National Transportation Safety Board

Office of Railroad, Pipeline, and Hazardous Materials Investigations
Human Performance and Survival Factors Division
Washington, DC. 20594

Crashworthiness Factual Report[1]

February 20, 2009

Collision of SCRRA ("Metrolink") Train 111 with Union Pacific Train LOF65-12, in the Chatsworth District of the City of Los Angeles, California, on September 12, 2008

NTSB Accident Number: DCA 08 MR 009

Compiled by: // s // Date February 20, 2009 .
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Supervisory review: // s // Date February 23, 2009 .
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[1] This report exclusively addresses selective vehicle crashworthiness elements of the accident, where, as a basic definition (as applied to this Investigation), *crashworthiness* is the ability of the vehicle to provide for the survival of its occupant(s) as a result of a collision / impact event.

Contents

Note – Photographs compiled during the investigation by the Crashworthiness Working Group will be forthcoming in a separate Addendum to the Crashworthiness Factual Report.

A. Accident Reference Information

NTSB Accident Number:	DCA 08 MR 009
Location:	Chatsworth, CA.
Date / Approx. Time of Event:	September 12, 2008 / 4:22 p.m. (PDT)[2]
NRC[3] Report No.	883610
Type of Incident	Collision of two trains
Railroad Property	Southern California Regional Rail Authority (SCRRA) (also known locally as "Metrolink")
Track Ref. Location (approx.)	Ventura Sub-Division, MP 444.12

Train 1

Owner:	SCRRA
Identification (Number)	111
Type	Regional Commuter Passenger
Consist	1 Locomotive + 3 passenger coach railcars, operating in a "push-pull" configuration, with locomotive in the lead
Weight (approximate)	308 tons
Length (with locomotive)	313 feet
Operating Direction [timetable]	westbound
Equipment Manufacturer	
Locomotive	EMD
Passenger Railcars:	
SCAX # 185, # 207	Bombardier Transit Corporation
SCAX # 617	UTDC
Operating [Crew] Contractor[4]	Connex Veolia
Equipment Maintenance Contractor	Bombardier Mass Transit Corporation[5]

Train 2

Owner:	Union Pacific Railroad
Identification (Number)	LOF65-12 (a.k.a. "Leesdale local")
Type of Train	Local Manifest Freight
Consist	2 Locomotives + 7 loads + 10 empties
Weight (approximate)	1,522 tons
Length (with locomotives)	1,164 feet
Operating Direction	eastbound
Locomotive Manufacturer	EMD [both units]

[2] Pacific Daylight Time
[3] National Response Center, a function of USCG, provides initial notification to specific USDOT / FRA and NTSB offices, of transportation related incidents that meet certain pre-established criteria. See http://www.nrc.uscg.mil for report.
[4] contractor which supplies the operating personnel (train crews) of the trains on this railroad.
[5] although the Equipment Maintenance Contractor has the same corporate parent as the railcar builder, they function as separate operating entities.

B. Synopsis[6]

On Friday, September 12, 2008, at approximately 4:22 p.m. pacific daylight time, westbound Southern California Regional Rail Authority (SCRRA, a.k.a. "Metrolink") passenger train No. 111 and Union Pacific freight train No. LOF65-12 collided head-on while operating in a 6-degree curve on Metrolink's Ventura Subdivision between Control Point Topanga and Tunnel No. 28 near Chatsworth, California. The Metrolink train derailed its locomotive and lead passenger car; the UP train derailed two locomotives and 10 cars. As a result of the collision, the Metrolink locomotive was shoved approximately 50 feet into the lead passenger car. Emergency response agencies reported that 102 injured persons were transported to local hospitals. There were 25 fatalities.

Damage is estimated at $10.6 million. Environmental conditions were daylight, clear skies, haze, calm winds and a temperature of 73 degrees F with visibility of four miles.

Parties to the investigation include Metrolink, Union Pacific (UP), Federal Railroad Administration (FRA), California Public Utilities Commission (CPUC), Brotherhood of Locomotive Engineers and Trainmen (BLET), United Transportation Union (UTU), Bombardier Transportation, Connex (contractor for Metrolink), Massachusetts Electric Construction Company, Los Angeles Police Department and Los Angeles Fire and Rescue.

The Accident:

About 4:22 p.m., on September 12, 2008, PDT, westbound Metrolink train No. 111, consisting of a locomotive and three passenger cars collided with eastbound Union Pacific Railway Company (UP) train LOF 65-12 consisting of two locomotives (UP 8485 in the lead, and UP 8491 trailing) with 17 cars; 7 loads and 10 empties was approximately 1,164 feet long with 1,522 tons. The Metrolink train was 313 feet in length. The accident occurred in the Chatsworth District of the City of Los Angeles, California, which is approximately 30 miles northwest of "downtown" Los Angeles.

The head-on train accident occurred west of Metrolink's Topanga Control Point at about milepost 444.12, which is located in the full body of a 6 degree curve. The westbound Metrolink train was routed and signaled to stop on the main track east of the Topanga control point clear of the No. 20 turnout. The eastbound UP freight train, the Leesdale local, was routed from the single track into the Topanga control point and through the No. 20 turnout onto the side track. However, the Metrolink did not stop at Topanga and proceeded westbound onto the single track main and met the UP train near the middle of the 6 degree curve on single track. The collision resulted from the two trains operating on the same track in opposite directions. The trains collided at milepost (MP) 444.12 located about 1,394 west of the Topanga Control Point switch and about 634 feet east of MP 444.0 or the east portal of tunnel No. 28.

Metrolink designates the maximum authorized timetable speed on their single main track prior to Topanga as 70 mph and between Topanga and tunnel No. 28 as 40 mph, which would be Federal

[6] Draft, as of 10/30/2008, and subject to revision; compiled by the Investigator in Charge, in conjunction with technical support as provided by the Investigation team.

Railroad Administration (FRA) Class 4 and 3 track, respectively. The 40 mph reduction in speed is due to a permanent speed restriction for the curvature of the track.

Metrolink estimated that the total annual gross tonnage, passenger and freight, is about 10.6 million gross tons. On the Ventura sub-division, Metrolink operates, on average, about 22 passengers trains daily, Amtrak operates about 12 passengers trains daily (under trackage rights agreements), and the UP operates about about nine freight trains daily (under trackage rights agreements). Fewer passenger trains are operated on the weekends.

Weather:

At about 3:51 PDT, the Van Nuys surface weather station, which is about 5.4 nautical miles east of Chatsworth, California, recorded that the environmental conditions were daylight, clear skies, haze, calm winds and a temperature of 73 degrees F with visibility of four miles.

Select Acronym Nomenclature used in this Report

APTA	American Public Transportation Association, a professional trade association, as described in http://www.apta.com/
AAR	Association of American Railroads, a professional trade association, as described in >> http://www.aar.org/Homepage.aspx
BP	barometric pressure
PDT	Pacific Daylight Time
DP	dew point [temperature]
°F	degrees Fahrenheit [ambient temperature]
ft	feet
FRA	Federal Railroad Administration
gals	gallons [liquid / fuel]
Hazmat	hazardous materials
hrs	hours
in. Hg	inches of mercury [barometric pressure]
kts	knots [wind speed]
lbs	pounds [weight]
MP	milepost [railroad]
mph	miles per hour
NWS	National Weather Service
RH	relative humidity (percentage)
SCRRA	Southern California Regional Rail Authority
UP	Union Pacific Railroad

C. Crashworthiness - Working Group Participants

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[7] a.k.a. "Metrolink"

D. Facts of the Investigation

1.0 Summary Description of the Accident

1.1 Accident Scenario

As a basic description of the event, the evidence identified is generally consistent with an accident scenario involving a 'head-on collision' of a moving westbound (timetable direction) regional commuter passenger train, which was owned and operated by the Southern California Regional Rail Authority (SCRRA), which is also known locally as "Metrolink", with a moving eastbound (timetable direction) freight train, which was owned and operated by the Union Pacific Railroad (UP). The SCRRA train was comprised of one locomotive and three passenger railcars, and the UP train was comprised of two locomotives and 17 freight railcars. The collision resulted in the derailment of the locomotive and the first trailing passenger coach of the SCRRA train, and the remaining two passenger coaches did not derail in the event. The two locomotives and the first 10 freight railcars of the UP train derailed in the event. The accident occurred on a segment of curved track, and resulted in severe damage to the SCRRA locomotive and first passenger coach behind the locomotive, and less extensive damage to the remaining two SCRRA passenger cars. Extensive damage resulted to the two locomotives of the UP train, and more severe damage to a number of the freight railcars of that train.

1.2 Accident Site – Property Ownership

The owner and operator of the trackage involved at the accident site is the SCRRA (referred to in the railroad business as the 'host railroad'), upon which the UP operates freight train traffic pursuant to an "overhead trackage rights" agreement.

1.3 Employment of Train Crewmembers

The crewmembers of the SCRRA train involved in the accident (a conductor and a locomotive engineer) were employed by Connex Veolia (an operating contractor of SCRRA). The crewmembers of the UP train involved in the accident (a conductor, a locomotive engineer, and a brakeman) were employed by UP.

1.4 Accident Site – Summarized Description

The accident occurred on a segment of curved track in single-track territory, on the SCRRA Ventura County Line, proximate to MP 444.12, which is between the Metrolink passenger stations at Chatsworth (MP 445.5) and Simi Valley (MP 437.9)[8], as further described in this report (see also § 2.2).

Location maps of the accident site and vicinity are included in Exhibit 1.

[8] ref: SCRRA Track Chart for Ventura Subdivision, rev date 05/08 (as made available by SCRRA to the Track Working Group)

An engineering drawing, illustrating the configuration of the wreckage distribution of the accident site and related trackage, was compiled by the Investigation, as further described in this report (see § 6.4).

Additional detail information on the track structure is provided in the Track Group - Factual Report.

1.5 Approximate Point of Collision

The approximate 'point of collision' is estimated (by the Crashworthiness Investigation[9]), utilizing data of the lead UP locomotive On-Board Video/Audio recording system[10], to be approximately 634 feet (ft) to the east [timetable direction] of the east portal of railroad tunnel Number 28, which is also proximate to railroad milepost {MP} 444.12.

The Track Group Investigation, in exclusively utilizing 'ground-based' Site Survey datum measurements, relative to where the two non-derailed passenger coach railcars came to rest and the datum location of MP 444.0 (i.e. the east portal of railroad tunnel Number 28), had preliminarily identified the approximate point of collision to be about 650 ft to the east of the east portal of railroad tunnel Number 28 [11].

Note – although the Track Group Investigation identifies a preliminary 'point of collision' in its map documentation, the Crashworthiness Investigation utilizes (in this report) the approximate 'point of collision' as determined by the Crashworthiness Investigation calculations (which is about 16 ft west of the location as preliminarily identified by the Track Group Investigation).

1.6 Meteorological

The weather at the time of the accident was reported[12] as daytime, dry (no active precipitation), clear sky conditions, a visibility of about 4 miles, with haze, a 6 mph wind, with a temperature in the 74° F range, and the RH about 60 %. Sunrise and sunset were reported[13] to occur at 6:35 am, and 7:03 pm, respectively.

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[9] as represented by the Crashworthiness Working Group Chairperson (the 'organizing author' of this report)
[10] the approximate 'point of collision' determination utilized recorded images and data in a Video/Audio recording as captured by the lead UP locomotive On-Board Video/Audio recording system (which is fitted inside the Operator's Cab, to observe the view [through the windshield] forward of the 'short hood' of that Unit), as described in the On-Board Video/Audio Recording Group Chairman's Factual Report for this Investigation, with the distance traveled calculation, to identify the estimated point of collision, as further described in Exhibit 20 of this report.
[11] the Track Group Investigation deemed this preliminarily derived dimension to be sufficiently accurate for purposes of their Investigation at that time (see Track Group Factual Report, and associated Site Map and Tabular documentation, for further detail), and also recognizes that this method of point of collision determination is not as precise as utilizing actual recorded data of the event (as employed by the Crashworthiness Investigation), which was not available when the Track Group performed their Site Survey / point of collision determination activities.
[12] source: NOAA -Record of Climatological Observations data archive for weather station "Van Nuys Airport", Van Nuys, CA; WBAN site # 23130, for Sept. 12, 2008 at 15:51 hrs (i.e. data recorded for the time closest to accident event), [Internet: http://lwf.ncdc.noaa.gov/oa/climate/stationlocator.html]
[13] source: U.S. Naval Observatory / Astronomical Applications Dep't. (i.e. data recorded for the identified time of the accident event) [http://aa.usno.navy.mil/data/docs/RS_OneDay.php]

The altitude and azimuth (east of north) of the sun, at the time of the accident (16:22 PDT), were reported[14] to be 20.0 and 260.7 degrees, respectively.

1.7 Prior SCRRA Accidents Involving the Type of BiLevel Railroad Passenger Coach Equipment as Involved in this Accident

The Safety Board investigated (or initiated investigations of) five prior SCRRA accidents involving the type of BiLevel railroad passenger coach equipment as involved in this accident[15], which are identified in Exhibit 2.

Two additional prior accidents, which occurred in Canada, involving the type of BiLevel railroad passenger coach equipment as involved in this accident, were identified in a prior NTSB Investigation[16], the documentation of which is available in the NTSB public docket[17].

2.0 SCRRA

2.1 Background of Railroad Operations

The SCRRA is a regional-based commuter railroad operation, which operates standard gauge track[18], which maintains seven scheduled routes (referred to by the organization as "Route Corridors"), which utilizes about 512 total route miles, and operates (an average of) about 145 trains in its weekday schedule[19].

As described by the company[20], "Metrolink is truly a united effort, made possible by the Los Angeles County Metropolitan Transportation Authority (Metro), the Orange County Transportation Authority, the Riverside County Transportation Commission, San Bernardino Associated Governments and the Ventura County Transportation Commission. In 1991, the Southern California Regional Rail Authority (SCRRA), a Joint Powers Authority (JPA), consisting of the five county transportation planning agencies listed above, was formed to develop a regional transit service to reduce the congestion on highways and improve mobility throughout the Southern California region. In October 1992, Metrolink was born.

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[14] source: U.S. Naval Observatory / Astronomical Applications Dep't. (i.e. data recorded for the identified time of the accident event) [http://aa.usno.navy.mil/data/docs/AltAz.php]

[15] one of these accidents was the Investigation of a Collision of Burlington Northern Santa Fe Freight Train With Metrolink Passenger Train, Placentia, California, [that occurred on] April 23, 2002 (documentation available at [Internet] >> http://www.ntsb.gov/publictn/2003/RAR0304.pdf), in which Crashworthiness elements of that Investigation were documented in the Survival Factors Factual Report, wherein, because that accident involved very similar passenger coaches as in this Investigation, certain applicable narrative elements contained in the Placentia, CA. - Survival Factors Factual Report are repeated, essentially verbatim, in this report (as noted accordingly).

[16] the accident occurrences (both in Canada), as identified in the NTSB Placentia, CA, Accident Investigation, were (1) a Collision of Go-Transit Trains # 831 and # 841 at Union Station, Toronto, Ontario on 19 Nov 1977, and (2) a Collision of a Go-Transit Passenger Train with a Loaded Flat Bed Truck Abandoned on a Railroad Right-Of-Way, at Hamilton, Ontario, on 15 September 1989; both accidents were investigated by the Transportation Safety Board of Canada {TSB of Canada}; as further described in [Internet] >> http://www.tsb.gc.ca/.

[17] NTSB Investigation published report ref. [Internet] >> http://www.ntsb.gov/publictn/2003/RAR0304.pdf

[18] U.S. standard gauge track is 56.5 inches.

[19] ref. [data – Sept 2008]: http://www.metrolinktrains.com/documents/About/Fact_Sheet_Sep_08.pdf

[20] descriptive quotation (dated 2007) ref. - http://www.metrolinktrains.com/about/, and as otherwise noted.

Today, in its 15th year of operation[21], Metrolink continues to provide the people of Southern California a safe, reliable and environmentally friendly commute option. What began with three lines of service, 12 stations and a little over 5,000 passengers has grown to seven lines, 56 stations and 45,000 passengers."

Additional information on this operation is available in the Internet website of this organization[22].

A schematic map illustrating the SCRRA system is provided in Exhibit 3.

2.2 General Site Characteristics – Topographical / Geographical

The accident occurred on single-track territory on a railroad line referred to as the Ventura Sub-Division, which is owned by the Southern California Regional Rail Authority (SCRRA). As noted previously in this report (§ 1.5), the point of collision is estimated to be approximately 634 feet (ft) to the east [timetable direction] of the east portal of railroad tunnel Number 28.

The accident site is comprised of track that is situated within the full-body of a curve (measuring 6 degrees) and has a slight upgrade (approximately 0.75 %) to the west. The railroad right-of-way, proximate to the identified approximate point of collision, is geographically generally oriented in an approximate northwest / southeast (compass relative) direction[23], with the terrain immediately adjacent to both sides of the track having a slight downgrade slope away from the track. The railroad right-of-way, proximate to the accident site, traverses through what could be characterized as a suburban residential / semi-rural area of the Chatsworth district [community] within the City of Los Angeles, CA, with the accident site also located proximate to a recreational facility (nature preserve) known as "Stoney Point Park" [24, 25].

Additional detail information on the track structure is provided in the Track Group - Factual Report.

2.3 Train Consist of the Accident Train – Summarized Description

The Train Consist of the SCRRA train is as described in Exhibit 4.

As elaboration of the above, westbound SCRRA train [identification reference] Number 111 is a regional commuter train, which normally operates in a 'Push-Pull' configuration. As configured on September 12, 2008, the Consist of Train 111 was configured in a 'Pull' mode orientation, which was comprised of a diesel-electric locomotive operating at the lead-end of the train, in a cab-forward orientation, which provided the motive power of the train, which was coupled to

[21] note – with the descriptive quotation being dated 2007, the "15th year of operation" apparently refers to that year.
[22] ref: [Internet] http://www.metrolinktrains.com/
[23] the northwest / southeast directional reference is relative to a 'point of tangency' (of the track) proximate to the identified point of impact
[24] property owned / maintained by the City of Los Angeles - Recreation and Parks Department; source, and for additional information: [Internet] http://www.laparks.org/dos/parks/facility/stoneyPointPk.htm
[25] the SCRRA track passes through a tunnel (Number 28), which passes beneath a segment of Stoney Point Park, which is located a short distance west of the accident site.

(trailed-by) three passenger railcar coaches, all of which were in revenue service and were occupied by revenue passengers. The train weight was about 308 tons, and the train length was about 313 ft.

The locomotive of the Train Consist was manufactured by the Electro-Motive Division of General Motors, as further described in this report (see § 4.2.2).

The first two passenger cars of the Train Consist (SCAX [26] # 185 and # 207), which were conventional coaches, were manufactured by Bombardier Transportation Corporation[27] {Bombardier}, and the remaining passenger coach of the Train Consist (SCAX # 617), which consisted of a 'cab-car', which was operating essentially as a conventional coach[28], was manufactured by UTDC (a company that was later bought by Bombardier, Inc). All of the railcars are (or were, as in the case of UTDC) identified, in the respective manufacturers' product line, as a "BiLevel™ Coach" [29] (as also described in equipment procurement contract documentation[30]), as further described in this report (see § 5.2).

The SCRRA utilizes a contractor by the name of Bombardier Mass Transit Corporation to perform scheduled maintenance services of its passenger railcar and locomotive fleet [31, 32], which is conducted at the SCRRA Central Maintenance Facility in Los Angeles, CA.

The SCRRA utilizes a contractor by the name of Veolia Transportation[33] to supply operating personnel (train crews) for its passenger train operations, which is operated from its Central Maintenance Facility in Los Angeles, CA. The operating crew consisted of one Locomotive Engineer (the train operator), who was the sole occupant of the locomotive, and one Train Conductor, who was located in the last passenger railcar coach [SCAX # 617] of the Train Consist. Additional information detail on the train crew is provided in the Human Performance Group - Factual Report, and the Operations Group - Factual Report.

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[26] railroad industry reporting code (designation) for SCRRA railroad equipment is "SCAX" (as labeled on the equipment).
[27] descriptive quotation ref.: Press Release dated 2/19/02 in Bombardier's [parent corporation] website (ref: http://www.bombardier.com/)
[28] a 'cab car' is essentially as a conventional coach railcar, which has an "operator's cab" fitted to one end of the railcar (as further described in this report; see § 5.2), in which also (as described [ref. email, dated Jan. 30, 2009] to the Investigation by Bombardier) "although a cab car visually appears to be a conventional coach railcar which has an operator's cab fitted to one end, the structural requirements for the "cab ends" of cab cars have over time become greater than for conventional coach railcars."
[29] although the Bombardier coach railcars are cited (by the company) as a "BiLevel" coach in the procurement documentation, and also Bombardier refers to this railcar design as a "double-deck coach" in its sales literature (Internet website), the railcars actually have three separate levels of passenger seating accommodations, as further described in this report.
[30] ref. SCCRA Procurement Contract [Nos. 200, 207, and 214] between SCRRA and Bombardier and/or UTDC, for the delivery of three groups of coach railcars.
[31] although the Equipment Maintenance Contractor has the same corporate parent as the railcar builder, they function as separate operating entities.
[32] as facilitation to the Investigation, given that the Equipment Manufacturer and the Equipment Maintenance Contractor share the same ultimate parent company, the Party to the Investigation representative (to the Crashworthiness Working Group) of the Equipment Maintenance Contractor was also utilized to obtain technical information concerning the railcar equipment from the Equipment Manufacturer.
[33] as described in, and for further information, see [Internet] >> http://www.veoliatransportation.com/

3.0 Union Pacific Railroad

3.1 Background of Railroad Operations[34]

"Union Pacific Railroad is an operating subsidiary of Union Pacific Corporation. It is the largest railroad in North America, operating in the western two-thirds of the United States. The railroad serves 23 states, linking every major West Coast and Gulf Coast port and provides service to the east through its four major gateways in Chicago, St. Louis, Memphis and New Orleans. Additionally, Union Pacific operates key north/south corridors and is the only railroad to serve all six major gateways to Mexico. UP also interchanges traffic with the Canadian rail systems.

The railroad has one of the most diversified commodity mixes in the industry, including chemicals, coal, food and food products, forest products, grain and grain products, intermodal, metals and minerals, and automobiles and parts.

Although Union Pacific Railroad's primary role is transporting freight, it also runs a substantial commuter train operation in Chicago."

The company, having a heritage that dates to the construction of the first transcontinental railroad (completed in 1869), operates in 23 states and maintains its corporate offices in Omaha, NE. The railroad currently utilizes about 32,200 route miles and about 50,900 total track miles, has about 50,100 employees, and maintains a roster (as units owned or under lease) of about 8,600 locomotives.

3.2 Train Consist of the Accident Train – Summarized Description

The Train Consist of the UP train is as described in Exhibit 4.

As elaboration of the above, eastbound UP train [identification reference] LOF65-12 was a local manifest freight train, which is also informally identified by the company as the "Leesdale local". As configured on September 12, 2008, the Train Consist was comprised of two diesel-electric locomotives, which provided the motive power of the train, which were coupled together and operating at the lead-end of the train. The lead locomotive unit was in a cab-forward orientation and the second unit was in a cab-aft orientation, which was coupled to (trailed-by) 17 freight railcars. The train weight was about 1,522 tons, and the train length was about 1,164 ft.

The locomotives of the Train Consist were manufactured by Electro-Motive Diesel, Inc., as further described in this report (see § 4.2.1).

The operating crew consisted of one Locomotive Engineer (the train operator), and one Train Conductor, who collectively occupied the lead locomotive unit of the Train Consist. Another crewmember, a brakeman, was the sole occupant of the second locomotive unit of the Train Consist. Additional information detail on the train crew, all of which were employees of UP, is

[34] ref. (as quoted from) http://www.uprr.com/aboutup/corporate_info/uprrover.shtml, with additional data as sourced from, and available at, http://www.up.com/, including the Union Pacific Corporation 2007 Annual Report (Form 10-K, as filed with the SEC).

provided in the Human Performance Group - Factual Report, and the Operations Group - Factual Report.

4.0 Railroad Locomotive Equipment Involved in the Accident

As briefly described above, the railroad locomotive equipment involved in the accident was manufactured by Electro-Motive Diesel, Inc. (known in the locomotive manufacturing business as “EMD”)[35], or its predecessor company, the company and equipment of which is further described as follows [36].

4.1 Company Background

As a basic description of the company, EMD, as one of the two principal railroad locomotive manufacturers in the U.S., is a global-supplier of diesel-electric locomotives and industrial-use diesel engines (principally for electrical power generation, pump, and marine applications). The company, which employs about 2,600 employees (company-wide), has supplied, since the mid-1920’s, through its current or predecessor companies, over 58,000 locomotive units[37] to the railroads of all industrialized continents. The company maintains its corporate offices, and some component production facilities, in LaGrange, IL, and maintains its principal manufacturing (final assembly) facilities in London, Ontario, Canada, and also utilizes other [subcontractor] final assembly venues. Additional information on this firm is available in the Internet website of the company.

4.2 Locomotive Models Involved in the Accident

A summarized description of the two individual model types of locomotive equipment involved in the Accident is as follows.

Basic illustrations (‘outline drawings’) of the two individual locomotive model types, as described in the following report sections, are provided in Exhibit 5 of this report.

In addition to the above, to potentially address factual considerations and observations of locomotive crashworthiness safety, relative to the two specific model locomotives involved in the Accident, the Crashworthiness Working Group may pursue additional technical discussion with technical principals of the locomotive manufacturer, on the prospect of potentially gaining useful technical insight into locomotive crashworthiness safety, as might not be apparent by field examination of the equipment or review of technical documentation describing the locomotive model types, wherein, accordingly, information obtained would potentially be made available in an Addendum Factual Report of the Investigation.

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[35] the company, which had been founded under the name of Electro-Motive Division of the General Motors Corporation, was sold to an investor group in April 2005, and is currently known as Electro-Motive Diesel, Inc., as further described in [Internet] http://www.emdiesels.com/

[36] ref. information from a technical representative of the manufacturer, and [Internet] http://www.emdiesels.com/, or other sources as noted.

[37] Apr. 2005 production data; ref: [Internet] http://www.berkshirepartners.com/news_press_2005april04.shtml

4.2.1 SD70ACe [38] (of the UP Train)

Basically described, this locomotive unit, initially produced in 2005 and currently in production by the manufacturer, is a six-axle / two-truck, 4300 THP[39], 'road switcher' type, diesel-electric locomotive. It is equipped with an EMD [produced] model 16-710G3C-T2, turbocharged, diesel engine that is mechanically coupled to an EMD [produced] model TA17/CA9A alternator (which functions as a 'main generator', which produces alternating current), which is further electrically coupled to six traction motors (one fitted to each truck axle). The unit measures approximately 74 ft (length), by 10 ft (width), by 16 ft (height), and weighs (fully loaded with fuel, traction sand, etc.) about 420,000 lbs. The design incorporates an Operator's Cab (where the crew normally is located during operation of the unit) at the lead end [40] of the unit, and utilizes a fabricated steel centersill element that extends the length of the unit, upon which the diesel engine / alternator components are mounted (aft of the cab location). A fuel tank, having a capacity of about 5,000 gals, is located (suspended from the underside of the centersill) between a pair of three-axle power truck assemblies. The unit can incorporate (as a customer selected option) an on-board Digital Video Recorder System, which is fitted inside the Operator's Cab, to observe the view [through the windshield] forward of the 'short hood' ("cowl") of the unit (immediately preceding the Operator's Cab) [41].

The particular locomotives of the Accident, which were manufactured in 2006, were built pursuant to a crashworthiness design standard as prescribed in the AAR Standard S-580, revision date 2001, as further described in this report (see § 4.3.1), in which also crashworthiness features incorporated into the design of this model include:

- Impact resistant fuel tank
- 1,000,000 lb. "buff load" capacity[42]
- Full-height collision posts with combined one million pounds resistance[43]
- Frame-mounted anti-climbers[44]

4.2.2 F59PH [45] (of the SCRRA Train)

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[38] ref. General Information data sheets (published by the manufacturer), and information from a technical representative of the manufacturer, and in (and for further information detail): [Internet] http://www.emdiesels.com/emdweb/products/sd70ace.jsp

[39] traction horsepower

[40] note – irrespective of directional references that might be used by this equipment manufacturer, in this report, forward (lead end) and aft directional references are relative to the normal [forward] direction of travel.

[41] ref., and for further information detail: http://www.emdiesels.com/emdweb/products/pdf/EMD_LDRV.pdf

[42] refers to (as generically sourced from language in 49CFR229.141) the criteria that "the body structure [of a locomotive / railcar] shall resist a minimum static end load of a specified amount [measured in lbs.] at [as applied to] the rear draft stops ahead of the bolster on the center line of draft [which essentially refers to a maximum compressive load that can be applied to the centersill, or overall carbody frame structure], without developing any permanent deformation in any member of the body structure".

[43] collision posts refers to (as sourced from 49CFR229.5) "structural members of the end structures of a rail vehicle that extend vertically from the underframe to which they are securely attached and that provide protection to occupied compartments from an object penetrating the vehicle during a collision".

[44] anti-climber refers to (as sourced from 49CFR229.5) "the parts at the ends of adjoining rail vehicles in a train that are designed to engage when subjected to large buff loads to prevent the override of one vehicle by another".

[45] ref. General Information data sheets (published by the manufacturer), and information from a technical representative of the manufacturer.

Basically described, this locomotive unit, produced by the manufacturer 1988 - 1994, inclusive, is a four-axle / two-truck, 3000 THP, 'road' type, diesel-electric locomotive. It is equipped with an EMD [produced] model 12-710G3A, turbocharged, diesel engine that is mechanically coupled to an EMD [produced] model AR15/CA6A alternator, which is further electrically coupled to four traction motors (one fitted to each truck axle). The unit measures approximately 58 ft (length), by 10 ft (width), by 15.75 ft (height), and has a [published] weight (loaded on rail) of about 270,000 lbs. The design incorporates an Operator's Cab (where the crew normally is located during operation of the unit) at the lead [front] end of the unit, and utilizes a fabricated steel centersill element that extends the length of the unit, upon which the diesel engine / alternator components are mounted (aft of the cab location). A fuel tank, having a [published] capacity of 2,200 gals, is located (suspended from the underside of the centersill) between a pair of two-axle power truck assemblies.

The particular locomotive of the Accident, which was manufactured in 1992, was built pursuant to a crashworthiness design standard as prescribed in the AAR Standard S-580, revision date 1989, as further described in this report (see § 4.3.1), in which also crashworthiness features incorporated into the design of this model include:

- Collision posts with combined one million pounds resistance
- 1,000,000 lb. "buff load" capacity

4.3 Locomotive Crashworthiness Design Criteria – Industry Standards / Regulation

4.3.1 Industry Standard – AAR S-580

The two models of locomotives described in this report (§ 4.2.1 and § 4.2.2) were built to crashworthiness design standards as prescribed in Association of American Railroads[46] {AAR} Manual of Standards and Recommended Practices, Standard S-580 "Locomotive Crashworthiness Requirements", which is an industry standard as promulgated by the AAR[47]. The Standard S-580 provides crashworthiness design criteria for specific features to be incorporated into the equipment, such as "anti-climber" elements, collision posts, etc., the design criteria content of which has evolved since its inception, as further reflected in the several date revisions of the Standard (as described in the applicable report Sections; see § 4.2.1 and § 4.2.2).

4.3.2 Regulatory Requirements

Review of regulation for Locomotive Crashworthiness Design Requirements, as applicable to locomotives manufactured or remanufactured on or after January 1, 2009, as would be applicable to the type of locomotive equipment and railroad operating environment as observed in this

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[46] Association of American Railroads {AAR}, a professional trade association, as described in [Internet] >> http://www.aar.org/Homepage.aspx

[47] the AAR Standard S-580 is a document that maintained under copyright protection of the AAR, which is also available from that organization (see [Internet] >> http://www.aarpublications.com/), or review access is available from the National Archives, as described in [Internet] >> http://www.archives.gov/federal-register/cfr/ibr-locations.html.

Accident, indicates that the requirements under 49 CFR 229.205, 49 CFR 229.206, and 49 CFR 229.207, et seq., would apply[48]. Review of the cited Regulation sections indicates that many of the crashworthiness design criteria as prescribed in the AAR Standard S-580 are "incorporated by reference" in the Regulation sections. The Investigation recognized that as both locomotive design types involved in the Accident were manufactured prior to the implementation ("Applicability") date of the Regulation[49], the specific requirements of these Regulations would not apply.

5.0 Railroad Passenger Coach Equipment Involved in the Accident

The railroad passenger coach equipment involved in the accident was manufactured by Bombardier Transit Corporation, or UTDC (a company that was later bought by Bombardier, Inc.), in which the current manufacturer of the passenger coach equipment is further described as follows.

5.1 Company Background [50]

Bombardier, Inc., is a major manufacturer of business jets, regional aircraft, and rail transportation equipment (passenger coach railcars and locomotives) for the International market. Bombardier also provides, on a contractual basis through its subsidiary corporations, third-party maintenance services to North American transit authorities, which includes SCRRA (as further described in this report; see § 2.3)[51]. This firm, which describes itself as "… a world leader in innovative transportation solutions, from regional aircraft and business jets to complete rail transportation equipment, systems and services …" cites a corporate address in Montreal, Province of Quebec, Canada. Additional information on this firm is available in the Internet website of the company[52].

Bombardier Transportation {Bombardier}, a division of Bombardier Corporation, is a major manufacturer of railroad passenger railcar and locomotive equipment in the International market[53]. Bombardier produces a non-powered, three-level, passenger coach railcar design for the regional / commuter rail service market, referred to as a BiLevel™ coach [54], the design of which was involved in this event, and as further described in this report. The company also produces "single-deck" (single-level), and "multi-level" passenger railcar coach designs for the regional / commuter rail service market, as well as a number of other passenger railcar designs for other service applications (e.g. hi-speed, light-rail, intercity, rapid-transit / Metro [subway], monorail). Bombardier maintains railcar manufacturing facilities in Thunder Bay, Ontario, and La Pocatière, Québec, Canada, and operates three railcar manufacturing sites and three railcar overhaul facilities in the states of New York and Pennsylvania.

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[48] as available at [Internet] >> http://ecfr.gpoaccess.gov/
[49] ref. 49 CFR 229.203(a), which is available at [Internet] >> http://ecfr.gpoaccess.gov/
[50] ref: http://www.bombardier.com/, and other sources as noted
[51] the equipment maintenance operation functions as separate operating entity of the parent company
[52] ref. [Internet] >> http://www.bombardier.com/en/transportation
[53] as further described in [Internet] >> http://www.bombardier.com/files/en/supporting_docs/Bombardier_US_12_2007_LR_en.pdf
[54] BiLevel was noted (in the Internet website of the company) as a Trademark of Bombardier Inc., or its subsidiaries.

Additional information on the Bombardier BiLevel Coach railcar design is as follows.

5.2 BiLevel Coach – Carbody Design[55]

5.2.1 Background and Fleet Information[56]

The BiLevel Passenger Coach carbody design, as utilized by the SCRRA, originated with, and was initially manufactured by, a predecessor company (Hawker Siddeley, 1977 – 1984 inclusive). The manufacture was subsequently taken over by a successor company (Urban Transit Development Corp. {UTDC}, 1984 – 1991, inclusive), with the railcar currently manufactured by Bombardier (1992 – present). Additional technical detail of the BiLevel Coach design is further provided in this report.

A basic illustration of the BiLevel Coach railcar design is provided in Exhibit 6.

Bombardier reported to the Investigation that an official Fleet Production Count Tabulation of the BiLevel Railcar design, as delivered to-date, indicated 943 BiLevel railcars have been ordered and 893 BiLevel railcars have been delivered, all of which are in North America.

A Tabulation of the Fleet Production Count of the BiLevel Railcar design, as compiled by Bombardier, describing the deliveries by customer [destination city] and by carbody side-panel assembly method (i.e. 'riveted' vs. 'welded' method), is provided in Exhibit 7.

5.2.2 BiLevel Coach – General Configuration[57, 58]

The SCRRA passenger coach fleet is composed of three groups of BiLevel Coach railcars supplied by Bombardier, or UTDC (a company that was later bought by Bombardier, Inc.), which are identified by the 'Delivery Series' number and delivery dates, with the delivery of the individual groups occurring several years apart. Bombardier also refers to the three individual

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[55] as information on the 'Contract 200' delivery series railcars was developed [researched / reported] in NTSB's Investigation "Collision of Burlington Northern Santa Fe Freight Train With Metrolink Passenger Train, [in] Placentia, California, [on] April 23, 2002" (NTSB Accident # DCA02MR004), applicable narrative information on the 'Contract 200' delivery series railcars, as cited in the Survival Factors Factual Report of that Investigation, has been reproduced, essentially verbatim, in this section of this report (with the concurrence of Bombardier and SCRRA), as further noted in this report section.

[56] ref. data developed [researched / reported] in the Survival Factors Factual Report of the NTSB Placentia, California, Metrolink [SCRRA] / BNSF Accident Investigation, which remains applicable to this Investigation.

[57] source – NTSB on-scene investigation, Bombardier [Party to the Investigation - technical representative], Go-Transit Internet Website [http://www.gotransit.com/] , and Trains Magazine article (Sept. 1997) "GO Transit" by Matt Van Hattem [Internet >> http://www.trains.com/]

[58] Note – this report Section contains data developed [researched / reported] in the Survival Factors Factual Report of the NTSB Placentia, California, Metrolink [SCRRA] / BNSF Accident Investigation, which (because the Placentia accident involved some of the same type of equipment as the Chatsworth accident) remains applicable to this Investigation, <u>except</u> as where specifically noted in applicable sub-sections of this report Section (which contains <u>new data</u> as developed in this Investigation).

(sequential) groups, or "generations", of railcar deliveries as the "Contract 200", "Contract 207", and "Contract 214", respectively [59].

The BiLevel coach equipment involved in the accident were comprised of railcars from the first 'delivery series' group (i.e. SCAX # 617 [a Cab-car] from the Contract 200, which comprise cars having delivery dates 1992-93, inclusive), and from the third 'delivery series' group (i.e. SCAX # 185 and # 207 [both trailer coaches] from the Contract 214, which comprise cars having delivery dates in 2001-2002, inclusive).

The 'delivery series' information detail for the SCRRA passenger railcar and locomotive fleet is summarized in the SCRRA Equipment Inventory Summary, Exhibit 8, in this report.

The interior features of the BiLevel Coach railcars of the three 'delivery series' are all essentially similar in design to each other, with minor variants in design occurring between the delivery series, and some of the mechanical components are interchangeable between each delivery series.

5.2.3 Carbody Dimensions and Floorplan Layout[60]

Generally described, the BiLevel Coach railcars measure 85.0 ft in overall length[61], about 9.83 ft in width, are about 15.92 ft in overall height[62], and has an empty weight of approximately 115,777 lbs. The railcars utilize a pair of conventional passenger [service] truck-assemblies, each of which incorporate two pair of (33 inch wheel diameter) wheel-sets, and the cars utilize a pair of conventional AAR short shank Type H interlocking [railroad car] couplers.

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 § 5.2.4), 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.

The design of this coach equipment incorporates two full decks (an 'upper' and 'lower') in the center of the railcar and an 'intermediate level' deck situated over the truck assemblies at each end of the car, with all three decks provided with passenger seating accommodations (as further described in this report; see § 5.2.5).

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[59] SCRRA refers to the three individual 'Delivery Series' groups of railcars in procurement documentation as Contract No. R60-CR-001, Contract No. PO 150, and Contract No. EP100, respectively.
[60] source – Bombardier technical specifications documentation for the subject railcars
[61] as measured between opposite [carbody] end 'coupler faces'.
[62] as measured from the top of rail to top of carbody roof.

The BiLevel Coach / Cab-car and the Coach / Trailer carbody service types are both configured to the same basic seating arrangement in their respective passenger compartments. The only significant difference between the two service types is that the Coach / Cab Car incorporates an 'Operators Cab' (compartment) that is fitted to one end of the railcar, with passenger compartment areas occupying to balance of the car. The Cab is fitted with operating controls, and is occupied by the Engineer of the train when the train is operated with the Cab Car situated at the lead end[63] of the train. The SCRRA BiLevel Cab Car and Coach - Trailer units have seating to accommodate 142 and 143 passengers[64], respectively, and both coach railcar designs have a crush load[65] capacity of about 360 passengers[66].

There are two stairwells provided in the BiLevel Coach design[67], with the stairwells providing access between the 'lower level' deck, the 'intermediate level' (at each opposite end of the railcar), and the 'upper level' deck of the railcar (in the center of the railcar). Four main (passenger ingress / egress) side-exit, pneumatically operated, two-leaf (panel) sliding pocket doors[68] 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. The 'intermediate level' of the coach is provided with a door at each end bulkhead of the railcar, which allows passage (through a 'diaphragm' assembly[69]) to an adjacent (BiLevel) coach.

Exemplar engineering illustrations of the BiLevel Passenger Coach (for the Contract 200 and Contract 214 Delivery Series), depicting the longitudinal / vertical plane cross-section, a basic 3-view perspective of the car, and select elements of the sidewall structure assembly and under-frame structure assembly, are provided in Exhibit 9.

5.2.4 Carbody Structural Design Criteria

The BiLevel Coach railcars of the three SCRRA 'delivery series' types are very similar to each other, where, as a basic description, the carbody incorporates a 'non-linear structural steel centersill element' (under-frame weldment)[70] that is manufactured from a "low alloy high

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[63] note – irrespective of directional references used by this railroad operator, in this report, forward (lead end) and aft directional references are relative to the normal [forward] direction of travel.
[64] without bicycles or wheelchairs
[65] *Crush Load* is the maximum number of passengers that can possibly be riding in the vehicle (standing and sitting very closely together).
[66] in contract procurement documentation reviewed (Contract PO150 modifications section, pg 1-1), a citation was observed that these railcars had a passenger crush load of 438 and 413 for trailer and cab cars, respectively.
[67] the stairwells are located at approximately the ¼ point and the ¾ point along the length of the carbody.
[68] 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
[69] 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.
[70] 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).

tensile" (LAHT) steel. The structural steel centersill element of the carbody for all three 'delivery series' railcar designs also bears a significant structural load-bearing function in the overall carbody structure. The first and second SCRRA 'delivery series' cars (i.e. the Contract 200 and 207) employed a "riveted" carbody side-panel assembly construction, where the third 'delivery series' cars (Contract 214) employed a "welded" carbody side-panel assembly construction. Also, the first and second SCRRA 'delivery series' cars incorporate aluminum corner posts at the non-cab-end of the car, while the coach cars of the third 'delivery series' incorporate steel corner posts [71].

To address considerations of what role the non-linear structural steel centersill element might have contributed in this event, a review was conducted of the SCRRA [design engineering] procurement documentation for the two railcar carbody construction types involved in the event, the observations of which are briefly summarized as follows.

a. "Contract 200" and "Contract 207" Equipment [72]

As noted above (in this report section), the BiLevel railcars supplied under the Contract 200 and Contract 207 employed a 'riveted' carbody side-panel assembly construction.

Review of 1995 procurement documentation[73], as supplied to the investigation by SCRRA, for a group of BiLevel railcars purchased 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".

Correspondence[74] (from an engineering consultant to SCRRA[75], employed to provide technical support in the procurement of the Bombardier railcars) indicated that the [Hawker Siddeley] structural test reports on the static end load testing requirements, as well as for other carbody element structural strength criteria, were on file for several of the BiLevel railcar procurement contracts executed by SCRRA, where the railcars were designed to satisfy the requirements of the AAR Manual of Standards and Practices, Part C, for Passenger Cars, and the 49 CFR 229.141(a), Non-M.U. control cab locomotives in a train of more than 600,000 lb. empty weight". Structural test report documentation attached thereto, as support to the procurement process, indicated that 'static end load structural testing' was conducted on an exemplary railcar carbody by Hawker Siddeley in May and June 1977 to accommodate a delivery requirement of a

[71] ref. email dated Jan. 30, 2009; information from Bombardier Party representative
[72] ref. data as developed in the NTSB Placentia, California, Metrolink [SCRRA] / BNSF Accident Investigation.
[73] ref. [SCRRA] Contract Agreement No. PO150 for Trailer and Cab Control Vehicles for Rail Passenger Service Between SCRRA and Bombardier Corporation, Conformed Contract Issued November 27, 1995, which is also referred to as the "Contract 207" by Bombardier.
[74] transmittal documentation, provided to the investigation by SCRRA
[75] ref. correspondence from LTK Engineering Services to SCRRA, dated May 6, 2002; SCRRA Contract # EP100 Engineering, Technical and Management Support for Rolling Stock Procurement Contract R60-CR-001 and Contract No. PO150 Structural Test Reports.

customer[76], wherein “under an 800,000 lb. buff load applied on the center-line of draft, no permanent deformation or permanent buckling was observed”.

b. “Contract 214” Equipment [77]

As noted above (in this report section), the BiLevel railcars supplied under the Contract 214 employed a ‘welded’ carbody side-panel assembly construction.

Similar to the design review process as noted above for the [original Hawker Siddeley designed] riveted carbody side-panel assembly construction BiLevel railcar design (§ 5.2.4.a), structural testing was performed by the railcar manufacturer on an exemplar welded carbody side-panel assembly railcar, in which key aspects demonstrative of this testing are briefly summarized as follows[78].

Review of 1999 procurement documentation[79], as supplied to the investigation by SCRRA, for a group of BiLevel 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”.

Narrative text content in the (Contract 214) procurement contract documentation [Preamble] cites language indicating, to the effect, that the July 31, 1998, procurement contract executed between Bombardier and Central Puget Sound Regional Transit Authority (CPSRTA), which Bombardier references as the “Contract 212”, includes an option for [the manufacture of] up to 35 additional BiLevel railcars for possible purchase by SCRRA, in which also narrative text content of the SCRRA Contract 214 procurement contract documentation (supplied to the Investigation) indicates that the SCRRA Contract 214 is an execution of that option cited in the CPSRTA Contract 212.

Review of technical sections of the [CPSRTA] Contract 212 indicates that structural testing was conducted on exemplar B-End Corner Post structure and sidewall frame assembles of the railcar

[76] Toronto Area Transit Operating Authority

[77] ref. data as developed in this Investigation (and not as previously reported in the NTSB Placentia, California, Metrolink [SCRRA] / BNSF Accident Investigation).

[78] ref. correspondence received from an engineering principal of Bombardier, dated 17 Dec.2008 and 31 Dec. 2008, which provided several correspondence items on this subject, depicting dialog between the principal participating parties of the railcar procurement transaction (SCRRA and Bombardier) and engineering consultant to SCRRA [LTK Engineering Services], culminating in [supplied] correspondence from Bombardier to LTK Engineering Services, dated March 29, 2000; Commuter Rail Vehicle Procurement Project, SCRRA Contract # EP100, FAI on Side Frame Assemblies, Ref Part 3, Specification Section 13.3.2.3.

[79] 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.

design (as supplied to CPSRTA in the Contract 212), wherein also, further narrative text content (of the CPSRTA Contract 212 transaction) indicated, to the effect, that the testing conducted had sufficiently demonstrated that the subject structural components complied with the mechanical stress loading requirements of the Contract.

Corresponding to the above, as documentation supplied (by Bombardier) to the Investigation demonstrated that the described structural testing had been successfully conducted on exemplar railcar equipment as delivered in the CPSRTA Contract 212, where it was also demonstrated that, with the SCRRA railcar procurement being an executed option of the CPSRTA Contract 212, the BiLevel railcar equipment as manufactured for delivery by Bombardier in the CPSRTA Contract 212 is structurally identical to the railcars supplied to the SCRRA Contract 214, that the structural testing performed for the CPSRTA Contract 212 equipment would also obviously apply to the SCRRA Contract 214 equipment, which, accordingly, demonstrates that the supplied SCRRA Contract 214 BiLevel railcars are in compliance with the structural testing conducted pursuant to the requirements of the AAR Manual of Standards and Practices, Part C, for Passenger Cars, and under 49 CFR 229.141, as applicable to the subject railcars / railroad operation.

Supportive of the above (paragraph), Bombardier supplied additional documentation from an engineering consultant to SCRRA, which had been employed to provide oversight technical support in the procurement of the SCRRA Contract 214 railcars, which SCRRA also deems to be an independent, technically-competent, professional resource in matters such as this (which also had been used in the two prior BiLevel railcar equipment procurements), which indicated that a detailed technical review conducted by that engineering consultant, of the structural testing conducted pursuant to the CPSRTA Contract 212 railcar equipment delivery contract, affirmed that the structural testing conducted pursuant to the CPSRTA Contract 212 did satisfy the [contractual] technical specifications of the SCRRA Contract 214, which, accordingly, demonstrated that the railcars as supplied under the SCRRA Contract 214 were designed to satisfy the requirements of the AAR Manual of Standards and Practices, Part C, for Passenger Cars, and the 49 CFR 229.141(a), Non-M.U. control cab locomotives in a train of more than 600,000 lb. empty weight".

5.2.5 Passenger Seating Accommodations

Generally described, passenger seating accommodations on board the SCRRA BiLevel Coaches consist of a combination of transverse and longitudinal mounted 'fixed seat' assemblies[80], 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 in the SCRRA BiLevel coach railcar fleet 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).

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

The 'fixed seat' assemblies found in the SCRRA coach railcar fleet are comprised of two different 'seat-pan' designs[81], depending upon the 'delivery series' of the railcar (as further described in this report; see § 5.2.4). The fixed seat assemblies for the Contract 200 and Contract 214 delivery series railcars utilize a (molded) fiberglass seat-pan design, whereas the fixed seat assemblies for the Contract 207 delivery series railcars utilize a (extruded) steel seat-pan design. Both fixed seat designs employ an upholstered seat cushion insert, and incorporate an upholstered headrest above the seatback. The fixed seat assemblies for the Contract 200 and Contract 214 delivery series cars have a 'rigid' (built-in) armrest between the seats, whereas fixed seat assemblies for the Contract 207 delivery series cars have a movable armrest, which can be rotated, manually, to an upright location (between the two seatbacks).

An illustration of the 'paired seating sets' (i.e. the opposing 'face-to-face' seating layout) and the 'Work-Station Tables' of the passenger seating accommodations, and a related illustration showing the seat numbering arrangement for the BiLevel Coach, are provided in Exhibit 10.

5.2.6 Work-Station Tables Fitted to the BiLevel Coaches

a. Summary Background

There are eight 'Work-Station Tables' that are situated throughout the SCRRA BiLevel Coaches (four on the upper level and two at each intermediate level, at each opposite end of the railcar), which are fitted between paired seating sets of opposing passenger seats. The tables are a basic design, consisting of a one-piece tabletop assembly that is cantilevered from and secured to the carbody sidewall, with a single (metal) support leg [pedestal] that is attached to the tabletop underside and secured to the floor. The table pedestals in the first and second 'delivery series' (Contracts 200 and 207) were attached to (i.e. screwed into) the wooden sub-floors of the carbody, where the table pedestals for the third 'delivery series' (Contract 214) were attached to metal components under the floor with machine screws into tapped holes [82].

The tabletops are trapezoidal in shape and all of a uniform size (approximately), and measure about 33 ½ inches in length (carbody sidewall to opposite side dimension). The tabletop width measures about 16 inches (the trapezoidal major dimension, measured at its attachment to the carbody sidewall), which tapers to about 12 ¼ inches (the trapezoidal minor dimension, along the aisle. The tabletop measures about one inch thick and the top surfaces are about 29 ¾ inches above the floor. The tabletops are manufactured of a high-pressure laminate material, which is principally comprised of a rigid 'particleboard' material [83], which is surfaced with a 'melamine' [resilient plastic] material [84].

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[81] 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.
[82] ref. email dated Jan. 30, 2009; information from Bombardier Party representative
[83] 'particleboard' is a non-structural product made from wood particles which are mixed with resins and formed, under heat and pressure, into a strong, solid board product (as described by one [exemplar] manufacturer of this type of product [Internet] >> http://www.flakeboard.com/particleboard.asp), which (in this application) is surfaced by a thin sheet of thermally fused ['laminated'] melamine, as further described in this report.
[84] 'melamine' is a resilient thermosetting plastic material, as used in Formica, and other similar products.

Information provided by Bombardier to the NTSB Placentia, CA, Accident Investigation indicated that all of the BiLevel Coach railcars, as delivered to its customers, had been fitted with the 'Work-Station Tables' [85]. Bombardier advises this Investigation, as an update, and/or clarification of information provided to the NTSB in the Placentia, CA, Accident Investigation, that a more detailed review of its records (conducted subsequent to the Placentia Investigation efforts) has determined that not all BiLevel Coach railcars as delivered to customers are fitted with the [described] 'Work-Station Tables' [86].

b. Observations of the Placentia, CA, Investigation

The NTSB investigation of the Metrolink [SCRRA] / BNSF collision in Placentia, CA (April 2002) identified that serious occupant injury resulted from occupant impact with the 'Work-Station Tables'. Bombardier, manufacturer of the BiLevel passenger railcar coaches, also identified [to the NTSB in that Investigation] that prior to the accident, they had not conducted any biomechanical engineering analysis, testing, or injury causation assessment of occupant impact against the 'Work-Station Tables' as fitted to the BiLevel Coach railcars [87].

Bombardier advises this Investigation, as an update, and/or clarification of information provided to the NTSB in the Placentia, CA, Accident Investigation, that "prior to the Placentia accident, Bombardier had designed the tables to comply with customer specifications and applicable FRA regulations as to structural integrity, smoothed surfaces and shape and to comply with passenger rail car compartmentalization crashworthiness concepts. It had not, however, performed any "biomechanical engineering analysis" or crash testing to determine table impact damage to anthropomorphic dummies in collisions and derailments. Such work was initiated by the FRA in late 2003 with the promulgation of performance standards for an experimental table to reduce thoracic and abdominal injury and related commissioning of the construction of experimental tables (see Rail Crashworthiness Research Support Services Contract Specification DOT/FRA/Volpe Contract DTRS57-04-D-30008, DTD 24-DEC-03). Part of this work included February, 2004, testing on these tables with anthropomorphic dummies to obtain baseline abdominal loads and in full-scale train car crash tests in March of 2006. This work continues and Bombardier reports that it is closely following the progress. Bombardier also reports that is actively collaborating with customers and regulators around the world in designing crushable, or otherwise more crashworthy, tables" [88].

5.2.7 Research Initiatives Proactively Employed by SCRRA to Address Injury Causation Concerns of the Work-Station Table Design Installed in BiLevel Coaches

SCRRA was afforded an opportunity to report to the Investigation information on research initiatives, as proactively employed by organization, to address occupant injury concerns of the

[85] ref. NTSB Railroad Accident Investigation – Placentia, CA, Metrolink [SCRRA] / BNSF collision in April 2002; Survival Factors Factual Report § 2.2.6.
[86] ref. email dated Jan. 30, 2009, et seq.; information from Bombardier Party representative
[87] ref. NTSB Railroad Accident Investigation – Placentia, CA, Metrolink [SCRRA] / BNSF collision in April 2002; Survival Factors Factual Report § 2.2.6.
[88] ref. email dated Jan. 30, 2009; information from Bombardier Party representative

'Work-Station Table' design as fitted to the BiLevel Coach railcars, as identified in the Placentia, CA, Investigation. The organization responded that two research project initiatives had been initiated subsequent to the Placentia accident, to assess occupant impact against the 'Work-Station Tables', on the prospect of identifying possible alternate 'Work-Station Table' design options that might help ameliorate resulting occupant impact injury. One project involves an effort comprised of SCRRA / LTK Engineering Services [89] / Volpe National Transportation Systems Center [90] / FRA resources, and the other project involves efforts by Hyundai Rotem for a design to be fitted to the new / forthcoming SCRRA railcar delivery order from Hyundai Rotem. The current SCRRA BiLevel railcar fleet will be retrofitted with a new design 'Work-Station Table' as developed in this research effort.

SCRRA was invited to submit summary descriptive documentation on these research project initiatives, the response received of which is provided in Exhibit 11.

5.2.8 Evolution of Crashworthiness and Safety Changes in Bombardier BiLevel Rail Cars since 2002

Bombardier was afforded an opportunity to report to the Investigation information on the evolution of crashworthiness and safety changes in its BiLevel rail cars since 2002. The company responded correspondence [91] that summarized a number of initiatives that had been implemented, a copy of which is provided in Exhibit 12.

5.2.9 International Research Initiatives to Address Injury Causation Concerns of Work-Station Table Designs

The Investigation identified a research initiative undertaken by the Rail Safety and Standards Board [92], of the U.K., to address injury causation concerns of 'Work-Station Table' designs (as identified by a technical review of a number of UK railway accidents, and two SCRRA rail accidents). The organization also produced a report for this initiative titled "Improving the design of seats and tables to minimise passenger injuries" [sic], dated Sept. 2008, which described sophisticated computer-based occupant kinematics simulation modeling (by the name of MADYMO [93]) as employed in the analysis, in which also a copy of the report documentation is available from this organization [94].

5.3 Carbody Design – Structural Strength Requirements

[89] SCRRA's rail equipment consultant (a professional engineering and consulting firm, as further described in [Internet] >> http://www.ltk.com/)
[90] Volpe National Transportation Systems Center is a part of the U.S. D.O.T's Research and Innovative Technology Administration (RITA), and is "an innovative, federal, fee-for service organization, [having a mission] to improve the Nation's transportation system, which performs work primarily for the D.O.T., as well as other federal agencies and state, local, and international entities", as further described in [Internet] >> http://www.volpe.dot.gov/index.html)
[91] ref. email dated Nov. 25, 2008, et seq.; information from Bombardier Party representative
[92] ref., and for further information, see [Internet] >> http://www.rssb.co.uk/index.asp
[93] ref., and for further information, see [Internet] >> http://www.tass-safe.com/cms/index.php
[94] report copy available at [Internet] >> http://www.rssb.co.uk/pdf/reports/research/T201_rb_final_tables.pdf

Technical specifications as issued by SCRRA for the delivery of the Contract 200 and Contract 214 ('delivery series') BiLevel passenger railcars, to address aspects of carbody structural strength, prescribe that the design of the equipment comply with the following Regulatory and Industry Standards, as follows.

5.3.1 Cab Car Regulatory Requirements - 49 CFR 229.141

Review of the regulatory requirements under the applicable sections of 49 CFR 229.141 "Design Requirements; Body structure, MU locomotives" indicates the railcars are subject to physical testing to demonstrate, for example, compliance with "buff strength" and collision post strength loading, anti-climber features, etc., as further described in Exhibit 13.

5.3.2 Industry Standards - AAR[95] Manual of Standards and Recommended Practices, Section A, Part III, Passenger Car Requirements

Review of the '214 Contract' language, under Part 3, Section 2.1 cites a requirement that "... The cars shall be designed, and constructed, in full compliance with all applicable rules, and regulations, of the FRA and the AAR Manual of Standards and Recommended Practices, Section A, Part III, Passenger Car Requirements, Revision dated 1984 (as cited in the administrative section of the contract).

Review of the AAR specification documentation indicates that the applicable subsection therein to address aspects of carbody structural strength is comprised within the AAR Standard S-034-69 "Specifications of the Construction of New Passenger Equipment Cars" (wherein the -69 designates a 1969 date revision for this particular Standard), which provides technical criteria for physical testing to demonstrate, for example, compliance with "buff strength" and collision post strength loading, anti-climber features, etc., as further described in Exhibit 14.

5.4 Passenger Equipment Safety Standards – Industry Standards / Regulation

Irrespective of the applicable Contractual (technical specification) requirements for the delivery of the BiLevel passenger railcars (described in § 5.3), criteria of 'passenger equipment safety standards' relative to other recognized Industry Standards and/or Regulation were identified / reviewed, which are briefly summarized as follows.

5.4.1 Industry Standards [96]

Review of industry standards for railroad passenger equipment, relative to carbody structural strength, and other engineering design criteria, indicates a document titled "APTA Manual of Standards and Recommended Practices for Rail Passenger Equipment" [97] has been published by

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[95] Association of American Railroads {AAR}, a professional trade association, as described in >> http://www.aar.org/Homepage.aspx

[96] as a general observation, Industry Standards are employed for 'voluntary compliance' by the subscriber (customer / client) and have no regulatory authority, unless "incorporated by reference" into a Regulation.

[97] this document is maintained under copyright protection of the APTA, in which a copy is also available from that organization (see [Internet] >> http://www.apta.com/).

the American Public Transportation Association [98]. Review of the document content indicates it to contain many of the technical elements as are contained in the AAR Manual of Standards and Recommended Practices, Section A, Part III, Passenger Car Requirements (as previously described in this report; see § 5.3.2).

5.4.2 Regulation [99]

Review of Regulation for railroad passenger equipment, relative to carbody structural strength, as applicable to passenger equipment ordered on or after September 8, 2000 or placed in service for the first time on or after September 9, 2002, and as would be applicable to the railroad operating environment as observed in this Accident, indicates that the requirements under 49 CFR 238 Subpart C Specific Requirements for Tier I Passenger Equipment (i.e. 49 CFR 238.201, et seq.) would generally apply [100, 101].

Selective "applicability" exceptions to the above noted "ordered" or "in-service" date criteria of 49 CFR 238 Subpart C were observed, which cited an applicability date of the equipment (that was to be subject to the Regulation) that was earlier than the prescribed "ordered on or after September 8, 2000 or placed in service for the first time on or after September 9, 2002" date criteria. Such an observed exception included, for example, 49 CFR 238.201 Static end strength, which prescribes (in summary) that all railroad passenger equipment [in service] on or after November 8, 1999 be able to "… resist a minimum static end load of 800,000 pounds applied on the line of draft without permanent deformation of the body structure". Additional applicability exceptions were noted for certain railroad operating environments, specialized equipment considerations, etc.

5.5 SCRRA compliance with 49 CFR 238 Subpart C

Principals of SCRRA represented to the Crashworthiness Investigation that the SCRRA passenger railcar fleet is in compliance with applicable Regulatory Passenger Equipment Safety Standards, which would also apply to Regulation (as described in § 5.4.2) that became effective subsequent to the delivery of the most recent 'Delivery Series' group of BiLevel Coach railcars (in 2001-2002). As verification of this, the Crashworthiness Investigation[102] reviewed the technical elements of the applicable Regulation under 49 CFR 238 Subpart C, where, for the three 'Delivery Series' groups of BiLevel Coach railcars in the SCRRA fleet (i.e. the Contract 200, Contract 207, and Contract 214 railcars), a comparison was made of the Regulatory technical elements against the technical specifications to which the SCRRA passenger equipment was built to (e.g. AAR Standard S-034-69 "Specifications of the Construction of New Passenger

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[98] ref., and for additional information, see [Internet] >> http://www.apta.com/

[99] resulting from a Final Rule [issued by the FRA, titled] "Passenger Equipment Safety Standards", published [in the Fed. Register] May 12, 1999, which became effective subsequent to the delivery of the most recent 'Delivery Series' group of BiLevel Coach railcars.

[100] as available at [Internet] >> http://ecfr.gpoaccess.gov/

[101] ref. 49 CFR 238.201, the "structural standards" of 49 CFR 238 Subpart C specifically include §238.203 static end strength; §238.205 anti-climbing mechanism; §238.207 link between coupling mechanism and car body; §238.209 forward-facing end structure of locomotives; §238.211 collision posts; §238.213 corner posts; §238.215 rollover strength; §238.217 side structure; §238.219 truck-to-car-body attachment; and §238.223 locomotive fuel tanks.

[102] as represented by the Crashworthiness Working Group Chairperson (the 'organizing author' of this report).

Equipment Cars"). The comparative review revealed the technical specifications to which the SCRRA passenger equipment was built to were comparable to, or exceeded, the technical elements of the applicable Regulation under 49 CFR 238 Subpart C, which, accordingly, is consistent with the representation of SCRRA in this regard, and affirms that, the SCRRA passenger railcar fleet is in compliance with the applicable Regulatory Passenger Equipment Safety Standards (as described in § 5.4.2).

6.0 Pre-Recovery / Inspection Summary – Railroad Equipment and Accident Site

Principals of the Crashworthiness Working Group[103] inspected the accident site and examined the railroad equipment commencing about 18 hours post-event[104]. Local responding emergency services authorities, and management principals of both railroad companies, indicated to the Investigation that due to considerations of exigent extrication of injured passengers or decedent recovery, wreckage clearing of the damaged locomotive equipment of both railroad companies, and some of the freight railcars of the UP train, and the site clean-up process, commenced at about 4:00 am that morning. For this process, the derailed railroad equipment was hoisted using heavy wreckage recovery apparatus, as employed by the wreckage recovery / site clean-up contractor, and laterally moved a short distance to locations immediately adjacent to where the derailed railroad equipment initially came to rest, where it temporarily remained until the final site clearing process (upon completion of the extrication of injured passengers or decedent recovery).

For the railroad equipment that was not disturbed / relocated prior to arrival of the Crashworthiness Working Group at the accident scene, the Crashworthiness Working Group participants were able to conduct an examination of, and directly record observations of, the artifacts of the accident scene. For the railroad equipment that was disturbed / relocated prior to arrival of the Crashworthiness Working Group at the accident scene, accommodations were employed to document the accident site and equipment, to the extent possible.

6.1 Summarization of Observations

As a brief summarization of overall conditions of the railroad equipment, as observed by the Crashworthiness Working Group participants at the accident scene:

- the three SCRRA passenger coach railcars had remained where they initially came to rest, although certain component elements of the lead SCRRA passenger coach railcar (SCAX 185) were disturbed / relocated as a result of the exigent extrication of injured passengers and/or the decedent recovery process (as described above). The disturbed component elements of this railcar (SCAX 185) car included, for example, much of the carbody side and roof panels and much of the interior component elements (e.g. seats, floor, partitions, hand-hold stanchion posts, etc), which were temporarily placed in a debris pile immediately adjacent to where the railcar initially came to rest.

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[103] i.e. staff of the various organizations who would later comprise the Crashworthiness Working Group, several of which arrived several hours prior, and already had commenced with the inspection and documentation process.

[104] the event occurred about 4:22 pm (Friday, Sept. 12), wherein the Crashworthiness Working Group, as represented by the Group Chairperson, arrived at the accident scene about 10:30 am the following day (Saturday, Sept. 13).

- the other derailed railroad equipment (comprised of the SCRRA locomotive and essentially all of the derailed UP equipment) had been hoisted and laterally moved a short distance to locations immediately adjacent to where the equipment initially came to rest, which also made it available, to a certain degree, for subsequent post-recovery examination (as further described in this report; see § 7.0).

- the collision and derailment had also resulted in a relatively minor hazardous material {Hazmat} release and a localized / relatively small fire[105], although evidence on the soil / ballast surfaces been disturbed / obliterated as a result of initiating the wreckage recovery / site clean-up process (by the wreckage recovery / site clean-up contractor), as described above.

Additional information detail on the pre-recovery examination of the railroad equipment and the accident site, as conducted by the Crashworthiness Working Group, is summarized as follows.

6.2 Railroad Equipment Wreckage – Observations[106]

As noted above, some of the railroad equipment was disturbed / relocated prior to arrival of the Crashworthiness Working Group at the accident scene, wherein accordingly, no pre-recovery technical examination was performed on that equipment. In an effort to document the pre-recovery locations, and physical conditions (to a certain degree) of the disturbed equipment prior to relocation, the Investigation made use of several map graphics (using information as sourced from aerial photographs) that were constructed in the Investigation (as further described in this Report; see § 6.4), and also made use of aerial, and ground-based photographic images.

For the railroad equipment that was not disturbed / relocated prior to arrival of the Crashworthiness Working Group at the accident scene, the Crashworthiness Working Group participants were able to conduct an examination of, and directly record observations of, the artifacts of the accident scene.

6.2.1 SCRRA Locomotive (SCAX # 855)

Briefly summarized, as a result of a frontal ("head-on") collision with the lead locomotive of another train, this locomotive, which was occupied solely by the train engineer, sustained severe damage in the event (a complete loss of [Operator's Cab] occupant survival space), which resulted in fatal injury to the locomotive engineer.

Regarding the value of this locomotive as an evidentiary artifact, this locomotive unit was found to have been disturbed and relocated prior to on-scene arrival of the Crashworthiness Working Group, in which also the Crashworthiness Investigation had been advised that a quantity of aerial and ground-based photographs had been taken prior to disturbing this railcar, and that map graphics would be compiled to describe the pre-recovery location / condition of the equipment

[105] a discharge of diesel fuel from the SCRRA locomotive fuel tank occurred, which apparently subsequently ignited.
[106] note – irrespective of directional references used by this railroad operator, in this report, forward (lead end) and aft, and left and right, directional references are relative to the normal [forward] direction of travel.

(of which both sources of information would be subsequently available to the Crashworthiness Investigation). Normally, pursuant to prevailing Crashworthiness Working Group investigative practice (regarding documentation of on-scene evidence[107]), the disturbance to / relocation of the equipment would potentially have compromised its value as an evidentiary artifact, and thus, no effort would have been made to further conduct a pre-recovery technical examination on this piece of railroad equipment. However, given considerations of allowing the Investigation to potentially address locomotive crashworthiness (i.e. loss of [Operator's Cab] occupant survival space), and that a quantity of aerial and ground-based photographs would [later] be available, the Crashworthiness Investigation elected to proceed, nonetheless, with a pre-recovery technical examination on this locomotive, as the preponderance of potential evidentiary data value gained by the Investigation would override considerations of potentially compromised evidence.

Accordingly, examination observations were compiled directly by the Crashworthiness Working Group participants, as well as by utilizing the described map graphics and/or aerial and ground-based photography (as provided to the Investigation), the key consolidated observations points of which are briefly summarized as follows:

- the locomotive was operating at the lead-end of the train, in a cab-forward orientation.
- the locomotive came to rest on its right side (to the northeast [compass] side of the track), at a location to the immediate right side of the track, in which the locomotive carbody was longitudinally oriented roughly parallel to the track centerline (see also below).
- (corresponding to the above, to present a more precise measurement) the front end, and aft end, of this locomotive came to rest laterally displaced (located) to the northeast [compass] of the track datum (centerline), distances of about 20 ft, and about 10 ft, respectively.
- the front end of this locomotive was located a distance estimated to be about 76 ft to the east [compass direction] of the identified / approximate point of collision[108].
- obvious severe collision impact and batter damage was sustained to the front end, both side panel areas, the Operator's Cab, and aft end of the locomotive, wherein also:
    - the front end of this locomotive was firmly wedged against the front end of the lead UP locomotive (UP # 8485).
    - the aft end of this locomotive penetrated the leading bulkhead panel of the first coach to which it was coupled (SCAX # 185), where the locomotive came to rest in a longitudinal orientation, positioned within the confines of the occupant compartment of the leading approximately two-thirds segment of that coach railcar[109].
    - the Operator's Cab sustained an apparent complete loss of occupant survival space.

[107] procedures for the documentation of on-scene evidence by the Crashworthiness Investigation (and the Survival Factors Investigation, for that matter) are generally in accordance with those prescribed by the American Academy of Forensic Science {AAFS; as further described in [Internet] http://www.aafs.org}, which are also described in a number of professional publications on that topic as utilized by the forensic science profession (e.g. Siegel, Jay A., et al., Encyclopedia of Forensic Sciences, Academic Press, New York, NY, © 2000 – 3 volume set).
[108] ref § 1.5 of this report.
[109] the penetration of a colliding railcar, or locomotive, into the occupant compartment of another railcar during severe end-structure collisions is referred to in railroad accident investigations as a carbody 'telescoping' action.

- length measurements of the locomotive (taken post-recovery [which wouldn't likely vary from those of pre-recovery], as further described in this report) indicated that the front end, and the aft end of the unit, had compressively displaced, as a result of the collision impact damage, distances of about 15 ft, and about 1 ft, respectively (relative to the corresponding non-damaged dimensions), which totals to an overall compressive displacement distance of about 16 ft (i.e. the unit was collectively compressed to an overall length of about 42 ft, as compared to a non-damaged / overall length of about 58 ft).
- the fuel tank (containing diesel fuel) had separated from the locomotive, which was found resting on the track ballast, a short distance to the right side of the track, approximately adjacent to where the front of the locomotive came to rest, where the tank had also had been breached and experienced a loss of its contents.
- the lead power-truck assembly had separated from the locomotive, which was found resting, upright, close to the centerline of the track approximately adjacent to the mid-point of where the lead UP locomotive (# 8485) came to rest.
- the aft power-truck assembly remained attached to the locomotive.

6.2.2 SCRRA Passenger Coach Railcar Equipment

a. BiLevel Trailer Coach – SCAX # 185

Briefly summarized, this railcar, a conventional trailer-coach, which was the first passenger car located aft of the locomotive, had sustained severe structural damage in the event which also severely compromised its occupant survival space. Also, according to the on-scene emergency responders and Los Angeles County Department of Coroner personnel, of the 24 passengers in the train that sustained fatal injury, 22 of those passengers were identified to have been located in this railcar at the time of the collision, with one passenger identified to have been located in the second SCRRA coach railcar at the time of the collision (SCAX # 207), and the location of one passenger, at the time of the collision, was not able to be identified (as of the date of this report).

Examination by the Crashworthiness Working Group indicated that this railcar had been disturbed from its accident condition, but had not been relocated, prior to the on-scene arrival of the Crashworthiness Working Group. As described by the on-scene emergency responders, the disturbance to the railcar basically consisted of the disassembly and removal of a substantial quantity of component elements of this railcar, which was performed as a result of the exigent extrication of injured passengers and/or the decedent recovery process. The removed components consisted of, for example, carbody sidewall and roof panels, and much of the interior component elements (e.g. seats, floor, partitions, hand-hold stanchion posts, etc), which were temporarily placed in a debris pile immediately adjacent to where the railcar came to rest. The Crashworthiness Working Group was also advised that a quantity of aerial and ground-based photographs had been taken prior to disturbing this railcar, and that map graphics would be compiled to describe the pre-recovery location / condition of the equipment (of which both sources of information would be subsequently available to the Crashworthiness Investigation).

Normally, pursuant to prevailing Crashworthiness Working Group investigative practice (regarding documentation of on-scene evidence[110]), the disturbance that resulted to the equipment would have potentially compromised its value as an evidentiary artifact, and thus, no effort would have been made to further conduct a pre-recovery technical examination on this railcar. However, given considerations of the quantity of passenger fatalities that occurred in the railcar, the degree of severe damage sustained / loss of occupant survival space that occurred, and that a quantity of aerial and ground-based photographs would [later] be available, the Crashworthiness Investigation elected to document, nonetheless, the pre-recovery condition of the railcar (in lieu of a direct technical examination of the railcar), as the preponderance of potential evidentiary information value gained by the Investigation would override considerations of potentially compromised evidence.

Accordingly, examination observations were compiled directly by the Crashworthiness Working Group participants, to the extent possible, as well as by utilizing the described map graphics and/or aerial and ground-based photography (as provided to the Investigation), the key consolidated observations points of which are briefly summarized as follows:

- the railcar was operating in a B-end forward orientation.
- the railcar derailed, and came to rest leaning heavily toward its right side (as further described; see data below), at a location to the immediate right side of the track.
- obvious exterior and interior severe collision impact and batter was damage was sustained to essentially the entire carbody structure, which, briefly described, consisted of:
  - the leading end of the carbody sustained a longitudinal end-structure collision intrusion (commonly referred to as "carbody telescoping") resulting from the aft end of the locomotive (SCAX # 855), to which this railcar was coupled, having penetrated the leading bulkhead panel of the railcar, to where the locomotive came to rest, in a longitudinal orientation, within the occupant compartment of the leading approximately two-thirds segment of this railcar, the approximate longitudinal distance of which was later measured to be about 52 ft (relative to the leading bulkhead panel of the railcar).
  - as identified by on-scene evidence and photographic review, upon penetration of the aft end of the locomotive through the leading bulkhead panel of the railcar, the B-end section of this railcar (i.e. the leading ¼ length-segment of the railcar, encompassing the aft 'intermediate level' passenger compartment of the railcar, which is located above the lead-end truck) separated at the centersill 'gooseneck' and telescoped into the carbody with the lead truck which remained attached to this section of the car.
  - the telescoping of the carbody shell resulted in the purging of the entire interior carbody content in the telescoped segment of the railcar, such that essentially only the outer sidewalls, which had bulged and peeled outward (as a result of the above described locomotive 'telescoping' action), and roof structure of the carbody shell remained.
  - the telescoping of the carbody, and subsequent purging of interior carbody content, resulted in what can be referred to as a 'wall of collision debris' to occur, which accumulated at a location aft of where the aft end of the locomotive came to rest, which

[110] see footnote 107

consisted of a tightly compressed mass of dislodged / displaced / crushed seats, floor, ceiling panels, stanchion posts, 'work-station' tables, and other interior elements, as well as the leading bulkhead panel structure of the railcar, in which the compressed mass of debris was later measured to comprise a linear (longitudinal) distance of about 10 ft.

- the 'leading-end intermediate', the 'lower', and the 'upper' passenger compartments of the railcar sustained a complete loss of occupant survival space as a result of the above described locomotive 'telescoping' action (which measured about 52 ft, as previously described), which, in incorporating the (above described) linear distance that comprised the 'wall of collision debris' (containing the 'tightly compressed mass of interior elements'), was later measured to comprise a total linear (longitudinal) distance of about 62 ft (relative to the leading bulkhead panel of the railcar), which represents about 73 % of the total carbody length.

▫ the aft 'intermediate level' passenger compartment (located above the aft-end truck), including the spaces of the aft stairwells, were substantially undamaged, and did not sustain a significant loss of occupant survival space.

▫ the railcar was longitudinally oriented approximately parallel to the track centerline.

▫ the railcar, where it came to rest, displayed a measured transverse inclinometer reading of 67° (0° would be vertical, 90° would be horizontal), and a longitudinal inclinometer measurement of +5° (0° would be true horizontal; +5° means the east end was elevated [slightly] above the west end of the railcar).

▫ the aft end of this railcar was located a distance estimated to be about 175 ft to the East [compass direction] of the identified approximate point of collision[111].

▫ given the location of the aft end of this railcar (per above), for an 85 ft long railcar, the [theoretical] front end [point] of this railcar was located a distance estimated to be about 90 ft to the East of the identified approximate point of collision.

▫ the lead truck remained attached to the B-end section of this railcar (i.e. the leading ¼ length-segment of the railcar, encompassing the lead-end 'intermediate level' passenger compartment of the railcar, which is located above the lead-end truck) and came to rest a short distance forward of the aft vestibule section of the railcar.

▫ the aft truck assembly had separated from the A-end section of the railcar, which was found resting, upright, on the track ballast immediately adjacent to its normally mounted location on the railcar.

▫ no evidence of fire damage was observed in this railcar.

▫ coupler shank at the aft end [A-end] of this railcar was found to display evidence of fracture and was bent in a downward direction, in which the type of fracture and bend was also observed to be consistent with the apparent vehicle dynamics as might have occurred in the collision / derailment dynamics scenario.

▫ this railcar had separated from the adjacent railcar (SCAX # 185) at its aft end to which it was coupled, which is consistent with the (above noted) coupler fracture / shank bend, with the separation distance [to the adjacent railcar] measured to be about 32 ft.

[111] ref. § 1.5 of this report.

b. BiLevel Trailer Coach – SCAX # 207

Briefly summarized, this railcar, a conventional trailer-coach, which was the second passenger car located aft of the locomotive, did not sustain severe structural damage, nor was its occupant survival space significantly compromised in the event. One of the passenger fatalities of the accident was noted (by the local Coroner's office, and local emergency responders) to have occurred in this railcar.

Examination by the Crashworthiness Working Group indicated that this railcar had not been disturbed from its accident condition prior to the on-scene arrival of the Crashworthiness Working Group, wherein, accordingly, pre-recovery technical examination observations were compiled directly by the Crashworthiness Working Group participants, the key consolidated observations points of which are briefly summarized as follows:

- the railcar was operating in a B-end forward orientation.
- the railcar did not derail, and came to rest in its normal orientation on the track[112].
- no obvious exterior or interior catastrophic collision impact damage (carbody intrusion) was apparent.
- interior damage was observed, which generally consisted of fractured seatbacks, dislodged seats, bent and separated stanchion [vertical handhold] posts, dislodged / separated slider door and utility compartment panels, dislodged / separated work-station tables, ceiling panels dislodged / separated, etc.
- numerous indications of apparent blood transfers / blood loss were present at various locations in the railcar (principally on the floor and seats), which is consistent with personal trauma having been sustained in this railcar.
- a number of 'emergency windows' were missing (i.e. not in place), where they were also found at various places within the railcar, which is consistent with the windows having been "pulled" as a result of the emergency response to the accident.
- the front end of this railcar was located a distance estimated to be about 191 ft to the East [compass direction] of the identified approximate point of collision[113].
- no evidence of fire damage was observed in this railcar.
- coupler shank at the leading end [B-end] of this railcar was found to display evidence of fracture and was bent in an upward direction, where also the coupler head of the aft coupler of the adjoining railcar was found to be still engaged with the coupler head of this railcar, in which the condition of the coupler components was also observed to be consistent with the apparent vehicle dynamics as might have occurred in the collision / derailment dynamics scenario.

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[112] although the railcar was found resting on the rails, no determination could be made if the railcar experienced a small amount of wheel-lift during the collision dynamics of the event, in which the railcar also subsequently came to rest with its wheels positioned on the rails.

[113] ref. § 1.5 of this report.

- this railcar had separated from the adjacent railcar (SCAX # 185) at its leading end to which it was coupled, with the separation distance measured to be about 32 ft.
- this railcar remained coupled the adjacent railcar (at its aft end; SCAX # 617) to which it was coupled.
- several ripples were observed in the exterior carbody [sheet metal sheathing] side-panels.

c. BiLevel Trailer Coach – SCAX # 617

Briefly summarized, this railcar, although it was technically a Cab-Car coach, in this train it was operating as a conventional coach, which was the third passenger car located aft of the locomotive, which also did not sustain severe structural damage, nor was its occupant survival space significantly compromised in the event.

Examination by the Crashworthiness Working Group indicated that this railcar had not been disturbed from its accident condition prior to the on-scene arrival of the Crashworthiness Working Group, wherein, accordingly, pre-recovery technical examination observations were compiled directly by the Crashworthiness Working Group participants, the key consolidated observations points of which are briefly summarized as follows:

- the railcar was operating in a B-end forward orientation.
- the railcar did not derail, and came to rest in its normal orientation on the track[114].
- no obvious exterior or interior catastrophic collision impact damage (carbody intrusion) was apparent.
- interior damage was observed, which generally consisted of fractured seatbacks, dislodged seats, bent and separated stanchion [vertical handhold] posts, dislodged / separated slider door and utility compartment panels, ceiling panels dislodged / separated, etc.
- numerous indications of apparent blood transfers / blood loss were present at various locations in the railcar (principally on the floor and seats), which is consistent with personal trauma having been sustained in this railcar.
- a number of ‘emergency windows’ were missing (i.e. not in place), where they were also found at various places within the railcar, which is consistent with the windows having been “pulled” as a result of the emergency response to the accident.
- no evidence of fire damage was observed in this railcar.
- this railcar remained coupled the adjacent railcar (at its leading end; SCAX # 207) to which it was coupled.
- the aft truck (relative to the normal [forward] direction of travel) retention device fasteners were found to be sheared.
- no evidence of damage observed to the aft coupler of this railcar.

[114] see footnote 112

- the aft end of this railcar was located a distance estimated to be about 361 ft to the East [compass direction] of the identified approximate point of collision[115].

6.2.3 UP Locomotives

a. Lead Unit # 8485

Briefly summarized, the damage sustained to this locomotive in the accident, relevant to Locomotive Crashworthiness, which was occupied by two crewmembers, consisted principally of extensive (frontal) damage to the unit, and some fire damage, although no loss of [Operator's Cab] occupant survival space occurred.

Examination of this locomotive by the Crashworthiness Working Group indicated that this equipment had been substantially disturbed from its accident condition prior to the on-scene arrival of the Crashworthiness Working Group. The owner of the equipment indicated that, as a result of wreckage recovery / site clean-up efforts, the disturbance to the locomotive consisted of up-righting the unit, and relocating it back on the track a short distance from its derailed location (as preparation for it's removal from the accident site), which thus precluded efforts by the Crashworthiness Working Group to conduct a pre-recovery technical examination on this locomotive.

Examination by the Crashworthiness Working Group, however, revealed that the Operator's Cab areas of the locomotive had not been substantially disturbed / modified from its accident condition as a result of the wreckage recovery / site clean-up efforts, which accordingly, did not significantly compromise its value as an evidentiary artifact, and allowed the Crashworthiness Investigation to document the damage sustained to the unit in a post-recovery technical examination of the equipment, which was subsequently conducted (as further described in this report; see § 7.1.3.a).

b. Trailing Unit # 8491

Briefly summarized, the damage sustained to this locomotive in the accident, relevant to Locomotive Crashworthiness, which was occupied by one crewmember, as later described by principals of the owner of the equipment [UP], consisted essentially of substantial distortion to the Operator's Cab roof structure, where a segment of the roof panel was lifted upon apparently being contacted, during the derailment dynamics, by one or more of the derailed freight railcars.

Examination of this locomotive by the Crashworthiness Working Group indicated that this equipment had been substantially disturbed from its accident condition, and had been relocated, prior to the on-scene arrival of the Crashworthiness Working Group. The owner of the equipment indicated that, as a result of wreckage recovery / site clean-up efforts (similar to that as described for other pieces of railroad equipment), the disturbance to / modification of the locomotive cab structure consisted of compressing the distorted cab roof structure downward (using heavy wreckage recovery equipment) so that it would not make contact with the walls of Tunnel # 28 when being removed from the accident site.

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[115] ref. § 1.5 of this report.

Accordingly, pursuant to prevailing Crashworthiness Working Group investigative practice (regarding documentation of on-scene evidence), the disturbance to / modification of the locomotive cab structure from its accident condition compromised its value as an evidentiary artifact, which thus precluded efforts by the Crashworthiness Working Group to further conduct a pre-recovery, or a post-recovery, technical examination of this locomotive.

Additional detail information on the locomotive equipment is provided in the Mechanical Group - Factual Report of the Investigation.

6.2.4 UP Train - Freight Railcars

Examination of this equipment by the Crashworthiness Working Group indicated that this equipment had been substantially disturbed from its accident condition prior to the on-scene arrival of the Crashworthiness Working Group as a result of wreckage recovery / site clean-up efforts (similar to that as described for other pieces of railroad equipment), which was affirmed by the operator of the train [UP], wherein, accordingly, with the evidentiary value of this equipment having been compromised, no pre-recovery, or post-recovery, technical examination was performed by the Crashworthiness Working Group on this equipment[116].

Additional detail information on the freight railcar equipment is provided in the Mechanical Group - Factual Report of the Investigation.

6.3 Railroad Trackage / Right-of-Way – Site Configuration

Examination of the track and trackage right-of-way, and adjacent soil areas proximate to the collision and derailment site, by the Crashworthiness Working Group indicated that these areas had been substantially disturbed from its accident condition prior to the on-scene arrival of the Crashworthiness Working Group as a result of wreckage recovery / site clean-up efforts, wherein, accordingly, with the evidentiary artifacts of the accident scene having been compromised, no pre-recovery technical examination was performed by the Crashworthiness Working Group on these areas.

Additional detail information on the track structure is provided in the Track Group - Factual Report of the Investigation.

6.4 Site Map Documentation of the Wreckage Distribution

In an effort to document pre-recovery locations, and physical characterizations (to a certain degree), of the railroad equipment prior to relocation, aerial photography was conducted at the accident scene, the information of which is depicted in several map graphics that were

[116] physical data of the individual freight railcars in the Train Consist, except for dimensional size, weight, and perhaps cargo content, is usually not of significant consequence to the Crashworthiness Investigation, wherein documented characterizations of freight railcars generally is not performed by the Crashworthiness Investigation.

constructed in the Investigation[117], in which one of the constructed maps, which provides an illustration of the Wreckage Distribution Detail, is included in Exhibit 15 of this report.

Additional ground-based photography was performed by various entities at the accident scene, the images of which were subsequently made available to the Investigation (in which, as previously noted, key images are to be available in a separate Factual Report of the Investigation).

7.0 Post-Recovery – Equipment Inspection and Technical Documentation Review[118]

7.1 Physical Inspection

7.1.1 Locomotive – SCAX # 855

A post-recovery technical examination was conducted by the Crashworthiness Working Group on the SCRRA Locomotive # 855, to the extent possible, during the on-scene phase of the Investigation, with the observations documented by the participants in various report sheets, copies of which are provided in Exhibit 16 of this report.

7.1.2 SCRRA Passenger Coach Equipment

A post-recovery technical examination was conducted by the Crashworthiness Working Group on the SCRRA passenger coach equipment, to the extent possible, during the on-scene phase of the Investigation, with the observations documented by the participants in various report sheets, copies of which are provided in Exhibit 17 of this report.

7.1.3 UP Locomotives

a. Lead Unit # 8485

A post-recovery technical examination was conducted by the Crashworthiness Working Group on this locomotive, to the extent possible, during the on-scene phase of the Investigation, with the observations documented by the participants in various report sheets, copies of which are provided in Exhibit 18 of this report.

b. Trailing Unit # 8491

As previously indicated in this report (see § 6.2.3.b), because the evidence had become compromised, no effort was made to further document the condition of the locomotive.

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[117] map graphics compiled for the Investigation were constructed by resources of SCRRA (and their technical support contractor), in conjunction with the Track Group Investigation, as supported by the Crashworthiness Investigation.

[118] the Technical Documentation Review process comprises a review of prior significant accident damage sustained by the railroad equipment involved in the accident, relevant vehicle speed / event recorder information, and other investigations involving the type of railroad equipment as involved in the Accident.

7.2 Prior Significant Accident Damage to the Involved Railroad Equipment[119]

7.2.1 SCRRA[120]

SCRRA reported to the Investigation that a review of SCRRA maintenance records by SCRRA technical staff, and research by Bombardier (SCRRA's mechanical maintenance contractor) and LTK Engineering Services [121], have revealed no prior significant accident damage, or prior structural repair or modification since delivery (new), for locomotive SCAX 855, and coach cars SCAX 185, SCAX 207, and SCAX 617.

7.2.2 UP

A review of UP maintenance records by UP maintenance staff indicated that no prior significant accident damage, or prior structural repair or modification since delivery (new), had occurred for the two locomotives involved in the event.

7.3 FRA Review of 'Nonconforming Material Report' Documentation of Passenger Railcar Equipment the Involved in the Accident[122]

Analogous to the review by the Investigation of SCRRA compiled maintenance records to affirm the railcar equipment the involved in the accident sustained no prior significant accident damage, review of 'Nonconforming Material Report' (car history) documentation for the subject railcars (compiled at the time of delivery to customer SCRRA), by FRA oversight resources[123], revealed notations present in the car history documentation of two passenger railcars, suggesting possible exceptions were taken by SCRRA, at the time of delivery of the equipment, which also may not have been resolved (by the railcar manufacture) to the satisfaction of the FRA. SCRRA submitted to NTSB and FRA (during this Investigation) all pertinent documentation that they believed satisfactorily demonstrated closure of the items in question (with the notation points as summarized below).

Generally described, the identified documentation noted exceptions that involved:

Car Number	Identified Issue
207	"gap evident at DP # 8"
207	"NCR 106110 huck gap at upper floor crossing connections above door"
617	"aluminum side sill weld defects"

Responsive to the above, the FRA indicated to the Investigation that an internal review of the identified documentation was conducted to assess relevance (of the identified issues) to the

[119] as might be influential to assessing the damage condition to the equipment in this accident.
[120] ref. email dated Dec. 29, 2008; information from Bombardier Party representative.
[121] SCRRA's rail equipment consultant (a professional engineering and consulting firm, as further described in [Internet] >> http://www.ltk.com/)
[122] as might be influential to assessing the damage condition to the equipment in this accident.
[123] i.e. the Crashworthiness Working Group - designated Party to the Investigation representative of the Federal Railroad Administration (FRA).

accident, and/or if a further review / assessment of the data, and/or the railcar equipment itself, is warranted, wherein, upon review of the information provided and contained in the "Nonconforming Material Report", the FRA advised no exceptions were taken with the identified notation items, which thus concluded this review action.

7.4 Relevant Vehicle Speed / Event Recorder Information[124]

At the time of the collision, the speed of the SCRRA train was about 43 mph, and the speed of the UP train was about 41.3 mph.

Additional information detail on the vehicle speeds is provided in the Event Recorder Group - Factual Reports for the respective locomotives identified in this investigation.

8.0 Medical and Pathological Summary[125, 126]

As support to the Crashworthiness and Survival Factors Investigations[127], a review of injury and casualty (fatality) data is typically conducted by Safety Board staff on [confidential] medical records, and medico-legal autopsy documentation, as obtained from the local medical facilities utilized in the event, and the jurisdictional Medical Examiner's / Coroner's Office, respectively, in an effort to identify, to the extent possible, probable mechanisms of injury and potentially common causative factors, on the prospect of recognizing possible remedial measures to help prevent future occurrences.

Following the above protocol, medical record documentation of the injuries, and autopsy report documentation, was requested of the respective medical facilities, and jurisdictional Medical Examiner's / Coroner's Office, in which some responsive documentation was received by the Investigation, although additional documentation on same is anticipated to be forthcoming for the organizations contacted.

Based upon the content of medical records, and autopsy documentation, as received to-date by the Investigation, a preliminary review of the data was conducted. Briefly summarized, as preliminarily identified by the Investigation, there were 25 fatalities, and approximately 102 individuals were reported to have been transported to local medical facilities for treatment, the data of which is further summarized as follows.

8.1 Passenger Injuries

8.1.1 Minor / Serious Injuries Reported

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[124] source: Event Recorder Group - Factual Reports for the respective locomotives identified in this investigation.
[125] information sources: documentation of, and interviews with principals of the emergency services agencies, and/or local medical facilities utilized in the event, and/or local Medical Examiner's / Coroner's Office, as referenced.
[126] confidential documentation reviewed by the Investigation in this report section was obtained under subpoena authority, pursuant to 49 CFR 831.9, in which, for considerations of personal privacy, which is also pursuant to HIPAA regulations (ref. US Dept. of Health & Human Services / HIPAA regulations; Public Law 104-191, as described in [Internet] http://www.hhs.gov/ocr/hipaa), the information remains confidential to the investigation (i.e. accessible only to authorized NTSB staff, or other authorized entities).
[127] this report section was compiled in conjunction with the Survival Factors Investigation

The Investigation identified that a total of approximately 102 individuals (i.e. 98 passengers, and four railroad crewmembers) presented (i.e. either self-transported, or were transported) to local medical facilities for emergency medical examination and/or treatment.

Based upon the data reviewed as of the completion of this report, generally described, a review of the documentation received suggested the manner of injury was consistent with injury in which the individual was subjected to an impact, at a relatively high velocity, against a non-energy attenuating (unyielding) surface.

In as much as additional information is anticipated to be forthcoming from the medical facilities contacted, this investigative topic will be further addressed, to the extent possible, in a forthcoming Addendum Factual Report of the Investigation, as later compiled in the Investigation.

8.1.2 Fatalities[128, 129]

Twenty-four passengers sustained fatal injury in the accident, in which medico-legal autopsies were performed on all of the fatalities, documentation of which was provided to the investigation.

Review of the autopsy documentation received (to-date) indicated that, of the 24 passengers in the train that sustained fatal injury in the Accident, 22 of those passengers were identified to have been located in the first SCRRA coach railcar at the time of the collision (SCAX # 185, which was located immediately behind the SCRRA locomotive), one passenger was identified to have been located in the second SCRRA coach railcar at the time of the collision (SCAX # 207), and the location of one passenger, at the time of the collision, was not able to be identified (as of the date of this report).

Based upon the data reviewed as of the completion of this report, generally described, the manner of death of the individuals was due to “multiple blunt force injuries” or “multiple traumatic injuries”, which is consistent with the loss of occupant survival space, or the individual was subjected to an impact, at a relatively high velocity, against a non-energy attenuating (unyielding) surface.

In as much as additional information is anticipated to be forthcoming from the jurisdictional Medical Examiner’s / Coroner’s Office, and/or medical facilities utilized in the accident, this investigative topic will be further addressed, to the extent possible, in a forthcoming Addendum Factual Report of the Investigation, as later compiled in the Investigation.

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[128] source: documentation of, and interviews with principals of the local Coroner’s Office (i.e. Los Angeles County Coroner), which is also the jurisdictional Medical Examiner, in which information cited in quotations are direct quotations from the Coroner’s report documentation.
[129] for considerations of personal privacy, and in respect to the families / survivors of the fatalities, personal identities of fatalities have been omitted from this report, the information of which remains confidential to the investigation (i.e. accessible only to authorized NTSB staff, or other authorized entities).

8.2 Railroad Crewmember Injuries

8.2.1 SCRRA Train

The locomotive engineer sustained fatal injury, in which, as cited in the autopsy documentation, the manner of death was "multiple blunt force injuries", which is consistent with the loss of occupant survival space, or the individual was subjected to an impact, at a relatively high velocity, against a non-energy attenuating (unyielding) surface.

The conductor sustained serious injury in the accident, in which a review of the documentation received suggested the manner of injury was consistent with injury in which the individual was subjected to an impact, at a relatively high velocity, against a non-energy attenuating (unyielding) surface.

In as much as additional information is anticipated to be forthcoming from the medical facilities contacted, this investigative topic will be further addressed, to the extent possible, in a forthcoming Addendum Factual Report of the Investigation, as later compiled in the Investigation.

8.2.2 UP Train

The locomotive engineer and conductor sustained serious injury, and the brakeman sustained minor injury in the accident, in which a review of the medical documentation received suggested the manner of injury for the individuals was consistent with injury in which the individuals were subjected to an impact, at a relatively high velocity, against a non-energy attenuating (unyielding) surface.

In as much as additional information is anticipated to be forthcoming from the medical facilities contacted, it is anticipated that this investigative topic will be further addressed, to the extent possible, in an Addendum Factual Report of the Investigation, as later compiled in the Investigation.

8.3 Summary Tabulation of Injuries Reported in the Accident

The investigation solicited, and obtained, medical documentation from the medical facilities utilized in the incident, and other authoritative sources, which described the manner and types of injury sustained in the event, the collective data of which is summarized in a Tabulation of Injuries Reported in the Accident.

In as much as additional information is anticipated to be forthcoming from the medical facilities contacted, this investigative topic will be further addressed, to the extent possible, in a forthcoming Addendum Factual Report of the Investigation, as later compiled in the Investigation.

8.4 Injury Criteria Tabulation (49 CFR 830.2)

From the injury data obtained in the Investigation (ref. § 8.3 in this report), a tabulation is compiled, which is based on injury criteria (49 CFR 830.2) of the International Civil Aviation Organization (ICAO), which the National Transportation Safety Board also uses in accident reports for all transportation modes.

In as much as additional information is anticipated to be forthcoming from the medical facilities contacted, this investigative topic will be further addressed, to the extent possible, in a forthcoming Addendum Factual Report of the Investigation, as later compiled in the Investigation.

9.0 Proactively Employed Crashworthiness Safety Initiative Measures / Actions - Implemented Subsequent to the Accident [130]

9.1 SCRRA[131]

9.1.1 Relevant to 'Work-Station Tables'

Measures on the topic of assessing occupant impact against the BiLevel railcar 'Work-Station Tables' were enumerated as previously described in this report (see § 5.2.7).

9.1.2 Relevant to Other Crashworthiness Measures

SCRRA initiated, and participated in, an ad hoc Crash Energy Management {CEM} Working Group, as organized by the FRA, with the support of the Federal Transit Administration and the APTA, which developed recommendations for including crush zones in rail passenger cars for SCRRA to include in its procurement specification of new passenger railcars (as now ordered from Rotem), in which also the Volpe Center[132] provided technical information from research on passenger equipment crashworthiness it is conducting for FRA[133].

Measures currently considered for crashworthiness and safety improvements in the existing rail car fleet are:

1. Installation of 'push-back' couplers [to the passenger railcar fleet].
2. Installation of frangible 'Work-Station Tables' [as further described in this report; see § 5.2.7].
3. Reconfiguring the seating arrangements in order for the passengers to be "compartmentalized".
4. Installation of a more robust ADA 'personal mobility vehicle [wheelchair] tie-down mechanism'.
5. Installation of wireless Public Announcement (PA) system.

[130] Information reported in this Section is responsive to an inquiry by NTSB staff to the Party representatives (email, dated Jan. 26, 2009), where, to the extent possible, the information tendered from the organizations was quoted verbatim, to the extent possible (i.e. allowing for correction of incidental typographical errors, minor truncation editing of detailed / lengthy submissions, terminology definition, etc., as might be appropriate for the report).
[131] ref. email dated Jan. 29, 2009, et seq.; information from, and discussion dialog with, the Party representative.
[132] see footnote 90
[133] CEM Working Group as further described in [Internet] http://www.fra.dot.gov/downloads/Research/rr0703.pdf

6. Installation of new Emergency Exit / Access Windows that are easier to remove in an emergency. The installation of new Emergency Windows is underway and completion is expected by the last quarter of 2009.

The new [passenger] railcars [as ordered] from Rotem, with expected delivery [to be in] the third quarter of 2009, will have all these [above described] measures incorporated.

Additional measures implemented by SCRRA are as described in a presentation graphic (Power-Point® slides) utilized in a SCRRA Board Meeting [on] Mechanical Safety Equipment Update – Equipment Safety / Technology Improvements, a copy of which is provided in Exhibit 19.

9.2 Bombardier[134]

Measures relevant to the "Evolution of Crashworthiness and Safety Changes in Bombardier BiLevel Rail Cars since 2002" were enumerated as previously described in this report (see § 5.2.8).

9.3 Federal Railroad Administration[135]

Utilizing the (commissioned) resources of the Volpe Center[136], the FRA participated in an initiative project to assess occupant impact against the BiLevel railcar 'Work-Station Tables', as further described in this report (see § 5.2.7).

The FRA has been conducting ongoing research on passenger rail equipment crashworthiness to develop technical information needed to promulgate passenger rail equipment safety regulations, in which its principal focus has been the development of structural crashworthiness and interior occupant protection strategies. The research also involved full-scale crash testing of passenger railcars and locomotives, to help establish the degree of enhanced performance of alternative design strategies for passenger rail crashworthiness, referred to as Crash Energy Management {CEM}, where collision energy is absorbed in defined unoccupied locations throughout a train in a controlled progressive manner[137]. By controlling the deformations at critical locations, the CEM train is able to protect against two very dangerous modes of deformation: override and large scale lateral buckling.

On behalf of SCRRA, the FRA organized an ad hoc CEM Working Group, as further described in this report (see § 9.1.2).

Other ongoing safety initiative projects of the FRA involve research of collision energy attenuation utilizing 'push-back couplers', and research of 'wheelchair securement' methods.

-- End of this Report Section --

[134] source - email to/from, and discussion dialog with, the Party representative
[135] source - email to/from, and discussion dialog with, the Party representative
[136] see footnote 90
[137] ref., with research as further described in: [Internet] http://www.fra.dot.gov/downloads/research/rr0705.pdf