Contents

Appendix A.1: Equipment Interactions

This appendix describes the interactions of the equipment, starting from the interaction of the colliding locomotives. The interactions of the coupled passenger equipment are described in detail, and an overview is presented of the interactions of the coupled freight equipment.

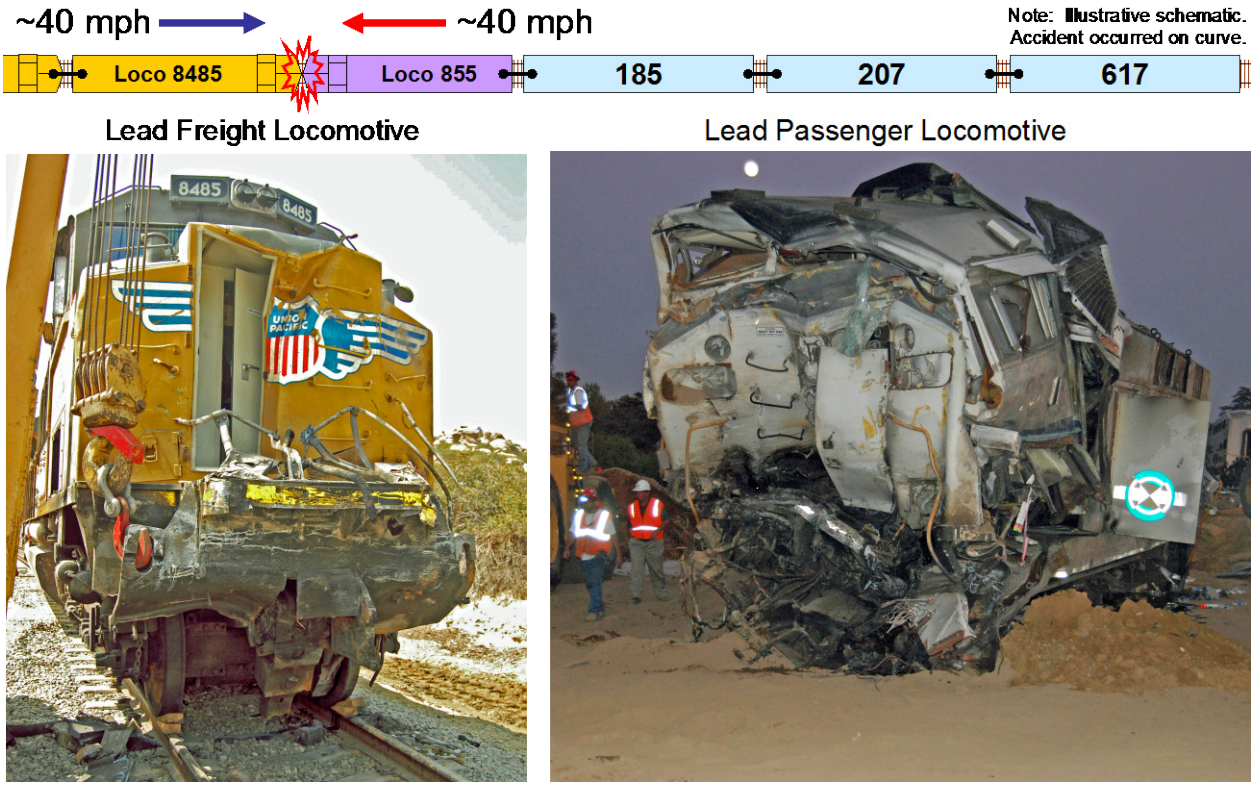


Figure A.1-1. Lead Freight and Passenger Locomotives, Impact Ends

Figure A.1-1 shows the impact ends of the lead passenger and freight locomotives. The freight locomotive sustained substantially less damage than the passenger locomotive. Damage to the freight locomotive includes separation of the plow, the breast plate bent up under the underframe, damage to the short-hood door and sheet metal. The draft gear box is largely destroyed, and the draft gear and broken coupler shank can be seen hanging down in the photograph. The collision posts remain essentially intact, and the truck is attached. The passenger locomotive is shown after it has been up-righted. While the shape of the cab appears recognizable, the cab has been pushed back over the rotating equipment, eliminating the operator's survival space. The collision posts have been separated from their attachments to the underframe, and the lead truck is not under this locomotive.

Lead Freight Locomotive

Broken coupler shank. Coupler draft pocket deformed and oriented downward.

Pilot fractured and tore away. Sides of draft gear pocket fractured.

Lead Passenger Locomotive

Coupler and draft gear pocket fractured off of locomotive underframe.

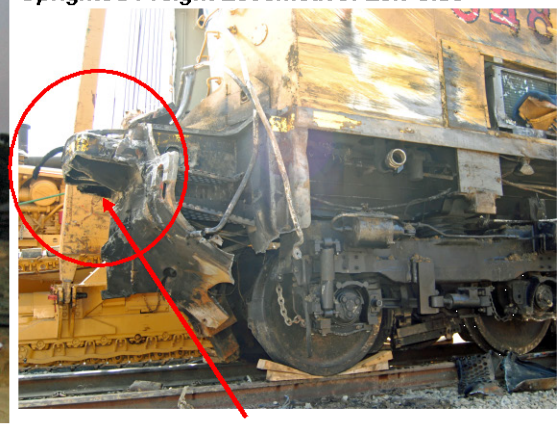
Figure A.1-2. Coupler and Draft Gear Damage, Lead Freight and Passenger Locomotives

Figure A.1-2 shows the remains of the coupler pockets and draft gear housings of the lead freight and passenger locomotives. Both are substantially damaged. Most of the draft gear housing has been separated from the passenger locomotive and the draft gear, yoke, and coupler are missing from the photograph. The freight draft gear housing also appears to be largely missing, but the draft gear, yoke, and broken coupler shank are hanging, and appear trapped by the bent breast plate.

Uprighted Passenger Locomotive

Passenger Locomotive Anti-climber Engages Beneath Freight Locomotive Anti-climber.

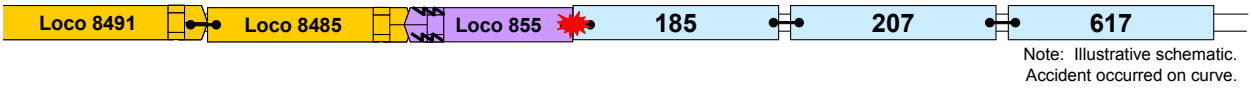
Uprighted Freight Locomotive: Left Side



Freight Locomotive Anti-climber Engages Above Passenger Locomotive Anti-climber.

Figure A.1-3. Anti-climber Engagement of Lead Freight and Passenger Locomotives

Figure A.1-3 shows the anti-climbers on the lead freight and passenger locomotives. The anti-climbers appear to have functioned as intended, helping to keep one locomotive from climbing the other. The anti-climber of the passenger locomotive appears to have locked under the anti-climber of the freight locomotive. The freight anti-climber appears to have speared through the short hood of the passenger locomotive, near its attachment to the underframe.



Note: Illustrative schematic.
Accident occurred on curve.

Figure A.1-4. Interaction of Passenger Locomotive and First Passenger Car

(Photograph from the *LA Times* Web site)

Figure A.1-4 shows the interaction of the passenger locomotive and the first passenger car. There was extensive structural damage to the passenger car, while there appears to be little damage to the trailing end of the locomotive. The photograph shows the locomotive telescoped into the passenger car. The locomotive is on its side, while the passenger car is not quite fully on its side. (Note: the photograph shows the cars in reverse position from the schematic above that illustrates the relative position of cars in the collision).

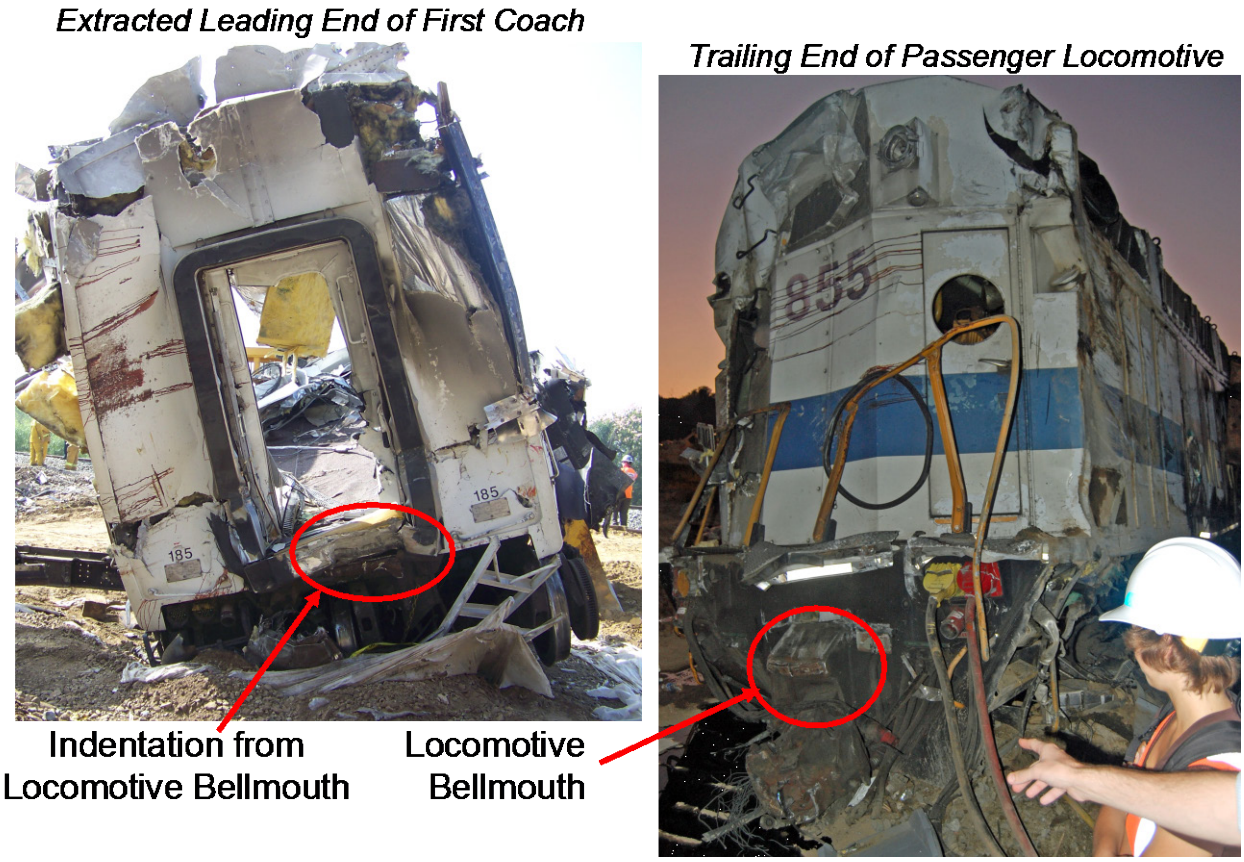


Figure A.1-5. First Passenger Car Lead End Frame Interaction with Locomotive Trailing End Bellmouth

Figure A.1-5 shows the lead end structure of the first passenger car, after it has been extracted from the body of the car. The collision and corner posts are essentially intact. There is a large dent in the underside of the end beam, circled in red. The shape of this dent corresponds to the shape of the bellmouth on the trailing end of the locomotive, which is also circled. This dent suggests that the rear of the passenger locomotive applied an upward vertical force to the front of the passenger car, as the front of the passenger car was also pitching downward.

The trailing end of Car #185 lifts upward relative to Car #207. The leading end of Car #207 pitches downward.

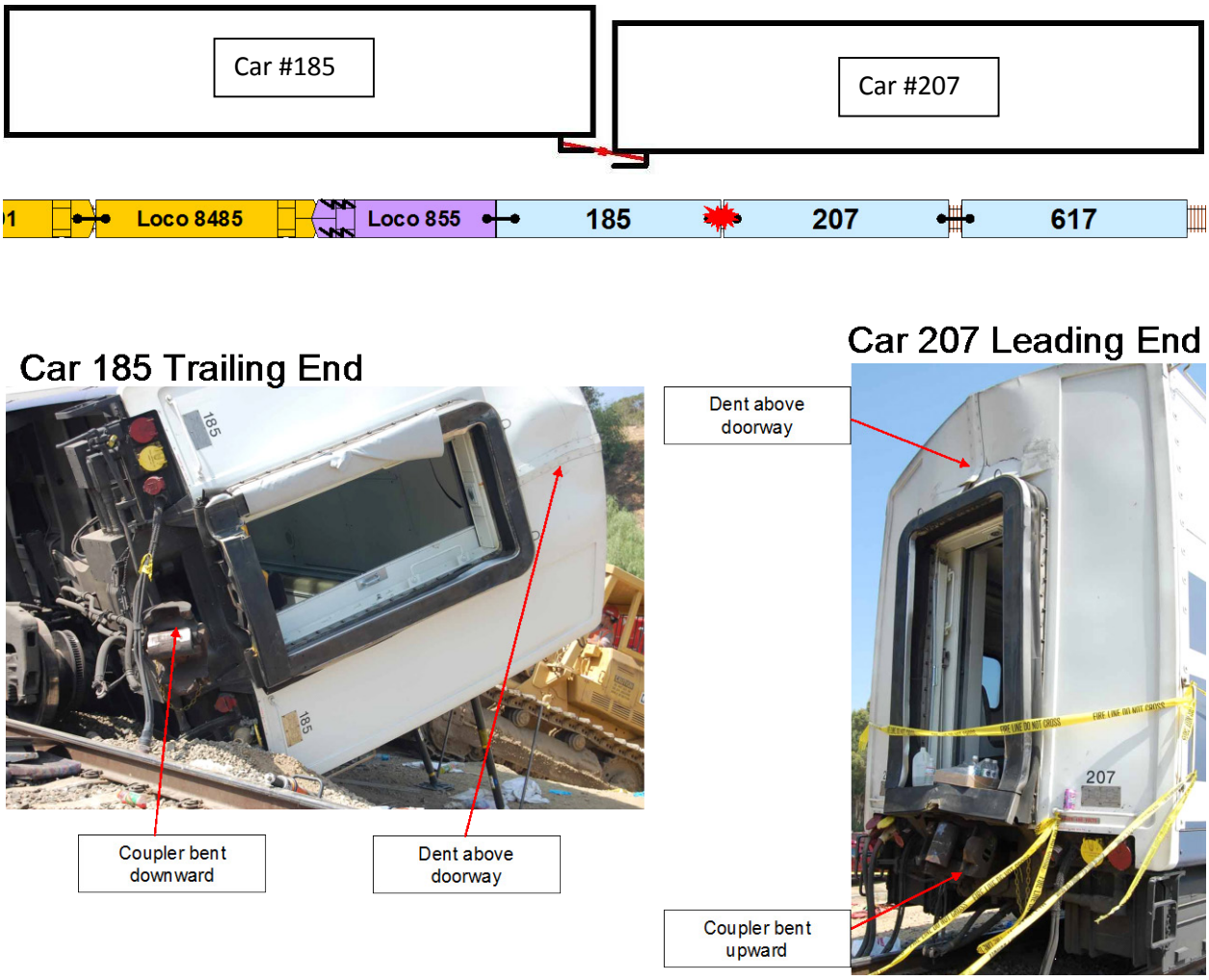


Figure A.1-6. Trailing End of First Passenger Car and Leading End of Second Passenger Car

Figure A.1-6 shows the interaction between the trailing end of the first passenger car and the leading end of the second passenger car. The first passenger car coupler head is bent downward. There is a dent in the lower corner of the door bellows, on the left side, and there is a dent above the doorway. At the leading end of the second passenger car, the coupler is bent upward. The left side collision post appears bent, near its attachment to the floor-level structure, and the right side post appears bent in a similar location but to a lesser degree. The damage suggests that both cars pitched forward, i.e., the front ends of both cars went down and the back ends went up.

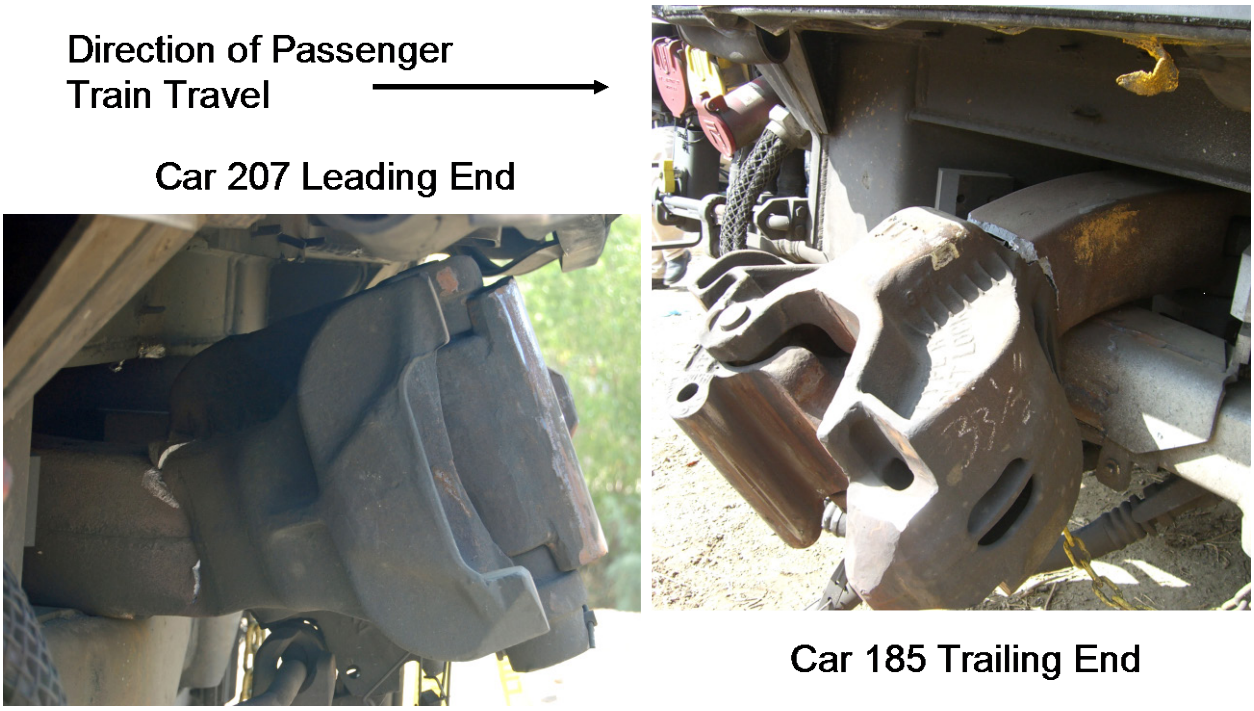


Figure A.1-7. Trailing Coupler of Lead Passenger Car and Leading Coupler of Second Passenger Car

Figure A.1-7 shows the trailing coupler of the lead passenger car and the leading coupler of the second passenger car. At some point during the accident, the cars became uncoupled, but the extent of damage suggests that the cars remained coupled for most of the impact, including the pitching forward discussed in relation to Figure A.1-5. There is significant material failure near where the head blends into the shank in both couplers. This damage suggests that the lead car tried to override the second car.

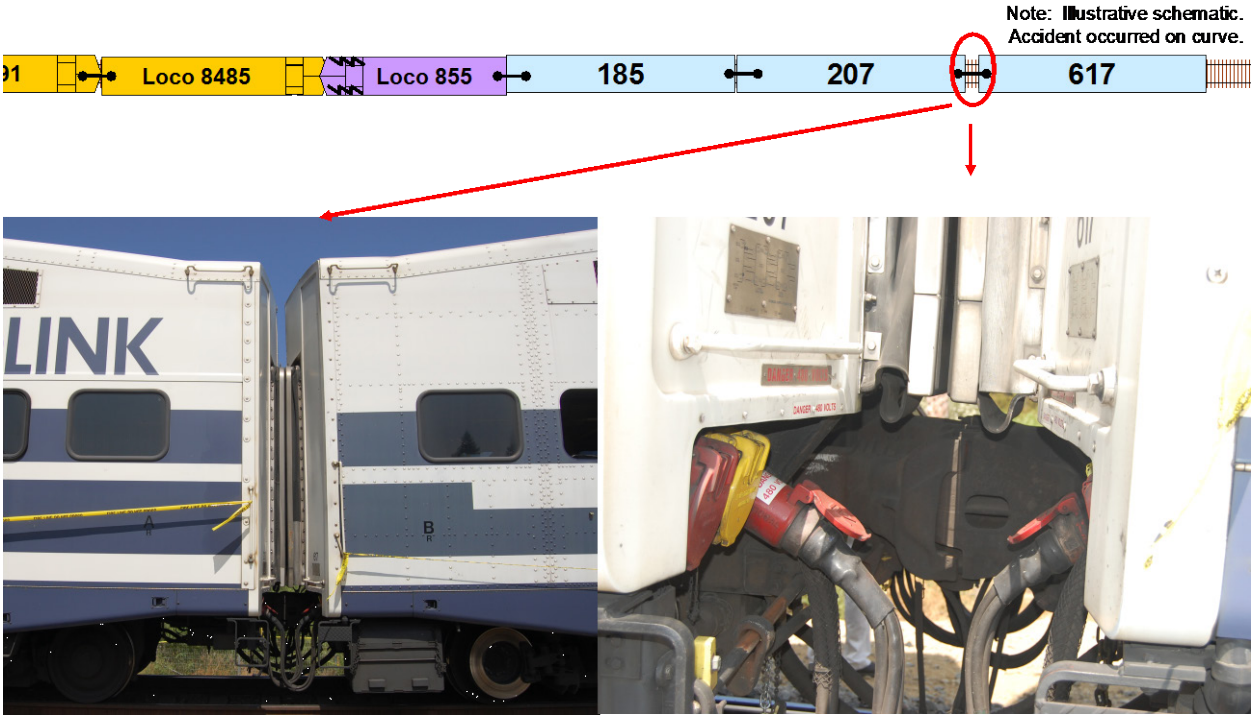


Figure A.1-8. Interaction of Second Passenger Car and Trailing Cab Car

Figure A.1-8 shows the coupled connection between the second passenger car and the trailing cab car. There is little damage at this interface. Both cars remained on the track, and rolled backward after the impact, for a distance of what is estimated to be between 80 and 100 feet.

Appendix A.2.1: Additional Detail on Structural Damage to Passenger Locomotive and Cars

Most of the damage to the passenger equipment was focused on the locomotive and first passenger car. The second and third passenger cars sustained little structural damage. Table A.2.1-1 summarizes the structural damage to the passenger locomotive and cars.

Table A.2.1-1. Summary of Structural Damage to Passenger Equipment

Equipment	Summary of Structural Damage
Lead Passenger Locomotive	- Reduced in length by ~15 feet - Complete loss of operator's compartment due to crushing - Lead truck detached - Fuel tank detached
First Passenger Car	- Reduced in length by 65 feet, from 85 to 20 feet - Trailing coupler damaged from impact - Trailing truck detached
Second Passenger Car	- Gooseneck slightly deformed - Lead coupler damaged - Some truck attachments failed
Trailing Passenger Car	- No significant carbody damage - Some truck attachments failed

Figure A.2.1-1. Typical Metrolink Train

Figure A.2.1-1 shows a typical Metrolink train in running condition. The train is led by four-axle Passenger Locomotive #856 which was built in the same production run as Passenger Locomotive #855, the locomotive involved in this accident. Passenger Locomotive #856 as shown here is followed by four passenger cars, while Locomotive #855 was followed by three trailing cars in the accident, two passenger cars and a cab car.

A.2.1-1. Passenger Locomotive Damage

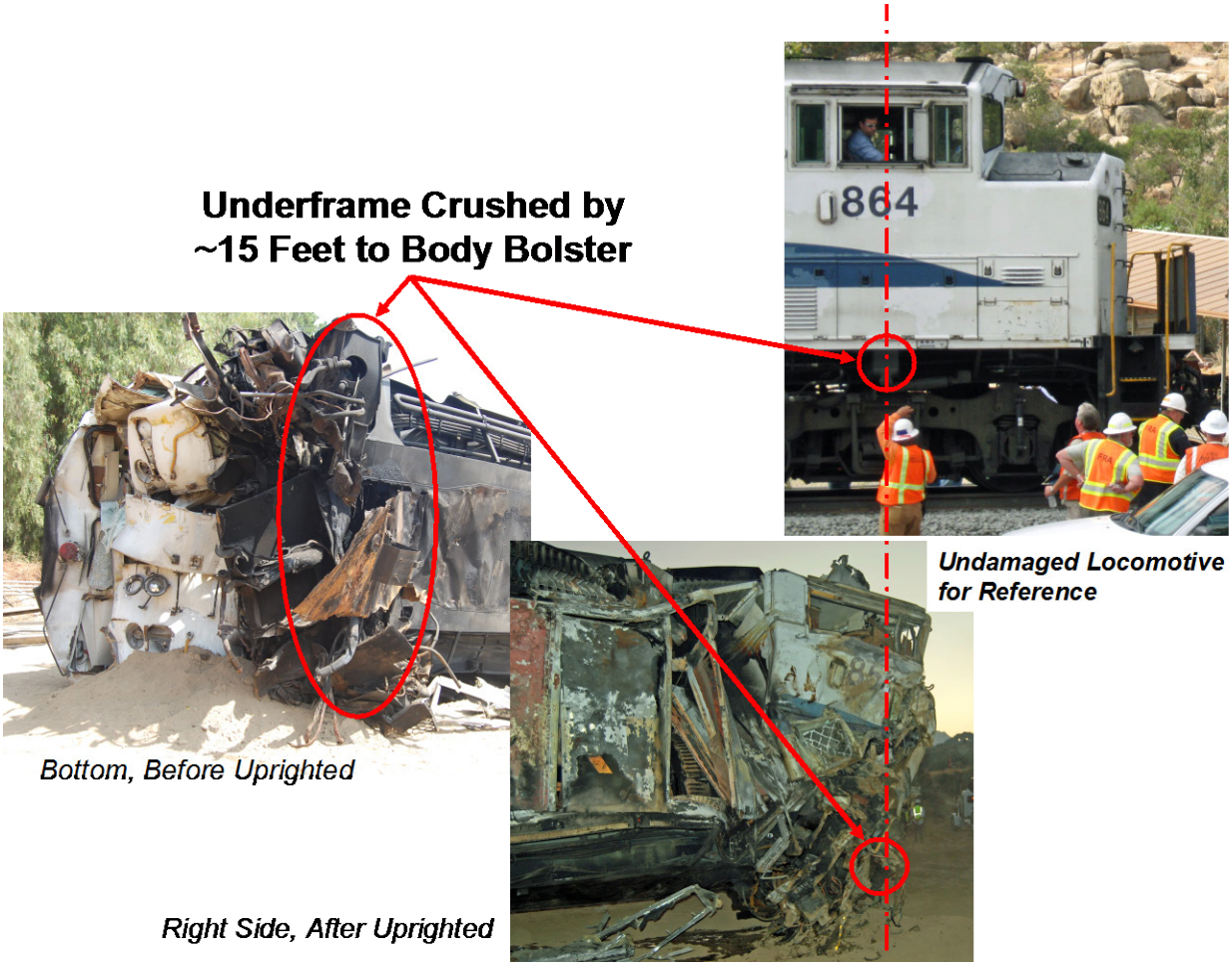


Figure A.2.1-2. Passenger Locomotive Lead End Crush

Figure A.2.1-2 shows the structural damage to the lead end of the passenger locomotive. A photograph of an undamaged locomotive is included for reference. While the side window frame is visible in the lower right photo, there is no interior cab space, as the cab has been pushed back over rotating equipment. The locomotive has been crushed approximately 15 feet, from the coupler back to the body bolster. The truck normally mounts to the frame at the body bolster; however, the attachments were destroyed in the collision. The lead truck separated from the equipment it supported, both the locomotive car and the fuel tank.

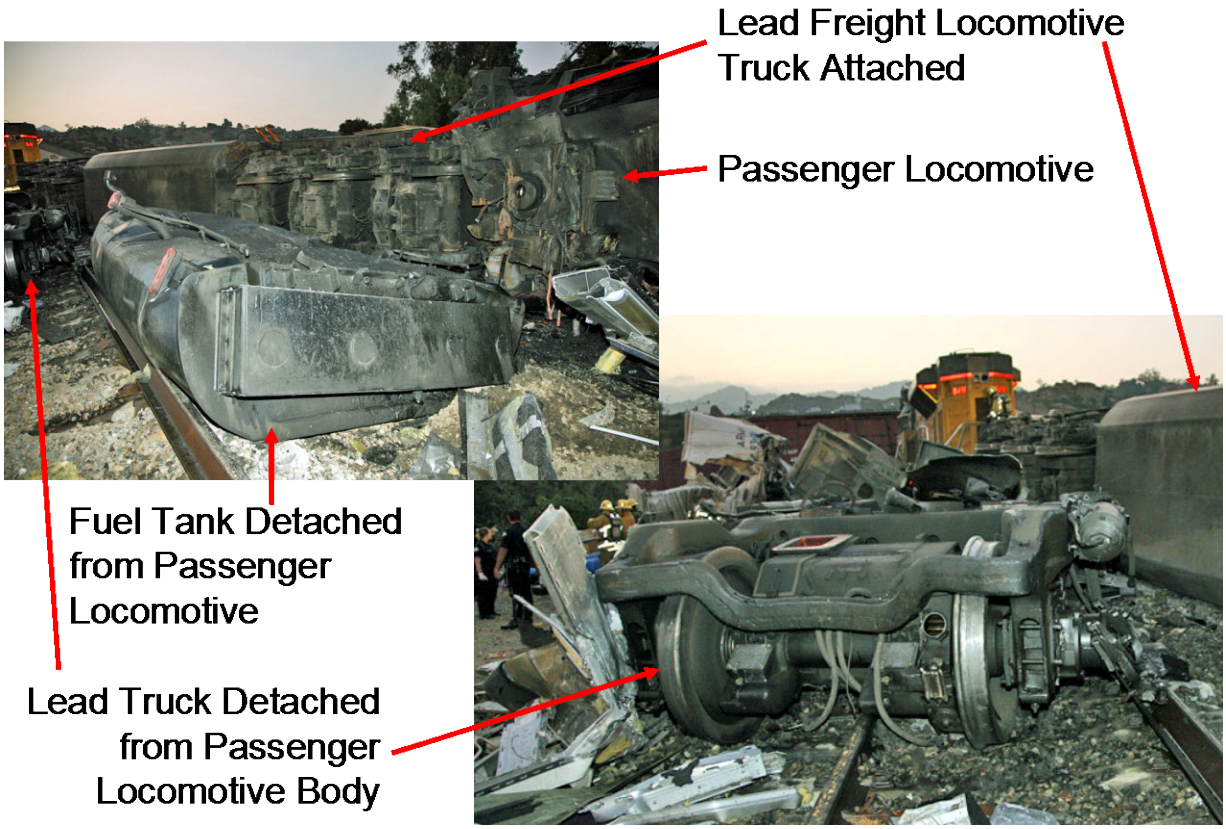


Figure A.2.1-3. Passenger Locomotive Fuel Tank and Lead Truck Separated from Locomotive

Figure A.2.1-3 shows the passenger locomotive fuel tank and lead truck. Both the fuel tank and truck were separated from the locomotive, and found proximate to the lead freight locomotive. It appears that the truck separated owing to crush of the attachments on the locomotive body bolster, and that the fuel tank separated due to impact with the lead truck. There were significant breaches of the fuel tank, and a fire fed by the spilled fuel. More detail on the fuel tank damage is provided in Appendix A.3.

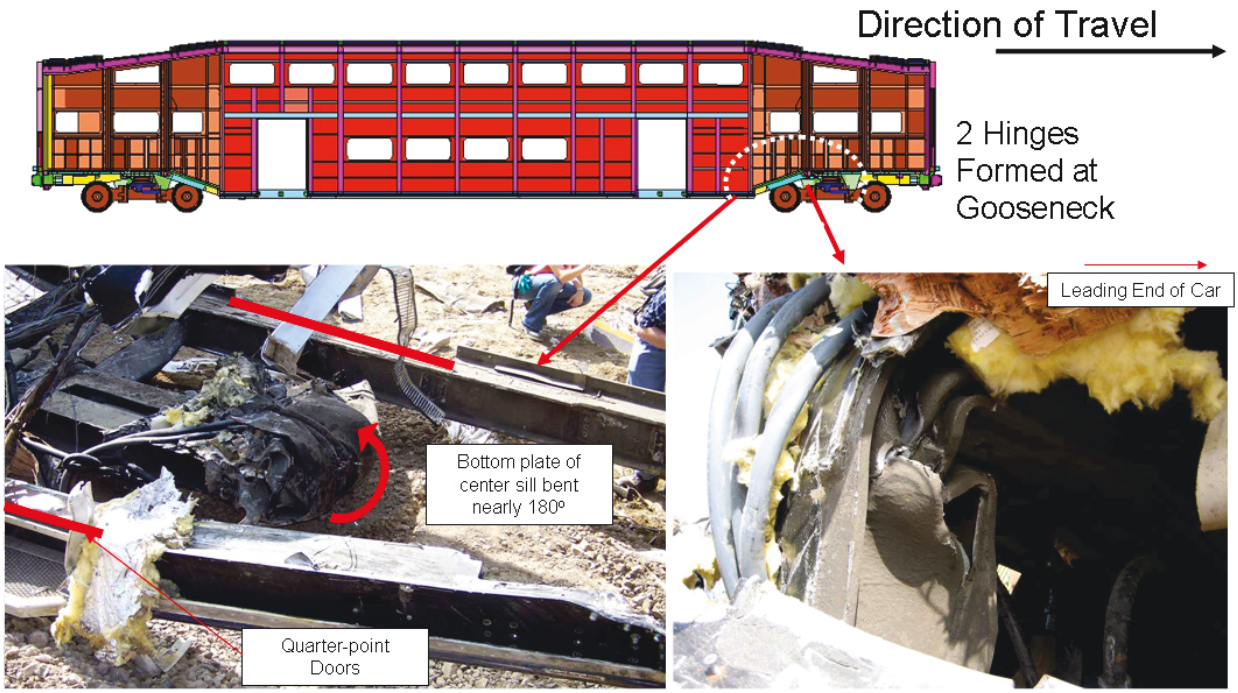


Figure A.2.1-4. Gooseneck Damage

Figure A.2.1-4 includes a schematic of the first passenger car, with the primary area of structural collapse circled. The primary area of structural collapse is termed the gooseneck. In this part of the structure, the underframe transitions from being above the truck, approximately 34 inches above top-of-rail (TOR), down to 18.5 inches above TOR. This transition is made to accommodate the two-level center section of the car. The diagonal section of the gooseneck was apparently destroyed in the accident; as no evidence of it was found. The photograph in the lower left of the figure shows the remains of the end of the lower center sill. It can be seen that the end has been pounded and bent nearly 180º into a 'U' shape. The lower side sills extend to essentially their initial length. Holes for the rivet connections to the diagonal portion of the gooseneck can be seen in the right side sill. The photograph on the right shows the remains of the end of the single-level portion of the center sill. This end has been bent down about 90 degrees into a 'L' shape. This end of the center sill does not appear to have been pounded repeatedly, as the lower end of the side sill in the left side photograph appears to have been.

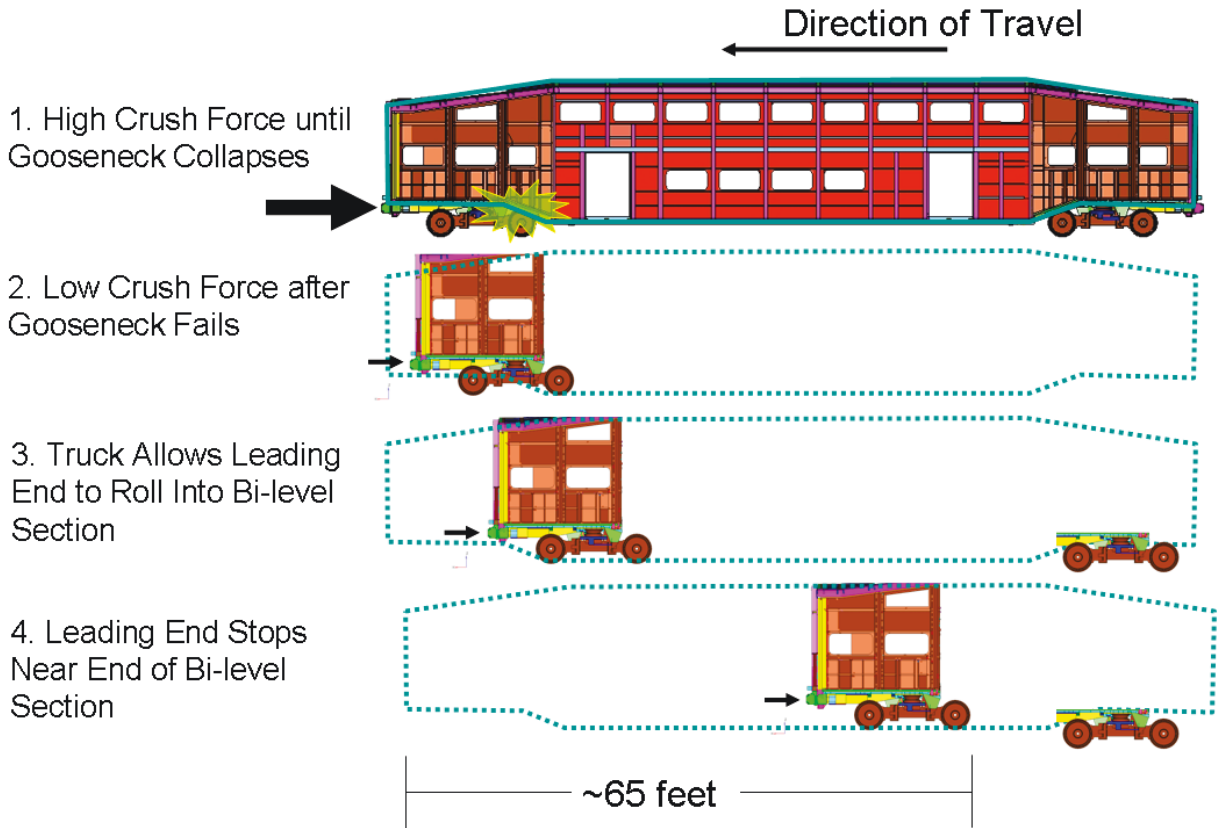


Figure A.2.1-5. Progression of Gooseneck Collapse and Failure

Figure A.2.1-5 shows schematics illustrating how the structural damage shown in Figure A.2.1-4 occurred. Shortly after the initial contact between the lead freight and passenger locomotives, a high force was generated between the leading passenger locomotive and leading passenger car. This force was sufficient to cripple and fail the gooseneck area of the passenger car underframe. Simultaneously, due to the geometry of the gooseneck and its mode of collapse, the end underframe and truck were vaulted upward. This upward movement raised the wheels of the lead truck to the height of the lower floor of the bi-level section of the car, and the center sill was no longer carrying a longitudinal force. A relatively low longitudinal load was provided by the remaining sidewall and roof structures. The end section of the car, including the truck that had lifted up, penetrated and moved backward through the bi-level section of the car with relatively little force.

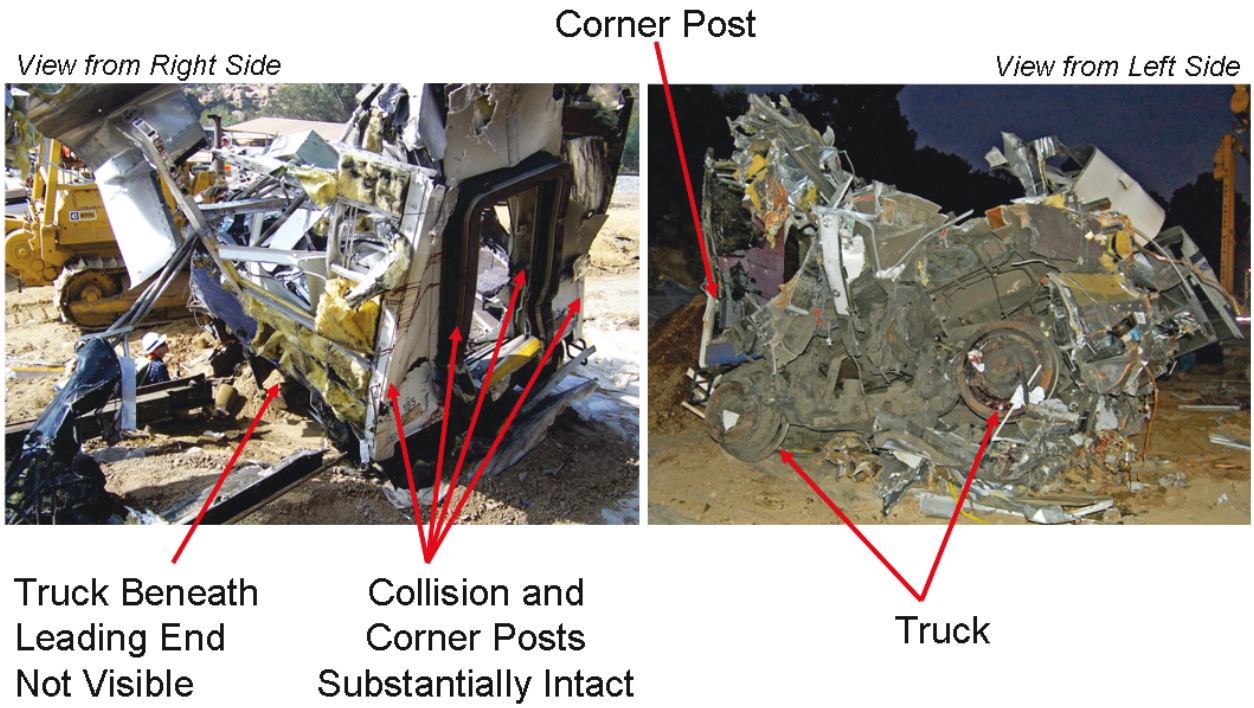


Figure A.2.1-6. Remains of First Passenger Car Lead End Mezzanine Level

Figure A.2.1-6 shows the remains of the lead end structure of the first passenger car, including the lead truck. The end frame, including both corner posts and both collision posts, is essentially intact. There is a significant amount of debris compacted onto the remains. The center and side sills of this single-level portion appear to be largely intact. The relatively light roof and sidewall structures have been stripped off, and likely contributed to the compacted debris.

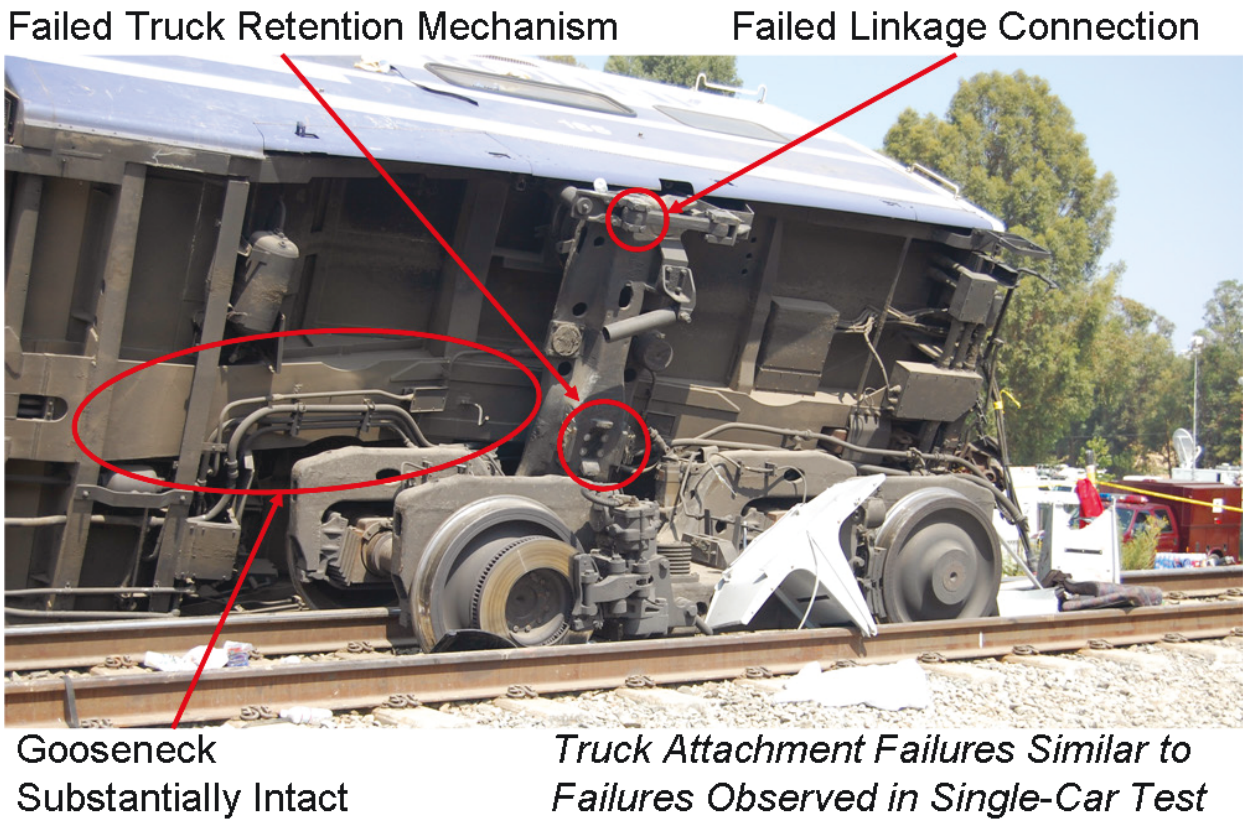


Figure A.2.1-7. Separation of Trailing Truck from Lead Passenger Car

Figure A.2.1-7 shows trailing end of the lead car. In the left side of the photograph, the transition structure of the underframe, including the gooseneck, can be seen to be nearly undamaged. The trailing truck, resting on the ground, is separated from the overturned carbody. The damaged truck-to-carbody connection elements are annotated. The damage to these elements is similar to damage observed in a single-car impact test of similar equipment [1].

Figure A.2.1-8. Right Side of Lead Passenger Car

Figure A.2.1-8 shows the right exterior wall of the lead passenger car, which is being supported by a piece of earth-moving equipment. There is little visible damage to the sidewall, indicating that the car side did not slide along the ground. On the left side of the photograph, damage to the end wall can be seen, and may have been caused by contact with the roof of the trailing car.

A.2.1-2. Second Passenger Car Damage

Figure A.2.1-9. Leading End of Second Passenger Car

Figure A.2.1-9 shows the leading end of the second passenger car. The bellows shows damage from contact with the car ahead. There are dents on the bellows frame, just above the spring loaded buffer beam. There is also damage to the fiberglass end cap above, just above the bellows. This damage is consistent with the leading car attempting to override this car.

Figure A.2.1-10. Leading (B) End Coupler of Second Passenger Car

Figure A.2.1-10 shows left-side and right-side view of the leading end coupler of Car #207. The coupler is bent at the connection area between the head and the shank. The head is bent upward at an angle of roughly 30 degrees. There are indications of material failure near the corners of the shank where it meets the head. The material of the sidewalls of the shank remained together. The damage suggests that separation of the head and the shank is imminent. This damage is also consistent with the lead car attempting to override Car #207.

Figure A.2.1-11. Scar on Carbody Above B End Outboard Axle Bearing Housing

Figure A.2.1-11 shows a scar on the underframe. This scar appears to be due to the bearing housing of the truck axle contacting the underframe. Such contact could occur if the truck pitched significantly during the impact.

Figure A.2.1-12. Second Passenger Car Sidewall and Truck Attachment Damage

Figure A.2.1-12 shows sidewall deformation near the gooseneck region of the underframe. Both ends of the car showed similar damage, on opposite sides. On the leading end, the sidewall damage appeared to be associated with a bubble-shaped deformation in the bottom plate of the draft sill, however, the bubble appeared to be shallow. It was not possible to measure the flatness of this plate with the truck in place to confirm the presence of a bubble. On the left side of the leading end, the bolts to the drag link attachment to the carbody were also broken. The failure of these bolts was similar to the failure seen on the trailing truck of the first car. Similar failures have also been observed in an impact test of similar equipment [1].

Figure A.2.1-13. Trailing Cab Car and Failed Truck Retention Mechanism

Figure A.2.1-13 shows the third passenger car, Metrolink Passenger Car #617. There was virtually no structural damage to this car, however the truck retention mechanism did fail (not visible in the photo). Despite this equipment failure, the running gear remained intact and the truck remained in place beneath the car.

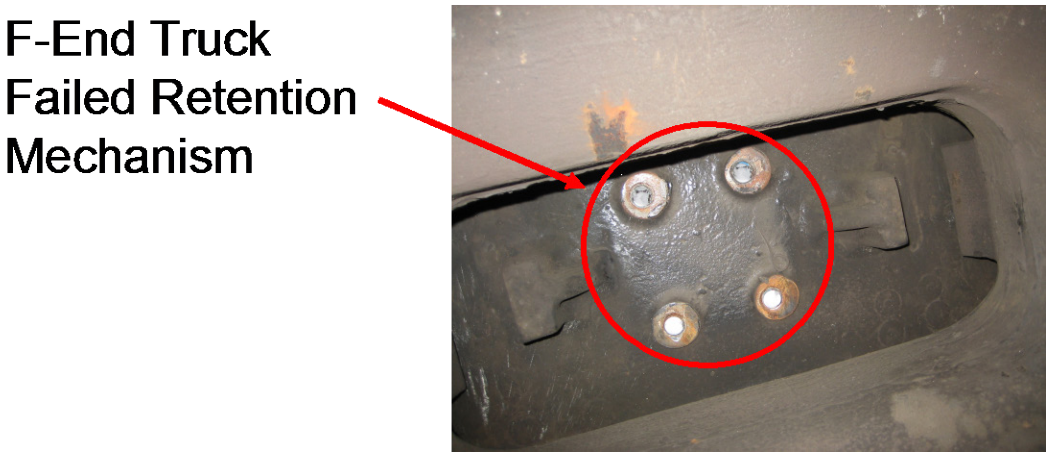


Figure A.2.1-14. Failed Truck Retention Mechanism on Trailing (F) End of Trailing Passenger Car

Figure A.2.1-14 shows the mounting boss for the truck retention mechanism, with the broken bolts visible. The truck retention mechanism is a tulip-shaped casting that protrudes through the rectangular hole in the truck frame. The base of the tulip normally mounts to the casting boss with four bolts. There is normally clearance between the rectangular hole and the tulip-shaped casting, which allows the truck to rotate, so the car can negotiate a curve. The failure of these bolts in the trailing cab car was similar to the failure of these bolts seen on the trailing truck of the first car. Similar failures have also been observed in an impact test of similar equipment [1].

Figure A.2.1-15. Intact Truck Retention Mechanism

For perspective, Figure A.2.1-15 provides visual comparisons showing on the left, the intact truck retention mechanism, and on the right, the bolts after an impact in which the truck retention mechanism failed.

Appendix A.2.2: Additional Detail on Structural Damage to Freight Locomotives and Cars

Following the accident, the Union Pacific Railroad (UP) freight train consisted of one forward-facing locomotive and one rear-facing locomotive in succession; freight cars that have folded perpendicular to the rails; and freight cars that have remained in-line.

Figure A.2.2-1. Aerial View of Freight and Passenger Equipment

The underframes of the freight equipment all remained essentially intact. The principal damage to the lead locomotive affected the ancillary structures on the front end—the draft gear housing, the plow, the breast plate, and the short hood. In the second locomotive, a portion of the roof peeled back, likely caused by an impact with an empty covered hopper car. Seven trailing freight cars stacked up sideways against the trailing end of the trailing freight locomotive, and consequently received damage to their superstructures. Behind the sideways freight equipment, three freight cars derailed but remained upright. These cars received fairly minor damage. The trailing seven freight cars remained upright and on the track, and did not appear to be damaged. Table A.2.2-1 summarizes the structural damage to the freight locomotives and cars.

Table A.2.2-1. Summary of Structural Damage to Freight Equipment

Equipment	Summary of Structural Damage
Lead Locomotive	- No significant underframe damage - Damage to the front plow, breast plate, and draft gear housing - Minor damage to rear breast plate - Paint scraped from left side of fuel tank
Second Locomotive	- No significant underframe damage - Damage to cab roof
Trailing Freight Equipment	- Five cars laterally buckled - Twelve cars with minimal or no damage

A.2.2-1 Lead Freight Locomotive

Figure A.2.2-3. Left Side of Lead Freight Locomotive

Figure A.2.2-3 shows that the right side of the locomotive has little damage. The underframe is essentially intact, and both trucks and the fuel tank remained attached.

A.2.2-2. Second Freight Locomotive

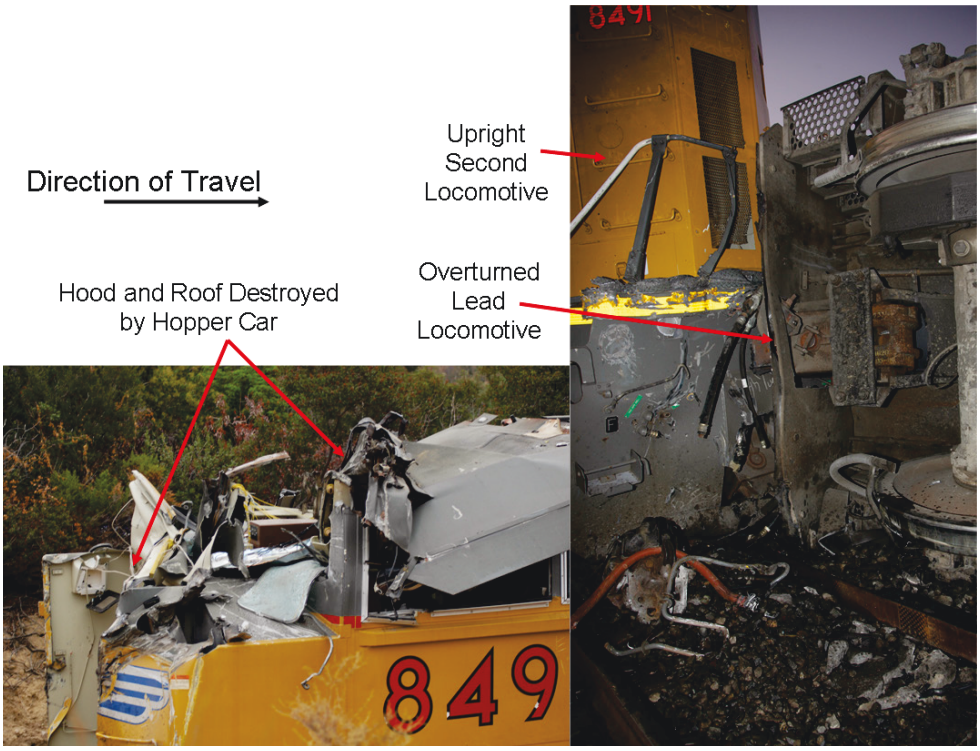


Figure A.2.2-5. Second Freight Locomotive Structural Damage

The photos in Figure A.2.2-5 depict the damage to the second freight locomotive inflicted by the hopper car and the damage caused by the interaction between the first and second freight locomotives.

A.2.2-3. Trailing Freight Equipment Damage

Figure A.2.2-6. Trailing Freight Equipment

Figures A.2.2-6 through A.2.2-8 show the trailing freight equipment. The second freight locomotive and its damaged roof can be seen in the upper-right portion of the photograph above. The end of the covered hopper car resting on the short hood can also be seen. The end of a second covered hopper car can be seen on the left side of the photograph. Three box cars are then stacked up perpendicular to the track. The next three box cars are upright and derailed. A rail can be seen near the two-people walking up to the middle upright and derailed freight car. The three freight cars near the bottom of the photograph are upright and on the track, as well as the remaining four trailing freight cars, which are not visible in the photograph.

Figure A.2.2-7. Derailed Freight Cars

Figure A.2.2-8. Displaced Rail and Derailed Freight Cars

UP Metrolink Chatsworth CA Collision
UP Train ID: LOF65-12 Consist Information

		Car Initial	Car Number	Tare tons	Load/ Empty	Lading tons	Total Tonnage tons	Total Length ft
	Locomotives	UP	8485	204.0			204.0	72.3
		UP	8491	204.0			204.0	72.3
	Cars							
Listed	1	CEFX	95334	28.2	E	na	28.2	45.8
From	2	CEFX	96307	27.9	E	na	27.9	45.8
Head End	3	ARMN	933964	46.6	L	76.3	122.9	64.9
of Train	4	GBRX	65014	27.9	E	na	27.9	45.8
	5	MP	374660	38.4	E	na	38.4	58.1
	6	SP	228550	39.0	E	na	39.0	58.0
	7	WC	22193	39.4	E	na	39.4	67.9
	8	DWC	793859	39.2	E	na	39.2	68.4
	9	GTW	517811	34.7	E	na	34.7	55.6
	10	DWC	793713	39.3	E	na	39.3	68.4
	11	LW	50237	38.8	E	na	38.8	67.1
	12	ARMN	768079	41.4	L	45.8	87.1	63.8
	13	ARMN	761840	43.2	L	67.0	110.2	58.3
	14	ARMN	768036	45.2	L	60.9	106.1	63.8
	15	ARMN	923979	46.4	L	76.3	122.7	64.9
	16	ARMN	769010	42.4	L	61.4	103.8	63.8
	17	FBOX	504734	36.4	L	72.2	108.6	58.9

Train Tonnage	1522 tons	*Includes locomotives
Car Tonnage	1114 tons	*Does not include locomotives
Train Length	1164 feet	*Includes locomotives
Car Length	1019 feet	*Does not include locomotives

Loads	7
Empties	10
Total Cars	17

Lines 1 through 10 derailed.
Both locomotives derailed; UP 8485 was on side.
A total of 10 cars and 2 locomotives were derailed.

This information was developed using the UP consist list (list of cars) and UMLER (car tare weights and length) and Waybills (lading weight).

Figure A.2.2-9. UP Freight Train Composition

Figure A.2.2-9 provides additional detail about the cars in the freight train.

Appendix A.3: Fuel Tank Damage

This appendix discusses the forensic evidence and interpretation related to the fuel tank of the passenger locomotive.

Figure A.3-1. Exemplar Passenger Locomotive Fuel Tank

An exemplar fuel tank, on an undamaged locomotive of the type involved in the accident, is shown in Figure A.3-1. The lead end of this fuel tank is located inboard of the lead truck, which is indicated in the figure.

Figure A.3-2. Fuel Tank Attachment to Underframe

The fuel tank on this type of locomotive is suspended from the underframe of the locomotive, attached to the locomotive by bolts and clips, as shown in Figure A.3-2. This arrangement is found at the four corners of the fuel tank. The particular location shown in Figure A.3-2 is at the rear of the fuel tank, on the locomotive's left-hand side.

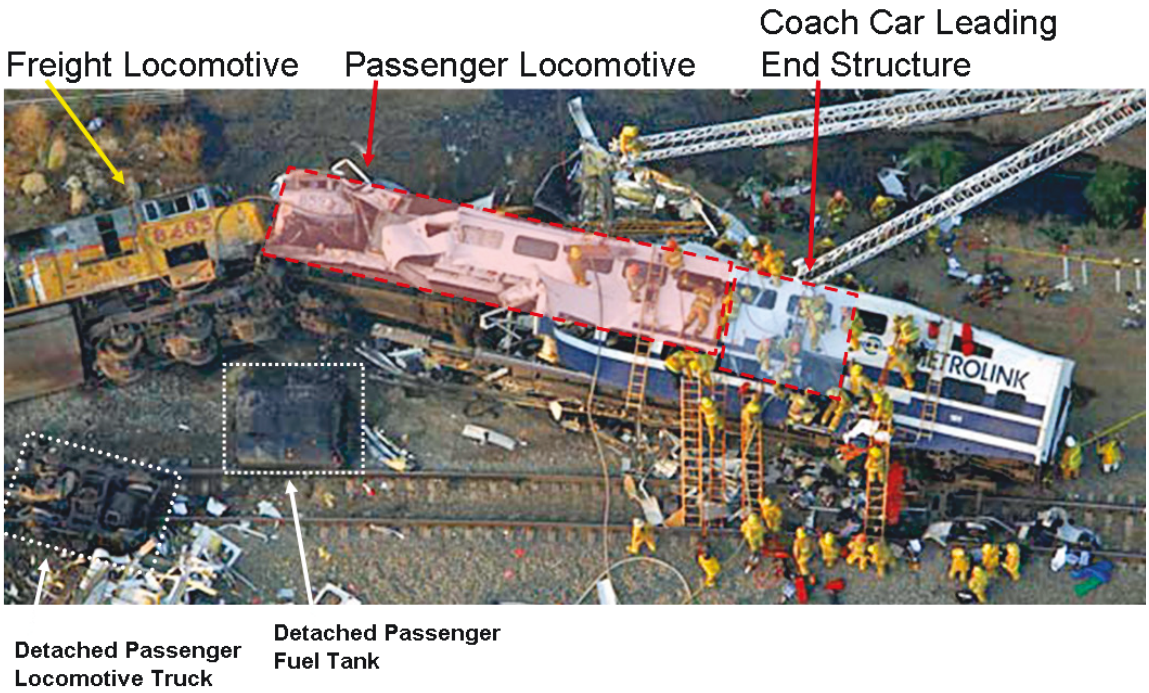


Figure A.3-3. Post-accident View of Locomotives and First Passenger Car (Photo from the *LA Times* Web site)

Post-accident, the fuel tank was found detached from the passenger locomotive, positioned on the ballast adjacent to the overturned freight locomotive. The lead truck of the passenger locomotive was also detached, and was found resting on the ballast adjacent to the running rails. An overhead view of the impacting locomotives and first passenger car are shown above in Figure A.3-3, with annotations showing the locations of the fuel tank and lead truck that detached from the passenger locomotive.

The fuel tank had been breached at its lead end, where the front end sheet and the top sheet come together, behind the mounting bracket. Figure A.3-4 shows this breach at the leading end of the fuel tank, viewed from the side. The front vertical sheet of the fuel tank has been bent backward, toward the trailing end of the leading locomotive. The mounting brackets at the lead end of the fuel tank have also been bent backward and downward.

Figure A.3-4. Damage to Fuel Tank Leading End

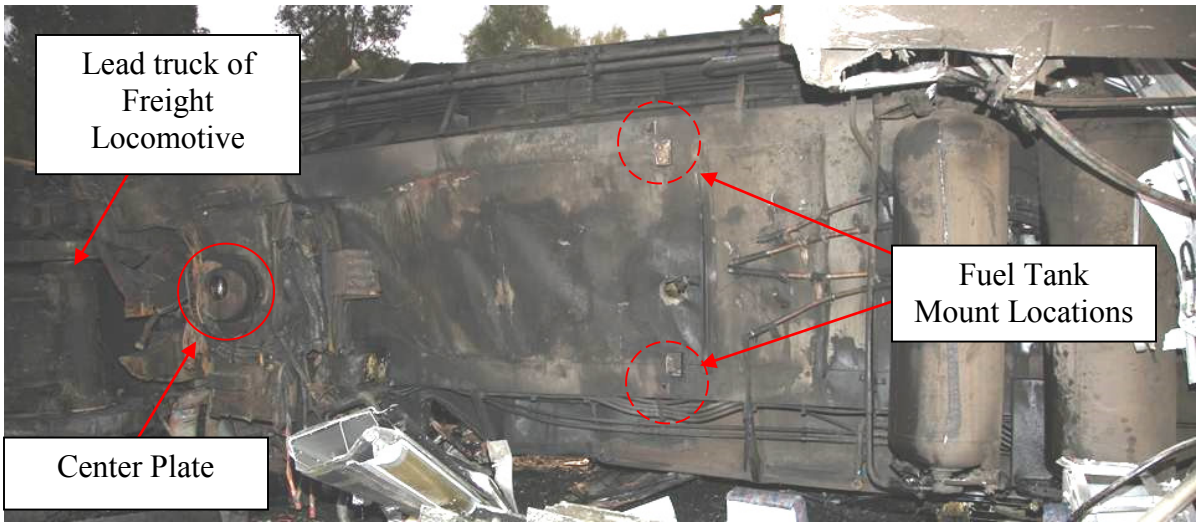


Figure A.3-5. Passenger Locomotive Underframe, Before Locomotive Moved by Rescue and Recovery Crew

The underside of the passenger locomotive is shown in Figure A.3-5. The passenger locomotive is resting on its right side. The wheels of the leading freight locomotive's lead truck are visible in the left of the photograph, indicating that the two locomotives have not yet been separated. This photograph was taken by on-scene personnel prior to the arrival of the crashworthiness team.

This photograph shows the passenger locomotive's center plate, the area where the lead truck is normally attached. The underframe of the locomotive has been deformed backward, resulting in the center plate moving toward the trailing end of the locomotive. Visible toward the center of the photograph are the locations of the trailing-end fuel tank mounts. The top location (left hand side of the upright locomotive) still contains a mounting bolt that has been fractured.

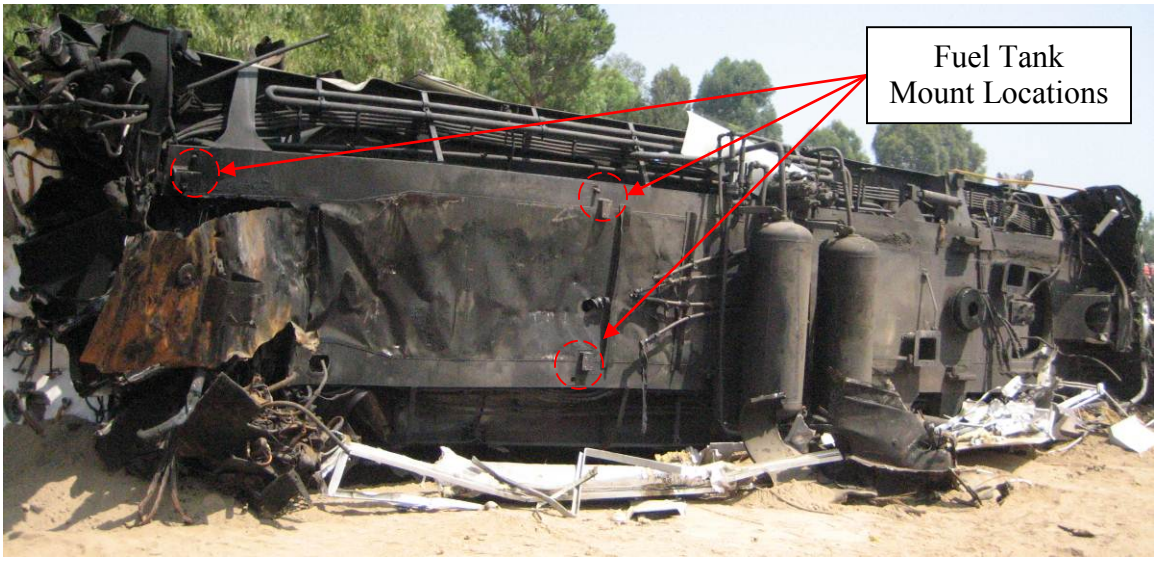


Figure A.3-6. Passenger Locomotive Underframe, After Locomotive Moved by Rescue and Recovery Crew

Prior to the crashworthiness team's arrival on scene, the freight locomotive and the passenger locomotive were moved as part of the rescue and recovery operations. As a result of this move, portions of the damaged passenger locomotive underframe were disturbed, including the center plate from the lead truck. Figure A.3-6 is a photograph of the underframe of the locomotive after it was moved from its post-accident location. Three fuel tank attachment locations are highlighted in this photograph. Two of these three locations include fractured mounting bolts still in their holes.

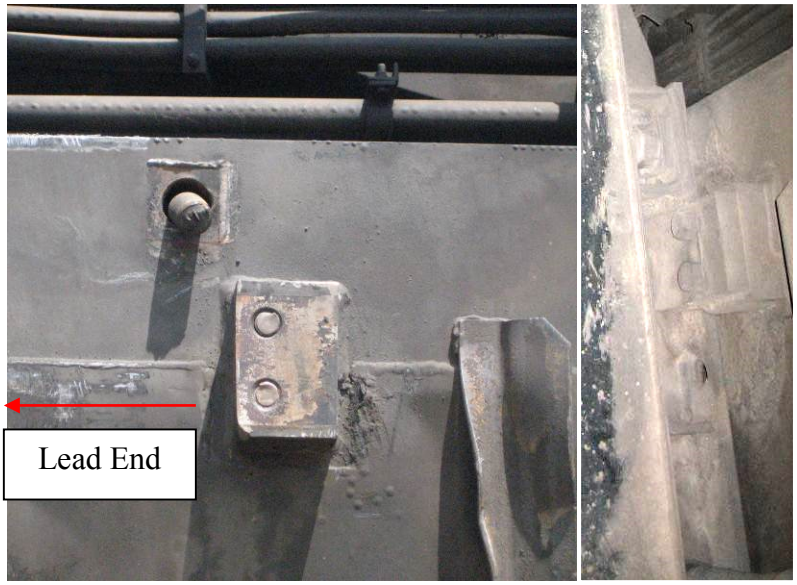


Figure A.3-7. Fractured Fuel Tank Mounting Arrangement (left), undamaged Exemplar Mounting Arrangement (right)

The left side of Figure A.3-7 shows one of the fractured bolts and damaged clips used to mount the fuel tank. This particular bolt was located on the left-hand side of the locomotive, at the trailing end of the fuel tank. The bolt is visibly bent toward the rear of the locomotive. It is unknown whether the orientation of the bolt was a result of the accident or a result of movement during rescue and recovery operations. Additionally, the clip has sustained damage, including shearing of the bolt heads and an apparent fracture to the clip itself. For reference, the right side of Figure A.3-7 shows an undamaged fuel tank mounting arrangement on an exemplar locomotive of a similar type to that involved in the accident. Note that the reference photograph has been rotated to provide a similar view to that of the overturned locomotive.

Figure A.3-8. Trailing End of Fuel Tank

Figure A.3-8 shows the accident fuel tank in its post-accident position. The end shown was toward the trailing end of the passenger locomotive. At the top of the fuel tank there is fracture in the area where the clip would have contacted the fuel tank, indicated above by the box. There does not appear to be a breach of the fuel tank at this end. This area of fractured fuel tank would have been mounted at the location depicted in Figure A.3-7.

Figure A.3-9. Passenger Locomotive Lead Truck: Leading End (left) and Trailing End (right)

Figure A.3-9 shows the lead truck of the passenger locomotive. Note that these photographs were taken at two different times. The left side photograph was taken after the truck had been moved, and the right side photograph was taken when the truck was still in its post-accident position, prior to the arrival of the crashworthiness team. The leading end of the truck, shown on the left, featured extensive structural damage to its frame. The lateral member has been bent backward and has fractured. The trailing end of the truck, shown on the right, also shows some structural damage. The trailing lateral member has been bent toward the lead end of the locomotive. It is

probable that the trailing end of the lead truck was able to contact the leading end of the fuel tank during the collision, contributing to the breach of the tank and its eventual attachment failure.

Appendix A.4: Train Collision Dynamics

A key objective of any accident investigation is determining the causes of severe injuries and fatalities. This appendix proposes a possible reconstruction of the train collision dynamics of the Chatsworth accident to understand the physical forces that passengers likely endured. Specifically, determining the dynamics of the incident is key to estimating the secondary impact velocities[1] of passengers in each vehicle. Secondary impact velocity data is correlated to the injuries presented in Appendix B.

The forensic team developed a collision dynamics model to aid in determining the cause of severe injuries and fatalities. The model helps to estimate the gross motions of the two trains and identify how the collision events progressed. Results from the collision dynamics model help reconstruct the sequence of events leading to intrusion of the occupant volume and estimate the gross motions of the colliding trains. Evidence collected from the on-scene investigation, such as the event recorder[2] data, provides supporting evidence of each train's motions.

A one-dimensional collision dynamics model was developed to estimate the longitudinal motions of the train and those experienced by the occupants. The model was developed using ADAMS, a commercial software package. The lumped-mass model of the accident scenario includes a spring-mass representation of each vehicle and is shown below in Figure A.4-1. The model construction accounts for the structural mode of deformation of the first bi-level car as it crippled and its subsequent motion as two separate sections. As described in the main report, the first coach car crippled at the gooseneck and the front portion of the first coach car plunged backward, crushing the middle passenger compartment of the car.

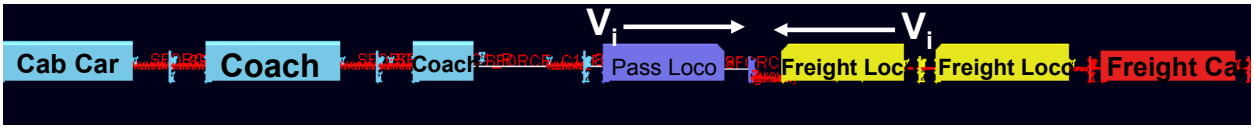


Figure A.4-1. Schematic of One-Dimensional Lumped-Mass Collision Dynamics Model of Chatsworth Accident

The key parameters for the model include the train make-up, vehicle weights, initial speeds of the colliding vehicles, level of braking, and the force-crush behavior of the equipment. The parameters known from the accident investigation are listed in Table A.4-1.

[1] The speed or velocity at which an occupant strikes the interior is termed the secondary impact velocity (SIV). The SIV is a function of the carbody deceleration time-history and the seating configuration. In general, as the distance an occupant travels before striking an interior feature increases, so does the SIV.

[2] An event recorder is a device, designed to resist tampering, that records data such as train speed and direction of motion. In accident investigations, a train event recorder plays a similar to the "black box" from an airplane.

Table A.4-1. Model Input Parameters: Train Make-up

Vehicle	Mass (lb)	Quantity	Initial Speed (mph)
SD70AC EMD Freight Locomotive	409,000	2	40 mph Brakes Applied
Other Freight Cars	Variable	17	
Complete Freight Consist	**3,046,000**	**----**	
F59PH EMD Locomotive	268,100	1	40 mph No Braking
Bombardier Multi-level Car	118,000	3	
Complete Passenger Consist	**616,100**	**----**	

The structural behavior of each vehicle is estimated based on the damage measured during the accident investigation and data from full-scale test results [1]. Both linear and non-linear springs were used in modeling the force-crush behavior of each vehicle end.

Table A.4-2. Summary of Measured Crush Per Vehicle

Vehicle End	Measured Crush
Locomotive Front	~15 feet
Locomotive Rear	~2 feet
First Multi-level Passenger Car Front	65 feet
First Multi-level Passenger Car Rear	None
Second Multi-level Passenger Car	None
Third Multi-level Passenger Car	None

An idealized force-crush behavior is defined at each car end. Key parameters of the estimated force-crush behavior are listed in Table A.4-3.

Table A.4-3. Summary of Key Parameters of Force-Crush Characteristics

Vehicle End	Peak Crush Load (million lb)	Average Crush Force (million lb)	Energy Dissipated (million ft-lb)
Passenger Locomotive	3.5	2.75	48
Multi-level Car	2.5	0.3	42

The passenger locomotive dissipated approximately 48 million ft-lb while it crushed about 15 feet. The adjacent multi-level passenger car dissipated approximately 42 million ft-lb as it crushed about 65 feet.

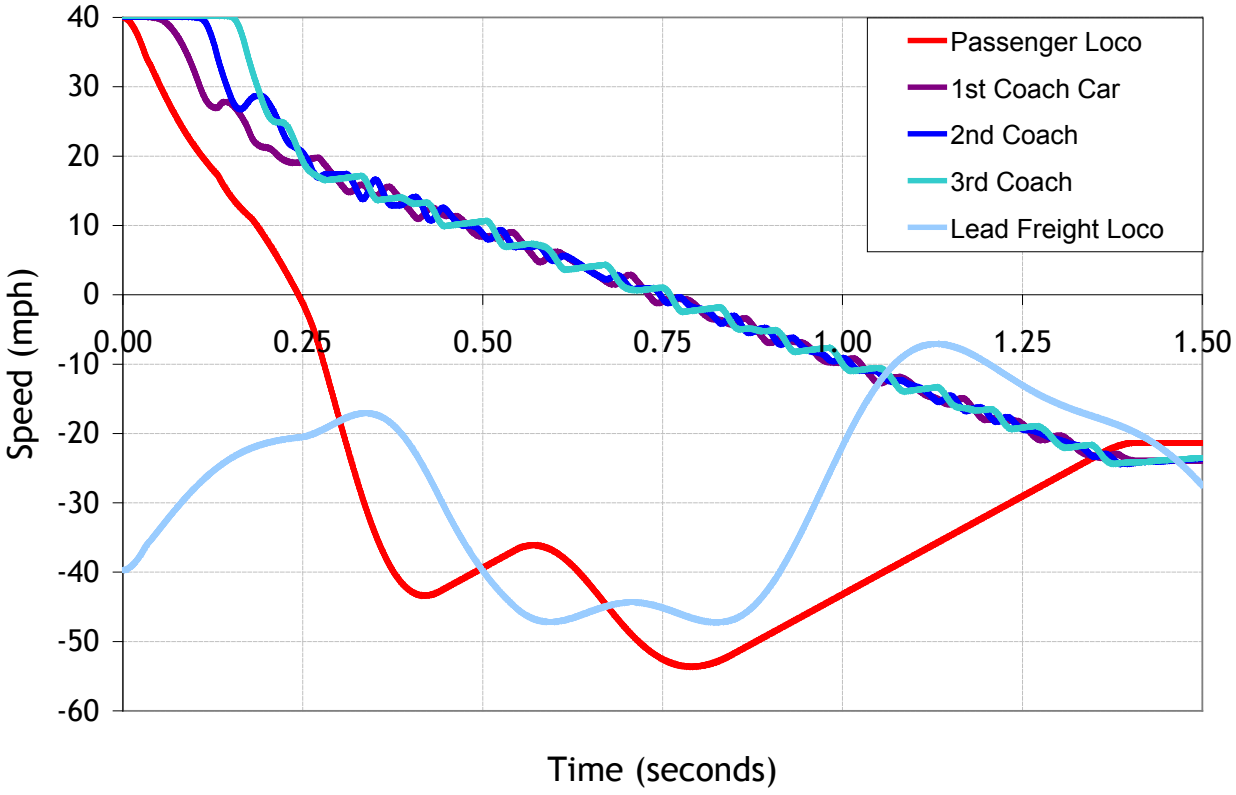


Figure A.4-4. Velocity-Time Histories for Each Vehicle Starting at the Time of Impact

Figure A.4-4 shows the velocity-time history of the passenger train and the first locomotive in the freight train. The two trains were traveling toward each other, with a closing speed[3] of about 80 mph. In the first 0.05 seconds after the impact, the passenger locomotive slowed to about 30 mph, a rate of approximately 7.3 gs.[4] There is about a 0.05-second delay before the following passenger cars begin to decelerate. The passenger train then decelerates at a rate of about 1.8 gs. The approximate timing of the simulation collision event correlates to timing estimated from reviewing the onboard locomotive cameras, as described in Appendix A.5.

[3] Closing speed is calculated as the speed differential between two vehicles traveling toward each other. In this case, calculated as the sum of the speeds of both trains.

[4] One "g" is the amount of force exerted upon an object by the earth's gravity. In this accident, the passenger locomotive decelerated under a force about seven times greater than the force of earth's gravity.

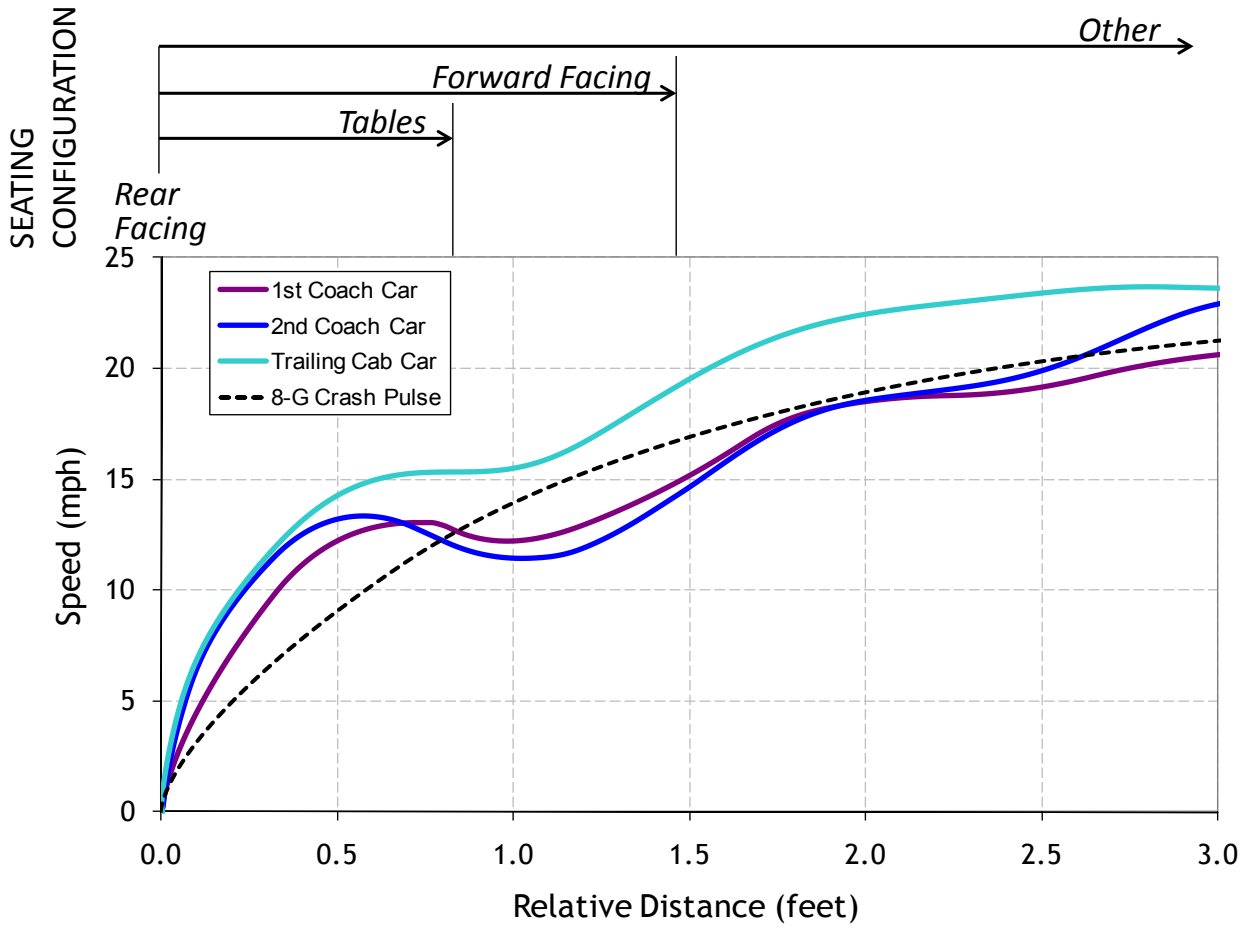


Figure A.4-5. Secondary Impact Velocities for Each Occupied Vehicle

Figure A.4-5 shows the SIVs for the passenger train. The horizontal axis at the bottom of the plot represents the distance travelled for an occupant in free flight with respect to the carbody (which varies with seating configuration as shown at the top of the plot). The vertical axis represents the velocity of an occupant in free flight, also with respect to the carbody. The first 0.3 seconds of the gross motions in Figure A.4-4 are used to plot the relevant SIV data for this accident. For comparison, the SIV plot associated with the 8-g crash pulse (used for passenger seat crashworthiness testing) is also plotted in the graph.

This plot can be used to estimate the relationship between seating configuration type, travel distance possible, and severity of secondary impact for passengers in each car. The arrows at the top of the figure show the approximate travel distances associated with different interior seating configurations in Metrolink's bi-level passenger cars: passengers in a rear-facing seats travel essentially no distance (if their backs are against the seat at the time of incident) in a collision event; passengers seated at tables can travel up to 1 foot; passengers in forward-facing seats can travel up to 1.5 feet; and passengers in other scenarios, with nothing to obstruct them, may travel through the car until striking a fixed object.

Generally, the SIVs of the Metrolink passengers increased with the relative distance they traveled before striking part of the interior. The graph shows that SIVs were highest in the trailing passenger car, and nearly equivalent in the first and second passenger cars. For

passengers seated at forward-facing or facing seats without tables, the high end estimate of the SIVs was 21-24 mph. The results show that the last coach experiences a high deceleration, resulting in a more severe secondary impact. For passengers who are not compartmentalized, large travel distances correlate to an even higher SIV. In this accident, two fatalities were caused by long travel distances in the interior resulting in fatal impact with the interior.

These results correlate to the evidence of interior damage of the third passenger car, described in Appendix B.3.

Appendix A.5: Freight Locomotive Onboard Videos

This appendix summarizes a review of the onboard videos from the two freight locomotives. As described in the main report, the freight train was led by two UP locomotives. The first locomotive was oriented forward-facing, pulling the train, and the second locomotive was oriented rear-facing. Each locomotive was equipped with a digital video camera, mounted on the upper inner corner of the left front windshield. The following is a summary of observations from the video data that provides details of 1) the sequence of events during the collision and 2) the emergency egress events.

A.5.1 Approximate Time Range of Collision Event Based on Data from Camera in Windshield of Lead Freight Locomotive*

Collision

0:00:00.00	Brakes Applied.
0:00:03.27	Locomotive traveling at 41 mph.
0:00:03.33	Impact occurs. Passenger locomotive hood has begun to crush; evidence of ripple in passenger locomotive hood just under right window.
0:00:03.40	Passenger locomotive hood is crushed. Freight hood has climbed up passenger locomotive.
0:00:03.47	Roof of passenger locomotive has begun to crush; evidence of ripple in roof structure.
0:00:03.53	Front left window of freight locomotive cab cracks.
0:00:03.87	Freight locomotive hood comes into view as hood begins to crush.
0:00:04.60	Freight locomotive rolls onto its left side.

Egress

0:19:35.00 PM	Emergency Responder arrives and begins to get window open by means of repeated hits with an ax.
0:22:17.00 PM	Emergency Responder has successfully broken and pried open the front left cab window. Operators exit through window.

A.5.2 Approximate Time Range of Collision Event Based on Data from Camera in Windshield of Second Freight Locomotive*

0:00:00.00	Brakes Applied.
0:00:02.53	Significant inter-car vertical and horizontal motion.
0:00:03.00	Third car in freight consist, ARMX car, begins to override the second locomotive.
0:00:03.33	Front plate of ARMX car starts to deform, bending around locomotive hood.

0:00:03.67	ARMX continues to deform, conforming to the shape of the locomotive hood. Approximately 5-10 feet of crush.
0:00:04.00	Loss of visibility due to debris.
0:00:05.60	View of inside of locomotive window frame indicating locomotive cab is deforming.
0:00:05.67	Barrel of strawberries impacts window indicating cargo from freight cars is no longer contained.
0:00:06.87	Locomotive window shatters.
0:00:07.27	Camera goes out.

* Please note: Timestamps from cameras in this accident have been normalized to the moment that the brakes were applied. The timestamps indicated do not correspond with actual times and are presented here to provide information on the relative timing of the sequence of events in the two freight locomotives.

Appendix B.1: Interviews with Injured Passengers and First Responders

B.1.1. Introduction

As part of the forensic investigation, the team made contact with hospitals where victims of the accident were transported. The team conducted interviews with victims for the purposes of establishing their relative location in the car, severity of injuries sustained, and an account of the events of the accident. This information is correlated with observations of the damaged interiors of the passenger cars, in an effort to determine potential causal mechanisms for injury.

In some cases, the seats where passengers may have been sitting have been identified with numbers. These numbers correspond to seating schematics that are provided in Appendix B.3. The passenger numbers from this appendix are also included in the car diagrams in Appendix B.3 when applicable.

The following accounts have had information removed from them which could identify the persons interviewed. Interview notes were collected by multiple members of the forensics team during some interviews. In those cases, both sets of notes are provided for a given passenger.

Interviews were conducted at the following hospitals:

- Cedars-Sinai Hospital
- Simi Valley Hospital
- Northridge Hospital Medical Center
- Ronald Reagan UCLA Medical Center (University of California – Los Angeles)

Additionally, two passengers who had been released from the hospital were contacted and agreed to phone interviews. The team assigned numbers to passengers in the order the passengers were approached at the hospital (i.e., the first passenger contacted was recorded as Passenger #1).

B.1.2. Passenger Interviews

Passenger #1, Declined to be interviewed.

Passenger #2, 6'2", 185 lbs. – notes from one member of the forensics team

Pre-accident location: Car #185, upper level, rear-facing seat at table, left-hand side of car. Likely seated at seat 52 or 60.

- Boarded the train at Union Station in downtown LA. The coach was pretty much empty after Chatsworth. There were not many riders left in the car after Chatsworth.
- In response to the question about commuters sitting in the same seats and having knowledge about other commuters, described this as a "flex train" and not a typical commuter train.
- Was riding in the first car on the upper level at the left rear side of the car.
- Was sitting at a table on the aisle, left side of train riding backwards.

- Was possibly positioned on top of the passenger locomotive that had intruded into the passenger car following the collision.
- It took about 45 minutes to an hour to be taken from the car and then put on a helicopter to the hospital.
- Injuries:
  - Bruised lungs
  - Bruised heart
  - Broken scapula
  - Broken right wrist, with displaced radial bone
  - Broken ribs, right and left
  - Broken sternum
  - Broken T-12 vertebra

Passenger #2, 6'2", 185 lbs. - notes from another member of the forensics team

- Passenger is a daily rider of the train.
- Mentioned this train was an off-hours train…"who gets out of work at 3 PM anyway?"
- Does not think conductor made a passenger count after leaving station prior to accident.
- Car #185, seated on left-hand side of upper level, aisle seat, thinks was rear-facing, thinks was at a table.
- Car was fairly empty at the time.
- Seated catty-corner across from 20-something passenger.
- Remembers person in professional clothing (possibly white shirt) seated at table across aisle before impact.
- Recalls telling self to breathe after impact, not thinking had head injury. Continues to find debris in hair/ears.
- Left arm was pinned, remembers an arm lying across body, experiencing numbness, thought arm was detached from socket. Realized arm on chest had different colored shirt (white) than passenger's shirt (green), must belong to another passenger.
- Felt like was in debris field, possibly near locomotive. When looked up, could see the sky above while trapped in wreckage.
- Remembers firefighters looking down from above.
- Remembers firefighters talking to/about self, does not remember being placed on ground.
- Injuries:

- Extensive bruising on right leg (calf, upper thigh, outside of leg)
- Bruised lung
- Bruised heart
- Broken ribs
- Broken scapula
- Broken T-14 (though later in interview said T-12)
- Broken right wrist (passenger believes this was from bracing self)
- Facial cuts
- EKG was negative

Passenger #3, 5'-5", 250 lbs. - notes from one member of the forensics team

Pre-accident location: Car #185, rear mezzanine, likely seat 1

- Boarded at Union Station and was traveling to Moorpark (end of the line).
- Was seated in the 2nd coach, lower level but did not remember which side of the coach was sitting on. Remembered very little of the events that occurred before, during, and after the accident.
- Was seated, looking toward friend during conversation.
- Remembered talking with friend and then awoke in the hospital.
- Friend **Passenger #4** has an excellent recall of the accident.
- Injuries:
  - Broken toe, left pinky
  - Concussion
  - Bruises-large on right front and back of left leg
  - Bruise in the middle of back
  - Laceration of the top of head that required staples to close
  - Numerous bruises on arms and the back of both shoulders

Passenger #3, 5'-5", 250 lbs. - notes from another member of the forensics team

- Passenger was riding in middle car of consist with coworker (**Passenger #4**). **Passenger #3** was seated in lower level, seated facing forward, in window seat. Interview with **Passenger #4** indicated both were seated in rear of car 185.
- Remembers being in hospital after accident. Was told by **Passenger #4** that they walked out together, and **Passenger #4** went back to get their bags for ID purposes.
- Injuries:
  - Broken pinkie toe
  - Concussion

- Large bruises on thighs
- Bruises on back, between the clavicles
- Head laceration
- Bruises on right forearm

- Passenger's spouse indicated that passenger continues to have short-term memory loss.

Passenger #4, 168 lbs. – notes from one member of the forensics team

Pre-accident location: Car #185, rear mezzanine, likely seat 2

- Boarded at Union Station with friend (**Passenger #3**).
- Was riding in the first car in the last two seats on the lower level by the emergency window. Was in the left seat on the aisle and friend was next to the window.
- A man and a woman were in the seats in front of them.
- Thought a train was coming at them and then woke up and the car was turned on its side.
- Was thrown diagonally across the car and friend was several rows behind. Ended up six seats ahead of original seat and on the windows, as the car had rolled onto its side.
- A man in a blue shirt came and opened the door for passengers to escape.
- Had no recollection of having trouble getting out of the car. *Interviewer Note: This description is confusing because Passenger #3 said that they were in the second coach and it remained upright, and that Passenger #s 3 and 4 were helped out of the car and went out and sat on some rocks until help arrived. A man in a brown suit was sitting on the rocks with them.*
- Stated no ill-will toward Metrolink and would ride tomorrow—not afraid.
- Comments:
  - People riding are not identified—there should be some way to identify passengers
  - The Metrolink webpage was not helpful
- Injuries:
  - Broken L-4
  - Broken ribs
  - Long abrasion on left leg
  - Bruises on right triceps and both buttocks
  - Bruises on right side of face
  - Slight concussion

Passenger #4, 5'-7", 164 lbs. - notes from another member of the forensics team

- Passenger is coworker of **Passenger #3**.

- Was seated with coworker in last row of Car #185. **Passenger #4** seated on aisle side, **Passenger #3** seated on window side.
- Saw other train through window (likely seated on left hand side of car).
- After collision, ended up six rows ahead of original seat, on opposite side of car, seated on a window.
- Saw the staircase railing nearby.
- Saw a man trapped with two broken legs.
- Coworker was also thrown across the aisle.
- Did not observe any windows further ahead of post-collision position, only the staircase.
- Believes could see the curve of the top of the exit door.
- Could smell diesel fuel.
- Could see out pass-through door, realized that the next car (#207) was detached and a long distance away from Car #185.
- Saw a man from outside the car, wearing a blue shirt, kick out the pass through door and enter the car. Helped another passenger get up, and then exit the car.
- Saw another passenger on the mezzanine clutching abdomen. This other passenger was helped outside by the man in the blue shirt as well.
- A man in a yellow shirt also came from outside and helped a male passenger from the mezzanine off as well. This male passenger had a suit on, possibly a brown one.
- **Passengers #3 and #4** exited through pass-through door. **Passenger #4** then returned for their bags with IDs.
- Does not remember struggling to exit the car.
- Injuries:
    - Broken L-4 in back
    - Six broken ribs (posterior)
    - Long abrasion to left leg
    - Muscle trauma to legs
    - Large bruises to the biceps and right triceps
    - Large bruises to the right and left buttocks
    - Bruising to upper face
    - Mild concussion
    - Bruised lung

Passenger #5, 150 lbs. - notes from one member of the forensics team

Pre-accident location: Car #207, lower level, right-hand side, likely in one of three seats: 120, 128, or 132

- Boarded at Union Station.
- Was riding in the second car (#207) facing forward on the right side.
- Was in a window seat in the four-occupant configuration.
- There was perhaps a couple in front; and teenager and father on the opposite side of the car.
- Was looking out the window at the time of impact.
- Hit the seat in front when the train came to a sudden stop.
- Came to rest on the floor across the aisle.
- Needed help getting out of the car and waited for the fire department for assistance out of the car.
- Was transported to the hospital by helicopter.
- Injuries:
  - Broken lower left leg and kneecap
  - Claimed major bruising over entire body

Passenger #5, 5'-4", 150 lbs. - notes from another member of the forensics team

- Seated in Car #207, lower level, right-hand side, forward-facing window seat.
- Thinks there might have been a couple seated in the row ahead, and a father/teenage son seated on opposite side of aisle.
- Passenger was looking out window before crash, possibly with legs crossed.
- Passenger remembers a jarring blow and flying forward at the impact.
- Lowered self to floor and laid across the aisle.
- Remembers being in the car for a long time after the crash.
- Injuries:
  - Broken left leg
  - Broken kneecap
  - Bruising across entire body
  - Right leg uninjured
  - No observed facial bruising or lacerations
  - Passenger indicated no abdominal injuries present

Passenger #6, 6', 180 lbs. (200 lbs. at time of accident, wearing work-related attire) - notes from one member of the forensics team

Pre-accident location: Car #617, lower level, likely seat 145

- Was seated in the rear car (#617) facing sideways on a bench seat. (This would be on the lower level of the car).
- Was talking with a man who was the only one in the area.
- Was slammed into the partition. It was not broken; it was cracked.
- Right side took the brunt of the trauma.
- Stated that could not imagine how it could have happened so suddenly; going from 40 mph to a dead stop in about a second. Described the collision as "sudden impact."
- Was able to leave the train, was stunned, but tried to help others.
- There were screams that the cars were on fire. Continued to help others off the train. Cab car and the one in front were not in danger from fire since they were disconnected from the engine.
- Walked up to the engine and looked at the first car. By that time emergency people were on the scene.
- Comment:
  - Wished there had been airbags to cushion the impact.
- Injuries:
  - Broken hand, surgery planned for following week
  - Laceration to left shin but not serious
  - Broken clavicle (collarbone) right side
  - Broken scapula (shoulder blade) right side
  - Broken ribs
  - Punctured lung
  - Lacerated liver
  - Broken left arm

Passenger #6, 6', 180 lbs. (200 lbs. wearing equipment) - notes from another member of the forensics team

- Seated in Car #617, lower level, facing sideways in fold down seat.
- Recalls the collision as, "Bam – dead stop" and describes as "unreal."
- Recalls a young man screaming that the car was on fire.
- Could see no immediate fire damage.
- Injuries:
  - Broken left hand
  - Left shin laceration

- Broken right clavicle (collarbone)
- Broken right scapula (shoulder blade)
- Broken ribs on the right hand side
- Punctured right lung
- Lacerated liver
- Facial bruises

Passenger #7, 6'1", 190 lbs.

Pre-accident location: Car #207, lower level, likely seat 142

- Was seated in the middle coach car (#207), lower level, left side, in aisle seat 142, forward-facing on a flip down seat in the handicapped seating area.
- There was no bulkhead in front, just ~10' of open space between passenger and the bathroom wall ahead.
- Friend was seated across the aisle in seat 143. **Passenger #7** stated that friend had a laceration on the back of head that required 5-6 staples. (Friend declined to be interviewed).
- **Passenger #7** and friend initially boarded the lead coach car, but it was too crowded, so they moved back to the second car and sat together.
- Stated that the car suddenly stopped. Went flying into the wall next to the bathroom door.
- With a huge surge of adrenaline, stood up and walked off the train, then dropped to the ground. Friend was with **Passenger #7** outside until help arrived.
- Injuries:
  - Four fractured ribs
  - Four fractured vertebra
  - Fractured tibia
  - Fractured forearm
  - Fractured finger

Passenger #8, 6'2", 282 lbs.

Pre-accident location: Car #617, upper level, likely seat 54

- Rides the train every day. The upper lever of the cab car was fairly empty (Note: friend, **Passenger #9**, stated the upper level was half full).
- More people tend to sit on the left side of the train, possibly because it is warmer from the sun in the afternoon.
- Was seated in the trailing cab car (#617), upper level, right side, forward-facing in aisle seat (likely seat 54), near the longitudinal center of the car.

- **Passenger #9** was seated catty-corner, rear-facing, in the window seat (likely seat 59).
- Was talking with **Passenger #9**, then woke up at the bottom of the stairs in the front mezzanine. Was lying perpendicular to the train, with head near the trash can on the right side of the train.
- When passenger woke up, saw a passenger in a black wheel chair blocking the stairs leading down from the front mezzanine to the lower level. Had likely been sitting in the handicapped seating area (seats 148/149). Travel distance from back of flip-down seat to bottom of stairs measured 15'5."
- *Interviewer's Note: the seat pan of seat 94 was cracked nearly across the entire width of the seat. It is likely that **Passenger #8** flew head first from the middle of the upper level, through the aisle, and down the stairwell, landing on or near seat 94. There were also rubber skid marks on the left stair wall, possibly left by shoes.*
- Injuries:
    - Fractured left fibula
    - Fractured left tibia
    - Fractured left rib
    - Fractured head of left humorous
    - Dislocated left shoulder
    - Laceration on right side of head

Passenger #9, 5'8"

Pre-accident location: Car #617, upper level, likely seat 59

- Was seated in an open bay seat with **Passenger #8**, in Car #617, upper level, right side, rear-facing in window seat (likely seat 59).
- Heard a loud bang, then everything stopped.
- **Passenger #9** never moved from seat, was just pushed into the seat back by inertia.
- Head whipped backwards. Eyes were shut for 3-5 seconds. When opened eyes, **Passenger #8** was gone.
- Most people were on the floor after the collision.
- There was a person on the floor reaching for help.
- Chair cushions were thrown about.
- Thought **Passenger #8** had quickly tried to exit the train. Found **Passenger #8**. at the bottom of the stairs in the front mezzanine. There were 6-7 bodies lying in same area, unconscious.

- Helped ~ 10 people to get off the car. It took about 5-10 minutes from the time of the accident until exited the car, via the front mezzanine, and out the side door on the lower level.
- Estimated that the upper level was ~ half full, maybe 30 people, at the time of the accident.
- Injuries:
  - Stiff neck and back
  - Headache

Passenger #10, 5'9", 200 lbs.

Pre-accident location: Car #207, lower level, likely seat 113

- Rides the train 3-4 times per week.
- Was seated in the middle coach car (#207), lower level, left side, forward-facing in aisle seat 113.
- There was no warning of the impending accident, no noise.
- Was reading with glasses at time of impact. Went into free-flight. Hands and book hit the facing seat back, and face hit the book. Glasses did not break.
- Left knee smashed into the facing seat in front. Fell to the floor, ending up in a sitting position with left leg under the forward seat and right leg in the aisle.
- There was a large person on top of **Passenger #10**. Possibly the person had been seated in the adjacent window seat, or across the aisle on the flip down bench seat.
- The facing seat pair facing had been unoccupied prior to the accident.
- Impacted seat 115 had small cracks in the head rest handles, no visible damage to the seat pan.
- Waited approximately 1 hour to be carried off the train on a stretcher. Emergency rescue personnel were attending to the more critically injured passengers first.
- Injuries:
  - Fractured left femur, near knee, lots of bone fragments requiring seven pins
  - Lacerations to face, nose, right leg, left arm
  - Slight concussion
  - Possible nerve damage to hands/wrists

Passenger #11, 5'4", 160 lbs.

Pre-accident Location: Car #185, trailing mezzanine, likely seat 10

- Was seated in the leading coach car (#185) in the rear mezzanine, left side, forward-facing in aisle seat 10 at table.
- Recalled two people talking together in the seats behind **Passenger #11**.

- Recalled a person with a nose ring in the front, right corner of the rear mezzanine, who was seated in the single seat facing the aisle, seat 19.
- Upon impact, struck the table. As the car rolled onto its right side, ended up in the right rear corner of the rear mezzanine.
- Was assisted in exiting by someone from the fire department.
- Injuries:
  - Seven fractured ribs
  - Lacerated liver
  - Bump on head

Passenger #12, 6'-1", 210 lbs.

Pre-accident location: Car #617, upper level, likely seat 24

- Seated in Car #617, upper level, forward-facing left-hand side window seat, toward rear of car, bulkhead seat.
- Passenger seated in middle of an area of 2x2 seats.
- Passenger's part of the car was relatively unoccupied at the time of the accident.
- Remembers one male passenger seated directly across aisle.
- Thinks no more than five passengers on upper level of car.
- Passenger thought more people were downstairs.
- Passenger estimates a dozen people on the lower level of Car #617.
- Recalls seeing adjacent emergency window with a pull-ring.
- Passenger had briefcase on lap, with one end placed against seat ahead. Believes briefcase acted as restraint during accident.
- Head impacted seatback ahead, causing nosebleed.
- Cushion on adjacent seat went flying.
- Saw people seated at opposite end of car in quad seating thrown into bulkhead.
- Spoke to man across from aisle, thought the other passenger was okay. Went downstairs, checked with conductor, talked to Deputy Sheriff before exiting train.
- Remembers conductor on the floor, next to desk, in some pain. Conductor was calling dispatch. Passenger does not think conductor could have opened doors based on physical condition. Passengers tried to get everyone off the car, then conductor followed. Went to pre-triage, then official triage.
- An anonymous passenger that was not interviewed was on feet, but "not really looking good."

- Someone was yelling "fire." Passenger realized fire was not in Car #617.Passenger noticed the disconnected Car #185 separate from the remaining two cars. Passenger remembers someone else taking the fire extinguisher from car.
- Injuries limited to facial injuries.

Passenger #13, 5'-9", ~200 lbs.

Pre-accident location: Likely Car #207, likely seat 89

- Claims to have been seated in Car #617, lower level, left-hand side, facing forward at a table. *Interviewer's note: Based on description of events and condition of the cars, it is likely that this passenger was sitting in Car #207 in seat 89. The table is bent and the emergency window is open at this location.*
- Sitting alone at the table, a tall lady was seated at the table across the aisle.
- Saw the moving freight train and braced self with hands on the table.
- Put body on the table.
- Heard the sheriff asking if anyone was alive and instruct one of the guys to open the window.
- Was removed through the window.
- Injuries:
  - Abdomen
  - Bowel
  - Mesenteric tear
  - Liver
  - Spleen
  - Pain in right elbow
  - Pain in left shoulder

B.1.3. Emergency Responder Interviews

During the on-scene portion of the investigation, members of the forensics team conducted interviews with emergency personnel that had responded to the accident (from the Los Angeles Fire Department and Los Angeles Sheriff's Department). Questions chiefly focused on the subject of the passenger injuries the responders had observed.

Los Angeles Fire Department Responder A

Observed passengers found in front lower level of middle coach car (#207):

- One male with massive head injury, indicated by raccoon eyes, appeared to be in critical condition, probably sitting in handicap area prior to the accident.
- One male with apparent leg injury. He wore an ankle brace prior to the accident.

- One woman with abdominal injury, possible rib fracture.
- One male with bruised chest.
- 69-year old female with hip injury.
- Several people with facial injuries.
- One male apparently fatally injured.
- Three passengers transported to Holy Cross.
- Three passengers transported to Kaiser, including man with ankle brace.

Los Angeles Fire Department Responder B

Observations:

- Approximately 20 helicopter flights to hospitals, 3-5 people per flight, for those with most serious injuries.
- Many fractured limbs, some compound fractures.
- Lots of abdominal and chest injuries.
- One passenger sitting with large chunk of metal lodged in head.
- Several head injuries.
- He praised the work of the Los Angeles Police Department.

Los Angeles Fire Department Responder C

Observations:

- Large passenger ~ 6'3", 250 lbs. with abdominal injury.
    - Cut and torn from left clavicle (collarbone) to lower right abdomen (like seat belt).
    - He had sore back, walked off train.
- Several lower-leg injuries, front and back of legs.
- Several fractured arms and legs.
- Several people bleeding from back of heads.
- Several people with bruises/pain on sides of back (possibly from fiberglass armrests between seat pairs).

Los Angeles County Sheriff's Department Responder

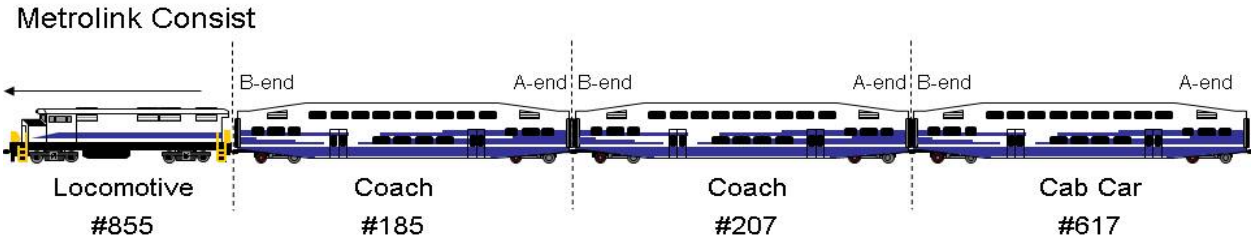
Had interviewed Metrolink conductor and reported that when the impact occurred, conductor was standing in the trailing cab car (#617), lower level, on the left side of the car, at the shelf behind the bulkhead. Conductor had injuries to legs and back.

Observations:

- 16 Personnel from LA County Sheriff's Department responded on the scene.
- 40 passengers flown to area hospitals.
- ~115 passengers treated on-scene.
- 165 total passengers on train (estimated by Metrolink conductor).

Appendix B.2: Indications of the Use of Emergency Egress/Response Features

This appendix discusses evidence of use of emergency tools and features in the passenger cars.



Car #185

Emergency release handles

The red handle on the right side A-end (trailing end) was pulled.

Jaws of Life

Emergency responders used the "jaws of life" to cut open the B-end (leading end of car), end door (opposite of door handle) and then used a saw to cut off the top portion of the door near the top of the window.

Saw

Emergency responders also used a saw to cut the sheathing between the right #4 and #5 windows on the upper level.

Car #207

Emergency release handles

Doors L (1 and 2) and R (1 and 2) exterior emergency release handles were activated. In the interior, A-end number 5 and 6 door emergency release handles were used.

Emergency tools

All B-end emergency tools (including first aid materials) had been removed from the locker, except for the saw.

Fire extinguishers

A-end lower level fire extinguisher was used. A and B end fire extinguishers were still in place.

Emergency windows

Upper level B-end left side emergency window was pulled. Upper level middle of car R side emergency window was pulled.

Car #617

Emergency release handles

Doors L (number 1) and R (number 1) exterior emergency release handles were activated. In the interior, emergency release handles for doors number 3, 4 and 5 were used.

Emergency tools

B-end lower level emergency equipment, the saw and the first aid kit were not used. The other tools, which may have included a pry bar and handheld flashlight, were used.

Fire extinguishers

F lower level fire extinguishers were used but the B-end fire extinguishers were still in place.

Emergency windows

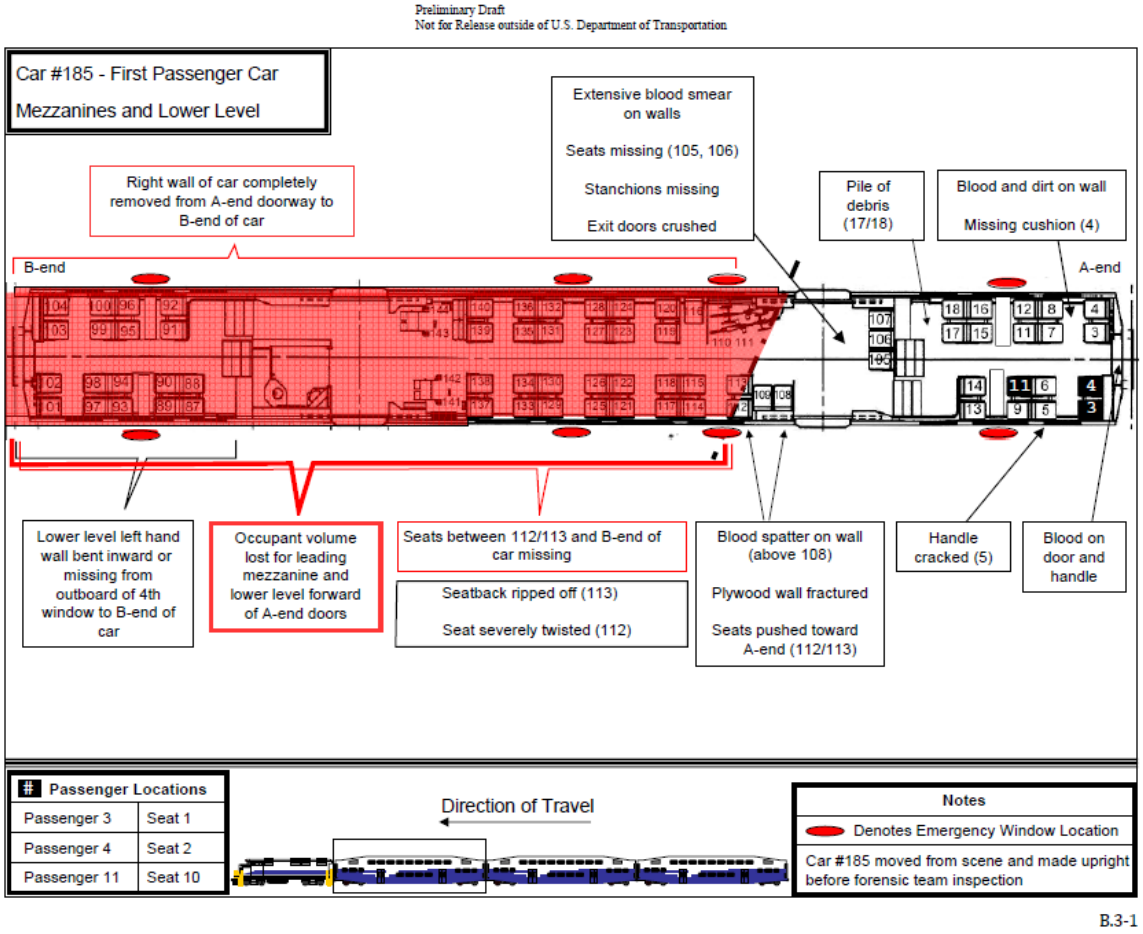
B-end R side emergency window lower level was pulled. Upper level by seat numbers 43 and 44, the window was pulled.

Appendix B.3: Interior Damage Diagrams

This appendix provides diagrams of interior damage in passenger cars, and estimated seat locations of passengers, based on passenger interviews.

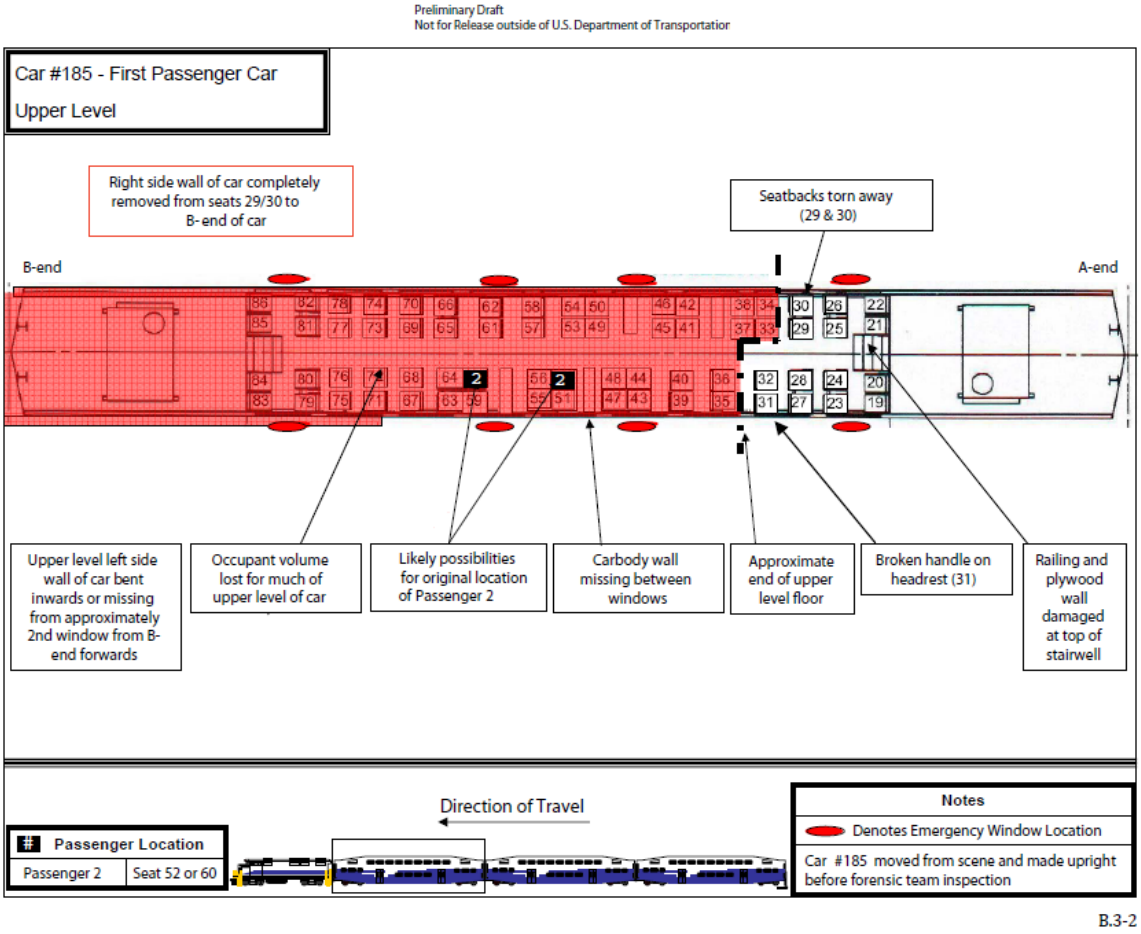
Car #185 – First Passenger Car

Mezzanines and Lower Level



B.3-1

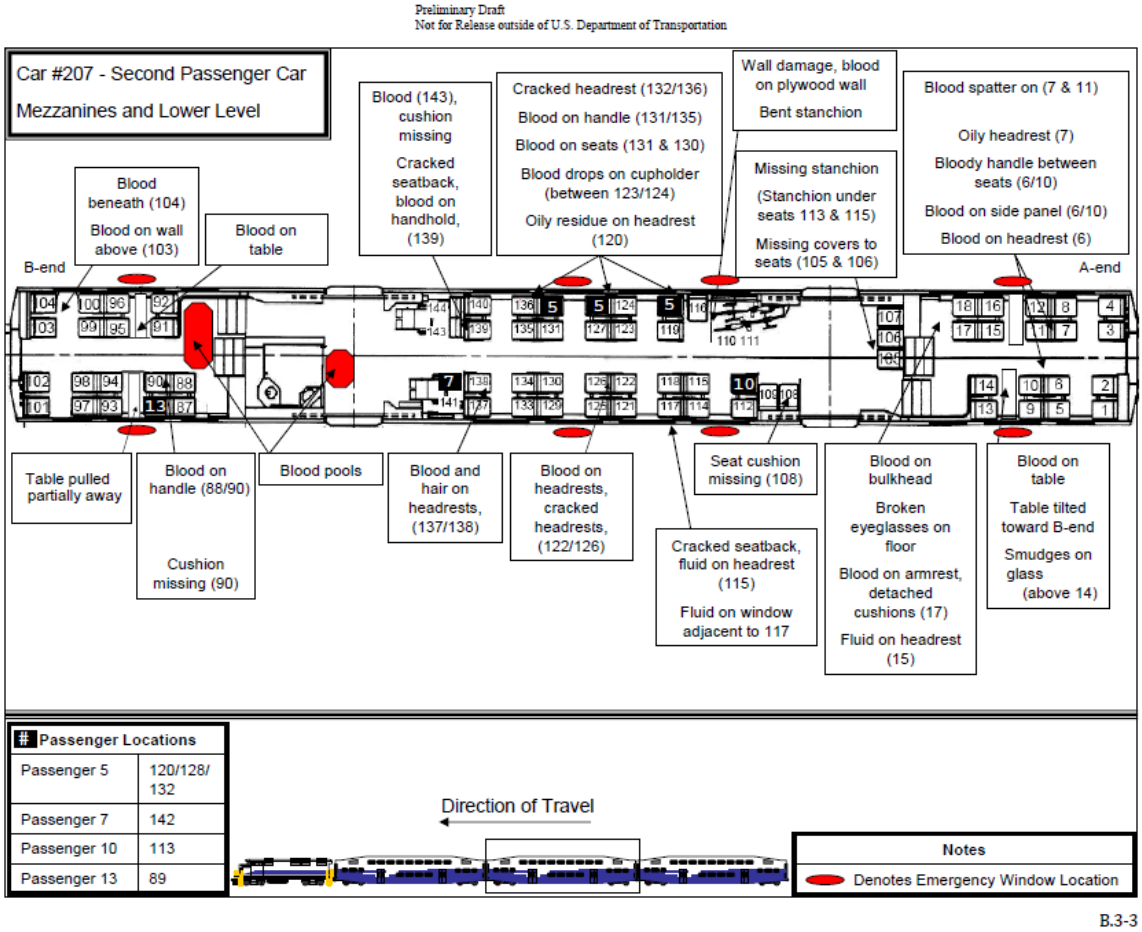
Upper Level



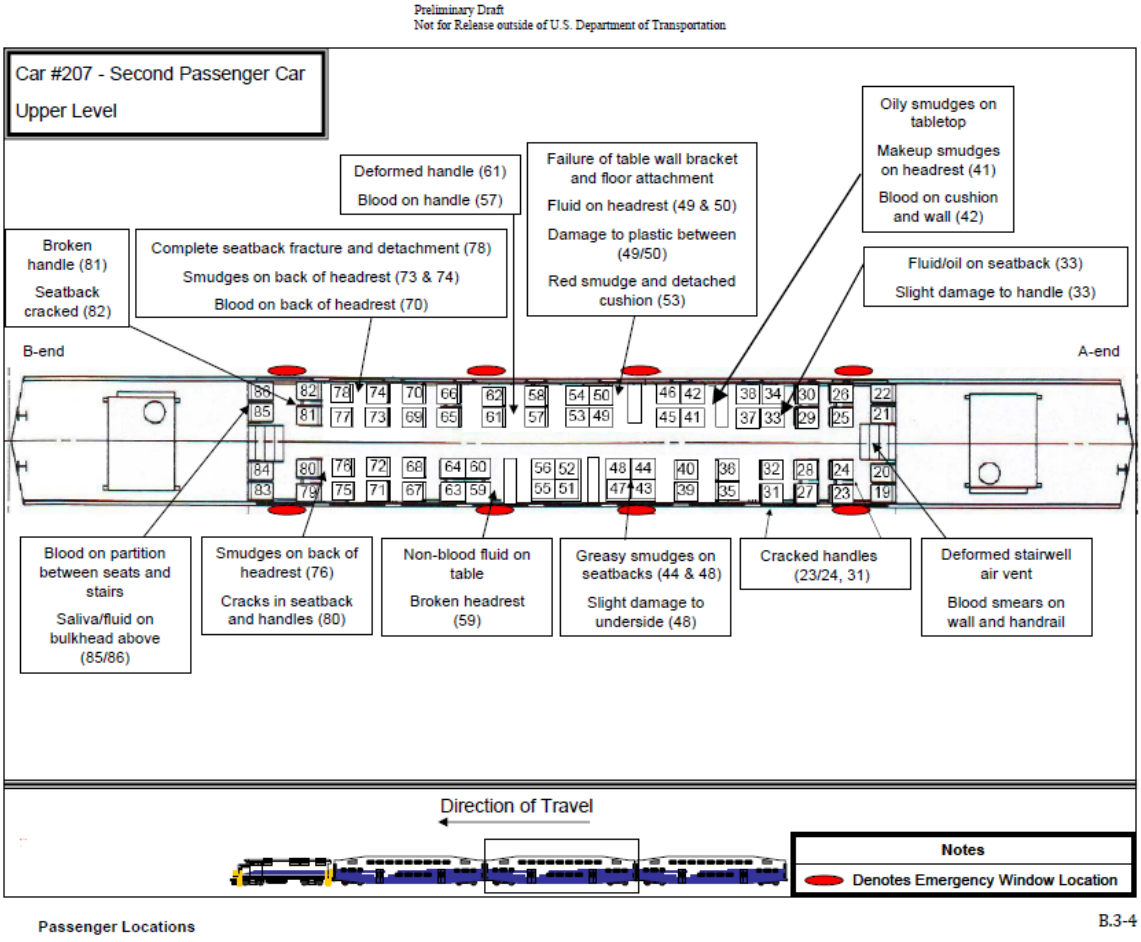
B.3-2

Car #207 – Second Passenger Car

Mezzanines and Lower Level



Upper Level

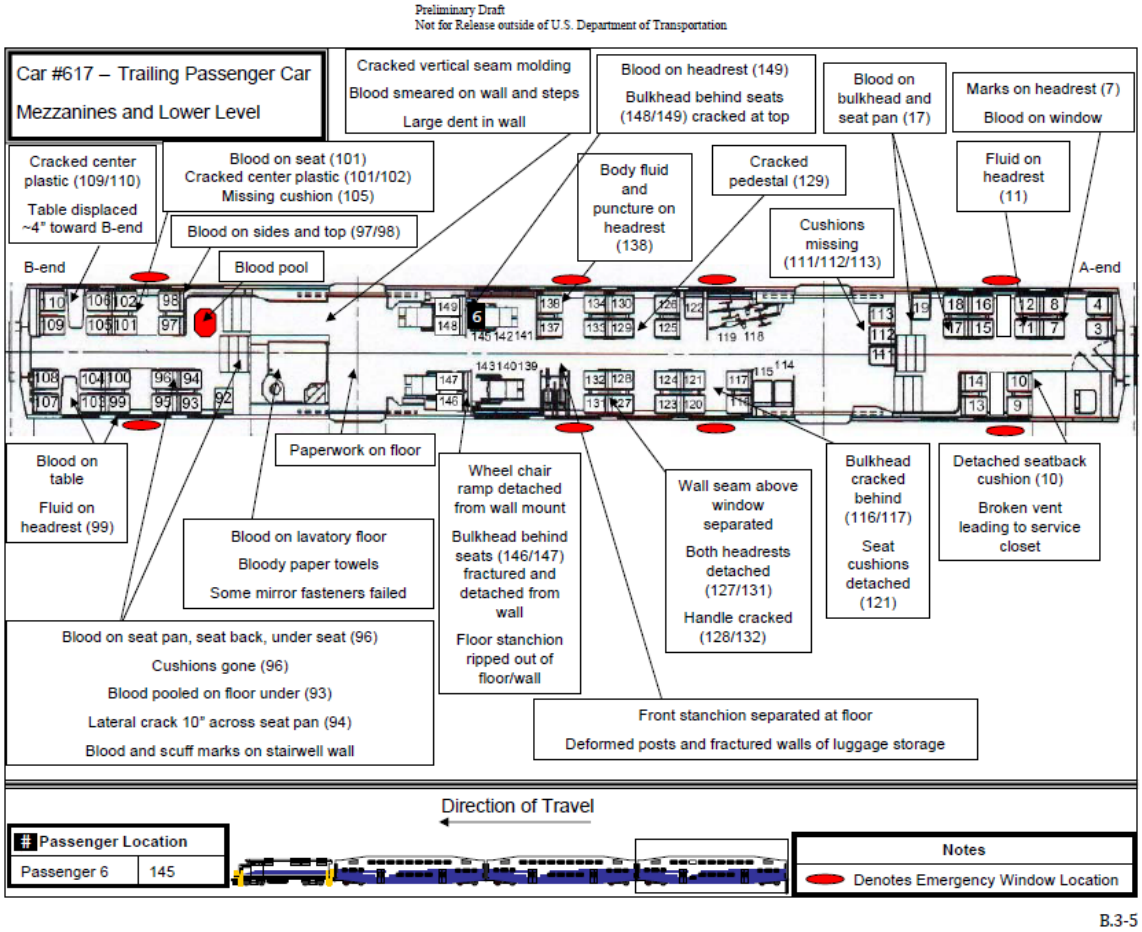


Passenger Locations

B.3-4

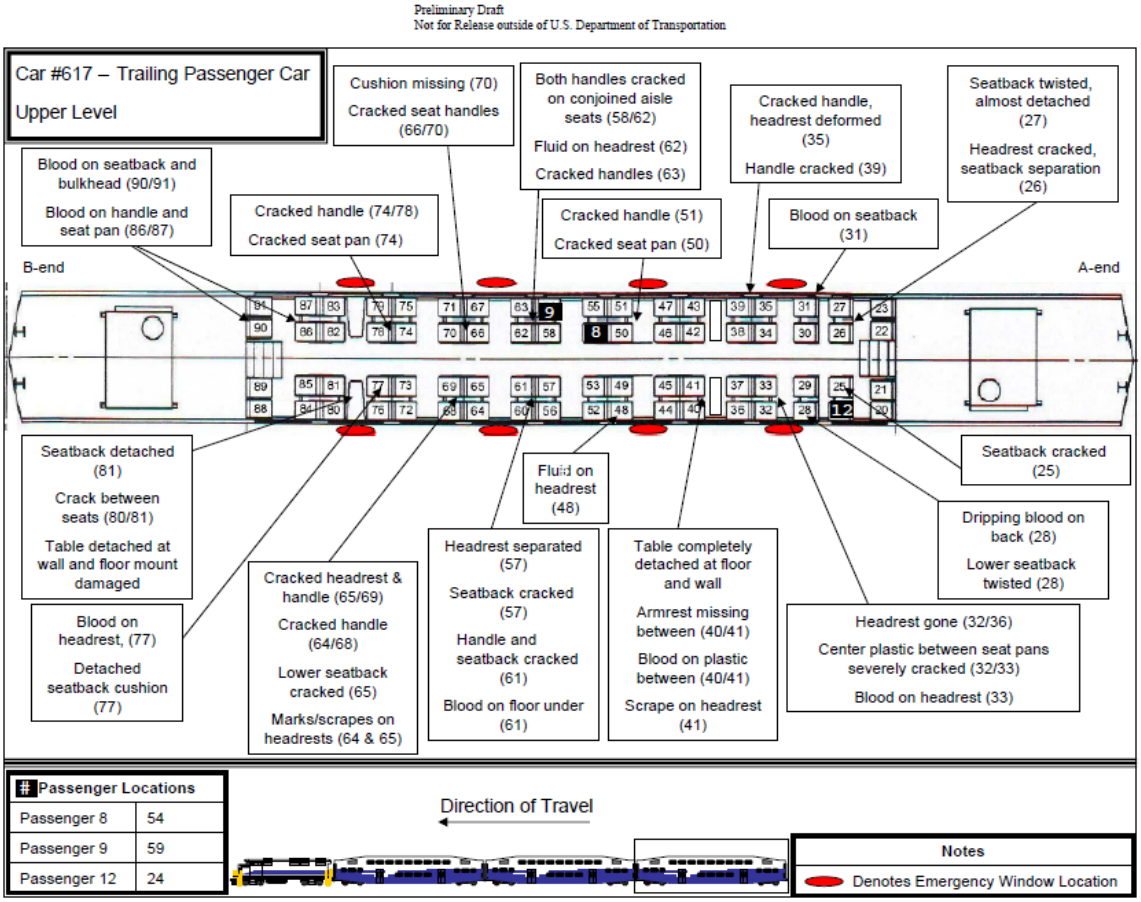
Car #617 – Trailing Passenger Car

Mezzanines and Lower Level



B.3-5

Upper Level



B.3-6

References

1. Priante, M. "Review of a Single Car Test of Multi-Level Passenger Equipment," American Society of Mechanical Engineers, Paper No. JRC2008-63053, April 2008.

Abbreviations and Acronyms

SIV	Secondary Impact Velocity
TOR	Top-of-Rail
UCLA	University of California – Los Angeles
UP	Union Pacific Railroad