented and is summarized as follows.

As a general observation, although the towed highway trailer (that was struck by the train) sustained extensive fire damage, none of the passenger railcars or the locomotive displayed visible evidence of fire damage.

Supplemental to the post-recovery equipment examination (as conducted by the Crashworthiness Technical Working Group, described below), an additional post-recovery examination, utilizing three-dimensional (3D) laser scanner equipment[83], was conducted by the 3D Laser Scanning Technical Working Group, the report of which is available in the NTSB public docket.

Select images of the post-recovery photo-documentation process, as utilized in the investigation, may be forthcoming as separate Crashworthiness factual report documentation.

4.1.1 Cab Car / Coach # 645

Generally described, the overall carbody was structurally intact and without breached openings of the bulkheads (end-panels) or sidewall panels, with the interior fittings / features generally intact and secured in place. Details of the examination are as follows.

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[82] The inspection was conducted on Feb. 27, 2015, the site of which was a secure Metrolink railcar storage yard, located adjacent to the UPRC mainline track, in Moorpark, CA.

[83] 3D laser scanner equipment is capable of capturing dimensional data and equipment configuration detail to a far greater degree of precision and accuracy than is possible utilizing manually recording techniques, as utilized by the Crashworthiness Technical Working Group in this post-recovery equipment examination activity.

a. Exterior

- no visible damage to roof panel.
- battery compartment:
  - visible soil on compartment door, with a substantial accumulation of soil found inside the compartment,
  - (upon clearing of soil accumulation) left-most cell was lifted slightly, other cells in place,
  - all cables intact, and terminals without damage (i.e., no grounding to cabinet).
- F-end bulkhead end-panel / FRP end-panel "mask":
  - obvious impact / batter damage to F-end right corner edge elements, with the damage extending to the right side panel, which was consistent with sliding contact of the carbody sidewall with the ground,
  - obvious imprint (indentation), about 89 inches above top of rail, apparent on left side,
  - pilot snowplow blade and entire arrangement missing,
  - mechanical coupler was encrusted with soil,
  - "auto train stop" bracket missing,
  - electrical connector fitting pushed in an aft direction,
  - right headlight lamp (bulb) missing,
  - step-stirrup displaced [pushed] in a rearward direction,
  - entire right side corner encrusted with soil,
  - battery switch box damaged,
  - both windshield window panels were intact (undamaged).
- right carbody sidewall panel:
  - in conjunction with the above batter damage (F-end front bulkhead FRP "mask" panel), a distinct pattern of obvious, somewhat horizontally oriented, striations / abrasion scuff marks were visible, with the marks extending toward the B-end of the car, which became somewhat horizontally oriented approaching the B-end, which was consistent with sliding contact of the carbody sidewall with the ground,
  - somewhat vertically oriented imprints / creases (indentations) observed about 11½ feet from the B-end corner (i.e., at the louver panel), and again about 16½ to 17½ feet from the B-end corner, which were consistent with sliding contact of the carbody sidewall with ground surfaces or contact with other objects,
  - #5 door panel pushed in, #3 and #7 door panels separated from door track with the steps displaced [bent] upward.
- right carbody sidewall windows:
  - the two side window panels at the F-end of the carbody (which were also the side windows of the train operator's compartment), were missing,
  - a number of the remaining side window panels were missing the outer pane of glass, in which the inner glass pane remained intact, although some of the panes were cracked / displaced [pushed] inward (i.e., all of these damaged windows, even though the outer glass pane was compromised, were not fully breached).
- left carbody sidewall panel:
  - left / rear corner bottom sill displayed obvious contact damage,
  - otherwise the entire length of the sidewall panel was intact and without apparent damage,
  - all windows remained intact (one window apparently "pulled"; see Interior notations),

- front / left - emergency door release, pull-handle ‘pulled’.

▪ B-end bulkhead panel:

- right corner edge was encrusted with soil full length (top to bottom),
- left corner bottom sill impact damage,
- right rear stirrup bent.

▪ visual inspection of the “push-back” mechanical coupler draft-gear ‘activation indicator’ flags indicated that both the A-end, and the B-end, had “not triggered”.

b. Interior

▪ visual inspection of the 3 levels of the car identified:

- ‘lower level’ – window at seat #88 ‘pulled’, window at seat #88 pushed inward with stones (ballast) on floor, window at seat # 114 was pulled inward, otherwise seats were without visible damage,
- restroom – door wedged open about 1 foot, the remaining areas were observed to be otherwise without damage,
- ‘intermediate level / F-end’ – staircase had a wall panel on left side fractured and a ceiling panel above staircase fractured, valance panel on right side dislodged, otherwise seats were without visible damage,
- ‘upper level’ – F-end valance panel dislodged, ceiling panel above staircase fractured, at mid-car area a fractured light fixture above seat 32/33, boot prints on right wall panel, at B-end dislodged light fixture cover panel above seat 72, apparent right sidewall inward deformation about 1-2 inches, ceiling panel at stanchion post fractured, window at door to train operator’s compartment missing, otherwise seats were without visible damage,
- ‘intermediate level / B-end’ – stairway down; crease in left frame element, lower sideframe structure bent, ceiling panel near stairway fractured, boot prints on right wall panel, otherwise seats were without visible damage, at stairway down the left sidewall panel was visually displaced about 1 inch, ceiling panel “squeezed” / bowing slightly.

▪ train operator’s compartment (‘intermediate level / F-end’):

- right window missing,
- first aid kit was wedged against the windshield,
- top panel on dashboard dislodged,
- the remaining areas were observed to be otherwise without damage.

c. CEM structural components

▪ F-end – visual inspection[84] of the CEM structural elements, collision post elements, and corner post elements indicated that the components did not appear to display indications of having been in contact with any other structural elements in that area of the car (i.e., the damage sustained to the F-end bulkhead end-panel of the carbody did not protrude beyond the FRP end-panel “mask”, which is consistent with, and supports that the CEM structure, collision post, or corner post elements had not engaged or were compromised in the event).

[84] an access door is provided on the ‘intermediate (mezzanine) level’ of the car, at the end bulkhead panel, that allows a visual inspection of the CEM components and related structural elements at the F-end of the car

- B-end – the exterior bulkhead panel did not sustain significant, visibly apparent damage, which is consistent with, and supports that the CEM components located within that wall panel had not engaged or were compromised during the event.[85]

4.1.2 Coach Car # 206

Generally described, the overall carbody was structurally intact and without breached openings of the bulkheads (end-panels) or sidewall panels, with the interior fittings / features generally intact and secured in place. Details of the examination are as follows.

a. Exterior

- no visible damage to roof panel.
- battery compartments (two provided to this car):
  - right side: cover panel latches deformed (requiring a forced-opening, upon which) batteries observed to be secured in place without damage,
  - left side: obvious impact damage - battery 'box' missing.
- at the A-end left side corner of the carbody and extending to the A-end bulkhead panel, the fiberglass fascia panel was missing ('torn-off'), which was consistent with impact damage.
- on the B-end left side carbody sidewall panel surface, a distinct pattern of obvious vertically oriented striations / abrasion scuff marks was visible, which was consistent with sliding contact of the carbody sidewall with the rail elements.
- a window panel (including grommet), at the location of (above described) vertically oriented striations / abrasion scuff marks on the B-end left side carbody sidewall panel, was shattered.
- the mechanical coupler elements (both A-, and B-end) of this car, having been securely transported from the accident site, had been placed in secure storage at this location[86] (as prospective evidentiary artifacts), in which an *action plan* for the further evaluation of the coupler elements was identified, and initiated, by the investigation as further described in this report (see § 4.3).

[85] Confirmation that the CEM structure, collision post, or corner post elements were not compromised can only be attained by an inspection of same, which would involve a disassembly of the wall panel, which could not be performed during the on-scene phase of the investigation, which would also be beyond the scope of the investigation, as the lack of physical damage to the wall obviated the need to examine the CEM components further.

[86] the Metrolink railcar storage yard, in Moorpark, CA.

b. Interior

- visual inspection of the 3 levels of the car identified:
  - 'lower level' – bridge on floor with securement strap in place, window grommet found at seat #136, boot prints observed on wall panels, otherwise seats were without visible damage,
  - restroom – appears undamaged,
  - 'intermediate level / A-end' – stairway up appears undamaged, A-end mezzanine window inside car with grommet in place, trashcan lid on floor, otherwise seats were without visible damage, stairway up - stanchion bar disconnected from ceiling securement bracket, horizontal stanchion bar loose from wall securement,
  - 'upper level' – above seats #34 and #53 broken light fixture cover, otherwise seats were without visible damage, stairway down - air conditioner access cover panel deformed ("bowed out"),
  - 'intermediate level / B-end' – the "safety tools" (as required to be on-board the car) were found on the floor [unable to determine how these were placed there, as on-scene information suggested that they may have been utilized by first responders], above seat #95 broken light fixture cover, otherwise seats were without visible damage, stairway down - "safety tools" compartment door removed [see notation above on possible utilization by first responders].

c. Collision Post / Corner Post components (49 CFR Part 238, Subpart C)

- both A-end, and B-end – (although the A-end corner / bulkhead panel sustained fascia panel damage) the exterior bulkhead panels did not sustain significant, visibly apparent damage, which is consistent with, and supports that the collision post / corner post components located within those wall panels had not engaged or were compromised during the event.

4.1.3 Coach Car # 211

Generally described, the overall carbody was structurally intact and without breached openings of the bulkheads (end-panels) or sidewall panels, with the interior fittings / features generally intact and secured in place. Details of the examination are as follows.

a. Exterior

- obvious impact damage sustained to air conditioner unit fan on roof panel (A-end of the car), otherwise roof panel was without apparent impact damage.
- battery compartment: individual cells slightly shifted, with all cables intact, and terminals without damage (i.e., no grounding to cabinet).
- right carbody sidewall panel:
  - visible impact damage at the A-end, bottom corner,

- at A-end, slight sidewall panel ripple that extends about ½ the distance to the top sill,
- sidewall panel otherwise appeared undamaged.

▪ left carbody sidewall panel:

- at the B-end, obvious striations / abrasion scuff marks, for the lower approximate ½ of the sidewall panel, which extends rearward to the mid-car area,
- B-end corner stirrup bent outward,
- at A-end, slight sidewall panel ripple that extends about ½ the distance to the top sill,
- A-end air conditioner cover panel pushed inward.

▪ right carbody sidewall windows: all intact (undamaged).

▪ left carbody sidewall windows:

- a number of the window panels were intact (undamaged),
- a number of the remaining window panels were missing the outer pane of glass, in which the inner glass pane remained intact, in which some of the inner panes were cracked / pushed inward (i.e., all of these damaged windows, even though the outer glass pane was compromised, were not fully breached).

▪ doors – left side:

- B-end door panels; one off-track, one on-track,
- A-end door panels; both door panels jammed by debris, both steps deformed.

▪ doors – right side: all intact (undamaged).

▪ visual inspection of the "push-back" mechanical coupler draft-gear 'activation indicator' flags indicated that both the A-end, and the B-end, had "not triggered".

▪ select mechanical coupler elements (of the A-end) of this car, having been securely transported from the accident site, had been placed in secure storage at this location[87] (as prospective evidentiary artifacts), in which an *action plan* for the further evaluation of the coupler elements was identified, and initiated, by the investigation as further described in this report (see § 4.3).

b. Interior

▪ visual inspection of the 3 levels of the car identified:

- 'lower level' – at mid-car area, on left side, fracture of (apparent impact damage to) light fixture, which was round in shape that contained what appeared to be fragments of human hair embedded into the fracture surfaces, apparent blood trauma found on window and wall surfaces at seat #100, at A-end boot prints observed on left wall panel,
- restroom – appears undamaged, boot prints observed on left wall panel, otherwise seats on this level were without visible damage,
- 'intermediate level / A-end' – stairway up and on the mezzanine level boot prints observed on left wall panel, otherwise seats on this level were without visible damage,
- 'upper level' – stairway up [to this level] - ceiling panel above stairway displayed inward deformation visually estimated to be about 1 foot (this damage corresponds to the air conditioner damage observed on the roof panel), at seat #76 observed glass

[87] Ibid.

shards on windowsill and seat cushion, at mid-car area and on B-end - boot prints observed on left wall panel, otherwise seats on this level were without visible damage,
- ‘intermediate level / B-end’ – at seat #83 observed glass shards, otherwise seats on this level were without visible damage, stairway down observed bridge plate bottom out of position but still secured by straps to the wall.

▪ Emergency exit:

- door ‘pull-handles’ - pulled: # 5 door,
- window ‘pull-handles’ - pulled: none.

c. CEM structural components

▪ both A-end, and B-end – the exterior bulkhead panels did not sustain significant, visibly apparent damage, which is consistent with, and supports that the CEM components located within those wall panels had not engaged or were compromised during the event.

4.1.4 Coach Car # 263

Generally described, the overall carbody was structurally intact and without breached openings of the bulkheads (end-panels) or sidewall panels, with the interior fittings / features generally intact and secured in place. Details of the examination are as follows.

a. Exterior

▪ minor ripple in roof panel at B-end.

▪ battery compartment: no anomalies identified (i.e., battery secure without damage).

▪ carbody sidewall panel surfaces (both left and right sides) were without striations / abrasion scuff marks.

▪ carbody bulkhead (end-panel) surfaces:

- A-end contained a subtle ripple on the lower right and left areas,
- B-end was without striations / abrasion scuff marks.

▪ A-end broken electrical fitting, and right side stirrup bent.

▪ visual inspection of the “push-back” mechanical coupler draft-gear ‘activation indicator’ flags indicated that both the A-end, and the B-end, had “not triggered”.

▪ all window panels were intact.

▪ A-end mechanical coupler missing.

b. Interior

▪ visual inspection of the 3 levels of the car identified:

- ‘lower level’ - no anomalies observed*,
- restroom - no anomalies observed*,
- ‘intermediate level / A-end’ - no anomalies observed *,
- ‘intermediate level / B-end’ - no anomalies observed *,
- ‘upper level’ - no anomalies observed.

*i.e., full securement of seats, tables, luggage racks, interior fittings, etc.

- Emergency exit:
  - door ‘pull-handles’ - pulled: # 5 door,
  - window ‘pull-handles’ - pulled: none.
- Bridge plate: secured in place.

c. CEM structural components

- both A-end, and B-end – the exterior bulkhead panels did not sustain significant, visibly apparent damage, which is consistent with, and supports that the CEM components located within those wall panels had not engaged or were compromised during the event.

4.1.5 Locomotive # 870

a. Exterior

- visual examination identified no apparent damage.

b. Interior

- as this unit was unoccupied during the accident, in which no apparent exterior damage was identified, no interior examination was conducted.

4.2 Highway Vehicles

A detailed examination of the truck and trailer combination vehicle was conducted by the Vehicle Factors Technical Working Group. The automobile, which reportedly sustained minor damage, was released from the scene prior to the arrival of NTSB investigators, and was not available for examination.[88]

See Vehicle Factors Group Factual report for additional information detail.

4.3 Evidentiary Specimens Recovered for Evaluation – Railcar Mechanical Couplers

The following describes actions of the evidentiary specimen recovery process (ref § 4.1.2.a, and § 4.1.3.a, above).

4.3.1 Evaluation Action Plan

An *action plan* for the further evaluation of the mechanical coupler elements (evidentiary artifacts) was identified by the investigation, as follows.

1. Conduct a further (initial) visual examination of all mechanical coupler artifacts (removed from the train) by qualified NTSB technical staff, in which a determination would then be made as to if a further, more detailed examination of the artifacts was warranted.

[88] ref Vehicle Factors Group Chairman's Factual Report

2. Mechanical coupler artifacts that warranted a more detailed physical examination (per step 1, above) were then to be sent to the NTSB Materials Laboratory[89] for appropriate formal metallurgical examination and/or physical testing.

3. The remaining mechanical coupler artifacts (per step 1, above) were to be held at appropriate Metrolink secure storage facilities, on the prospect that additional metallurgical examination and/or physical testing might need to be conducted on those artifacts (at a later date).

4.3.2 Execution of the Evaluation Action Plan

Responsive actions to the individual steps of the Action Plan (above) were as follows.

1. A visual examination was conducted by NTSB technical staff on the three sets of mechanical couplers removed from the accident train, in which a field report was compiled that described the observations of that examination, which is anticipated to be available in the NTSB public docket.

2. Of the three sets of mechanical coupler evidentiary artifacts examined, the coupler elements removed from the B-end of Metrolink car # 206 were observed to display indications (as cited in the above noted technical report) of what appeared to be potential manufacturing anomalies, consisting of "casting voids", "porosity and shrinkage cracks", and a "casting pin", wherein those coupler artifacts were sent to the NTSB Materials Laboratory for formal metallurgical examination and/or physical testing. Upon completion of the laboratory examination activities, it's anticipated that a report compiled by the NTSB Materials Laboratory, of the metallurgical examination and/or physical testing performed on the coupler artifacts removed from the B-end of Metrolink car # 206, will be available in the NTSB public docket of the investigation.

3. The other coupler elements examined, as removed from Metrolink car # 206 A-end, displayed what appeared to be potential manufacturing anomalies which were similar to that as observed in the B-end coupler of Metrolink car # 206, but to a lesser degree of severity. Accordingly, the elements of this mechanical coupler set were further placed in secure storage at the Metrolink Central Maintenance Facility[90], and the Metrolink railcar storage yard (Moorpark, CA), respectively, should it be determined that metallurgical examination and/or physical testing will need to be conducted on those artifacts as well. Examination of the coupler elements removed from car #211 indicated that there were no metallurgical anomalies, and no further investigation was required.

4.4 Prior Passenger Railcar Damage - Sustained / Repaired

A review of damage repair and/or structural modification history, as recorded in maintenance records maintained by a railroad, is typically conducted in an investigation on the damaged railroad rolling stock [passenger cars] / motive power [locomotives] involved in an accident, to identify if any prior serious accident damage and/or structural modification had occurred that might potentially influence the crashworthiness performance of the railroad equipment.

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[89] At the NTSB Headquarters facility, in Washington, DC

[90] CMF, 1555 San Fernando Road, Los Angeles, CA 90065

Review of Metrolink maintenance documentation of the passenger railcars involved in the accident (car numbers 645, 206, 211, and 263), dating back to initial delivery, did not indicate any data references that the railcars sustained any prior damage or structural modification.[91]

5.0 Actions / Safety Initiatives - Implemented Subsequent to the Accident by the Party to the Investigation Organizations of the Crashworthiness Technical Working Group

An opportunity was afforded to the Party to the Investigation participants to provide specific, documented, relevant data on this investigative topic for brief summarization in this report section.[92] Documented responses received are as follows.

5.1 SCRRA (representing Metrolink)[93]

The Party representative responded that no new specific initiative measures had been initiated.

5.2 Volpe National Transportation Systems Center (representing FRA)[94]

The Party representative responded that the organization had no information to add on this topic.

E. **Authorship**

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-- End of this Report Section --

[91] ref, email from Metrolink Party to the Investigation representative, dated 07/21/2015 10:56 AM
[92] ref, emails to Party to the investigation representatives of the Crashworthiness Group, dated July 21, 2015
[93] ref, [response] email from Party to the investigation representative, dated 7/28/2015 10:01 AM
[94] ref, [response] email from Party to the investigation representative, dated 7/28/2015 11:56 AM

--- List of Exhibits ---

1. List of Publications Researched by the Investigation

2. General Arrangement Illustration of Hyundai Rotem - Double-deck, Cab Car / Coach Car

3. Illustration Describing the Design Configuration of the “Guardian fleet” Type of Hyundai Rotem Passenger Railcar

4. General Arrangement Illustration of Bombardier Bi-Level Coach Car

-- End of Report (narrative) --