Transit Vehicle Collision Characteristics for Connected Vehicle Applications Research Update

2009-2014 Analysis of Collisions Involving Transit Vehicles and Applicability of Connected Vehicle Solutions

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16. Abstract

The transit industry has always shown a great interest in the adoption of transformational safety technologies to improve the safety of its passengers and drivers, as well as all road users including pedestrians. Due to its unique characteristics and behaviors, such as vehicle size and frequent stops/starts, transit often deals with safety challenges and priorities that are often different from those for light duty and commercial vehicles. The purpose of this report was to identify candidate transit collision scenarios for near-term connected vehicle safety research using data from the 2009-2014 National Transit Database (NTD). The study identifies motor bus collision types according to collision characteristics, including the type of object the transit vehicle collided with (e.g., pedestrian, motor vehicles, infrastructure elements, etc.), the location of the collision (e.g., mid-block or at an intersection), and the spatial relationship between vehicles when they collided. The study revealed some prominent characteristics (such as spatial relationship between vehicles) related to motor bus collisions, and how these characteristics are amenable to connected vehicle solutions. The study ranks collision types by frequency, cost, and average cost per collision. Findings from the study may be used to inform the USDOT in its prioritization of transit Connected Vehicle for Safety research, particularly to support application development in the following areas:

- Pedestrian Crossing Warning Applications: These applications could warn bus drivers of a pedestrian's presence in a crosswalk – at intersections and mid-block.
- Bus Stop Pedestrian Warning Applications: These applications could warn bus drivers and pedestrians of pedestrians in harm's way of bus movements at bus stops.
- Left Turn Warning Applications: These applications could provide information to drivers performing unprotected left turns to judge the gaps in oncoming traffic and to inform them of hazards to completing a safe left turn.
- Forward Collision Warning Applications: These applications could warn drivers if they fail to brake when a vehicle in their path is stopped or traveling substantially slower.
- Angle Collisions at Intersections Warning Applications: These applications could provide warnings to drivers of imminent angle or T-bone collisions at intersections, including highway-rail intersections (HRI).
- Blind Spot Warning/Lane Change Warning Applications: These applications could warn drivers when they try to change lanes if there is a vehicle in the blind spot of an overtaking vehicle.

This report is an update of the report, "Transit Vehicle Collison Characteristics for Connected Vehicle Applications Research: Analysis of Collisions Involving Transit Vehicles and Applicability of Connected Vehicle Solutions," November 2013 (FHWA-JPO-13-116).

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1 Introduction

A main focus of the United States Department of Transportation's (USDOT's) Connected Vehicle Research Program is to use connected vehicle technology to improve safety. Connected vehicle safety applications are designed to increase situational awareness and reduce collisions through vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) data transmissions that support driver advisories and warnings. Transit vehicles are expected to leverage these applications to improve transit safety through reduction of the occurrence of collisions that result in injuries and fatalities to passengers, motorists, pedestrians and bicyclists, as well as damage to vehicles and property. Transit collisions are responsible for hundreds of deaths, thousands of injuries, and millions of dollars in property damage each year.

To determine whether and the extent to which connected vehicles can effectively reduce the number and severity of traffic collisions that involve transit vehicles, a thorough understanding of transit collision characteristics becomes necessary. This study analyzed transit collision datasets from the National Transit Database (NTD) which is the Federal Transit Administration's (FTA's) primary national database for statistics related to the transit industry. The NTD includes data on transit organization characteristics, vehicle fleet size and characteristics, revenues and subsidies, operating and maintenance costs, safety and security, vehicle fleet reliability and inventory, and services consumed and supplied. This data has been used extensively by the transit community to derive values for transit performance measures and has become the sole source of standardized and comprehensive data for use by all constituencies of the transit industry. The transit collision analysis performed for this study analyzed 2009 through 2014 NTD transit collision data. The report identifies collision types according to collision characteristics, including the transit mode (e.g., motor bus, light rail, etc.), type of object the transit vehicle collided with (e.g., pedestrian, motor vehicles, etc.), the location of the collision (e.g., mid-block, bus stop, or at an intersection), and the spatial relationship between vehicles when they collided. The report then ranks collision types by frequency, cost, and average cost per collision. These rankings were then used to identify connected vehicle transit safety application areas for future USDOT connected vehicle research. This report is an update of the 2013 report, "Transit Vehicle Collison Characteristics for Connected Vehicle Applications Research: Analysis of Collisions Involving Transit Vehicles and Applicability of Connected Vehicle Solutions" (FHWA-JPO-13-116).

1.1 Connected Vehicle Research

The Intelligent Transportation Systems (ITS) Joint Program Office (JPO) is charged with planning and executing the ITS Program as authorized by Congress. The ITS JPO is part of the USDOT Office of the Assistant Secretary for Research and Technology (OST-R). This program encompasses a broad range of technologies applied to the surface transportation system. Under collaborative and transparent governance structure established for joint projects, the ITS JPO coordinates with and executes the program jointly in cooperation with all of the surface transportation modal administrations within the USDOT to ensure full coordination of activities and leveraging of research efforts.

The USDOT is engaged in assessing and supporting the development of applications that realize the full potential of connected vehicles, travelers, and infrastructure to enhance current operational

practices and transform future surface transportation systems management. This effort is a collaborative initiative spanning the ITS JPO, Federal Highway Administration (FHWA), Federal Transit Administration (FTA), Federal Motor Carrier Safety Administration (FMCSA), Federal Railroad Administration (FRA), and the National Highway Traffic Safety Administration (NHTSA). These agencies of the Federal Government work closely with the American Association of State Highway and Transportation Officials (AASHTO), which represents state transportation agencies across the country, as well as the numerous private sector interests (car manufacturers, technology companies, etc.) in working together to develop a nationwide system for ITS to be deployed in the future. The connected vehicle program is a major USDOT effort, focusing on the use of V2V and V2I transmission of information to promote safety, mobility, and environmental sustainability.

Connected vehicle research is both a concept and a program of services that can transform travel as we know it. Connected vehicle research combines leading edge technologies – advanced wireless communications, on-board computer processing, advanced vehicle-sensors, Global Positioning System (GPS) navigation, smart infrastructure, and others – to provide the capability for vehicles to identify threats, hazards, and delays on the roadway and to communicate this information over wireless networks to provide drivers with alerts, warnings, and real time road network information. At its foundation is a communications network that supports V2V two-way communications, V2I [1] one- and two-way communications, and vehicle or infrastructure-to-device [2] (X2D) one- and two-way communications to support cooperative system capability. In this context, the term “device” refers only to devices that are “carry-in” devices (i.e., devices that can be temporarily installed in vehicles and are not connected to in-vehicle information systems). These carry-in devices include those that could also be carried by pedestrians or other users of the roadways (e.g., cyclists), such as cell phones or other mobile devices. Connected vehicles enable a surface transportation system in which vehicles are less likely to crash and roadway operators and travelers have the information they need about travel conditions to operate more effectively. Connected vehicle research will establish an information backbone for the surface transportation system that will support applications to enhance safety and mobility. Research also supports applications to enhance livable communities, environmental stewardship, and traveler convenience and choices.

The ability to identify, collect, process, exchange, and transmit real-time data provides drivers with an opportunity for greater situational awareness of the events, potential threats, and imminent hazards within the vehicle’s environment. When combined with technologies that intuitively and clearly present alerts, advice, and warnings, drivers can make better and safer driving decisions. Additionally, when further combined with automated vehicle-safety applications, connected vehicle technology enables the vehicle to respond and react in a timely fashion when the driver either cannot or does not react quickly enough. Vehicle safety systems are expected to use dedicated short range communications (DSRC) technology for active safety applications because of the need for frequently broadcasted real-time data and low-latency requirements of safety application communications. Many of the other envisioned mobility and environmental related applications could use other technologies, such as third generation (3G) and fourth generation (4G) cellular or

[1] Although two-way communications between vehicles and infrastructure is usually called “V2I”, one-way communication is generally distinguished by designating the initiator of the communications first. Thus, one-way infrastructure-to-vehicle communications is called “I2V” and one-way vehicle-to infrastructure communications uses the more common “V2I” designation.

[2] In this context, the term “device” refers only to devices that are “carry-in” devices, i.e., devices that can be temporarily installed in vehicles and are not connected to in-vehicle information systems. These devices include ones (e.g., smart phones) that could also be carried by pedestrians or other users of the roadways (e.g., cyclists).

other Wireless Fidelity (Wi-Fi) communications, as well as DSRC. The rapid pace of technological evolution provides tremendous opportunities for connected vehicles, and the USDOT's connected vehicle program is positioned to capitalize upon these advances as they happen.

The USDOT currently has an active set of research programs focused on the development of collision avoidance systems based on both V2V and V2I (meaning both I2V and V2I) DSRC technology. Connected vehicle safety applications are designed to increase situational awareness and reduce collisions through V2V and V2I data transmission that support driver advisories and warnings. The connected vehicle safety program is divided into two areas, V2V communications for safety and V2I communications for safety:

- **V2V Communications for Safety.** V2V communications for safety is the dynamic wireless exchange of data between nearby vehicles offering the opportunity for significant safety improvements. By exchanging anonymous, vehicle-based data regarding position, speed, and location (at a minimum), V2V communications enables a vehicle to: sense threats and hazards with a 360 degree awareness of the position of other vehicles and the threat or hazard they present; calculate risk; and issue driver advisories or warnings to avoid and mitigate collisions. At the heart of V2V communications is a basic safety message (BSM). This message can be derived using non-vehicle-based technologies such as GPS to identify location and speed of a vehicle, or vehicle-based sensor data wherein the location and speed data are derived from the vehicle's computer and are combined with other data such as latitude, longitude, or angle to produce a richer, more detailed situational awareness of the position of other vehicles.
- **V2I Communications for Safety.** V2I communications is the wireless exchange of critical safety and operational data between vehicles and roadway infrastructure, intended primarily to avoid or mitigate motor vehicle collisions, but also to enable a wide range of other safety, mobility, and environmental benefits. V2I communications apply to all vehicle types and all roads, and transform infrastructure equipment into "smart infrastructure" through the incorporation of algorithms that use data exchanged between vehicles and infrastructure elements to perform calculations that recognize high-risk situations in advance, resulting in driver alerts and warnings through specific countermeasures. One particularly important advance is the ability for traffic signal systems to communicate the signal phase and timing (SPaT) information to the vehicle in support of delivering active safety advisories and warnings to drivers. Early implementation of the SPaT application can enable near-term benefits from V2I communications in the form of reduced collisions, which in turn demonstrates benefits that can help accelerate deployment.

The transit industry has always shown a great interest in the adoption of transformational safety technologies to improve the safety of its passengers and employees, as well as all road users and pedestrians. Due to its unique characteristics and behaviors, such as vehicle size and frequent stops/starts, transit operators often deal with safety challenges and priorities that are often different from those for light and commercial vehicles.

1.2 Update to the Transit Vehicle Collision Characteristics for Connected Vehicle Applications Research Overview

In 2013 the USDOT produced the report “Transit Vehicle Collision Characteristics for Connected Vehicle Applications Research” (FHWA-JPO-13-116). This report presented an analysis of NTD collision data for the year 2010 and was used to determine potential connected vehicle applications that could be used to decrease the frequency of reoccurring collision types.

Using the initial report as a source of guidance on transit collision types and frequencies, the USDOT has continued research into collision avoidance and pedestrian safety applications. In order to provide increased understanding of collision types, the USDOT tasked the analysis team with creating an update to the original report by examining additional years of NTD collision data (2009, 2011, 2012, 2013 and 2014) as well as 2010. This updated report presents the findings for the six year time frame and provides averages of the most frequent collision types over the six year period.

2 The National Transit Database

The NTD was established by Congress to be the nation's primary source for information and statistics on the transit systems of the United States. Recipients or beneficiaries of grants from the FTA under the Urbanized Area Formula Program (§5307) or Other than Urbanized Area (Rural) Formula Program (§5311) are required by statute to submit data to the NTD. Over 690 transit providers in urbanized areas currently report to the NTD through an Internet-based reporting system. Each year, NTD performance data are used to apportion over $5 billion of FTA funds to transit agencies. Annual NTD reports are submitted to Congress summarizing transit service and safety data. This section provides a summary of the type of data transit agencies enter into the NTD.

2.1 Reportable Incident Report Form (S&S-40)

The Reportable Incident Report form (S&S-40) was designed to capture detailed information on the most severe safety and security incidents occurring in the transit environment. Detailed data, available from sources such as accident, incident, or police reports are used to complete the Reportable Incident Report form (S&S-40). The information required on the form is intended to be of a level that can be collected at or near the time the incident occurred.

Transit agencies must complete one Reportable Incident Report form (S&S-40) for each reportable incident (safety or security incident) occurring during the reporting period. Commuter rail operators are only required to report security incidents to NTD. Commuter rail operators are currently required to report safety incidents to the Federal Railroad Administration. Reportable Incident Report forms (S&S-40) are due thirty days after the reportable incident occurred.

The NTD annually produces a Safety & Security Reporting Manual that defines reportable incidents and thresholds. This document is updated yearly and in certain instances there are slight changes to terminology and what is considered reportable. For example, the only change to 2014 S&S-40 reporting was a clarification on the immediate transport away from the scene of an incident for medical attention. Many of the changes involve how the transit agencies actually report the incidents, and in some years they require greater detail in reporting than the prior year.

2.2 Reportable Incidents

According to the NTD, a reportable incident is an event that involves a transit vehicle or occurs on transit-controlled property and meets one or more of the following conditions:

- A fatality (including a suicide or deaths resulting from Other Safety Occurrences),
- Injuries requiring immediate medical attention away from the scene for one or more persons,
- Property damage equal to or exceeding $25,000, and/or
- An evacuation for life safety reasons.

The following paragraphs highlight the important aspects of each reportable incident threshold. The descriptions are provided as a general overview of what the S&S-40 requires. For further detail on each aspect of reportable incidents, the annual Safety & Security Reporting Manuals are available on the NTD website for each individual year. It is important to point out that the collisions reported to the NTD might not include all collisions, such as minor incidents or other events that do not meet the thresholds of NTD required reporting.

2.2.1 Fatality

For NTD purposes, a fatality is a transit-caused death, confirmed within thirty days of a transit incident, due to a collision, derailment, fire, hazardous material spill, Act of God, evacuation, security incident or other incident. Fatalities include transit-related suicides. There is one exception to this rule: Deaths resulting from illnesses or other natural causes, or otherwise not associated with an incident, are not reported on either incident form. For example, if a person in a rail facility suffers a fatal heart attack it would not be reported to NTD.

2.2.2 Injury

For NTD reporting purposes, an injury requires immediate medical attention away from the scene of the incident. Immediate medical attention includes transport to the hospital by ambulance. It also includes transport immediately from the incident scene to a hospital or physician's office by another type of emergency vehicle, by passenger vehicle, or through other means of transport. Immediate medical attention means that medical attention was sought without delay after the incident occurred. An individual seeking medical care several hours after an incident or in the days following an incident is not considered to have received immediate medical attention. The medical attention received must be at a location other than the location at which the incident occurred. The intent of this distinction is to exclude incidents that only require minor first aid or other assistance received at the scene. This distinction is not, however, intended to be burdensome for the transit agency. It is not a requirement that an agency follow-up on each person transported by ambulance, for example, to ensure that they actually received medical attention at the hospital. It is acceptable to count each person immediately transported by ambulance as an injury. As a result there is a likelihood that many minor injuries go unreported to the NTD and as a result only serious injuries can be examined.

2.2.3 Property Damage

Incidents involving property damage equal to or exceeding $25,000 require the completion of a Reportable Incident Report form (S&S-40). The FTA does allow agencies to report estimated costs in order to meet this reporting requirement. In order to lower the reporting burden, transit agencies are allowed to determine standard property damage totals for specific event types. Property damage includes, but is not limited to, the following:

- Transit and non-transit vehicle damage,
- Stations as well as non-transit facilities,
- Right-of-way (ROW) and items surrounding ROW, such as utility poles,
- Bus stop shelters, private property such as buildings, fences, traffic signals, walls and,
- Bicycles and personal mobility devices.

The key points regarding estimated property damage are:

- Estimated damage does not only include transit property damage, but also damage to other vehicles and property (other than personal property) involved in the incident and not owned by the transit agency.
- The amount paid (or an estimate made for insurance purposes) is reported for property damage. In the case where replacement is necessary, the depreciated replacement cost is reported.
- The cost of clearing wreckage or damage to non-transit agency property is also included in the property damage value.
- The cost of an accident or a criminal investigation is not included in the estimated property damage.
- Damage to personal property, such as the value of laptops, cell phones, or other personal property items damaged or destroyed in an incident are not included in the estimated property damage.

2.3 Reporting Incidents

Incident types that are reported using the Reportable Incident Report form (S&S-40) include the following incident types. For the purposes of this analysis, only collisions are considered.

- **Collision.** All collisions involving at least one transit vehicle, or taking place on transit property, are reported using the Reportable Incident Report form (S&S-40). Collisions are subject to the thresholds for a reportable incident.
- **Derailment.** All derailments occurring on mainline track are considered a reportable incident. The mainline track is the primary rail over which rail transit vehicles travel between stations. It does not include yard and siding track. This threshold applies only to rail incidents (other than commuter rail (CR)).
- **Fire.** Fires occurring on or in transit property must meet the thresholds for a reportable incident. The fire requires the act of suppression to occur at the time of the incident.
- **Hazardous Material Spill.** Hazardous material spills that occur on or in transit property include bunker fuel, diesel, electric battery, ethanol, hybrid diesel, grain additive, liquefied natural gas, methanol, bio-diesel, compressed natural gas, dual fuel, electric propulsion, gasoline, hybrid gasoline, kerosene and liquefied petroleum gas. The hazardous material spill must have caused imminent danger to life, health, or the environment, and had special attention given at the time of the incident.
- **Act of God.** An Act of God is a natural and unavoidable catastrophe that interrupts the expected course of events, such as earthquakes, floods, hurricanes, tornados, other high winds, lightning, snow and ice storms.
- **Bomb Threat, Bombing, Chemical, Biological, Nuclear/Radiological Releases.** Security incidents that occur on or in transit property and meet the reporting thresholds for a reportable incident are any terrorism-related events such as bomb threats, bombings, chemical, biological, nuclear/radiological releases. Security incidents also include other system security events, such as arson, sabotage, hijacking and cyber security events.
- **Aggravated Assault, Robbery, Rape, Burglary, Suicide or Larceny/Theft, Vandalism.** Robberies, burglaries, larcenies/thefts or vandalism, as well as other personal events such as aggravated assault, rape, suicide, attempted suicide and homicide.

- **Arrest or Citation for Other Assault, Trespassing, Non-Violent Civil Disturbance, or Fare Evasion.** All arrests or citations for other assault, trespassing, non-violent civil disturbance, vandalism, or fare evasion are reported on the Safety and Security Monthly Summary Incident Report form (S&S-50).
- **Other Safety Occurrences not Otherwise Classified Incidents (Slip and Fall, Electric Shock, etc.).** Other safety occurrences not otherwise classified may include slip and fall accidents and electric shock incidents. Other safety occurrences not otherwise classified resulting in one or more injuries are reported using the Safety and Security Monthly Summary Report form (S&S-50) as Other Safety Occurrences not Otherwise Classified while incidents resulting in one or more fatalities are reported using the Reportable Incident form (S&S-40).

2.3.1 Reporting Rail Collisions

The Reportable Incident Report form (S&S-40) collects information about the number of rail transit and other motor vehicles involved, the location of the collision, what the vehicles were doing when they collided with, etc. Transit agencies are required to provide data for the following fields for a rail collision:

- **Number of Rail Transit Trains Involved.** The number of rail transit trains involved in the collision.
- **Location.** The location (i.e., revenue facility, grade crossing) at which the collision occurred. If the location is not listed, transit agencies can select 'Other' and use a 'Describe Box' to provide a location description.
- **Collision With.** The vehicle, object or person (other than the transit vehicle) involved in the collision.
- **Number of Other Motor Vehicles Involved.** The number of other motor vehicles (i.e., automobiles, buses) involved in the collision.
- **Number of Cars in Rail Transit Train.** The total number of cars in the rail transit train.
- **Number of Cars Derailed.** The total number of cars in the rail transit train that derailed as a result of the collision.
- **Train Action.** The action that the train was involved in when the collision occurred (i.e., going straight, making a stop). If the action is not listed, the transit agency can select 'Other' and use the 'Describe Box' to provide a description of the action.
- **Collision Type.** The orientation of the vehicle(s) when the collision occurred (i.e., rear-ended, angle, sideswipe). Each choice is from the point of view of the transit vehicle. For example, rear-ended means that another vehicle hit the back of the rail transit train, while rear-ending means the rail transit train hit the back of another vehicle.
- **Train Speed.** The speed (in miles per hour) at which the rail transit train was traveling when the collision occurred. If the transit agency does not know the exact speed, they may estimate the speed of the vehicle.
- **Other Motor Vehicle Type.** The type of other motor vehicle (i.e., automobile, motorcycle) that was involved in the collision. If the vehicle type is not listed, the transit agency can select 'Other' and use the 'Describe Box' to describe the vehicle type.

- **Other Motor Vehicle Action.** The action that the other motor vehicle was involved in when the collision occurred (i.e., going straight, making a turn). If the action is not listed, the transit agency can select 'Other' and use the 'Describe Box' to provide a description of the action.
- **Collision Type.** The orientation of the vehicle(s) when the collision occurred (i.e., rear-ended, angle, sideswipe). Each choice is from the point of view of the motor vehicle. That is, rear-ended means that another vehicle hit the back of the motor vehicle, while rear-ending means the motor vehicle hit the back of another vehicle.

2.3.2 Reporting Non-Rail Collisions

The non-rail transit collision screens ask the reporter to provide information about the number of transit vehicles and other motor vehicles involved, with what the collision occurred, as well as other collision information. Similar data fields are included in the Reportable Incident Report form (S&S-40) for non-rail collisions. These fields include:

- **Number of Non-Rail Transit Vehicles Involved.** The number of non-rail transit vehicles involved in the collision.
- **Location.** The location (i.e., revenue facility, grade crossing, bus stop) at which the collision occurred. If the location is not listed, the transit agency can select 'Other' and use the 'Describe Box' to provide a description of the location.
- **Collision With.** The vehicle, object or person (other than the transit vehicle) that was involved in the collision. If the list does not contain a description that fits the transit agency's needs, they can select 'Other'.
- **Number of Other Motor Vehicles Involved.** The number of other motor vehicles (i.e., automobiles, motorcycles) involved in the collision.
- **Transit Vehicle Type.** The type of transit vehicle involved in the collision. If the needed vehicle type is not listed, the transit agency can select 'Other' and use the 'Describe Box' to provide a description of the transit vehicle type.
- **Vehicle Action.** The action that the vehicle was involved in when the collision occurred (i.e., going straight, making a stop). If the needed action is not listed, the transit agency can select 'Other' and use the 'Describe Box' to provide a description of the action.
- **Collision Type.** The orientation of the vehicle(s) when the collision occurred (i.e., rear-ended, angle, sideswipe). Each choice is from the point of view of the transit vehicle. That is, rear-ended means that another vehicle hit the back of the transit vehicle, while rear-ending means the transit vehicle hit the back of another vehicle.
- **Vehicle Speed.** The speed (in miles per hour) at which the transit vehicle was traveling when the collision occurred.

3 Collision, Injury, and Fatality Trends (2005-2014)

This section provides an overview of collision data in the NTD, summarizing collisions for different transit modes between 2005 and 2014. A transit mode is defined by the NTD as "a system for carrying transit passengers described by specific ROW, technology, and operational features". Four transit modes are described in this section of the report, including demand response, heavy rail, light rail, and motor bus.

- **Demand Response.** A transit mode comprised of passenger cars, vans or small buses operating in response to calls from passengers or their agents to the transit operator, who then dispatches a vehicle to pick up the passengers and transport them to their destinations.
- **Heavy Rail.** A transit mode that is an electric railway with the capacity for a heavy volume of traffic. Heavy rail is characterized by: (a) high speed and rapid acceleration passenger rail cars operating singly or in multi-car trains on fixed rails, (b) separate ROW from which all other vehicular and foot traffic are excluded, (c) sophisticated signaling, and (d) high platform loading.
- **Light Rail.** A transit mode that typically is an electric railway with a light volume traffic capacity compared to heavy rail. Light rail is characterized by: (a) passenger rail cars operating singly (or in short, usually two car, trains) on fixed rails in shared or exclusive ROW, (b) low or high platform loading, and (c) vehicle power drawn from an overhead electric line via a trolley or a pantograph.
- **Motor Bus.** A transit mode comprised of rubber-tired passenger vehicles operating on fixed routes and schedules over roadways. Vehicles are powered by diesel, gasoline, battery, or alternative fuel engines contained within the vehicle.

Other modes such as automated guideway, cable car, ferryboat, Puerto-Rico's jitney system, trolley bus, and vanpool are grouped together and labeled as 'Other'. Definitions used in this report are included in Appendix B.

Please note that all values presented in tables in this section represent raw values reported in the NTD. These may not be consistent with normalized values presented in the more detailed analysis of years 2009-2014 in Section 5. A discussion of the normalization process is discussed in Section 4 and Section 5.

3.1 2005 – 2014 Transit Vehicle Collision, Injury and Fatality Trends

NTD data from 2005 to 2014 are summarized in Table 3-1. Please note that these are the raw values reported in the NTD and may not be consistent with normalized values presented in the more detailed analysis of years 2009-2014 in Section 5 of this report. As shown in the table, the total number of collisions reported per year to the NTD between 2005 and 2007 were significantly higher than the total number of collisions reported per year between 2008 and 2014. While it is not known exactly why these numbers vary, there were changes made in 2008 regarding how transit

agencies report data to the NTD. These changes may have included new criteria or rules for reporting data to the NTD which may account for the differences between the two timeframes. A notable change is that the "other safety occurrences not otherwise classified" threshold changed and increased (from 1 person to 2 persons) after 2008.

Table 3-1: NTD Transit Collisions Reported from 2005 to 2014 *(Source 2005-2014 NTD)*

Mode	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Demand Response	1,618	1,934	1,382	672	571	549	519	499	582	641
Heavy Rail	65	102	112	62	81	116	101	138	122	93
Light Rail	73	586	577	162	169	177	182	198	130	181
Motor Bus	6,327	8,341	7,932	3,161	3,132	3,224	3,260	3,197	3,441	3,642
Other	34	88	192	35	58	42	72	159	231	207
Total	**8,117**	**11,051**	**10,094**	**4,092**	**4,011**	**4,108**	**4,135**	**4,191**	**4,506**	**4,764**

Looking at the number of collisions by mode over the 10 years, motor buses have the highest number of collisions per year, followed by demand response, light rail, heavy rail, and other. The large number of motor bus collisions can be attributed to the fact that motor buses travel more miles per year than any other mode and thus have more opportunities to be in a collision than other modes. Additionally, there are more motor buses in the United States than vehicles from other modes. Finally, other modes such as heavy rail have dedicated right-of-way while motor buses travel on roads shared with motor vehicles, motorcycles, bicyclists, and pedestrians.

Table 3-2 depicts the number of injuries per year between 2005 and 2014 according to the NTD. Please note that these injury counts are the raw values reported in the NTD and may not be consistent with normalized injury counts presented in the more detailed analysis of years 2009-2014 in Section 5 of this report. Similar to Table 3-1, there are differences between data collected between 2005 and 2007 and data collected between 2008 and 2014. These differences primarily appear in the number of heavy rail injuries reported, which ranged from 3,000 to 5,000 between 2005 and 2007 to over 7,000 between 2008 and 2014. Overall, motor buses resulted in the highest number of injuries. The second highest number of injuries, however, was from heavy rail. The number of injuries per collisions for heavy rail is high with over 7,000 injuries per year even though there are on average only 102 collisions per year between 2008 and 2014. This increase reflects changes in reporting suicides and the injury reporting threshold.

Table 3-2: NTD Transit-Related Injuries Reported from 2005 to 2014 *(Source 2005- 2014 NTD)*

Mode	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Demand Response	1,180	1,607	1,768	1,979	1,896	1,651	1,502	1,455	1,554	1,744
Heavy Rail	3,766	4,728	4,980	7,248	7,536	7,518	7,100	7,226	7,703	6,241
Light Rail	614	656	843	1,006	1,054	914	941	839	771	940
Motor Bus	12,266	12,704	13,981	14,179	15,249	14,803	12,930	13,098	13,543	13,993
Other	173	274	303	205	525	337	445	707	1091	1,030
Total	**17,999**	**19,969**	**21,875**	**24,617**	**26,260**	**25,223**	**22,918**	**23,325**	**24,662**	**23,948**

Table 3-3 shows fatalities, reported by the NTD, between 2005 and 2014. Please note that these fatality counts are the raw values reported in the NTD and may not be consistent with normalized

fatality counts presented in the more detailed analysis of years 2009-2014 in Section 5 of this report. Over this time period, there is again a significant increase in heavy rail fatalities after 2007. A reason for the difference may be the results of changes in 2008 and onward where suicides are included in the data. Prior to 2008, suicides were not included. Looking at the table, between 2008 and 2014, heavy rail had the highest number of fatalities followed by motor buses. Between 2008 and 2014 there was an average of 102 heavy rail collisions per year with an average of 88 fatalities per year. This fatality-to-collision ratio is significantly higher than any other mode.

Table 3-3: NTD Transit-Related Fatalities Reported from 2005 to 2014 *(Source 2005-2014 NTD)*

Mode	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Demand Response	12	12	11	7	7	10	2	14	10	10
Heavy Rail	35	23	32	67	100	96	97	102	108	92
Light Rail	19	17	33	16	34	24	36	45	33	36
Motor Bus	75	107	104	80	78	84	92	97	103	85
Other	3	3	5	2	7	7	2	6	12	8
Total	**144**	**162**	**185**	**172**	**226**	**221**	**229**	**264**	**266**	**231**

Based on inspection of the NTD data, the analysis team decided to focus its analysis on transit collisions for the years of 2009 through 2014. This decision was made based on the following reasons:

- NTD data between 2005 and 2007 showed significant differences when compared to data from 2008 to 2014. The reasons for these differences can be attributed to how the data were collected over this time period.
- After examining the data, there were a lot of similarities between NTD data collected between 2009 and 2014. It was assumed that analyzing additional years would result in seeing trends similar to the 2010 analysis.

As a result of the Original Report (FHWA-JPO-13-116) the USDOT tasked the analysis team with expanding the study to include all years from 2009 through 2014. The team was able to obtain NTD data from the years of 2009 through 2014 from the USDOT. The additional data was examined using the same methodology as the earlier 2010 analysis, which will be detailed in Section 4.

3.2 2009-2014 NTD Transit Collisions, Injuries, and Fatalities

Table 3-4 shows a summary of the average number of transit collisions, injuries, and fatalities by transit mode from 2009 through 2014. Motor buses account for 77.4% of all transit collisions, followed by demand response (13.1%), light rail (4.0%), and heavy rail (2.5%). While motor bus collisions represent the largest majority of collisions (77.4%), they also accounted for 57.1% of all injuries. On the other hand, heavy rail accounted for only 2.5% of all collisions but resulted in 29.6% of all injuries and 41.4% of all fatalities, the largest percent of fatalities by mode. The high number of heavy rail injuries and fatalities is due to the fact that although heavy rail collisions are less frequent, they are often more severe than collisions from other transit modes. Additionally, there are a higher proportion of suicide attempts involving rail (particularly heavy rail) than other modes.

Table 3-4: 2009-2014 Average NTD Collisions, Injuries, and Fatalities by Mode *(Source 2009-2014 NTD)*

Mode	Number of Collisions *(%)*	Number of Injuries *(%)*	Number of Fatalities *(%)*
Demand Response	560 (13.1%)	1,634 (6.7 %)	9 (3.7%)
Heavy Rail	109 (2.5%)	7,221 (29.6%)	99 (41.4%)
Light Rail	173 (4.0%)	910 (3.7%)	35 (14.5%)
Motor Bus	3,316 (77.4%)	13,936 (57.1%)	90 (37.5%)
Other	128 (3.0%)	689 (2.8%)	7 (2.9%)
Total	**4,286**	**24,389**	**240**

3.3 2009-2014 Average NTD Transit Collisions Categorized by Object Hit

Table 3-5 breaks down the average of 2009 through 2014 NTD collisions by the object hit. Objects defined by the NTD include: motor vehicles, persons, fixed objects, rail vehicles, bus vehicles and other. As shown in this table demand response transit vehicles have the most collisions with motor vehicles (87.5%). The vast majority of heavy rail collisions occurred with a person (89.2%). Light rail vehicles have the most collisions with motor vehicles (52.8%), followed by collisions with persons (41.4%). Finally, motor buses have the most collisions with motor vehicles (83.0%), followed by collisions with pedestrians (13.2%). **Please note that due to the analysis methodology described in Section 4 of this document, the collision values presented in each table represent rounded values. As a result, the total values displayed throughout this document reflect the sum of the exact values and not necessarily the sum of the rounded values displayed in the tables.**

Table 3-5: 2009-2014 Average NTD Collision Data by Object Hit *(Source 2009-2014 NTD)*

Object Hit	Demand Resp. (%)	Heavy Rail (%)	Light Rail (%)	Motor Bus (%)	Other (%)	Total
With Motor Vehicle	489 (87.3%)	3 (2.3%)	91 (52.5%)	2,746 (82.8%)	99 (77.0%)	**3,428**
With Person	44 (7.9%)	97 (89.1%)	72 (41.4%)	435 (13.1%)	20 (15.7%)	**668**
With Fixed Object*	22 (3.9%)	2 (1.4%)	1 (0.5%)	76 (2.3%)	3 (2.5%)	**103**
With Rail Vehicle	0 (0.0%)	3 (3.1%)	4 (2.3%)	0 (0.0%)	1 (0.4%)	**8**
With Transit Vehicle	1 (0.4%)	0 (0.0%)	1 (0.3%)	30 (0.9%)	1 (0.9%)	**34**
With Other**	3 (0.5%)	5 (4.1%)	5 (3.0%)	29 (0.9%)	5 (3.5%)	**46**
Total	**560**	**109**	**173**	**3,316**	**128**	**4,286**

** Heavy and light rail collisions with fixed objects include collisions where an object falls onto the rail track or collisions where an object is fixed, but protruding over the rail track*

*** 'Other' includes modes such as automated guideway, cable car, ferryboat, Puerto-Rico's jitney system, trolley bus, and vanpool*

3.4 2009–2014 NTD Injuries and Fatalities

Between 2009 and 2014, the NTD reported that there were 146,286 injuries resulting from transit collisions with an average of 31,093 each individual year. This includes injuries to passengers, revenue facility occupants, people waiting or leaving a transit facility, employees, bicyclists, pedestrians, occupants of other vehicles, and suicide attempts. Table 3-6 and Figure 3-1 depict injuries by mode. The data show:

- **Demand Response.** Passengers account for 48.8% of all demand response injuries, followed by employees (13.3%), and other vehicle occupants (13.1%).
- **Heavy Rail.** Revenue facility occupants account for 47.3% of all heavy rail injuries, followed by people waiting or leaving a facility which accounted for 32.4% of the injuries.
- **Light Rail.** Passengers account for 31.9% of all light rail injuries, followed by revenue facility occupants (22.1%) and people waiting at or leaving a transit facility (20.2%).
- **Motor Bus.** The vast majority of motor bus injuries are with passengers (59.2%), and people waiting for or leaving a transit facility (13.6%) followed by injuries associated with other vehicle occupants (10.7%).

Please note that the injury values in previous tables in this section are calculated using the 'Total Injuries' field in the NTD. The NTD also contains a breakdown of injuries by person injured, as shown below in Table 3-6, but the total of these fields does not necessarily equal the 'Total Injuries' value. As a result, these values should not be considered distinct, i.e. an injured person may fall into one or more of these categories.

Table 3-6: 2009-2014 Average NTD Persons Injured by Mode *(Source 2009-2014 NTD)*

Person Injured	Demand Resp. *(%)*	Heavy Rail *(%)*	Light Rail *(%)*	Motor Bus *(%)*	Other *(%)*	Total
Passenger	883 (48.8%)	889 (7.4%)	368 (31.9%)	9,043 (59.2%)	325 (38.7%)	**11,507**
Rev Facility Occupant	71 (3.9%)	5,680 (47.3%)	255 (22.1%)	610 (4.0%)	87 (10.3%)	**6,703**
People Waiting or Leaving	283 (15.6%)	3,895 (32.4%)	233 (20.2%)	2,079 (13.6%)	232 (27.6%)	**6,722**
Employee	241 (13.3%)	115 (1.0%)	68 (5.9%)	1,102 (7.2%)	58 (6.9%)	**1,584**
Bicyclist	11 (0.6%)	1 (0.0%)	8 (0.7%)	106 (0.7%)	3 (0.3%)	**128**
Pedestrian	34 (1.9%)	4 (0.0%)	32 (2.7%)	266 (1.7%)	17 (2.0%)	**352**
Other Vehicle Occupant	238 (13.1%)	4 (0.0%)	72 (6.2%)	1,638 (10.7%)	62 (7.3%)	**2,013**
Suicide	0 (0.0%)	36 (0.3%)	8 (0.7%)	4 (0.0%)	1 (0.1%)	**49**
Other	50 (2.7%)	1,386 (11.5%)	111 (9.6%)	432 (2.8%)	57 (6.7%)	**2,035**
Total	**1,811**	**12,008**	**1,154**	**15,281**	**840**	**31,093**

Between 2009 and 2014 there were 1,437 total fatalities according to the NTD with an average of 278 per year. Table 3-7 and Figure 3-2 show a summary of 2009 through 2014 average fatalities by mode. Heavy Rail had the highest total average number of fatalities (119), followed by Motor Buses (103). An important note regarding heavy rail fatalities is that the majority were the results of suicides (41.5%). The highest number of motor bus fatalities were pedestrians (26.1%) and other vehicle occupants (28.2%). The data shows that:

- **Demand Response.** Other vehicle occupants account for 45.6% of all demand response fatalities, followed by passengers (26.3%).
- **Heavy Rail.** Suicides account for 41.5% of all heavy rail fatalities, followed by people waiting or leaving a facility which accounted for 18.5% of the fatalities.
- **Light Rail.** Pedestrians account for 33.2% of all light rail fatalities, followed by suicides (20.9%) and people waiting at or leaving a transit facility (13.6%).
- **Motor Bus.** Other vehicle occupants (28.2%) and pedestrians (26.1%), followed by people waiting or leaving a transit facility (15.6%), make up the highest number of fatalities.

Please note that the fatality values in previous tables in this section are calculated using the 'Total Fatalities' field in the NTD. The NTD also contains a breakdown of fatalities by person injured, as shown below in Table 3-7, but the total of these fields does not necessarily equal the 'Total Fatalities' value. As a result, these values should not be considered distinct, i.e. a fatally injured person may fall into one or more of these categories.

Table 3-7: 2009-2014 Average NTD Fatalities by Mode *(Source 2009-2014 NTD)*

Person Injured	Demand Resp. *(%)*	Heavy Rail *(%)*	Light Rail *(%)*	Motor Bus *(%)*	Other *(%)*	Total
Passenger	3 (26.3%)	5 (3.8%)	1 (2.6%)	6 (5.4%)	1 (18.6 %)	**15**
Rev Facility Occupant	0 (3.5%)	18 (14.8%)	4 (9.4%)	10 (9.4%)	0 (0.0%)	**31**
People Waiting or Leaving*	1 (10.5%)	22 (18.5%)	5 (13.6%)	16 (15.6%)	0 (4.7%)	**45**
Employee	0 (3.5%)	2 (1.5%)	0 (0.0%)	4 (3.7%)	1 (9.3%)	**7**
Bicyclist	0 (0.0%)	0 (0.1%)	2 (6.0%)	6 (6.0%)	0 (2.3%)	**9**
Pedestrian	1 (10.5%)	8 (6.3%)	13 (33.2%)	27 (26.1%)	1 (14.0%)	**49**
Other Vehicle Occupant	4 (45.6%)	1 (0.6%)	3 (7.7%)	29 (28.2%)	3 (39.5%)	**40**
Suicide	0 (0.0%)	49 (41.5%)	8 (20.9%)	3 (3.1%)	1 (9.3%)	**61**
Other	0(0.0%)	15 (12.9%)	3 (6.8%)	3 (2.4%)	0 (2.3%)	**21**
Total	**10**	**119**	**39**	**103**	**7**	**278**

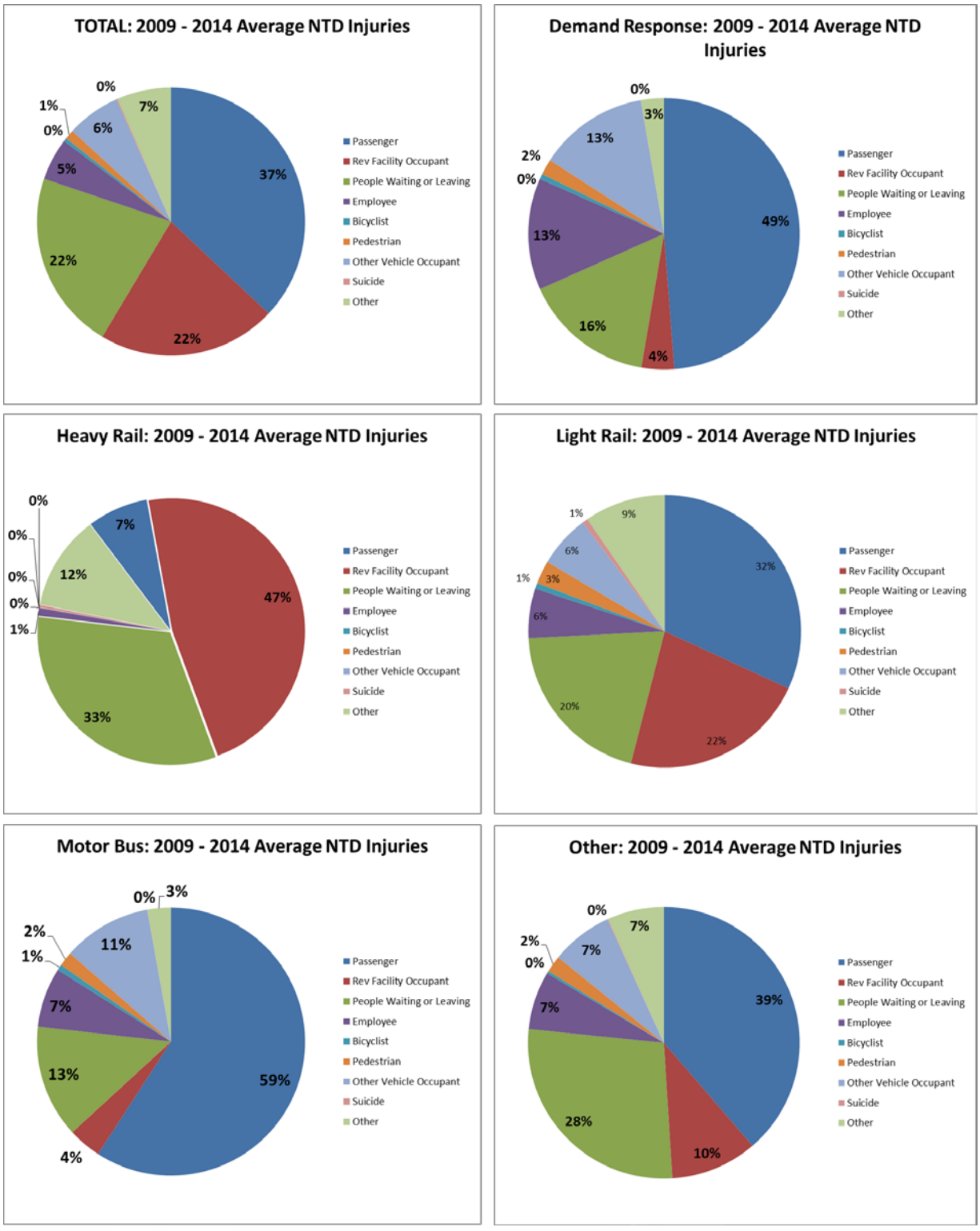


Figure 3-1: 2009-2014 NTD Injuries by Mode *(Source 2009-2014 NTD)*

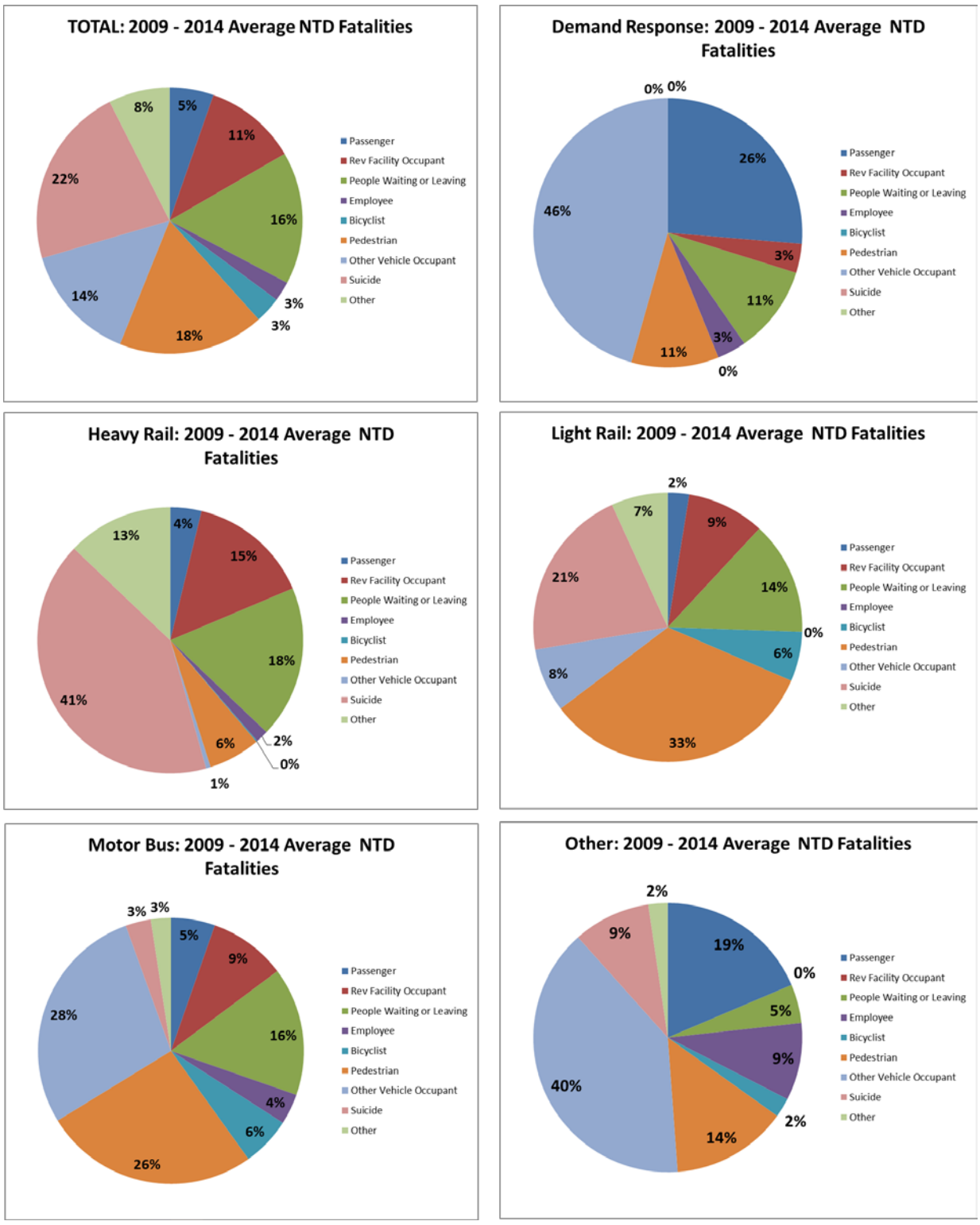


Figure 3-2: 2009-2014 NTD Fatalities by Mode *(Source 2009-2014 NTD)*

4 Transit Collision Analysis Approach

The information contained in Section 3 provides a high-level overview of transit collisions. To determine whether and the extent to which connected vehicles can effectively reduce the number of and severity of collisions involving transit vehicles, a more thorough understanding of transit collision characteristics is necessary. This section describes the approach used by the analysis team to conduct a detailed transit collision analysis. It describes an overview of the 2009 through 2014 NTD, gaps in the NTD data and how those gaps were overcome, the approach for categorizing transit collisions, and normalization / extrapolation of the NTD data. Figure 4-1 depicts the analysis approach that includes six (6) steps. The steps were conducted individually for each year analyzed. The average results over the six year period are reported in this paper.

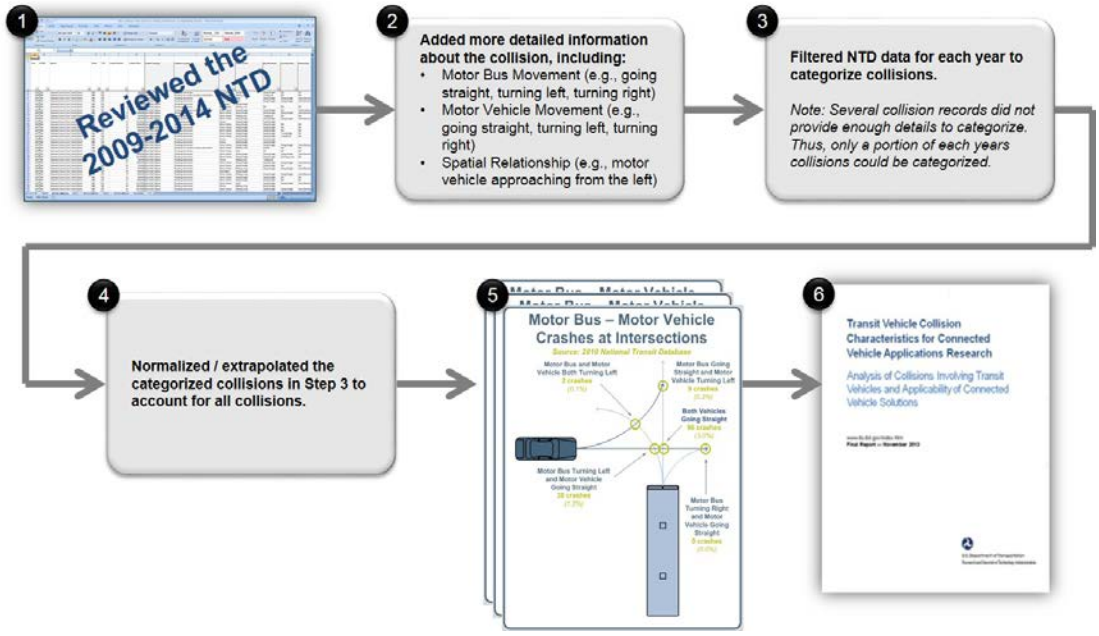


Figure 4-1: Transit Collision Analysis Approach

4.1 Step 1: Review the NTD

The first step was to review the NTD to determine what type of data was available for a detailed collision analysis. Upon reviewing the NTD, the following data fields were identified:

- **Agency.** The name of the transit agency.
- **Mode.** Data about the mode or type of transit vehicle. The NTD contains twenty modes. These modes ranged from motor buses to the jitney system in Puerto Rico.
- **Collision Location.** Data about the location of the collision. Examples of collision locations include revenue facility, roadway – grade crossing, roadway – non-grade crossing, and roadway – intersection. Beginning in 2011 the NTD added an additional category: bus stop.

- **Collision With.** Data about the type of object the transit vehicle collided with. Examples include motor vehicle, person, animal, and fixed object.
- **Transit Vehicle Action.** Data about the action the transit vehicle was taking when it collided with the other object. Examples include going straight, making a turn, leaving a stop, and making a stop.
- **Collision Type.** Data about the type of collision including whether the collision was a head-on collision, sideswipe, rear end, or angle collision.
- **Vehicle Speed.** Data about the speed of the transit vehicle when it collided with the other object.
- **Incident Description.** Detailed descriptions of the collision. These descriptions are entered as free form text from the reporting transit agencies.

These data fields provided from the NTD S&S-40 were contained within a Microsoft Excel spreadsheet that allowed the data to be sorted or queried easily. Figure 4-2 provides an overview of the S&S-40 provided data fields. By sorting the data, it was possible to determine some initial results including the number of collisions occurring at intersections or at mid-block, the number of head-on collisions versus sideswipes, or the number of collisions between motor buses and motor vehicles as compared to collisions between motor buses and pedestrians.

Year		Agency	Mode			Collision Location		Collision With	Transit Vehicle Action	Collision Type		Property Damage	Event Descriptions
Year	NTDID	Agency	Mode		Incident Number	Collision Date	Incident Category	Collision Location	Collision With	Vehicle Action	Collision Type	Vehicle Speed	Property Damage	Incident Description
2010	9014	Alameda-Contra Costa Transit District	MB	DO	1	1/4/2010	Non-Rail Collision	Roadway: intersection	Motor Vehicle	Going Straight	Angle	30	$11,917	A Suburu ran a stop light and hit the bus. The car T Boned the bus.
2010	9014	Alameda-Contra Costa Transit District	MB	DO	2	1/7/2010	Non-Rail Collision	Roadway: not a grade crossing or intersection	Motor Vehicle	Making a turn	Sideswipe	15	$271	AC Transit bus was preparing to make a left hand turn when a car came and sideswiped the car.
2010	9014	Alameda-Contra Costa Transit District	MB	DO	3	1/10/2010	Non-Rail Collision	Roadway: intersection	Motor Vehicle	Other	Rear-ended	0	$357	AC Transit bus was picking up passengers at a bus stop when a car rear ended the bus.
2010	9014	Alameda-Contra Costa Transit District	MB	DO	4	1/10/2010	Non-Rail Collision	Roadway: intersection	Motor Vehicle	Other	Rear-ended	0	$1,652	AC Transit bus was sitting at the stop light when a car rear ended the bus.
2010	9014	Alameda-Contra Costa Transit District	MB	DO	6	1/22/2010	Non-Rail Collision	Roadway: intersection	Motor Vehicle	Making a turn	Head-On	5	$150	AC Transit bus was at the intersection when a car ran the stop light and hit the front of the bus.
2010	9014	Alameda-Contra Costa Transit District	MB	DO	7	2/8/2010	Non-Rail Collision	Roadway: not a grade crossing or intersection	Motor Vehicle	Going Straight	Angle	3	$551	AC Transit Bus was traveling down the street, when a car backed out of the driveway hitting the front right side of the bus.
2010	9014	Alameda-Contra Costa Transit District	MB	DO	8	2/19/2010	Non-Rail Collision	Roadway: intersection	Motor Vehicle	Going Straight	Rear-ending	2	$0	AC Transit Bus was traveling down San Pablo Avenue and rear ended a car.
2010	9014	Alameda-Contra Costa Transit District	DR	PT	9	3/23/2010	Non-Rail Collision	Roadway: intersection	Motor Vehicle	Making a stop	Rear-ended	15	$357	AC Transit vehicle was rear ended by a car.

Figure 4-2: NTD S&S-40 Data Fields

4.2 Step 2: Add Additional Data to the NTD

While the NTD contains a range of data fields describing details of a collision, it lacked data necessary to perform a more detailed analysis including the vehicle's turning movements at the time of the collision. These limitations are summarized below:

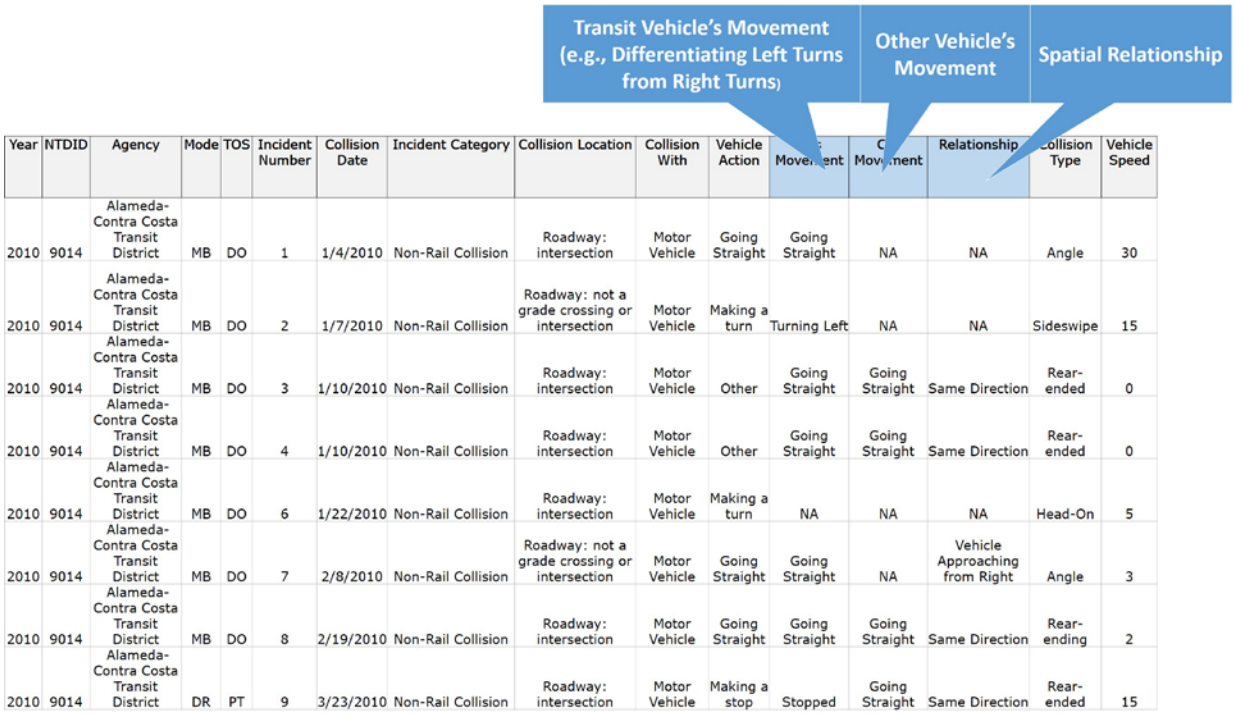
- **Transit Vehicle's Turning Movement.** The NTD included a data field for the transit vehicle's action as 'making a turn'; however it did not differentiate whether the transit vehicle was making a left turn or a right turn.
- **Motor Vehicle's Action.** The NTD did not include a data field for a motor vehicle's movement (e.g., going straight, turning left, or turning right).
- **Vehicle Spatial Relationship.** The NTD did not include a data field describing the spatial relationship between two vehicles that were involved in a collision. For example, it was not possible to determine if the motor vehicle was approaching the transit vehicle at an intersection from the left, from the right, driving in the same direction, or approaching the transit vehicle from the opposite direction.

While the existing data fields did not include data to address the limitations identified above, there was an "incident description" data field in the NTD that contained more specific information for each collision record. Data in the "incident description" data field was entered as free form text and varied in the level of detail. For example, some collision records had very detailed information about collisions making it easy to obtain additional characteristics about the collision. These details included the transit vehicle's turning movement and spatial relationship as two vehicles approached an intersection. Other collision records lacked this detail; simply stating that "The Motor Vehicle hit the Bus."

Data from the "incident description" data field was analyzed further for each of the motor bus and light rail collision records. These collision records were analyzed to obtain more detailed information about collisions such as the:

- Transit vehicle's turning movement
- Motor vehicle's action
- Vehicle's spatial relationship prior to the collision

New data fields were added to the NTD spreadsheet used by the analysis team to account for these actions and their relationship. This manually obtained data was entered into these new data fields accordingly, as show in Figure 4-3. For collision records where it was not possible to determine the turning movement or relationship between vehicles, 'NA' was entered into the data field.



Year	NTDID	Agency	Mode	TOS	Incident Number	Collision Date	Incident Category	Collision Location	Collision With	Vehicle Action	Movement	Movement	Relationship	Collision Type	Vehicle Speed
2010	9014	Alameda-Contra Costa Transit District	MB	DO	1	1/4/2010	Non-Rail Collision	Roadway: intersection	Motor Vehicle	Going Straight	Going Straight	NA	NA	Angle	30
2010	9014	Alameda-Contra Costa Transit District	MB	DO	2	1/7/2010	Non-Rail Collision	Roadway: not a grade crossing or intersection	Motor Vehicle	Making a turn	Turning Left	NA	NA	Sideswipe	15
2010	9014	Alameda-Contra Costa Transit District	MB	DO	3	1/10/2010	Non-Rail Collision	Roadway: intersection	Motor Vehicle	Other	Going Straight	Going Straight	Same Direction	Rear-ended	0
2010	9014	Alameda-Contra Costa Transit District	MB	DO	4	1/10/2010	Non-Rail Collision	Roadway: intersection	Motor Vehicle	Other	Going Straight	Going Straight	Same Direction	Rear-ended	0
2010	9014	Alameda-Contra Costa Transit District	MB	DO	6	1/22/2010	Non-Rail Collision	Roadway: intersection	Motor Vehicle	Making a turn	NA	NA	NA	Head-On	5
2010	9014	Alameda-Contra Costa Transit District	MB	DO	7	2/8/2010	Non-Rail Collision	Roadway: not a grade crossing or intersection	Motor Vehicle	Going Straight	Going Straight	NA	Vehicle Approaching from Right	Angle	3
2010	9014	Alameda-Contra Costa Transit District	MB	DO	8	2/19/2010	Non-Rail Collision	Roadway: intersection	Motor Vehicle	Going Straight	Going Straight	Going Straight	Same Direction	Rear-ending	2
2010	9014	Alameda-Contra Costa Transit District	DR	PT	9	3/23/2010	Non-Rail Collision	Roadway: intersection	Motor Vehicle	Making a stop	Stopped	Going Straight	Same Direction	Rear-ended	15

Figure 4-3: Data Fields Created and Added to the NTD

4.3 Step 3: Filter the Data to Determine Collision Types for a Sample

Once the analysis team appended the additional data fields to the USDOT provided NTD data, it was then possible to filter the database to determine collision types for a large sample of the data. Fifteen categories were identified:

1. Motor Bus Collisions with Pedestrians at Intersections
2. Motor Bus Collisions with Pedestrians at Mid-Block
3. Motor Bus Collisions with Pedestrians at Bus Stops
4. Motor Bus Collisions with Motor Vehicles at Intersections – Motor Bus Turning Left
5. Motor Bus Collisions with Motor Vehicles at Intersections – Motor Bus Turning Right
6. Motor Bus Collisions with Motor Vehicles at Intersections – Motor Bus Going Straight
7. Motor Bus Collisions with Motor Vehicles at Intersections – Motor Bus Near a Bus Stop
8. Motor Bus Collisions with Motor Vehicles at Mid-Block – Motor Bus Going Straight
9. Motor Bus Collisions with Motor Vehicles at Mid-Block – Motor Bus Making a Turn
10. Motor Bus Collisions with Motor Vehicles at Mid-Block – Motor Bus Near a Bus Stop
11. Motor Bus Collisions with Motor Vehicles at Bus Stop – Motor Bus Leaving a Stop

12. Motor Bus Collisions with Motor Vehicles at Bus Stop – Motor Bus Making a Stop
13. Motor Bus Collisions with Motor Vehicles at Bus Stop – Motor Bus Stopped
14. Motor Bus Collisions with Motor Vehicles at Bus Stop – Other Motor Bus Movement
15. Light Rail Collisions with Motor Vehicles – Light Rail Vehicle Going Straight

These categories were further broken down by the movement of the motor bus / light rail and motor vehicle. As a result there were seventy-eight (78) motor bus collision types and ten (10) light rail collision types identified. Collision types are provided in Table 4-1. An important note is that beginning in 2011, the NTD began to include a new collision location – 'bus stop'. This additional location provides an increased level of detail to the NTD reporting. As a result, the analysis for 2011 and onward includes the following new categories; Bus Stop – Motor Bus Leaving a Stop; Bus Stop – Motor Bus Making a Stop and Bus Stop – Motor Bus Stopped.

Table 4-1: Collision Categories and Collision Types

MOTOR BUS COLLISIONS WITH PEDESTRIANS

Collisions at Intersection
- Motor Bus Going Straight
- Motor Bus Turning Left
- Motor Bus Turning Right
- Motor Bus Leaving a Bus Stop
- Motor Bus Making a Bus Stop

Mid-Block Collisions
- Motor Bus Going Straight
- Motor Bus Making a Turn
- Motor Bus Leaving a Bus Stop
- Motor Bus Making a Bus Stop

Collisions at Bus Stops
- Motor Bus Leaving a Bus Stop
- Motor Bus Making a Bus Stop
- Motor Bus Stopped
- Motor Bus Going Straight/Turning

MOTOR BUS COLLISIONS WITH MOTOR VEHICLES AT INTERSECTIONS

Motor Bus Turning Left
- Motor Vehicle Approaching from Left – Going Straight
- Motor Vehicle Approaching from Left – Turning Left
- Motor Vehicle Approaching from Left – Turning Right
- Motor Vehicle Approaching from Opposite Direction – Going Straight
- Motor Vehicle Approaching from Opposite Direction – Turning Left
- Motor Vehicle Approaching from Opposite Direction – Turning Right
- Motor Vehicle Approaching from Right - Going Straight
- Motor Vehicle Approaching from Right- Turning Left
- Motor Vehicle Approaching in Same Direction – Turning Left
- Motor Vehicle Approaching in Same Direction – Going Straight

Motor Bus Turning Right
- Motor Vehicle Approaching from Left – Going Straight
- Motor Vehicle Approaching from Opposite Direction – Turning Left
- Motor Vehicle Approaching in Same Direction – Turning Right
- Motor Vehicle Approaching in Same Direction – Going Straight

Motor Bus Going Straight
- Motor Vehicle Approaching from Left – Going Straight
- Motor Vehicle Approaching from Left – Turning Left
- Motor Vehicle Approaching from Opposite Direction – Going Straight
- Motor Vehicle Approaching from Opposite Direction – Turning Left
- Motor Vehicle Approaching from Right – Going Straight
- Motor Vehicle Approaching from Right – Turning Right
- Motor Vehicle Approaching from Right – Turning Left
- Motor Vehicle Driving in Same Direction – Non Rear-Ending/Ended
- Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus
- Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus
- Motor Vehicle Approaching in Same Direction – Rear-Ending
- Motor Vehicle Driving in Same Direction – Rear-Ended

Motor Bus at Intersection Bus Stop
- Motor Bus Leaving a Bus Stop
- Motor Bus Making a Bus Stop

MOTOR BUS COLLISIONS WITH MOTOR VEHICLES AT MID-BLOCK

Motor Bus Making a Turn
- Motor Vehicle Driving in Same Direction
- Motor Vehicle Approaching from Opposite Direction – Going Straight

Motor Bus at Mid-Block Bus Stop
- Motor Bus Leaving a Bus Stop
- Motor Bus Making a Bus Stop

Motor Bus Going Straight
- Motor Vehicle Driving in Same Direction – Rear-Ending
- Motor Vehicle Driving in Same Direction – Rear-Ended
- Motor Vehicle Approaching in Same Direction – Non Rear-Ending/Ended
- Motor Vehicle Approaching from Opposite Direction – Going Straight
- Motor Vehicle Approaching from Opposite Direction – Turning Left
- Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus
- Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus
- Motor Vehicle Approaching from Left or Right

MOTOR BUS COLLISIONS WITH MOTOR VEHICLES BUS STOPS

Motor Bus Leaving a Stop / Making a Stop / Stopped / Other
- Motor Vehicle Driving in Same Direction – Rear-Ending
- Motor Vehicle Driving in Same Direction – Rear-Ended
- Motor Vehicle Approaching in Same Direction – Non Rear-Ending/Ended
- Motor Vehicle Approaching from Opposite Direction - Going Straight
- Motor Vehicle Approaching from Opposite Direction – Turning Left
- Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus
- Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus
- Motor Vehicle Approaching from Left or Right

LIGHT RAIL COLLISIONS WITH MOTOR VEHICLES

Light Rail Vehicle Going Straight
- Motor Vehicle Going Straight
- Motor Vehicle Turning Left
- Motor Vehicle Turning Right

Terminology for motor vehicle approaches at intersections is illustrated in Figure 4-2 which shows that a motor vehicle may approach a motor bus at an intersection from: (1) the left, (2) the opposite direction, (3) the right, or (4) the same direction. This terminology is used throughout this report when identifying a motor vehicle's relationship to a motor bus at an intersection.

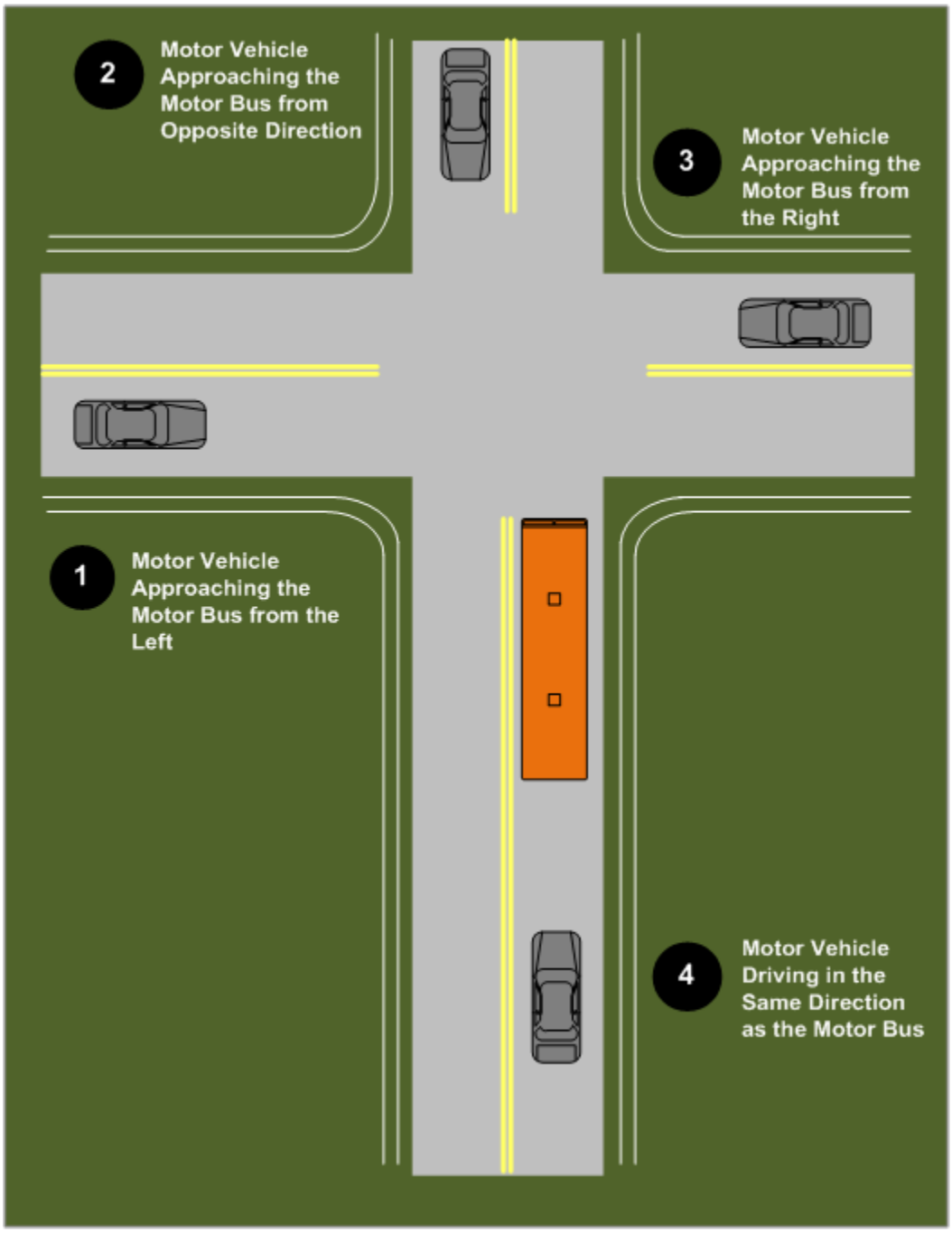


Figure 4-4: Terminology for Motor Vehicle Approaches at Intersections

The next step was to filter the NTD to determine the number of collisions for each collision type. For example, to determine the number of motor bus collisions with motor vehicles at intersections when the motor bus is going straight, the following filter was applied: (a) filter the 'mode' by 'MB', (b) filter by the 'collision location' by 'roadway: intersection', (c) filter 'collision with' by 'motor vehicle', and (d) filter 'bus movement' by 'going straight'. These filters were conducted for each of the collision types listed in Table 4-1 and the results were entered into a separate spreadsheet.

4.4 Step 4: Normalize/Extrapolate the Data

Categorizing a collision record required data from several data fields. Unfortunately, there were several collision records that lacked data from one or more data fields making it impossible to categorize the collision record.

As an example, following the filter steps described above for the 2010 NTD resulted in 2,244 of the 3,224 total motor bus collisions being categorized. This meant that 69.6% of all the collision records from 2010 could be properly categorized and 30.4% of collision records could not be categorized (these percentages are similar for each of the 6 years). Of these collision records there were 307 collision records where the bus's turning movement (e.g., turning left or right) was not known. Additionally, the car movement could not be determined for 757 collision records and the spatial relationship could not be determined for 799 collision records.

After looking at the collision categories and collision types, it was determined that some categories and types have more unknowns than other categories. For example, collisions between motor buses and pedestrians had fewer unknowns than collisions between motor buses and motor vehicles. The only potential unknown for a motor bus and pedestrian collision is the motor bus's turning movement (e.g., turning left or turning right). However, motor bus collisions with motor vehicles have three potential unknowns: (1) the bus's turning movement, (2) the motor vehicle's movement, and (3) the spatial relationship. Therefore there were a higher percentage of motor bus collisions with pedestrians that were analyzed than motor bus collisions with other motor vehicles. As a result, the analysis team determined that it was necessary to normalize and extrapolate the data so that the data set is expanded to account for all motor bus collisions of each type.

To normalize the data, for each collision category, the analysis team broke down the collisions into the following categories for each of the six years:

- **Motor Bus Collisions with Pedestrians.** There were 3,615 total collision records between 2009 and 2014 in the NTD of which 2,378 had enough data in the core set of NTD fields to analyze in Step 3.
- **Motor Bus Collisions with Motor Vehicles at Intersections.** There were 8,689 collision records between 2009 and 2014 in the NTD of which 4,672 had enough data in the core set of NTD fields to analyze in Step 3.
- **Motor Bus Collisions with Motor Vehicle at Mid-Block.** There were 5,190 collision records between 2009 and 2014 in the NTD of which 3,828 had enough data in the core set of NTD fields to analyze in Step 3.
- **Motor Bus Collisions with Motor Vehicle at Bus Stop.** There were 2,322 collision records between 2011 and 2014 in the NTD of which 2,043 had enough data in the core set of NTD fields to analyze in Step 3 (Category not available in 2009 and 2010).

To account for these discrepancies, the total number of collisions for a collision category from the NTD was divided by the number of collisions analyzed in step three for that collision category. The

result was then multiplied by number of collisions for a specific collision type. An example of this normalization from 2010 is shown below:

$$\text{Motor Bus Collisions with Motor Vehicles at Intersections when the Motor Bus was Going Straight and Motor Vehicle Approaching from Left and Going Straight} = \frac{(\text{Total Number of Motor Bus Going Straight Collisions Reported in the 2010 NTD})}{(\text{Number of Motor Bus Going Straight Collisions Analyzed in Step 3 })} \times (\text{Collisions from Step 3 for Motor Bus Collisions when the Motor Vehicle Approaching from Left and Going Straight})$$

$$\text{Motor Bus Collisions with Motor Vehicles at Intersections when the Motor Bus was Going Straight and Motor Vehicle Approaching from Left and Going Straight} = \frac{1375}{873} \times 82$$

$$\text{Motor Bus Collisions with Motor Vehicles at Intersections when the Motor Bus was Going Straight and Motor Vehicle Approaching from Left and Going Straight} = 129 \text{ collisions}$$

In summary, the normalization process resulted in the number of collisions analyzed being multiplied by a multiplier. This multiplier was specific to each collision category and varied depending on the number of unknowns for that particular collision category. This resulted in an extrapolation of the data according to the collision categories. This approach ensured that the total number of collisions used for this analysis equaled the total number of collision records for each year of NTD data. Normalized frequencies were first calculated for each year. When average frequencies for 2009-2014 are discussed in later sections, these represent an average of the yearly normalized frequencies.

This process should be viewed as an approximation and does not represent exact collision numbers. There is always the potential to over inflate some collision categories and not fully account for others when using normalization and extrapolation processes. However, after a thorough analysis and review of the data the analysis team was able to confirm with confidence that the process does provide a clear understanding of what the most “frequent” and reoccurring collision types are. The normalization/extrapolation process is beneficial to the USDOT because it allows for an understanding of what the most frequent collision types are as reported within the NTD. This information is in turn useful in determining which connected vehicle applications could be most applicable to transit vehicles.

4.5 Step 5: Conduct Data Analysis

Once the data were normalized, the analysis team summarized the collision data and created tables and graphics depicting the number of collisions for each collision type. These tables and graphics are included in Section 5, Section 6 and Section 7 of this report and were used by the analysis team to draw conclusions about collisions with higher frequencies. This allowed the analysis team to make recommendations on the types of collisions that should be further explored by the USDOT.

4.6 Step 6: Develop Transit Collision Analysis Reports

The final step was to create two project reports based on the NTD analysis. The initial report published in 2013 titled “Transit Vehicle Collision Characteristics for Connected Vehicle Research Applications” served as the initial project report and included the preliminary analysis using only 2010 NTD data. This report can be found online at the National Transportation Library (FHWA-JPO-13-116). The original report provided a base for the USDOT to assess and determine

appropriate connected vehicle applications for transit modes, primarily motor buses. In 2014 the USDOT tasked the analysis team with creating an updated report, based on additional years of NTD data. This current project report provides analysis on six years of NTD data (2009, 2010, 2011, 2012, 2013 and 2014) as well as expanded sections on light rail vehicles and pedestrian collisions.

5 Motor Bus Collisions

The NTD defines a motor bus as a shared-ride transportation service operating over regular streets and roads, according to fixed routes. According to the NTD, between 2009 and 2014 there were 19,896 motor bus collisions in the United States that resulted in 67,777 injuries and 745 fatalities[3]. This breaks down to a normalized average (described below) of which breaks down to approximately 3,535 motor bus collisions each year, with 7,357 injuries and 80 fatalities.

As mentioned in Section 4, the analysis and normalization process was completed for each individual year from 2009 to 2014. A year-to-year comparison of collision types and frequencies showed that the collision types and frequencies were largely consistent across the six years of data. While there were minor fluctuations in frequencies, there were no identifiable positive or negative trends over time and the most frequent collision types were similar between the years. For these reasons, the frequencies presented in this section are six (6) year averages of the normalized collision types described in Section 4. One caveat is that beginning in 2011 a new 'bus stop' location was added to the NTD, so these collisions were only averaged over the four (4) years in which they were available. **As a result, normalized averages presented in this section may not be consistent with raw values as reported by the NTD (see Section 3), but have been recalculated to account for these differences in NTD reporting across the six years.**

The following sections of the report discuss motor bus collisions in greater detail based on various collision characteristics such as location, collision type, and cost of collision. It should be noted that the numbers used for the analysis are the normalized/extrapolated numbers and are used as approximations in order to provide a greater understanding to the most frequent collision types. The normalized average figures mentioned above are used throughout this section. As discussed in Section 3.3, please note that due to the analysis methodology, the collision values presented in each table represent rounded values. As a result, the total values displayed throughout this document reflect the sum of the exact values and not necessarily the sum of the values displayed on the tables. For example, the values 3.3, 3.3, 3.4, and 3.5 will be rounded to the nearest integer, and thus would be displayed in a table as 3, 3, 3, and 4, respectively. However, the sum of these values (3.3 + 3.3 + 3.4 + 3.5 = 13.5) will be shown in the table as the rounded value, 14, even though the sum of the *rounded values* is 13 (3 + 3 + 3 +4 = 13).

The following is a breakdown of the analysis presented in this section:

- Section 5.1 breaks down the number of motor bus collisions by location.
- Section 5.2 provides a summary of motor bus collisions categorized by collision type.

[3] There were discrepancies in NTD reporting of injury and fatality counts. While NTD tables (as shown in Table 3-2 and Table 3-3) report 83,616 injuries and 539 fatalities for the 19,896 motor bus collisions, the analysis team found that the information provided in the incident descriptions of these 19,896 collisions resulted in a count of 67,777 injuries and 745 fatalities. Since the majority of this analysis draws on information provided in the incident descriptions, the analysis team made a decision to use these values moving forward.

- Section 5.3 discusses motor bus collisions with pedestrians. On average these collisions account for 461 of the 3,535 motor bus collisions a year or approximately 13.0% of all motor bus collisions.
- Section 5.4 discusses motor bus collisions with motor vehicles at intersections. This includes signalized intersections, un-signalized intersections, and intersections equipped with stop or yield signs. These collisions account for 1,448 collisions a year or 41.0% of all motor bus collisions.
- Section 5.5 discusses mid-block motor bus collisions with motor vehicles. On average, there were 865 mid-block collisions a year which accounts for 24.5% of all motor bus collisions.
- Section 5.6 discusses motor bus collisions with motor vehicles at bus stops. There were approximately 581 collisions a year at bus stops, accounting for 16.4% of all motor bus collisions.
- Section 5.7 presents an analysis of motor bus collision types by frequency, cost, and cost per collision.

5.1 Motor Bus Collisions Categorized by Location

The NTD defines eight categories for location: (1) Bus Stop, (2) Non-Revenue Facility, (3) Parking Facility, (4) Revenue Facility: Terminal Center, (5) Roadway: Grade Crossing, (6) Roadway: Intersection, (7) Roadway: Not a Grade Crossing or Intersection, and (8) Other. These locations are defined in Appendix B. The Bus Stop location was added to the NTD in 2011, and therefore was averaged over only four years. Table 5-1 provides a breakdown of the 2009-2014 NTD data by the collision location. These data show that 'Roadway: Intersections' had the highest average number of collisions per year with 1,771 or 48.4% of all motor bus collisions. The location with the second highest number of collisions was at 'Roadway: Not a Grade Crossing or Intersection' which accounted for 1,048 or 29.7% of all motor bus collisions. The 'Bus Stop' location accounted for 671 or 19.0% of all motor bus collisions. The remaining locations accounted for a little less than three percent of all motor bus collisions combined.

Table 5-1: 2009-2014 Average Number of Motor Bus Collisions per Year by Location

Location	Number of Collisions	Percentage
Bus Stop	671	19.0%
Non-Revenue Facility	6	0.2%
Parking Facility	1	0.0%
Revenue Facility: Terminal Center	41	1.1%
Roadway: Grade Crossing	27	0.7%
Roadway: Intersection	1,711	48.4%
Roadway: Not a Grade Crossing or Intersection	1,048	29.7%
Other	32	0.9%
Total	**3,535**	**100%**

Collision data can also be presented by Collision Category (see Table 4-1). When sorted by collision category (Table 5-2), the top three all involved collisions with motor vehicles. The highest percentage was at intersections, accounting for 41.0% of all motor bus collisions, followed by collisions at mid-block (24.5%) and at bus stops (16.4%). Motor bus collisions with pedestrians accounted for a little over 13.0% of all motor bus collisions with 6.4% of collisions occurring at intersections, 3.8% occurring at mid-block, 2.2% occurring at bus stops, and the rest occurring at other locations.

Table 5-2: 2009-2014 Average Number of Motor Bus Collisions per Year by Collision Category

Collision Category	Number of Collisions	Percentage
Motor Bus Collisions with Pedestrians at Intersections	225	6.4%
Motor Bus Collisions with Pedestrians at Mid-Block	134	3.8%
Motor Bus Collisions with Pedestrians at Bus Stops	77	2.2%
Motor Bus Collisions with Motor Vehicles at Intersections	1,448	41.0%
Motor Bus Collisions with Motor Vehicles at Mid-Block	865	24.5%
Motor Bus Collisions with Motor Vehicles at Bus Stops	581	16.4%
Motor Bus Collisions with Fixed Objects	76	2.1%
Motor Bus Collisions with Transit Vehicle	30	0.9%
Motor Bus Collisions with Other	29	0.8%
Miscellaneous Collisions with Motor Vehicles	46	1.3%
Miscellaneous Collisions with Pedestrians	25	0.7%
Total	**3,535**	**100%**

5.2 Motor Bus Collisions Categorized by Collision Type

Table 5-3 provides a breakdown of motor bus collisions by NTD collision type. The NTD includes eight collision types: angle, head-on, other front impact, rear-ended, rear-ending, side impact, sideswipe, and other. Definitions for these collision types are included in Appendix B. Between 2009-2014, collisions where the transit vehicle was rear-ended accounted for 24.5% of all collisions, followed by side impact collisions (20.9%), and other front impact collisions which accounted for 19.7% of all collisions. Angle, head-on, rear-ending, and sideswipe collisions were each between 7% and 10% of the total.

Table 5-3: 2009-2014 Average Number of Motor Bus Collisions per Year by NTD Collision Type

NTD Collision Type	Number of Collisions	Percentage
Angle	328	9.3%
Head-On	294	8.3%
Other Front Impact	697	19.7%
Rear-Ended	867	24.5%
Rear-Ending	271	7.7%
Side Impact	738	20.9%
Sideswipe	266	7.5%
Other	74	2.1%
Total	**3,535**	**100%**

5.3 Motor Bus Collisions with Pedestrians

This section contains an analysis of the categories and collision types of motor bus collisions with pedestrians from 2009-2014. As part of this update to the 2013 report, the research team expanded on previous analysis to include collisions with pedestrians while the Motor Bus is either Making a Bus Stop or Leaving a Bus Stop. The update can be found in Section 6, Motor Bus Making and Leaving a Stop: Collisions with Pedestrians.

From 2009 through 2014, there were an average of 461 motor bus collisions a year with pedestrians accounting for 13.0% of all motor bus collisions. Table 5-4 provides a summary of motor bus collisions with pedestrians. Of the 461 collisions, 48.8% of these collisions occurred at intersections, 29.1% at mid-block, and 16.7% when the motor bus was at a bus stop. The other 5.4% occurred at miscellaneous other locations. As shown in this table, collisions at mid-block where the motor bus was going straight accounted for the largest percentage of collisions (22.4%), followed closely by collisions at intersections where the motor bus was going straight (22.0%). Together collisions where the transit vehicle was going straight accounted for 44.4% of all motor bus collisions with pedestrians. Collisions with pedestrians were more likely to occur when the motor bus was turning left than turning right at an intersection, with 77 and 33 collisions respectively. Finally, there were slightly more collisions when the motor bus was leaving a bus stop (65 collisions) than when the motor bus was making a stop (30 collisions).

Table 5-4: 2009-2014 Average Number of Motor Bus Collisions per Year with Pedestrians

Category	Collision Type	Number of Collisions	% Pedestrian Collisions
Collisions at Intersections	Going Straight	101	22.0%
Collisions at Intersections	Turning Left	77	16.7%
Collisions at Intersections	Turning Right	33	7.2%
Collisions at Intersections	Leaving a Bus Stop	9	1.8%
Collisions at Intersections	Making a Bus Stop	5	1.1%
Collisions at Mid-Block	Going Straight	103	22.4%
Collisions at Mid-Block	Making a Turn*	11	2.3%
Collisions at Mid-Block	Leaving a Bus Stop	14	3.0%
Collisions at Mid-Block	Making a Bus Stop	7	1.4%
Collisions at Bus Stops	Leaving a Bus Stop	42	9.0%
Collisions at Bus Stops	Making a Bus Stop	18	4.0%
Collisions at Bus Stops	Stopped	5	1.1%
Collisions at Bus Stops	Going Straight or Turning	12	2.6%
Collisions at Other Locations	N/A	25	5.4%
Total		**461**	**100%**

** Collisions with pedestrians at mid-block in which the bus is making a turn often involve turning into a parking lot or similar entrance, and thus the direction of the turn (left or right) is often not indicated or is unclear from the incident description. For this reason, collisions at mid-block in which the bus is making a turn have been grouped together, regardless of turning direction.*

Figure 5-1, Figure 5-2, and Figure 5-3 depict collisions between motor buses and pedestrians using graphics to illustrate the collision type. Figure 5-1 shows motor bus collisions with pedestrians at intersections. It should be noted that the NTD does not differentiate between intersections equipped with traffic signals, stop signs, yield signs, or intersections without signage. While this information is available from other sources, these data were not provided in the NTD and thus were not included in the analysis. The graphic visually shows the average number of collisions per year when the motor bus is turning left, going straight, or turning right as well as when the motor bus is leaving or making a stop. Below the number of collisions, in italic text, is the percentage of that collision type of all motor bus collisions. For example, according to the graphic, collisions between a motor bus and a pedestrian where the motor bus is turning left account for 2.2% of all motor bus collisions. It is worth noting that while the distinction between a bus making and leaving a stop is clear, the NTD allows transit agencies to report these collisions as occurring at a bus stop, at mid-block, or at an intersection, and the criteria used to pick a location may vary from agency to agency. As a result, collisions involving buses making or leaving a stop may be similar at the three locations. The information presented in this report simply reflects the fields chosen by the agencies and reported in the NTD.

Figure 5-2 depicts mid-block collisions between motor buses and pedestrians. This graphic shows collisions in which the motor bus is going straight, making a turn, leaving a stop, and making a stop. Collisions in which the motor bus is making a turn represent a bus turning into a parking lot, shopping center, or similar facility. The majority of these mid-block collisions occur when the motor bus is going straight (2.9% of all motor bus collisions). Finally, Figure 5-3 depicts motor bus

collisions with pedestrians at bus stops. Bus stops are typically on-street locations at the curb or in a median, sometimes with a shelter, signs, or lighting. The diagram is broken down into four collision types, according to NTD data: (1) when the motor bus is leaving the bus stop, (2) when the motor bus is making a bus stop, (3) when the motor bus is stopped at a bus stop, and (4) when the motor bus is going straight or turning at a bus stop. Together these collisions account for an average of 2.2% of all motor bus collisions according to 2009-2014 NTD data.

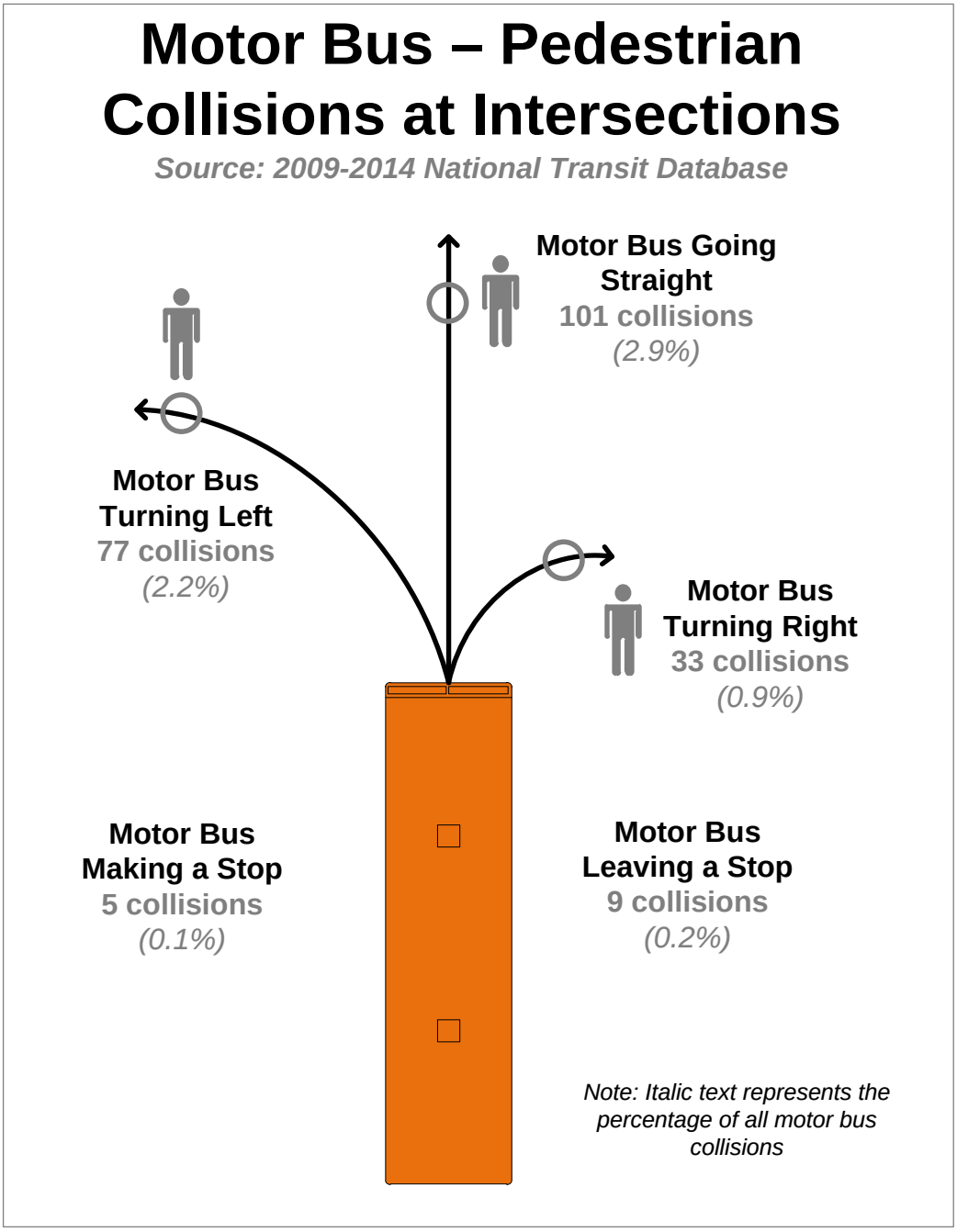


Figure 5-1: Motor Bus Collision with Pedestrians at Intersections

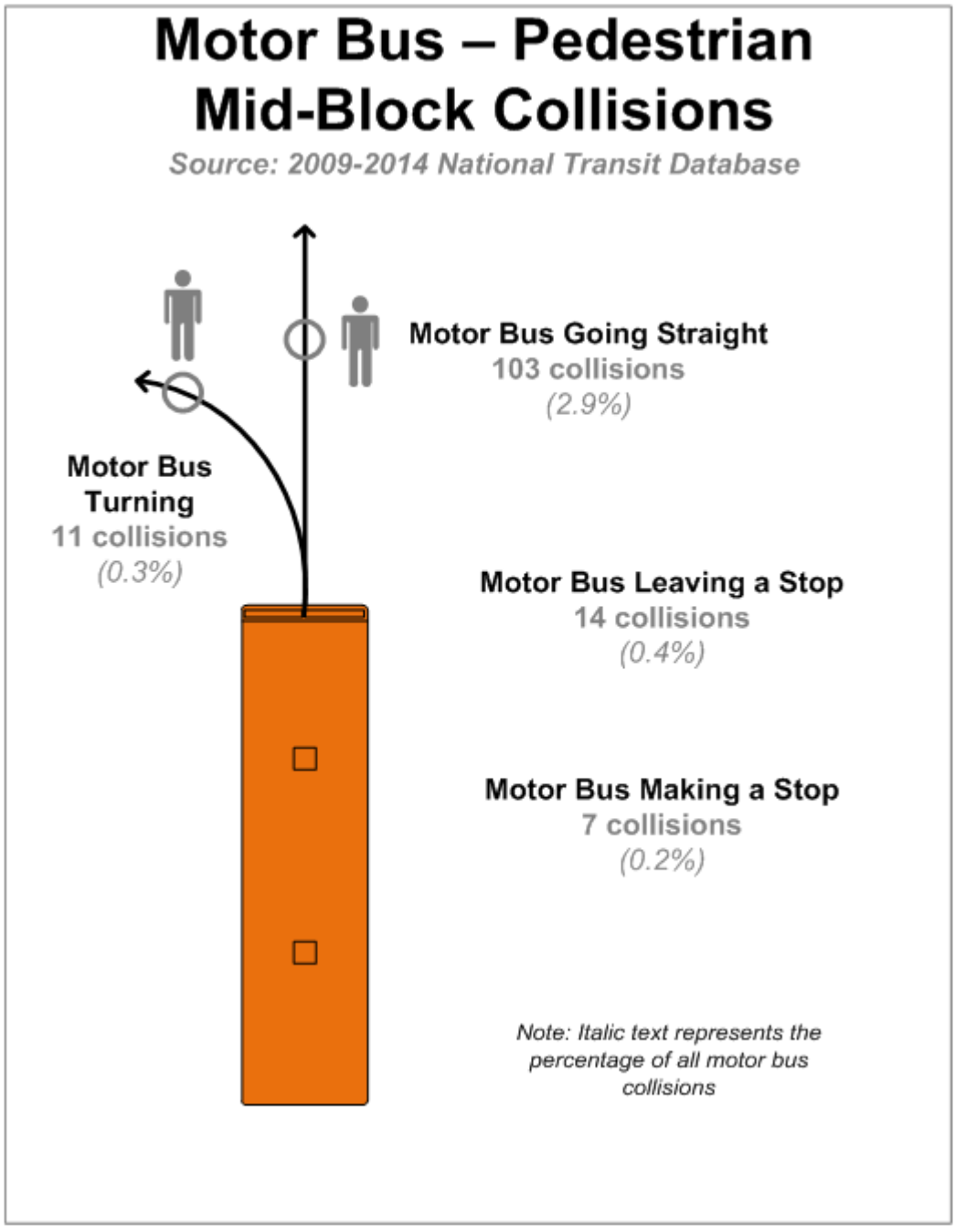


Figure 5-2: Motor Bus Collisions with Pedestrians at Mid-Block

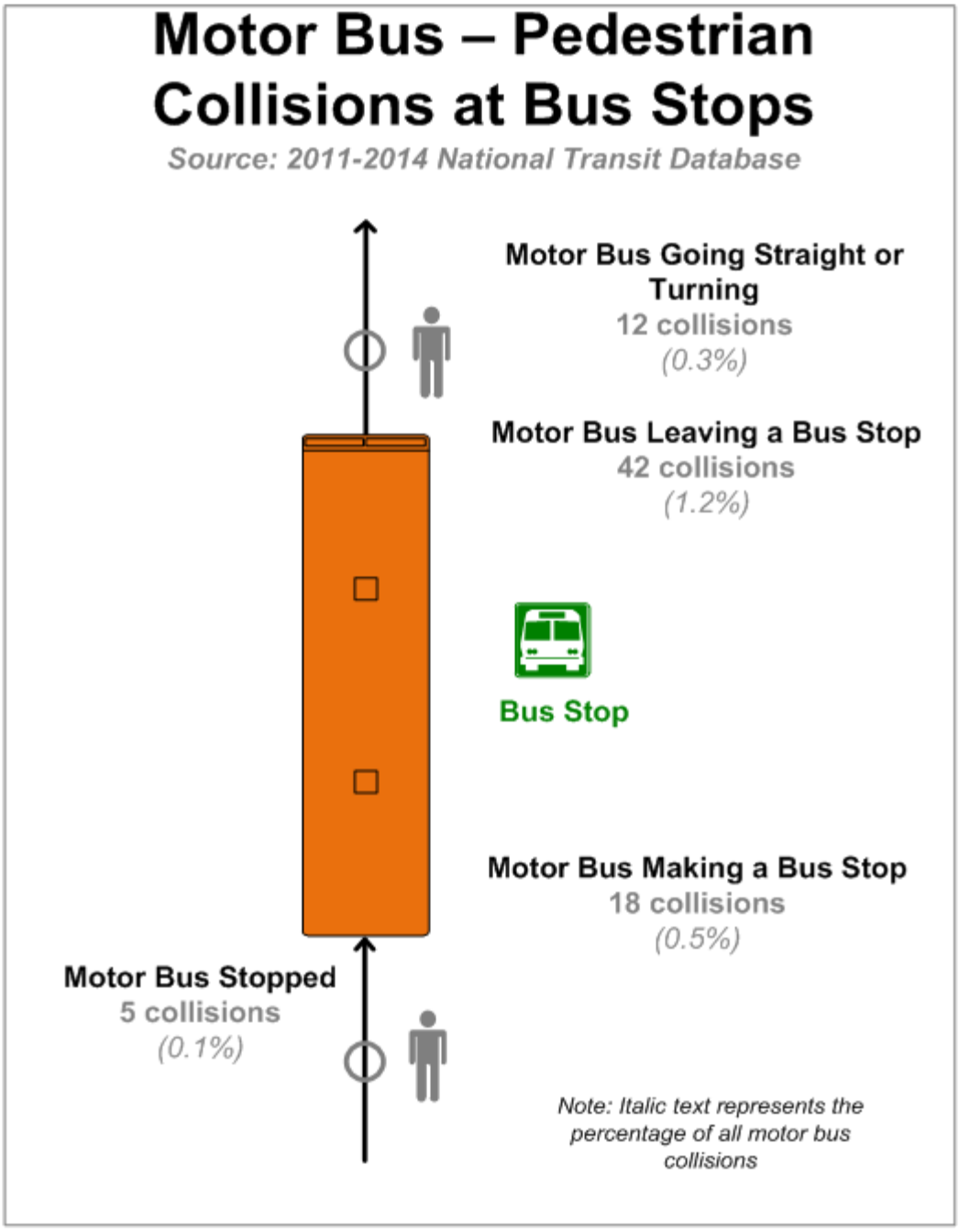


Figure 5-3: Motor Bus Collisions with Pedestrians at Bus Stops

5.4 Motor Bus Collisions with Motor Vehicles at Intersections

Motor bus collisions with motor vehicles at intersections account for a yearly average of 1,448 or 41.0% of all motor bus collisions. For this analysis, intersections include signalized intersections, intersections with traffic control signs (i.e., stop signs or yield signs), and intersections without traffic control devices. The NTD does not differentiate between intersection types. This section of the report investigates motor bus collisions with motor vehicles at intersections in more detail by looking at the motor bus movement, motor vehicle movement, and spatial relationship between the vehicles when they collided. An overview of Section 5.4 is provided below:

- Section 5.4.1 discusses collisions between motor buses and motor vehicles at intersections when both vehicles are traveling in the same direction.
- Section 5.4.2 discusses collisions between motor buses and motor vehicles at intersections when the motor vehicle is approaching the motor bus at the intersection from the left.
- Section 5.4.3 discusses collisions between motor buses and motor vehicles at intersections when the motor vehicle is approaching the motor bus at the intersection from the right.
- Section 5.4.4 discusses collisions between motor buses and motor vehicles at intersections when the motor vehicle is approaching the motor bus from the opposite direction at the intersection.
- Section 5.4.5 discusses collisions between motor buses and motor vehicles at intersection when the motor vehicle is either leaving a bus stop or making a stop.

5.4.1 Intersection Collisions – Vehicles Traveling in Same Direction

Table 5-5 provides details of motor bus collisions with motor vehicles at intersections when both vehicles are traveling in the same direction, which account for 838 or 57.9% of all intersection collisions. As shown in this table, the top three collisions occur when the motor bus and the motor vehicle are both traveling in the same direction. The largest number of collisions occurs when the motor bus is rear-ended by a motor vehicle, accounting for 18.3% of collisions at intersections, followed by collisions in which the motor bus rear-ends a motor vehicle (14.3%). Collisions in which the motor bus and motor vehicle are driving in the same direction and a non-rear-ending occurs is the third most frequent with 9.5% of collisions at intersections. These collisions may occur when vehicles are switching lanes or passing each other, often resulting in side impact. The fourth highest number of collisions occurs when the motor bus is in the right lane, either stopped or going straight, and a motor vehicle to the left of the motor bus attempts to make a right turn from the left lane in front of the bus. This occurred an average of 109 times per year which accounted for 7.5% of all motor bus collisions with motor vehicles at intersections.

Figure 5-4 illustrates rear-end and rear-ending collisions at intersections. Rear-end and rear-ending collisions account for 32.6% of all intersection collisions between a motor bus and a motor vehicle and 13.4% of all motor bus collisions. As shown in the figure, instances where the motor vehicle rear-ends a motor bus (266 times) occur more frequently than when a motor bus rear-ends a motor vehicle (208 times).

Figure 5-5 depicts motor bus collisions with motor vehicles where both vehicles are driving in the same direction and going straight, but no rear-ending is involved. These collisions include

sideswipes and side impact resulting from vehicles switching lanes or passing. These collisions account for 9.5% of all intersection collisions between a motor bus and a motor vehicle and 3.9% of the total number of motor bus collisions.

Figure 5-6 depicts scenarios where the motor bus is stopped or going straight and a motor vehicle attempts to turn in front of the motor bus from an adjacent lane. As shown in the figure, these collisions are more likely to occur when a motor vehicle tries to turn right in front of the bus than turn left. There were 109 collisions when the motor vehicle turned right in front of the bus and 25 collisions when the motor vehicle turned left in front of the bus. Based on incident descriptions in the NTD, the analysis team can infer that the turning right in front of the bus collisions tend to occur when the motor bus is stopped at a bus stop or near an intersection and a motor vehicle is behind the motor bus and moves to the left lane in an attempt to pass the bus, and then turns right in front of the motor bus as it begins to accelerate forward.

Figure 5-7 and Figure 5-8 depict the situation where the motor bus and motor vehicle are traveling in the same direction at an intersection and the motor bus turns left or right, respectively. Both figures show that it is equally likely for collisions to occur when the motor vehicle is going straight or turning. It should be noted that the NTD does not differentiate which lane the motor vehicle is in when these collisions occur.

Table 5-5: 2009-2014 Average Number of Motor Bus Collisions with Motor Vehicles at Intersections – Both Vehicles Traveling in Same Direction

Category and Collisions Group	Number of Collisions	% of Category	% of All Intersection Collisions
Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	266	31.7%	18.3%
Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	208	24.8%	14.3%
Motor Vehicle Driving in Same Direction - Both Vehicles Going Straight, Non Rear-Ending/Ended	138	16.4%	9.5%
Motor Vehicle Turning Right in Front of Motor Bus	109	13.0%	7.5%
Both Vehicles Turning Left	36	4.3%	2.5%
Motor Vehicle Turning Left in Front of Motor Bus	25	3.0%	1.7%
Motor Bus Turning Left and Motor Vehicle Going Straight	23	2.8%	1.6%
Motor Bus Turning Right and Motor Vehicle Going Straight	21	2.5%	1.4%
Both Vehicles Turning Right	13	1.5%	0.9%
Total	**838**	**100%**	**57.9%**

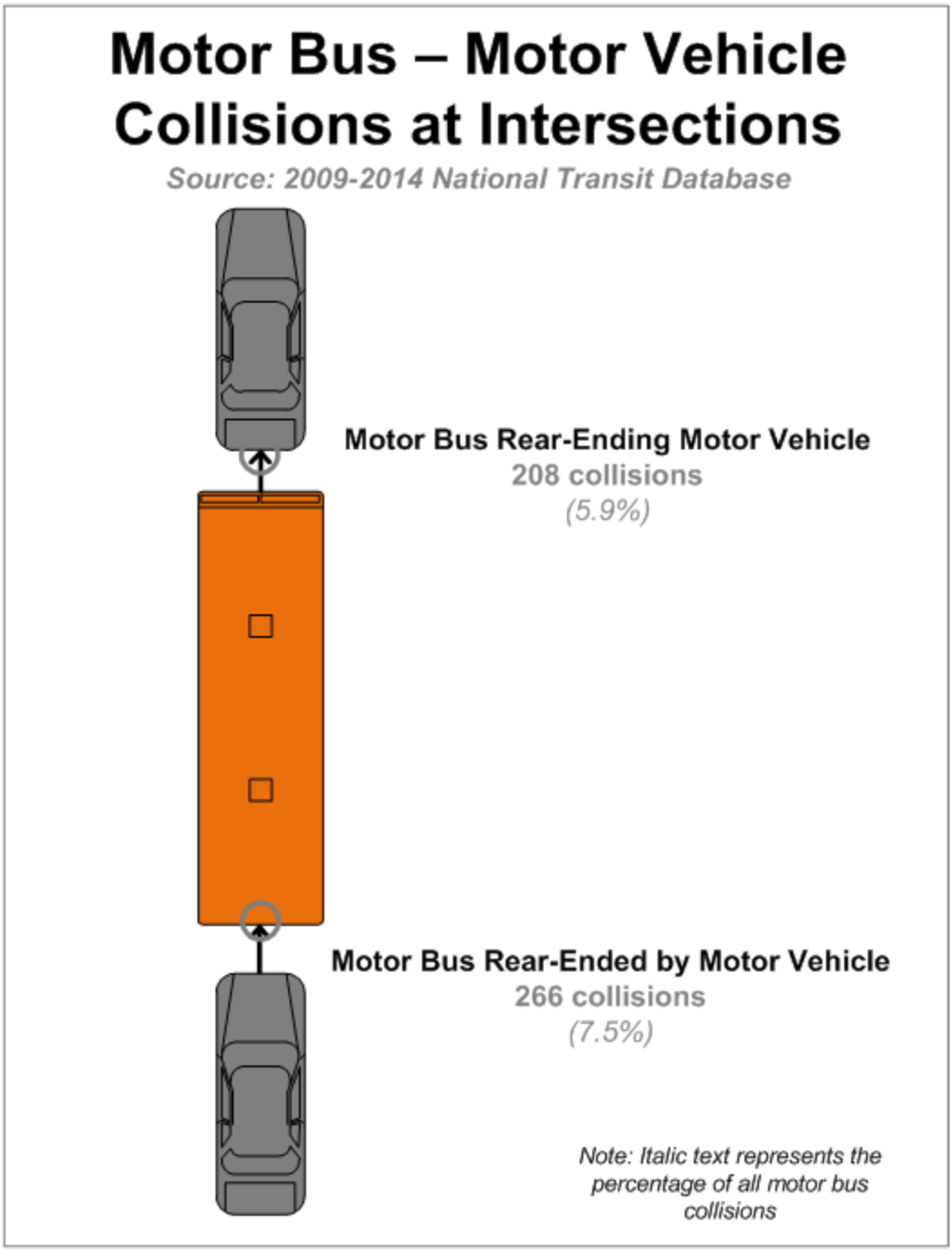


Figure 5-4: Motor Bus Going Straight and Motor Vehicle Going Straight at Intersections – Rear-End Collisions

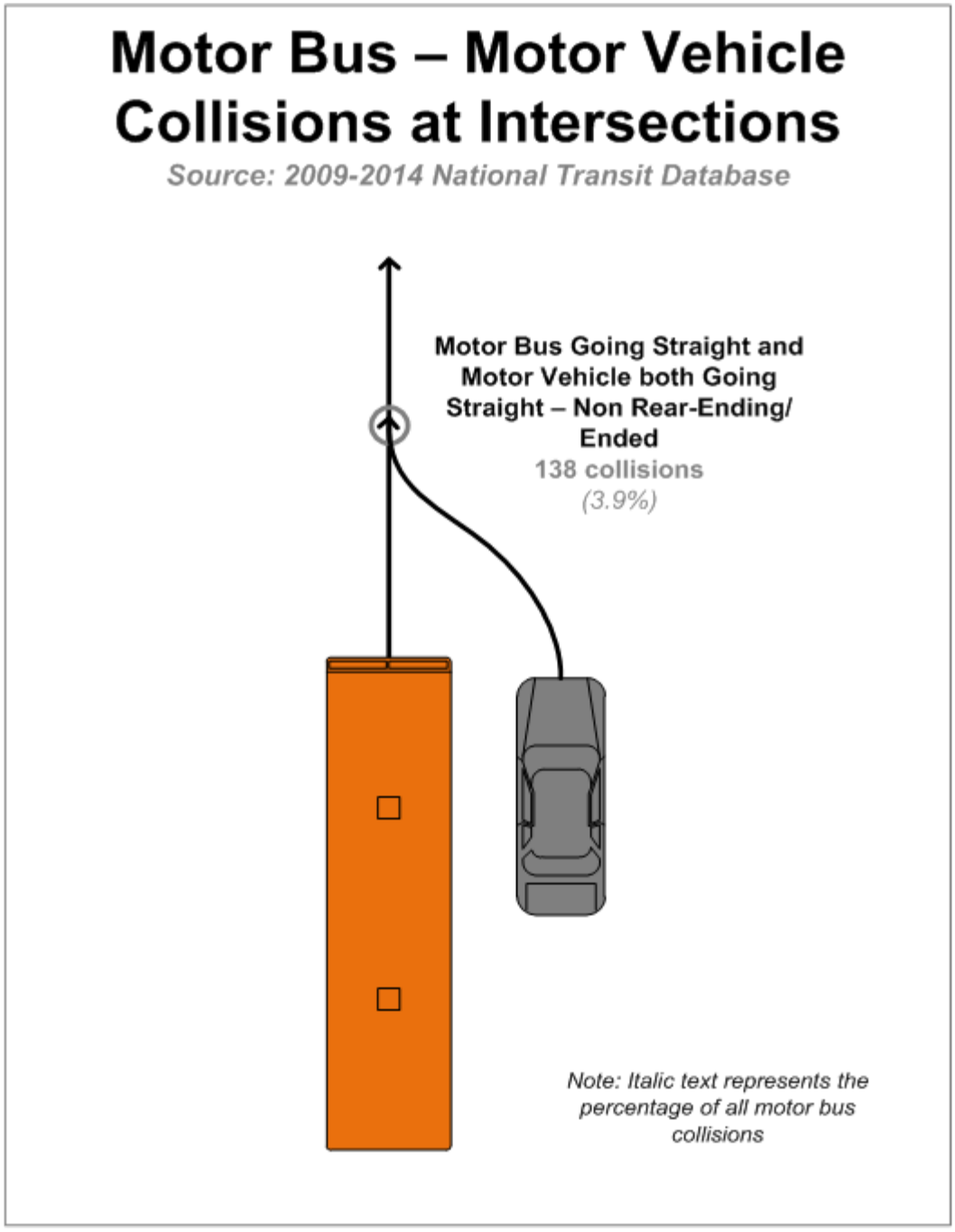


Figure 5-5: Motor Bus Going Straight and Motor Vehicle Going Straight at Intersections – Non Rear-Ending/Ended Collisions

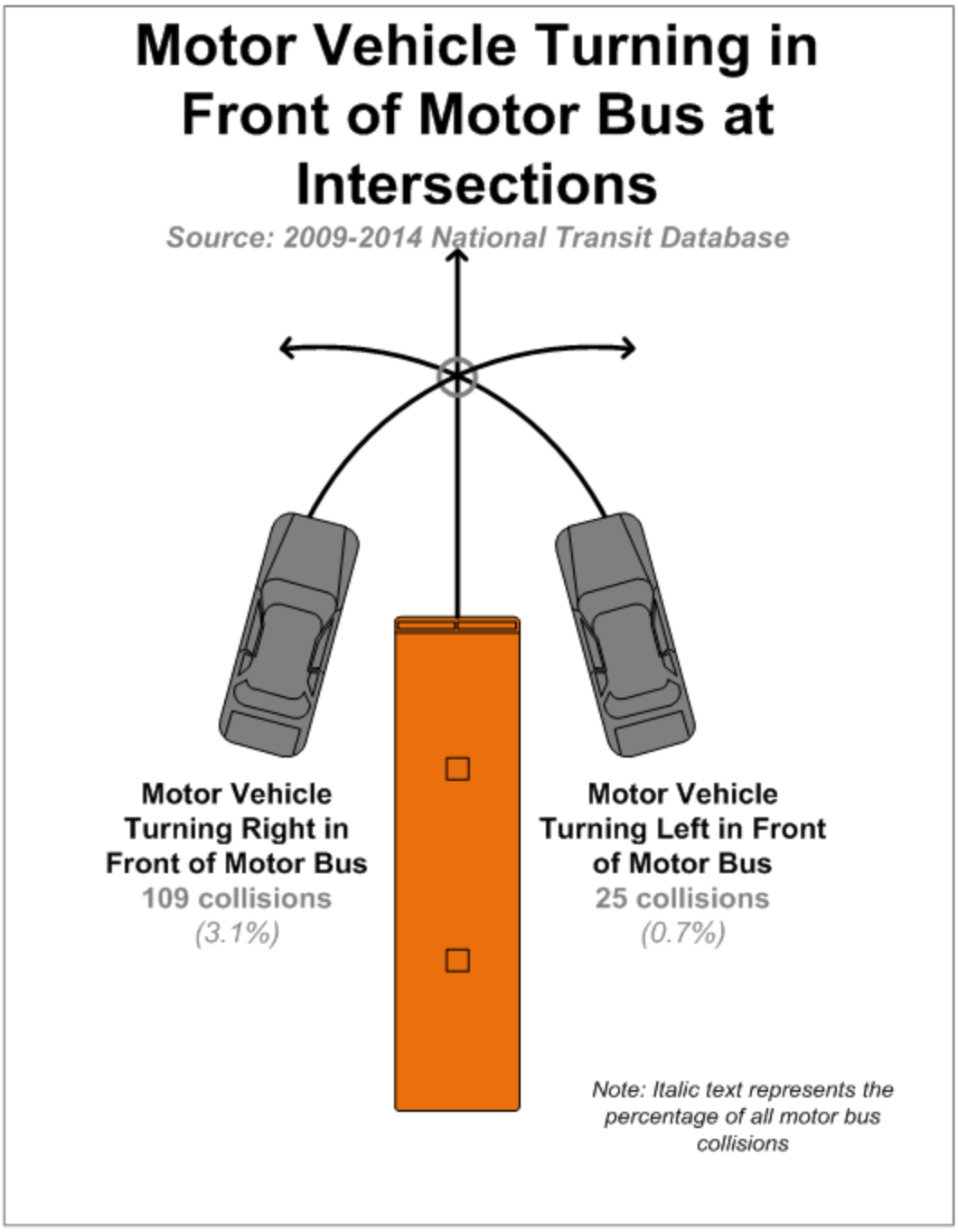


Figure 5-6: Motor Vehicle Turning in Front of Motor Bus at Intersection

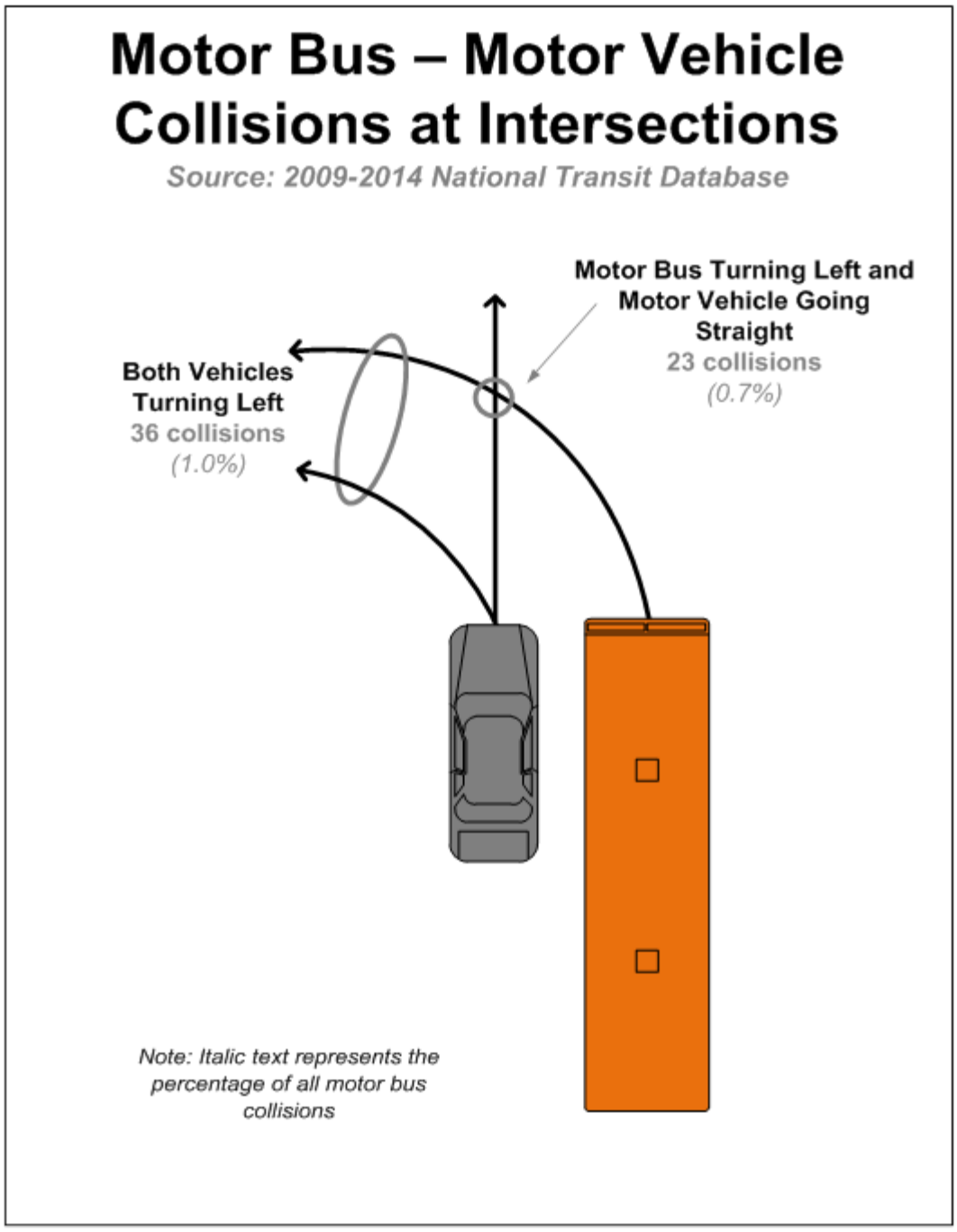


Figure 5-7: Motor Bus and Motor Vehicle Traveling in Same Direction – Motor Bus Turning Left at Intersection

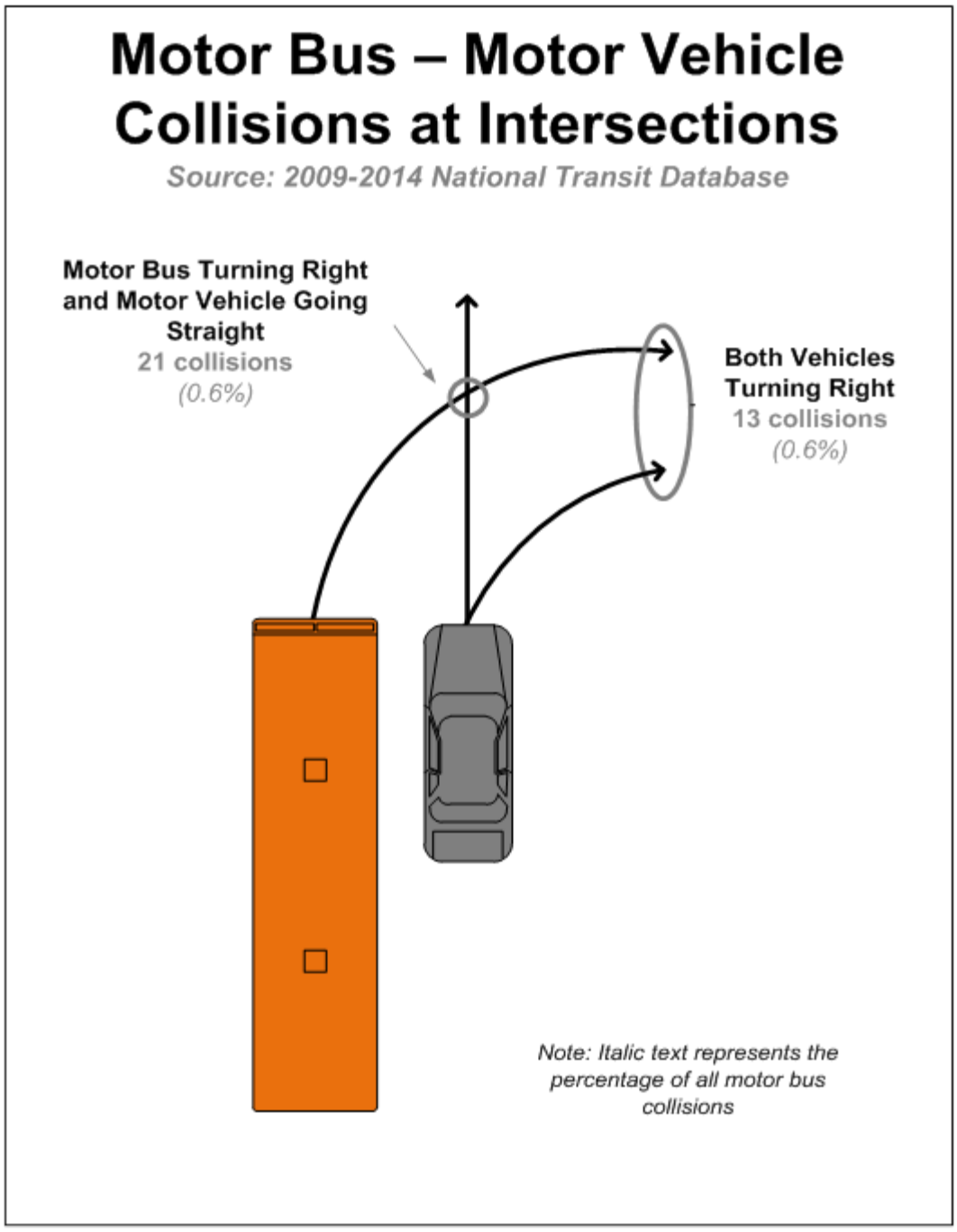


Figure 5-8: Motor Bus and Motor Vehicle Traveling in Same Direction – Motor Bus Turning Right at Intersection

5.4.2 Intersection Collisions - Motor Vehicle Approaching from Left

This section describes motor bus collisions with motor vehicles at intersections when the motor vehicle is approaching the motor bus at the intersection from the left. This accounted for an average of 138 collisions a year from 2009-2014, or 9.5% of all intersection collisions. As shown in Table 5-6, the largest percentage of collisions occurs when both vehicles are going straight through the intersection (103 collisions). The second highest number of collisions occurred when the motor bus turned left and the motor vehicle was going straight through the intersection, which accounted for 23 collisions. Figure 5-9 illustrates these types of collisions.

Table 5-6: 2009-2014 Average Number of Motor Bus Collisions with Motor Vehicles at Intersections – Motor Vehicle Approaching from Left

Category and Collisions Group	Number of Collisions	% of Category	% of All Intersection Collisions
Both Vehicles Going Straight	103	74.6%	7.1%
Motor Bus Turning Left and Motor Vehicle Going Straight	23	16.4%	1.6%
Motor Bus Going Straight and Motor Vehicle Turning Left	6	4.5%	0.4%
Motor Bus Turning Right and Motor Vehicle Going Straight	5	3.6%	0.3%
Motor Bus and Motor Vehicle Both Turning Left	1	0.9%	0.1%
Total	**138**	**100%**	**9.5%**

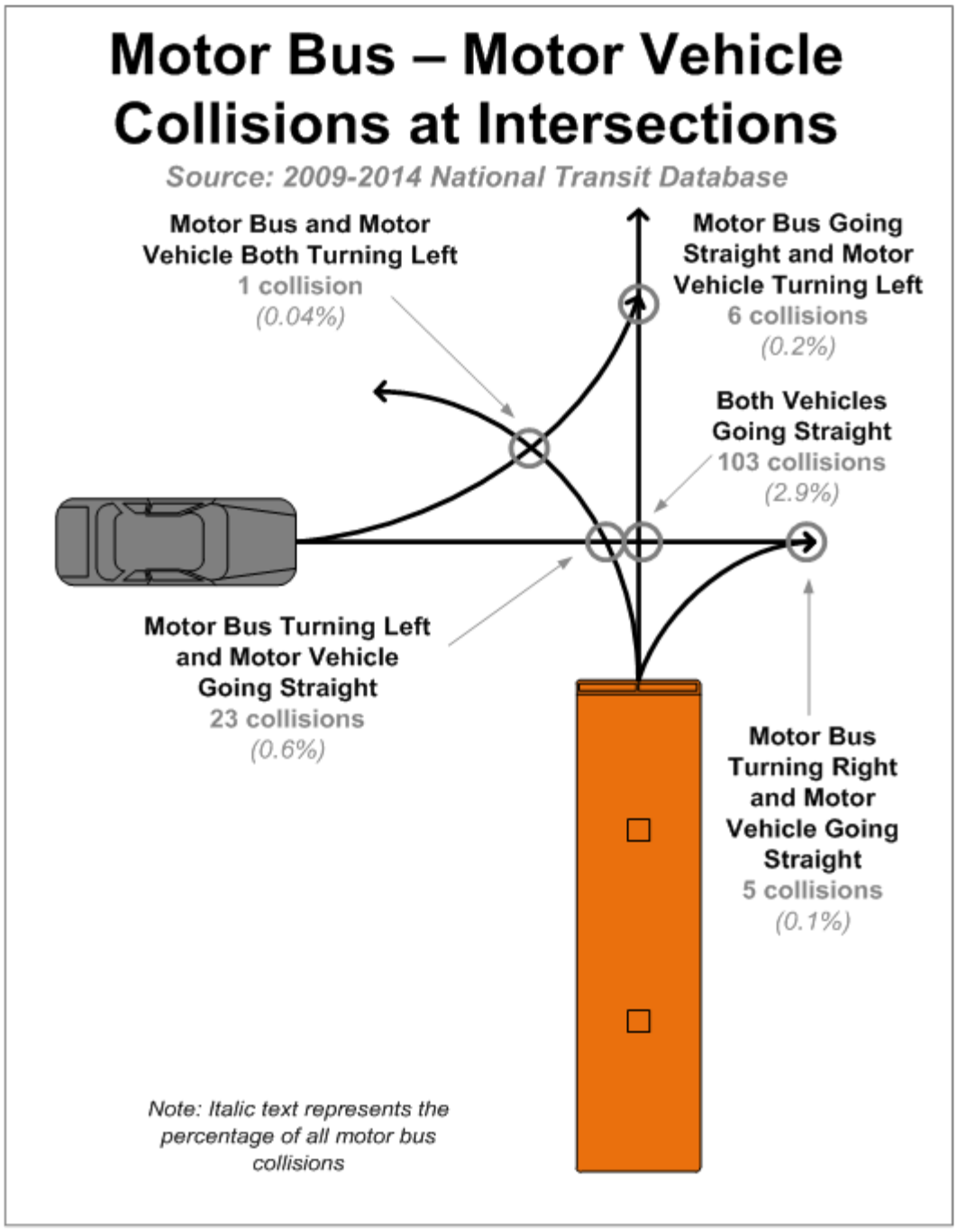


Figure 5-9: Motor Vehicle Approaching from Left at Intersection

5.4.3 Intersection Collisions - Motor Vehicle Approaching from Right

This section describes motor bus collisions with motor vehicles at intersections when the motor vehicle is approaching the motor bus at the intersection from the right. This accounted for approximately 169 collisions or 11.7% of all intersection collisions. As shown in Table 5-7, the largest percentage of collisions occurs when both vehicles are going straight, which accounts for 138 collisions. The second highest number of collisions occurred when the motor vehicle turned right and the motor bus was going straight through the intersection (16 collisions). Figure 5-10 illustrates these types of collisions.

Table 5-7: 2009-2014 Average Number of Motor Bus Collisions with Motor Vehicles at Intersections – Motor Vehicle Approaching from Right

Category and Collisions Group	Number of Collisions	% of Category	% of All Intersection Collisions
Both Vehicles Going Straight	138	81.8%	9.5%
Motor Bus Going Straight and Motor Vehicle Turning Right	16	9.5%	1.1%
Motor Bus Turning Left and Motor Vehicle Going Straight	9	5.1%	0.6%
Motor Bus Going Straight and Motor Vehicle Turning Left	6	3.6%	0.4%
Motor Bus and Motor Vehicle Both Turning Left	0	0.0%	0.0%
Total	**169**	**100%**	**11.7%**

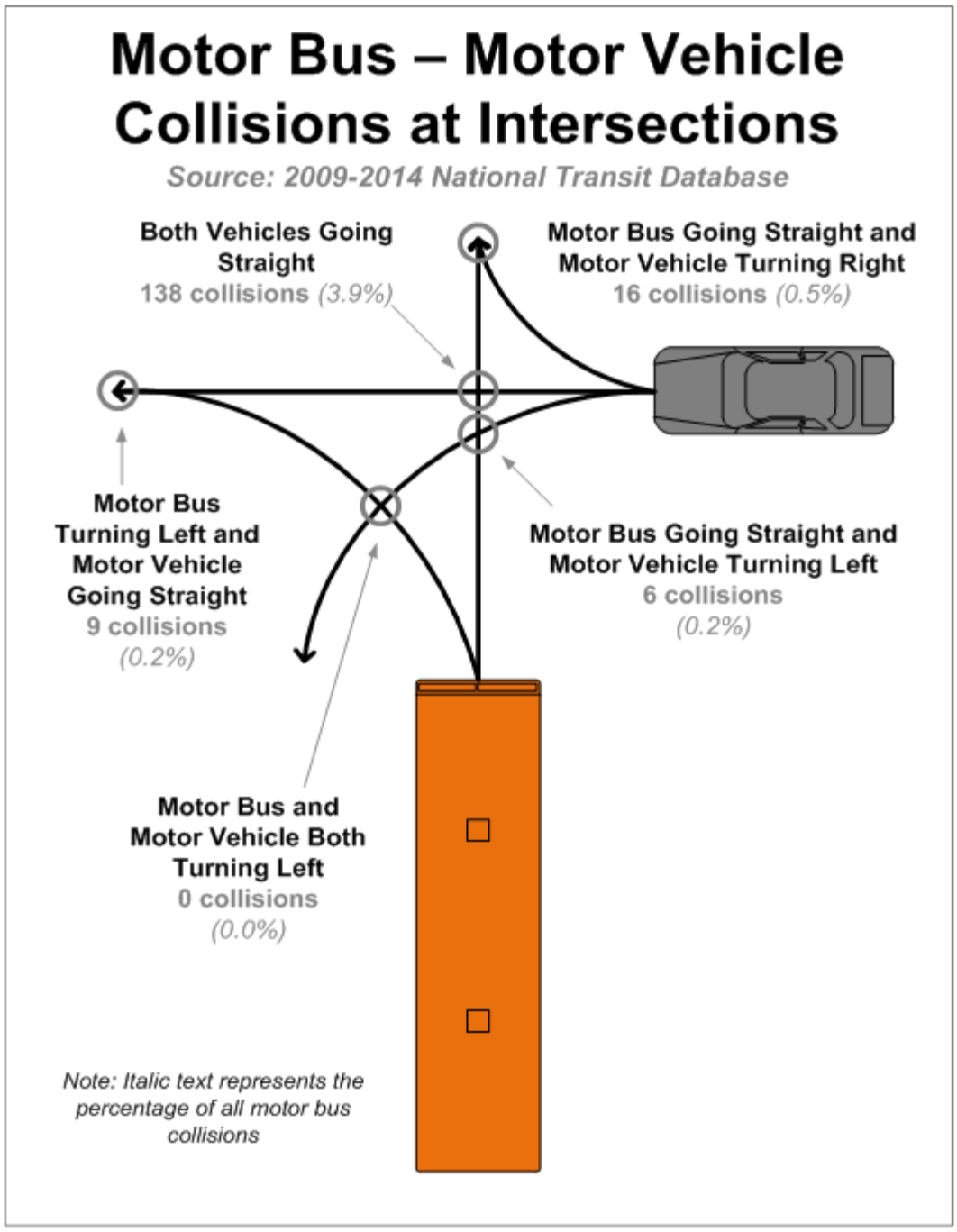


Figure 5-10: Motor Vehicle Approaching from Right at Intersection

5.4.4 Intersection Collisions – Motor Vehicle Approaching the Motor Bus at the Intersection from the Opposite Direction

Table 5-8 below summarizes collisions between motor buses and motor vehicles at intersections when the motor vehicle is approaching the motor bus at the intersection from the opposite direction. This accounted for an average of 185 collisions a year or 12.7% of all intersection collisions. These collisions are most likely to occur when one of the vehicles is turning left and the other is going straight. There were 75 collisions when the motor bus was going straight and the motor vehicle was turning left which accounted for 5.2% of all motor bus collisions at intersections. There were 64 collisions when the motor bus was turning left and motor vehicle was going straight which accounted for 4.4% of all motor bus collisions at intersections. These two collision types represent classic left-turn-conflict collisions.

There were 36 collisions when the motor bus and motor vehicle were both going straight in a head-on type accident, which accounted for 2.5% of all intersection collisions. The other collision categories represented only a small percentage of collisions at intersections. Figure 5-11 illustrates these types of collisions.

Table 5-8: 2009-2014 Average Number of Motor Bus Collisions with Motor Vehicles at Intersections – Motor Vehicle Approaching the Motor Bus at the Intersection from the Opposite Direction

Category and Collisions Group	Number of Collisions	% of Category	% of All Intersection Collisions
Motor Bus Going Straight and Motor Vehicle Turning Left	75	40.8%	5.2%
Motor Bus Turning Left and Motor Vehicle Going Straight	64	34.6%	4.4%
Motor Bus and Motor Vehicle Both Going Straight - Head-on Collision	36	19.3%	2.5%
Motor Bus Turning Left and Motor Vehicle Turning Right	4	2.4%	0.3%
Motor Bus Turning Right and Motor Vehicle Turning Left	3	1.7%	0.2%
Both Vehicles Turning Left	2	1.1%	0.1%
Total	**185**	**100%**	**12.7%**

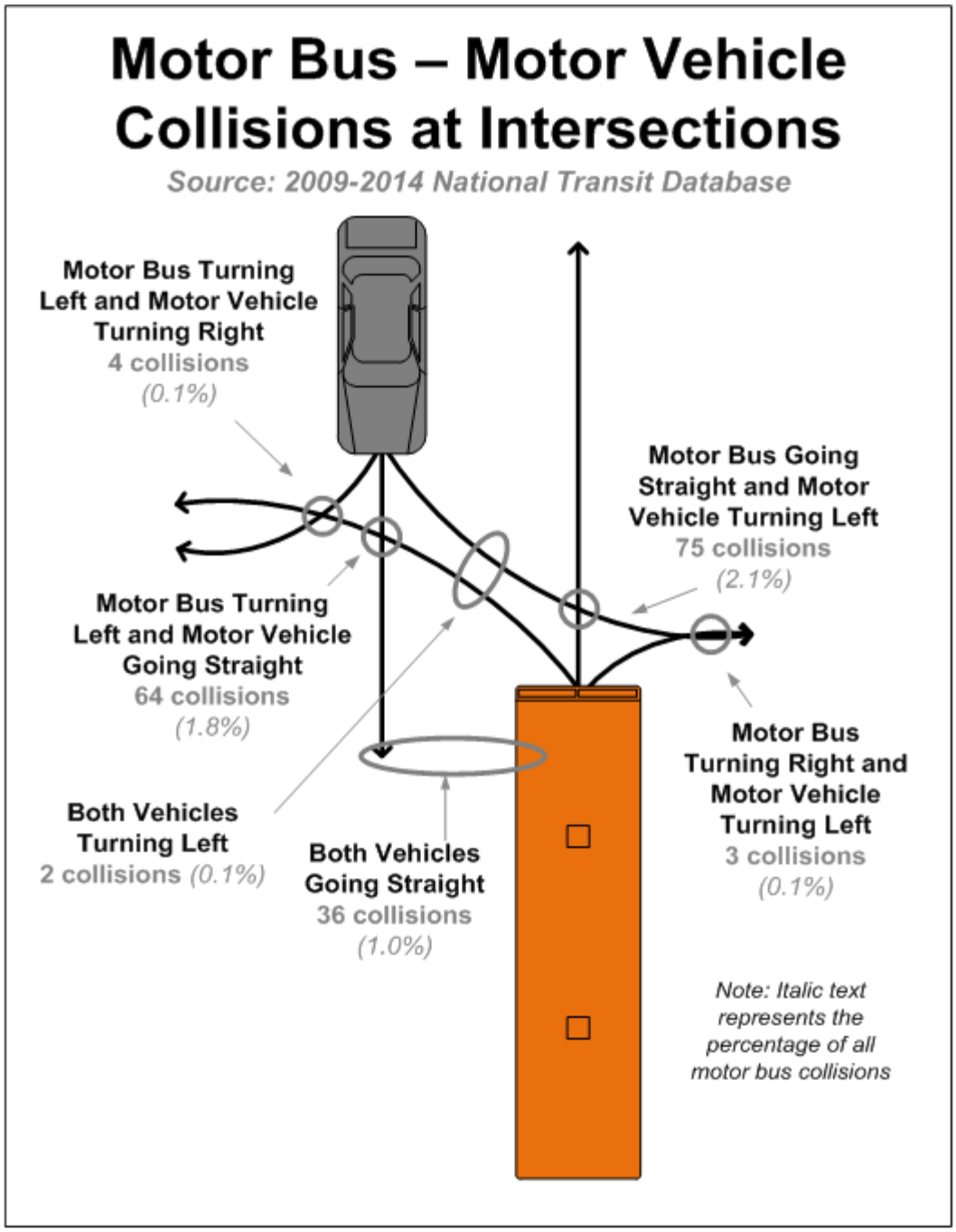


Figure 5-11: Motor Vehicle Approaching the Motor Bus at the Intersection from the Opposite Direction

5.4.5 Intersection Collisions – Motor Bus Leaving or Making a Stop

Table 5-9 describes motor bus collisions with motor vehicles at intersections when the motor bus is either leaving a stop or making a stop. On average there were 72 collisions a year when the motor bus was leaving a stop, which accounted for 5.0% of all intersection collisions. There were 47 collisions when the motor bus was a making a stop, accounting for 3.2% of all intersection collisions. These collisions figures show that there is a greater likelihood of the motor bus making contact with another vehicle when it is pulling out after completing a stop than when it is pulling into a stop. Figure 5-12 illustrates these types of collisions.

Section 6 of this report provides a greater analysis of motor bus collisions while the motor bus is leaving and making a stop.

Table 5-9: 2009-2014 Average Number of Motor Bus Collisions with Motor Vehicles at Intersections - Motor Bus Leaving or Making a Stop

Category and Collisions Group	Number of Collisions	% of Category	% of All Intersection Collisions
Motor Bus Leaving a Bus Stop	72	60.6%	5.0%
Motor Bus Making a Bus Stop	47	39.4%	3.2%
Total	**119**	**100%**	**8.2%**

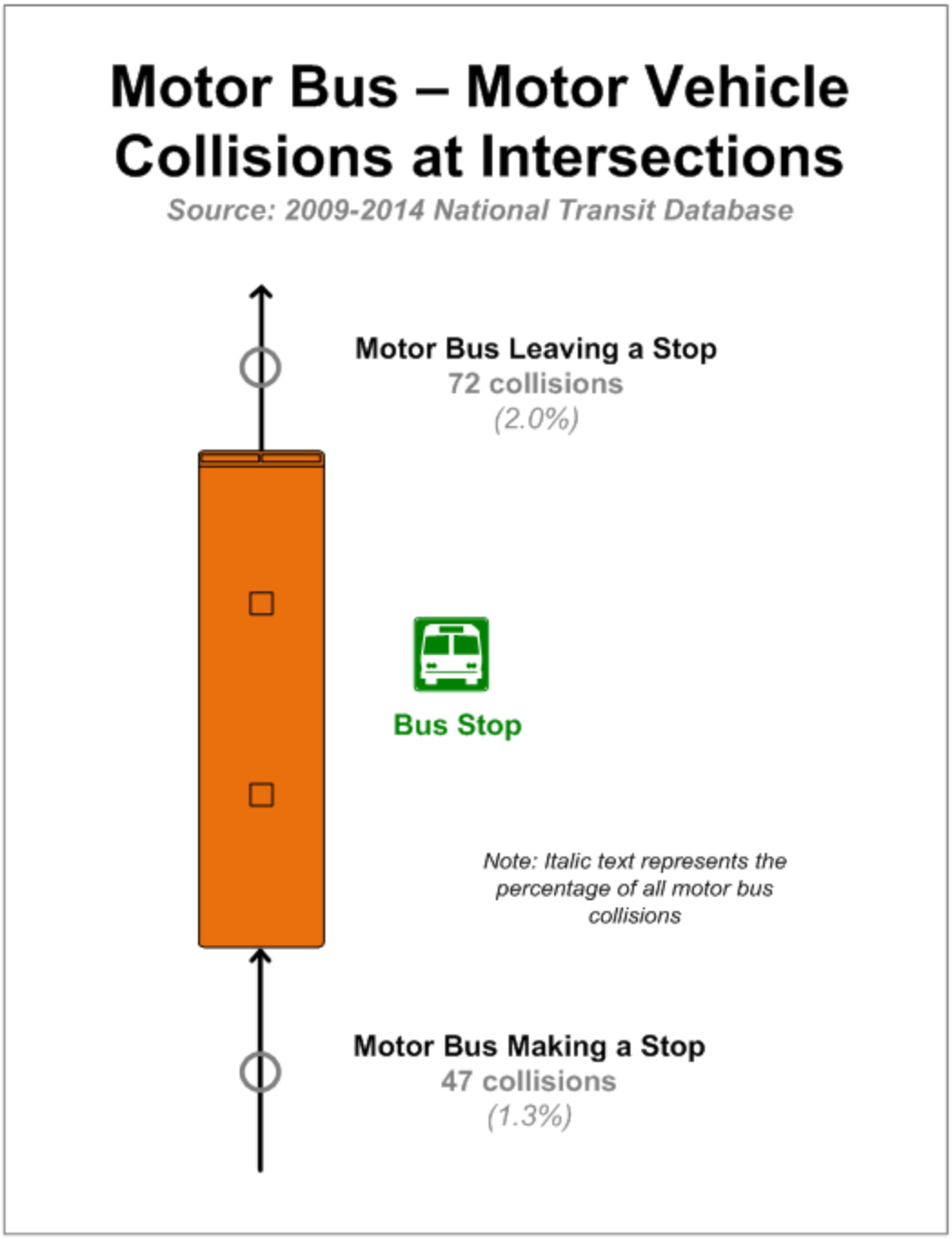


Figure 5-12: Motor Bus Collision with Motor Vehicles at Intersections near Bus Stops

5.5 Motor Bus Collisions with Motor Vehicles at Mid-Block

As shown in Table 5-10 there were an average of 865 mid-block collisions a year between motor buses and motor vehicles. Collisions in which the motor bus is not going straight (i.e., making a turn, leaving a stop, or making a stop) are labeled in the category and collision type field below. Collisions where both vehicles are going straight and driving in the same direction represent 69.9% of all mid-block collisions. Nearly half of all mid-block collisions (46.8%) involve rear-end collisions. Figure 5-13 illustrates these types of collisions. Instances where the motor vehicle rear-ends the motor bus occur more frequently than a motor bus rear-ending a motor vehicle, with an average of 238 and 167 collisions, respectively. Figure 5-14 illustrates collisions types where both vehicles are going straight and in the same direction, but a rear-end collision does not occur. These account for an average of 200 collisions a year or 23.1% of all mid-block collisions. Collisions in which both vehicles are going straight and the motor vehicle is approaching from the left or right accounted for an average of 41 collisions a year, or 4.8% of all mid-block collisions. It also illustrates collisions in which the motor vehicle approached the motor bus from either the left or right.

Table 5-10: 2009-2014 Average Number of Motor Bus Collisions with Motor Vehicle at Mid-Block

Category and Collision Type	Number of Collisions	% of Mid-Block Collisions
Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	238	27.5%
Motor Vehicle Driving in Same Direction - Both Vehicles Going Straight, No Rear-End	200	23.1%
Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	167	19.3%
Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	57	6.5%
Motor Vehicle Approaching from Left or Right	41	4.8%
Motor Bus Leaving a Stop	41	4.8%
Motor Bus Making a Stop	38	4.4%
Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	35	4.1%
Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	17	2.0%
Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	16	1.8%
Motor Bus Making a Turn - Motor Vehicle Driving in Same Direction*	11	1.3%
Motor Bus Making a Turn - Motor Vehicle Driving Towards Bus and Going Straight*	3	0.4%
Total	**865**	**100%**

** Collisions at mid-block in which the bus is making a turn often involve turning into a parking lot or similar entrance, and thus the direction of the turn (left or right) is often not indicated or is unclear from the incident description. For this reason, collisions at mid-block in which the bus is making a turn have been grouped together, regardless of turning direction.*

Figure 5-15 illustrates mid-block collisions when the motor vehicle is approaching the motor bus from the opposite direction. As illustrated in this figure, there were 57 head-on collisions when both vehicles were going straight, accounting for 6.5% of all mid-block collisions. There were 16 collisions reported when the motor vehicle turned left in front of the bus, accounting for 1.8% of all

mid-block collisions. These collisions may occur when a motor vehicle is turning left into a minor street such as a driveway or shopping center in front of the motor bus.

Figure 5-16 illustrates mid-block collisions where the motor bus and motor vehicle are traveling in the same direction and the motor vehicle attempts to: (a) turn right in front of the motor bus from the left lane, or (b) turn left in front of the motor bus from the right lane. This action is identical to the actions described at intersections and most likely occurs when the motor bus stops and the motor vehicle behind the motor bus attempts to pass the bus. Similar to intersections, there were more collisions that occurred when the motor vehicle attempted to turn right in front of the bus, at 35 times, than attempting to turn left, at only 17 times.

Figure 5-17 illustrates collisions where the motor bus was making a turn mid-block. These collisions tend to occur when the motor bus is turning into a mid-block entrance-way, off-street bus bay or transit station. These collisions were broken down into two categories based on the motor vehicle movements. An average of 11 of collisions occurred when the motor vehicle was driving in the same direction, accounting for 1.3% of all mid-block collisions. Only 3 collisions (0.4%) occurred when the motor vehicle was going straight and approaching the motor bus in the opposite direction.

Figure 5-18 illustrates mid-block collisions occurring as the motor bus is leaving or making a bus stop near a mid-block. Motor bus collisions with motor vehicles while leaving a stop account for an average of 41 collisions a year, accounting for 4.8% of all mid-block collisions. Motor bus collisions with motor vehicles while making a stop account for 38 collisions a year and 4.4% of all mid-block collisions. Collisions in this category were classified based on a field (leaving or making a stop) that transit operators can choose from when reporting a collision.

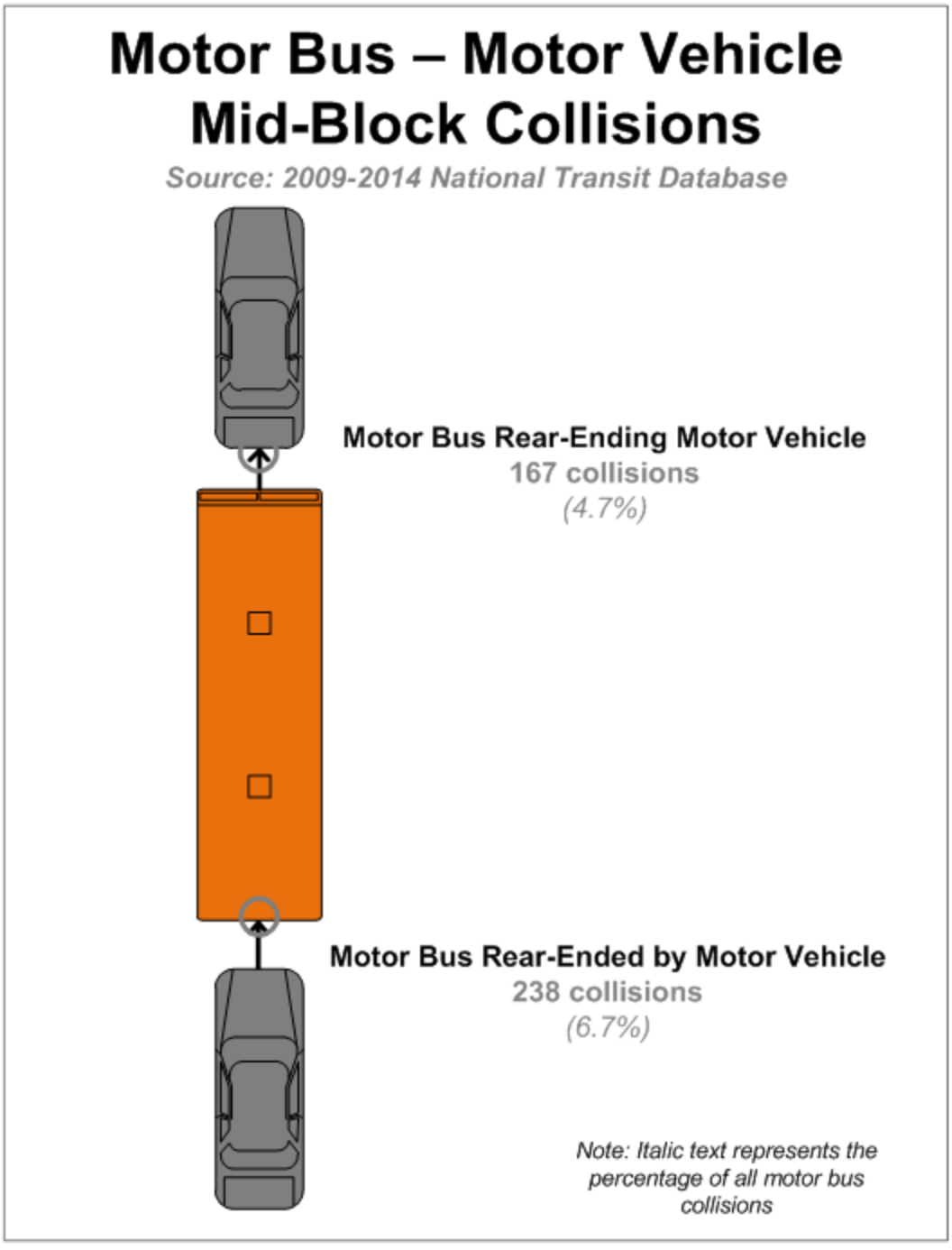


Figure 5-13: Motor Bus Going Straight and Motor Vehicle Going Straight at Mid-Block – Rear End Collisions

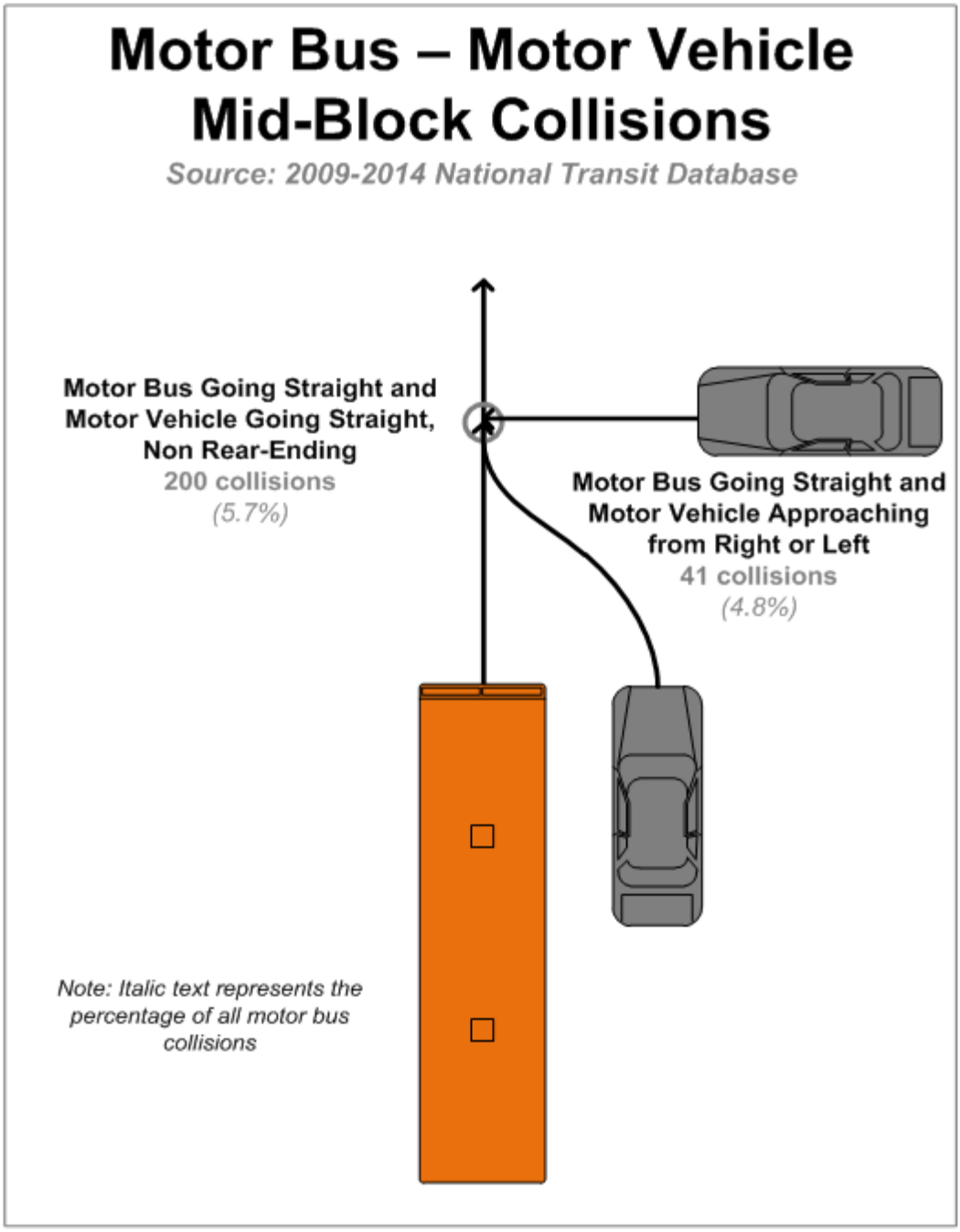


Figure 5-14: Motor Bus and Motor Vehicle Collisions at Mid-Block – Both Vehicles Going Straight Non Rear-Ending

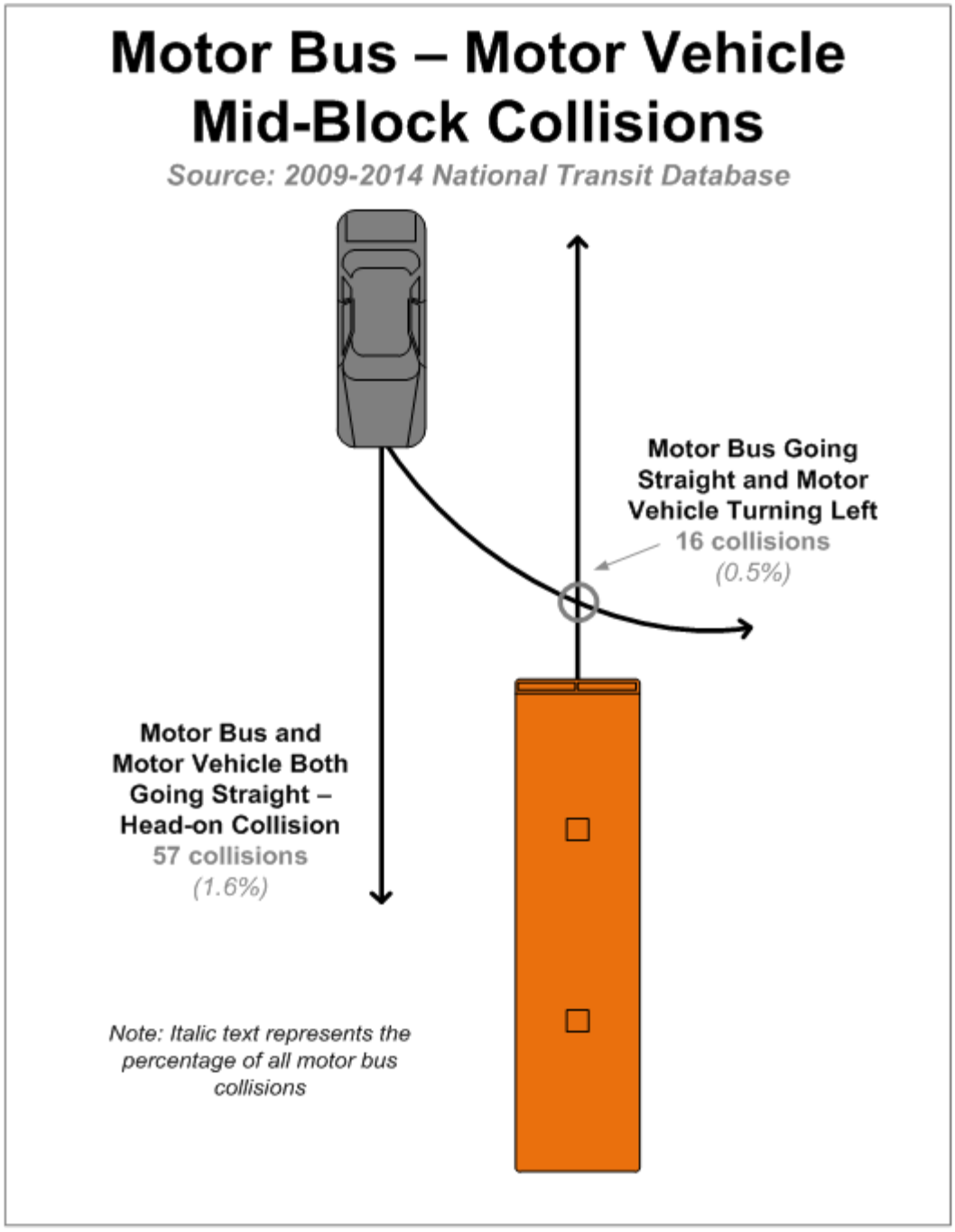


Figure 5-15: Motor Vehicle Approaching the Motor Bus from the Opposite Direction at Mid-Block

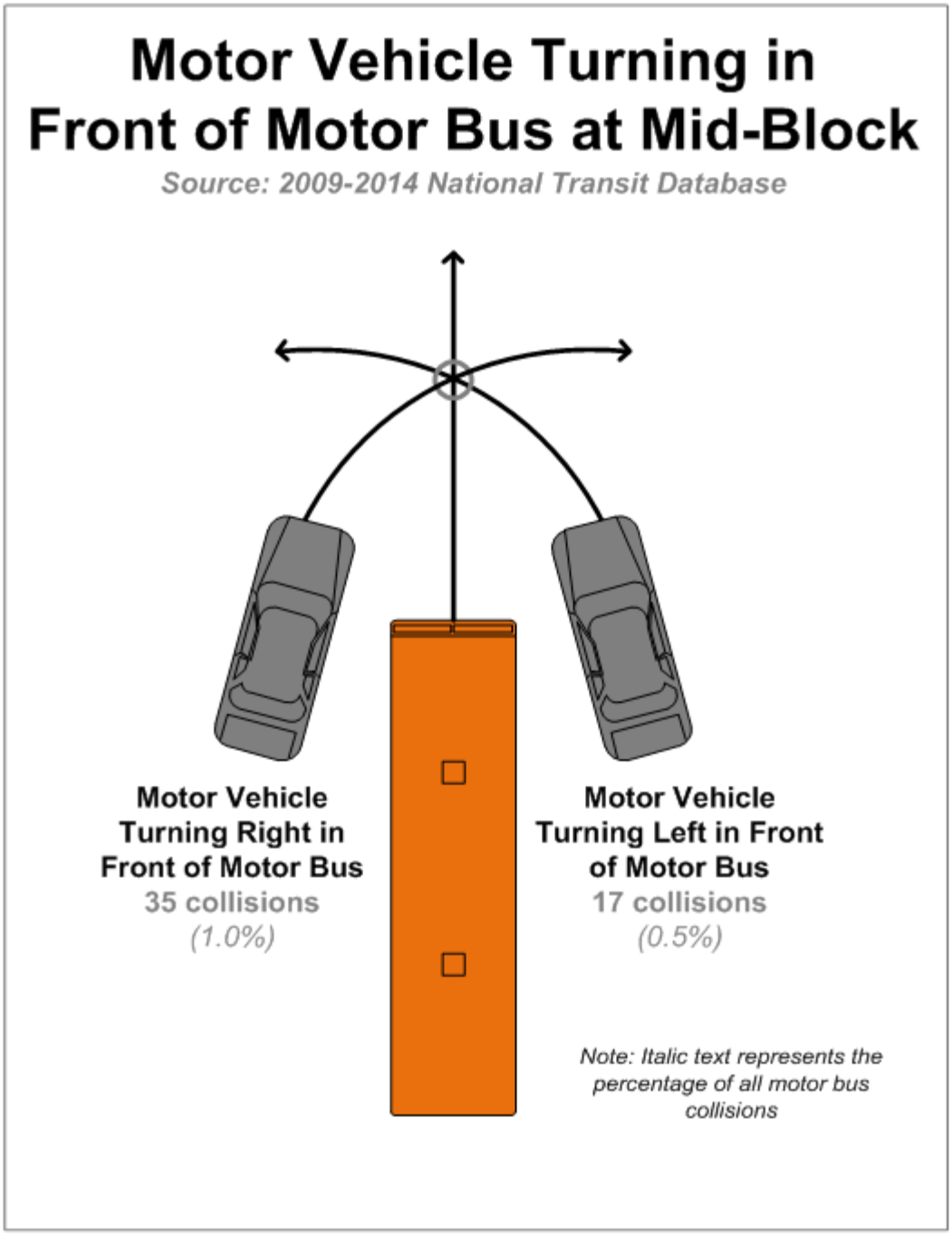


Figure 5-16: Motor Vehicle Turning in Front of Motor Bus at Mid-Block

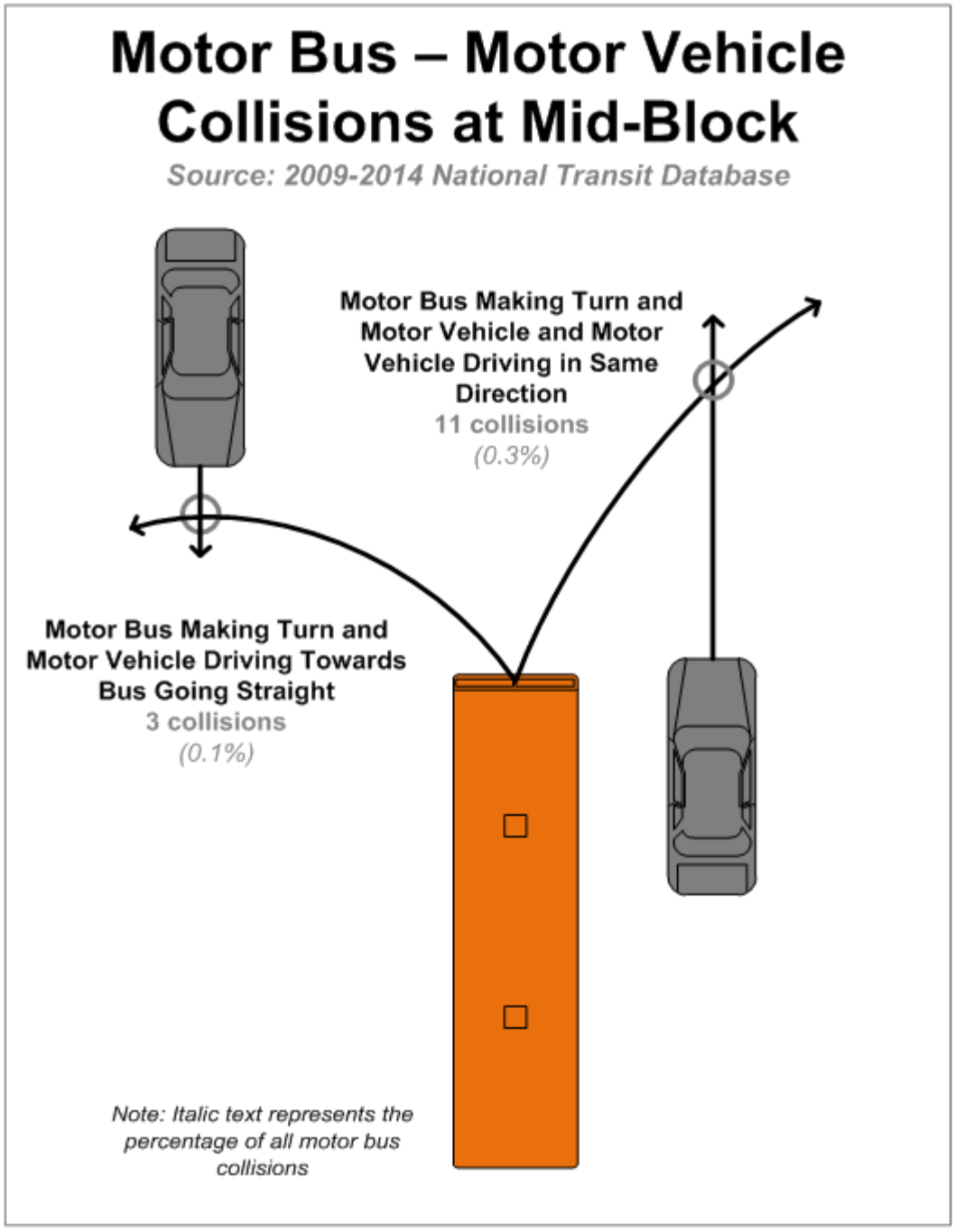


Figure 5-17: Motor Bus Making a Turn at Mid-Block

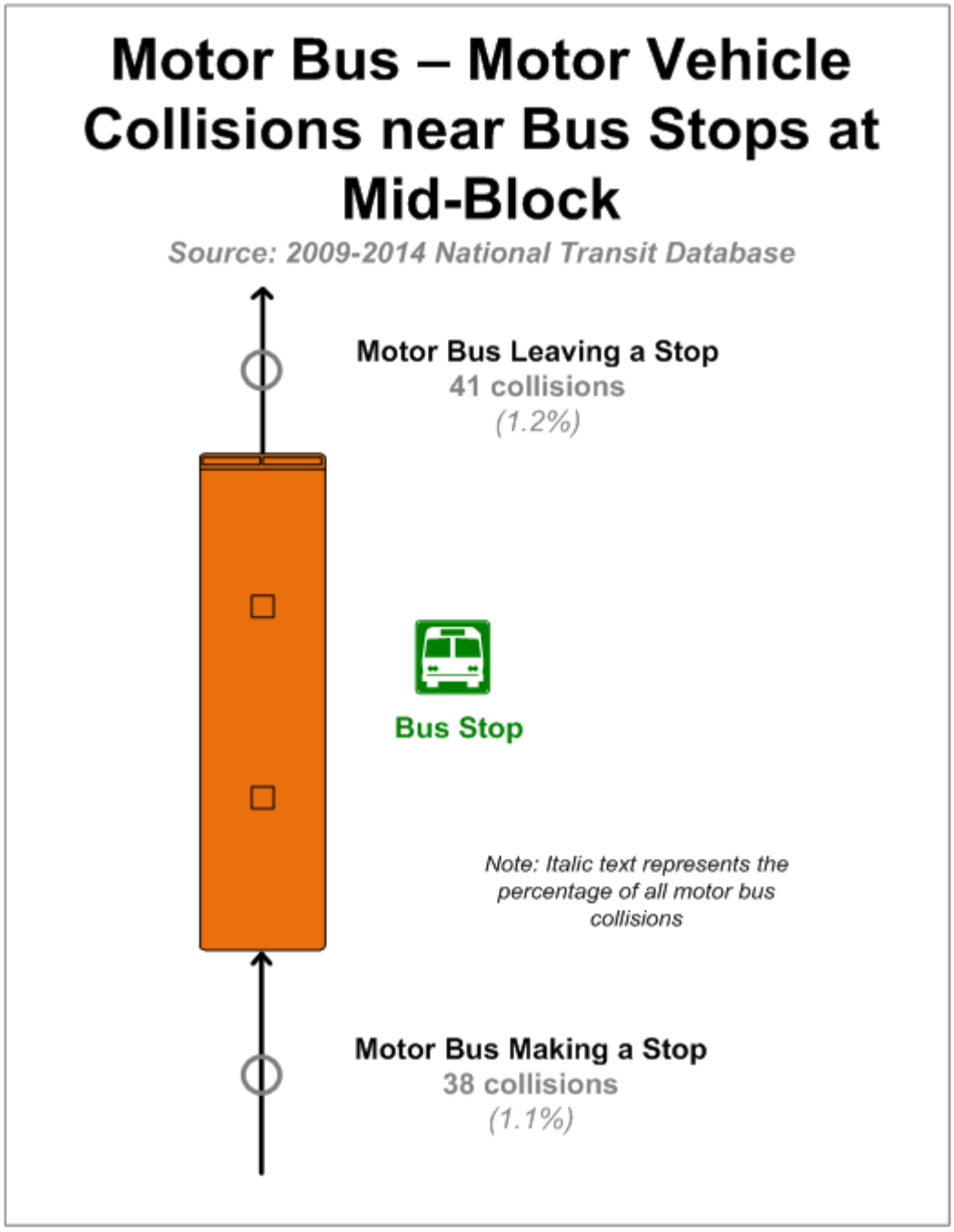


Figure 5-18: Motor Bus Collisions with Motor Vehicles near Bus Stops at Mid-Block

5.6 Motor Bus Collisions with Motor Vehicles at Bus Stops

Table 5-11 shows motor bus collisions with motor vehicles at bus stops. The bus stop location was added to the NTD in 2011; as a result, yearly averages are calculated only between the years that the categories were available. There were an average of 581 collisions at bus stops each year between 2011 and 2014. The majority of these (85.3% of bus stop collisions) occurred while the motor bus was stopped. Collisions where the motor bus was leaving a stop accounted for 6.9% of bus stop collisions and those where the motor bus was making a stop accounted for 6.2% of bus stop collisions. Only 1.6% of bus stop collisions involved other motor bus movements (going straight, making a turn, etc.) The table below breaks down collisions by both motor bus and motor vehicle movement, as well as the spatial relationship between the two vehicles.

The vast majority of bus stop collisions occur when the motor bus is stopped and is rear-ended by a motor vehicle. These collisions account for 72.6% of all bus stop collisions and 11.9% of all motor bus collisions. All other collision types each accounted for less than 10% of all bus stop collisions. Illustrations of the collisions categories are presented below in Figure 5-19, Figure 5-20, Figure 5-21, and Figure 5-22. The frequencies of each scenario are presented for motor bus leaving a stop, making a stop, and stopped at a bus stop. There were an average of 9 collisions a year in which the motor bus was not making one of these three movements and was instead going straight, making a turn, etc. These collisions are not shown in the figures since they represent only 1.6% of all bus stop collisions and 0.3% of all motor bus collisions and encompass a variety of different motor bus movements.

Collisions occurring when the motor bus is rear-ended by a motor vehicle are the most frequent for each of the three motor bus movements – making a stop, leaving a stop, and stopped. There were an average of 23 of these rear-ended collisions when the motor bus is making a stop, 19 collisions when the motor bus is leaving a stop, and 422 collisions when the motor bus is stopped at a bus stop. The analysis shows that rear-ended collisions are the most frequent type of collision at a bus stop, regardless of the motor bus action at the stop.

Table 5-11: 2009-2014 Average Number of Motor Bus and Motor Vehicle Collisions at Bus Stops

Motor Bus Movement	Category and Collision Type	Number of Collisions	% of Bus Stop Collisions
Stopped	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	422	72.6%
Stopped	Motor Vehicle Driving in Same Direction - Both Vehicles Going Straight, No Rear-End	52	9.0%
Making a Bus Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	23	4.0%
Leaving a Bus Stop	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	19	3.3%
Leaving a Bus Stop	Motor Vehicle Driving in Same Direction - Both Vehicles Going Straight, No Rear-End	10	1.7%
Other - going straight, making a turn, etc.	Motor Vehicle Driving in Same Direction - Motor Vehicle Going Straight	9	1.6%
Making a Bus Stop	Motor Vehicle Driving in Same Direction - Both Vehicles Going Straight, No Rear-End	9	1.5%

Motor Bus Movement	Category and Collision Type	Number of Collisions	% of Bus Stop Collisions
Stopped	Motor Vehicle Approaching from Left or Right	8	1.3%
Leaving a Bus Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	7	1.3%
Stopped	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	6	1.0%
Stopped	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	6	1.0%
Leaving a Bus Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	2	0.3%
Making a Bus Stop	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	2	0.3%
Making a Bus Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	1	0.2%
Stopped	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	1	0.2%
Leaving a Bus Stop	Motor Vehicle Approaching from Left or Right	1	0.2%
Leaving a Bus Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	1	0.1%
Making a Bus Stop	Motor Vehicle Approaching from Left or Right	1	0.1%
Stopped	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	1	0.1%
Leaving a Bus Stop	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	0	0.0%
Leaving a Bus Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	0	0.0%
Making a Bus Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	0	0.0%
Making a Bus Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	0	0.0%
Making a Bus Stop	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	0	0.0%
Stopped	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	0	0.0%
Total		**581**	**100%**

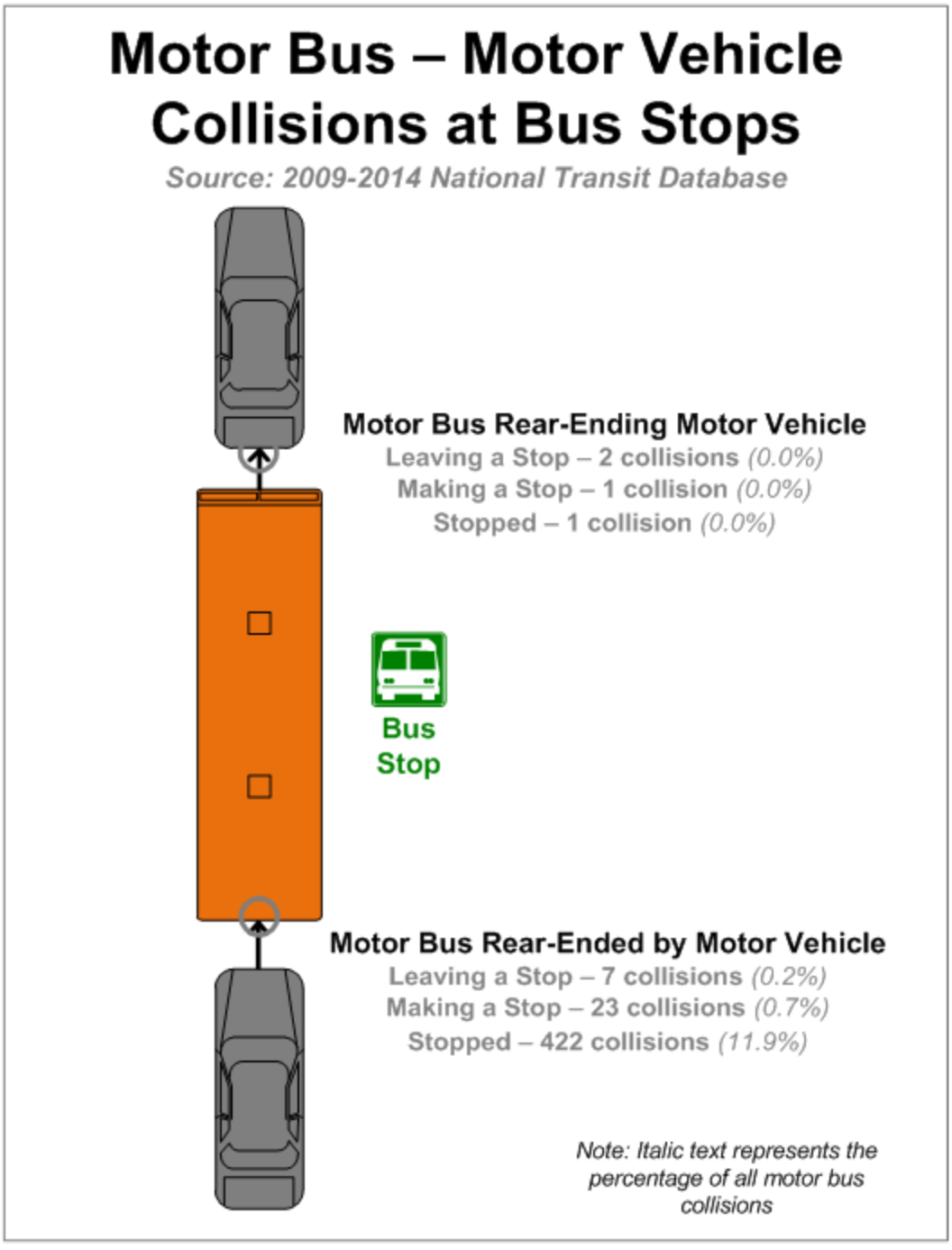


Figure 5-19: Motor Bus Collisions with Motor Vehicles at Bus Stops

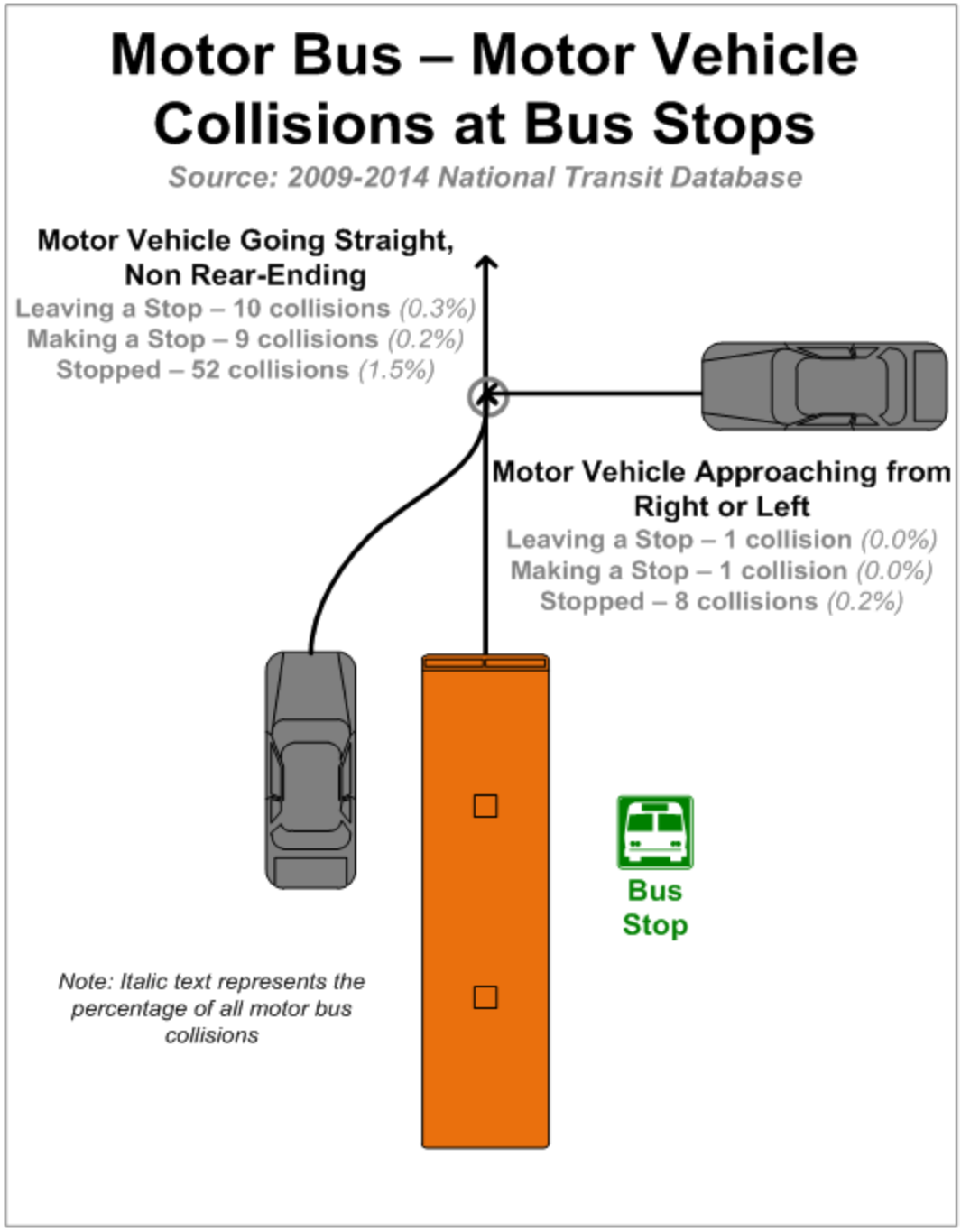


Figure 5-20: Motor Bus Collisions with Motor Vehicles at Bus Stops

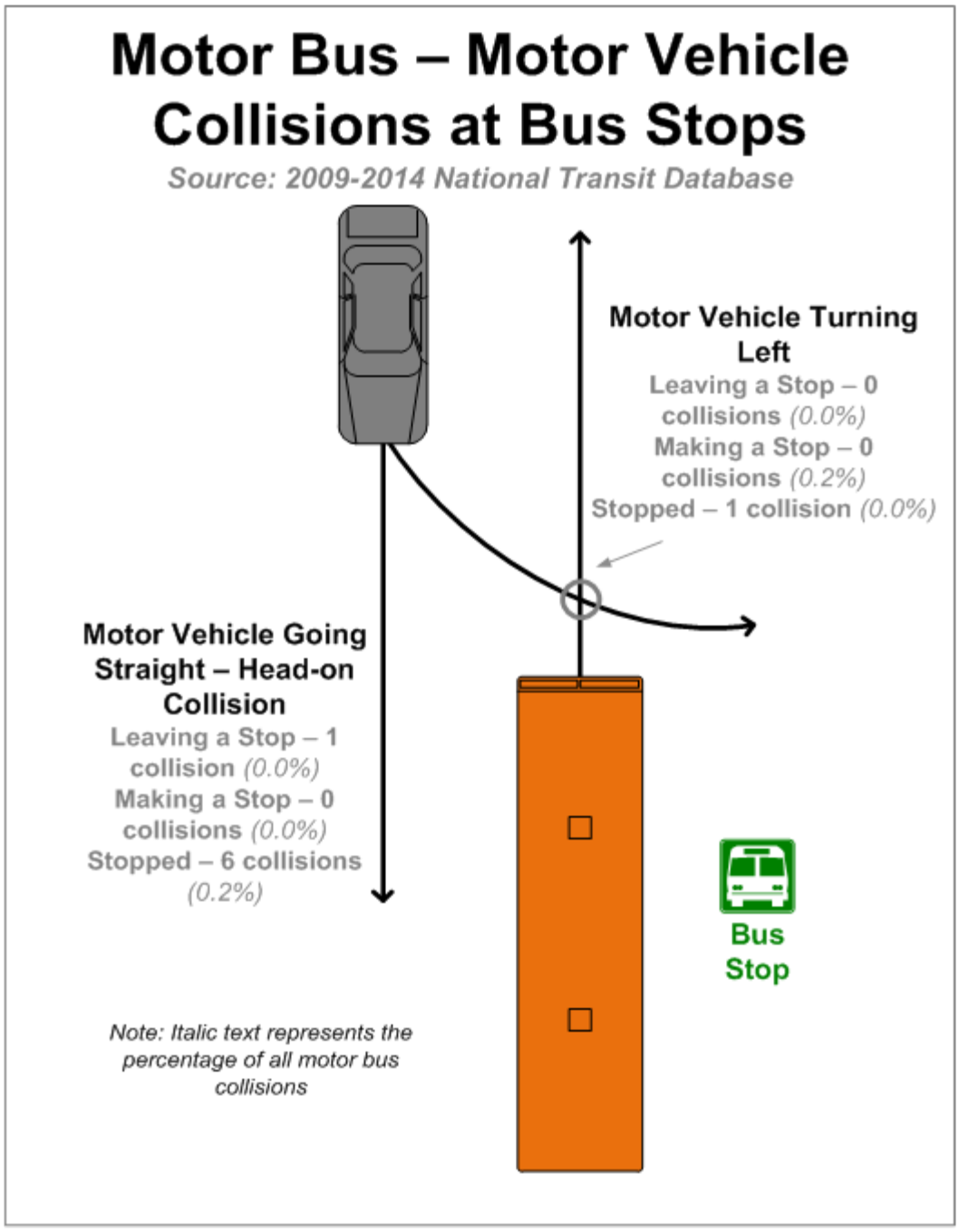


Figure 5-21: Motor Bus Collisions with Motor Vehicles at Bus Stops

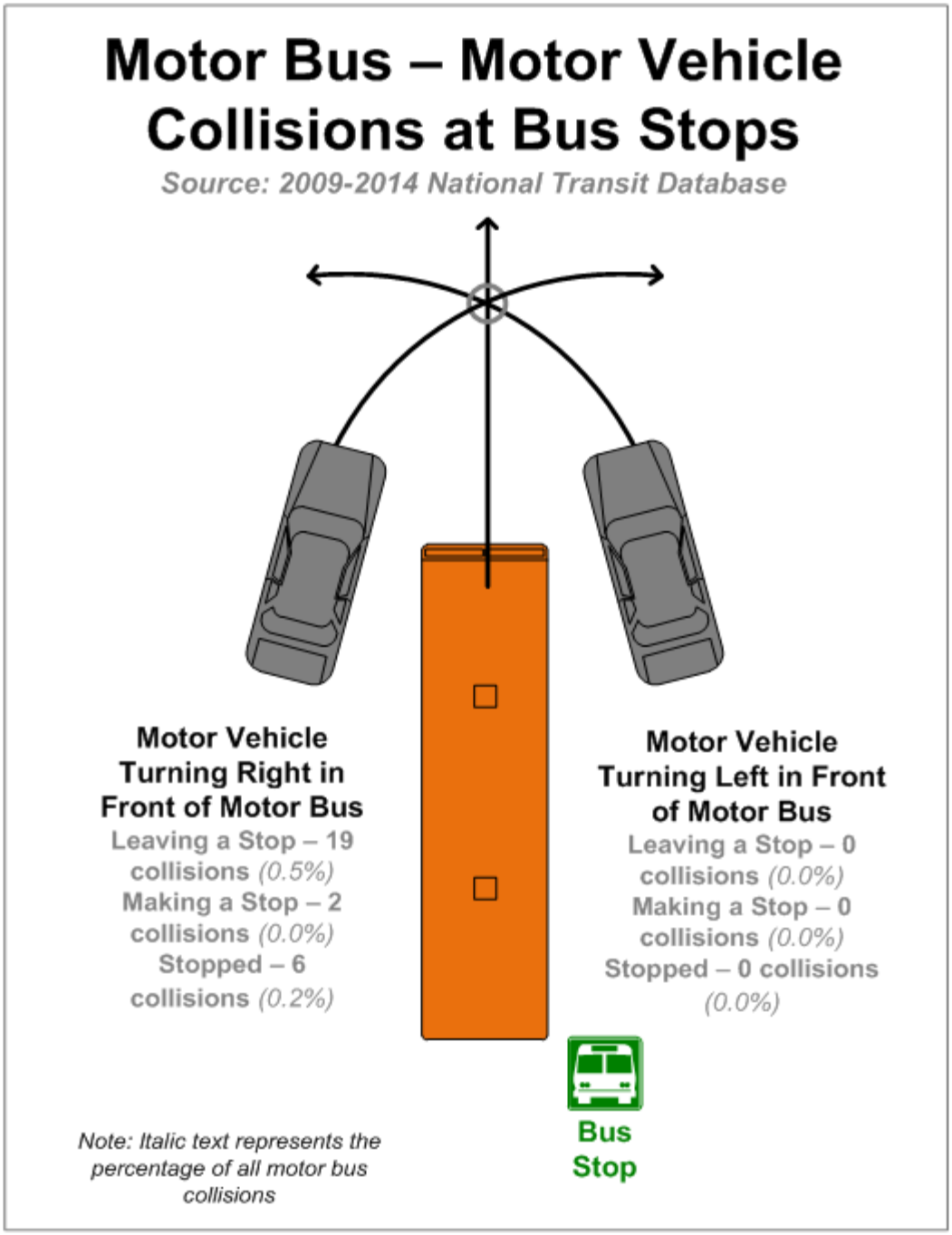


Figure 5-22: Motor Bus Collisions with Motor Vehicles at Bus Stops

5.7 Motor Bus Collision Analysis

5.7.1 Analysis of Collision Types by Frequency

Table 5-12 depicts the collision types sorted by the average yearly frequency of collisions from 2009-2014. As depicted in the table, the top eight collision types all involve both vehicles either going straight or stopped. Of the top eight, those involving a motor vehicle rear-ending a motor bus accounted for the top three categories; this occurred more often at a bus stop than at an intersection or mid-block. Other top collisions include a motor bus rear-ending a motor vehicle, collisions in the same direction that did not result in rear-end contact, and collisions in which the motor vehicle was approaching the motor bus from the left or right. As discussed in the introduction of Section 5, the top collisions by frequency and cost were largely consistent across the six years of data. Therefore, the numbers presented in this section represent the yearly averages of the normalized collision data based on the six years analyzed.

Collisions with pedestrians were less frequent than collisions with motor vehicles. The top pedestrian collisions took place when the motor bus was going straight and were of similar frequency at mid-block (103) and at intersections (101).

Table 5-12: 2009-2014 Average Collision Types per Year Sorted by Frequency

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions
1	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	422
2	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-4	266
3	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-13	238
4	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-4	208
5	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-14	200
6	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-13	167
7	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Going Straight	Motor Vehicle	Figure 5-10	138
8	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-5	138
9	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-6	109
10	Mid-Block Collisions	Motor Bus Going Straight	Pedestrian	Figure 5-2	103
11	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	103
12	Collisions at Intersections	Motor Bus Going Straight	Pedestrian	Figure 5-1	101

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions
13	Collisions at Intersections	Motor Bus Turning Left	Pedestrian	Figure 5-1	77
14	Collisions with Fixed Objects	Collisions with Fixed Objects	Fixed Object	N/A	76
15	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	75
16	Intersection - Bus Stop	Motor Bus Leaving a Stop	Motor Vehicle	Figure 5-12	72
17	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-11	64
18	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-15	57
19	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	52
20	Intersection - Bus Stop	Motor Bus Making a Stop	Motor Vehicle	Figure 5-12	47
21	Miscellaneous Motor Vehicle Collisions	Miscellaneous Motor Vehicle Collisions	Motor Vehicle	N/A	46
22	Bus Stop Collisions	Motor Bus Leaving a Stop	Pedestrian	Figure 5-3	42
23	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-14	41
24	Mid-Block - Bus Stop	Motor Bus Leaving a Stop	Motor Vehicle	Figure 5-18	41
25	Mid-Block - Bus Stop	Motor Bus Making a Stop	Motor Vehicle	Figure 5-18	38
26	Intersection - Motor Bus Turning Left	Motor Vehicle Driving in Same Direction - Turning Left	Motor Vehicle	Figure 5-7	36
27	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-11	36
28	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-16	35
29	Collisions at Intersections	Motor Bus Turning Right	Pedestrian	Figure 5-1	33
30	Collisions with Transit Vehicles	Collisions with Transit Vehicles	Transit Vehicle	N/A	30
31	Collisions with Other	Collisions with Other	Other	N/A	29
32	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-6	25
33	Miscellaneous Pedestrian Collisions	Miscellaneous Pedestrian Collisions	Pedestrian	N/A	25

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions
34	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	23
35	Intersection - Motor Bus Turning Left	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	Figure 5-7	23
36	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	23
37	Intersection - Motor Bus Turning Right	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	Figure 5-8	21
38	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-22	19
39	Bus Stop Collisions	Motor Bus Making a Stop	Pedestrian	Figure 5-3	18
40	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-16	17
41	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Turning Right	Motor Vehicle	Figure 5-10	16
42	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-15	16
43	Mid-Block Collisions	Motor Bus Leaving a Stop	Pedestrian	Figure 5-2	14
44	Intersection - Motor Bus Turning Right	Motor Vehicle Driving in Same Direction - Turning Right	Motor Vehicle	Figure 5-8	13
45	Bus Stop Collisions	Motor Bus Going Straight or Turning	Pedestrian	Figure 5-3	12
46	Mid-Block - Motor Bus Making a Turn	Motor Vehicle Driving in Same Direction	Motor Vehicle	Figure 5-17	11
47	Mid-Block Collisions	Motor Bus Making a Turn	Pedestrian	Figure 5-2	11
48	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	10
49	Bus Stop - Motor Bus Other Movement (Going Straight, Making Turn, etc.)	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	N/A	9
50	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	9
51	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Right - Going Straight	Motor Vehicle	Figure 5-10	9
52	Collisions at Intersections	Motor Bus Leaving a Stop	Pedestrian	Figure 5-1	9
53	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	8
54	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	7
55	Mid-Block Collisions	Motor Bus Making a Stop	Pedestrian	Figure 5-2	7

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions
56	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Left- Turning Left	Motor Vehicle	Figure 5-9	6
57	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Turning Left	Motor Vehicle	Figure 5-10	6
58	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	6
59	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-22	6
60	Bus Stop Collisions	Motor Bus Stopped	Pedestrian	Figure 5-3	5
61	Collisions at Intersections	Motor Bus Making a Stop	Pedestrian	Figure 5-1	5
62	Intersection - Motor Bus Turning Right	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	5
63	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Right	Motor Vehicle	Figure 5-11	4
64	Intersection - Motor Bus Turning Right	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	3
65	Mid-Block - Motor Bus Making a Turn	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-17	3
66	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	2
67	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	2
68	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-22	2
69	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	1
70	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left- Turning Left	Motor Vehicle	Figure 5-9	1
71	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	1
72	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	1
73	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	1

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions
74	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	1
75	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	1
76	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0
77	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left- Turning Right	Motor Vehicle	N/A	0
78	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Right - Turning Left	Motor Vehicle	Figure 5-10	0
79	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	0
80	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	0
81	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	0
82	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0
83	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0

5.7.2 Analysis of Collision Type by Cost

Another way of looking at the data is to associate costs to the collisions. This report updates and uses a modified version of the methodology used in the 2013 report to estimate collision costs.

In the 2013 version of this report, cost estimates for fatalities, injuries, and property damage were derived from estimates found in The Costs of Highway Crashes conducted by the Urban Institute and published by FHWA (FHWA-RD-91-055) in 1991. This updated report also uses the Urban Institute/FHWA study as the basis for cost estimates, but the derivation has been revised in response to new guidance from the USDOT. Table 5-13 is from the 1991 study and identifies the comprehensive costs per person and costs per collision by severity.

Table 5-13: Collision Cost Estimates (in 1988 Dollars)

Severity	Cost per Person	Cost per Collision
K – Fatality	$2,392,742	$2,722,548
A – Incapacitating Injury	$169,506	$228,568
B – Evident Injury	$33,227	$48,333
C – Possible Injury	$17,029	$25,228
A-B-C – Reported Nonfatal Injury	$46,355	$69,592
O – Property Damage	$1,734	$4,489

Source: The Urban Institute. "The Costs of Highway Crashes," Federal Highway Administration Research Report Number FHWA-RD-91-055, Washington, D.C., October 1991, (Table 11, page 39).

The USDOT released a memorandum in 2014 titled "Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in U.S. Department of Transportation Analyses – 2014 Adjustment" providing updated guidance regarding the economic value of a statistical life (VSL) in transportation analyses. This new guidance from the USDOT identified $9.2 million as the value of a statistical life to be used to assess the benefits of preventing fatalities. In accordance with this guidance, $9.2 million was identified as the cost estimate (2013 base year) for a fatality in this report. The USDOT VSL guidance also advised calculating the cost of injury using abbreviated injury scale (AIS) levels shown in Table 5-14.

Table 5-14: Relative Disutility Factors by Injury Severity Level (AIS)

AIS Level	Severity	Fraction of VSL
AIS 1	Minor	0.003
AIS 2	Moderate	0.047
AIS 3	Serious	0.105
AIS 4	Severe	0.266
AIS 5	Critical	0.593
AIS 6	Unsurvivable	1

As AIS 6 indicates, the VSL ($9.2 million x 1) is an appropriate estimate for fatality cost. Since the NTD does not provide information about the severity of an injury, an average injury cost was calculated. Information about the distribution of injuries by AIS level is not available, and a simple average of AIS levels 1 through 5 would provide a highly inflated cost estimate of $1.9 million, so the analysis team chose to scale the costs using the 1991 Urban Institute/FHWA study and VSL guidance combined. The following calculation was used to calculate a scaled injury cost estimate:

$$\$2013\ \text{Injury} = (\$2013\ \text{Fatality}) \times \frac{\$1988\ \text{Injury}}{\$1988\ \text{Fatality}} = (\$9.2\ \text{million}) \times \frac{\$46{,}355}{\$2{,}392{,}742} = \$180{,}000$$

The injury figure from the 1991 report was converted to 2013 dollars and rounded to two significant figures ($180,000) to maintain consistency with the VSL estimate.

An estimate for property damage was determined by converting the collision cost estimate from the Urban Institute/FHWA study from year 1988 to year 2013. To convert nominal dollars from year 1988 to year 2013, the Consumer Price Index for all items (CPI-All Items) for the year of interest (2013) was divided by the CPI-All Items for the year 1988. This method was recommended in Appendix D of the Urban Institute/FHWA 1991 study. The CPI-All Items for 1988, as reported in Appendix D of the Urban Institute/FHWA study, is 118.3 and the CPI-All Items for 2013 is 232.957. The 2013 CPI-All Items was provided in the USDOT VSL 2014 guidance.

To convert Year Y dollars into Year Z dollars, the following calculation is used:

$$\text{Year Z \$} = (\text{Year Y \$}) \times \frac{\text{Year Z CPI: All Items}}{\text{Year Y CPI: All Items}}$$

This results in an estimated 2013 injury cost of $4,489 x (232.957/118.3) = $8,800 to two significant figures. The calculations for the adjusted 2013 dollar values for fatality, reported nonfatal injury, and property damage are shown Table 5-15.

Table 5-15: Adjusted Costs (in 2013 Dollars) for Collisions, Fatalities, and Property Damage

Accident Type	Estimated $2013
Fatalities	$9,200,000
Injuries	$180,000
Property Damage	$8,800

To determine costs for the various different collision types, the costs from Table 5-15 were used. The 2009-2014 NTD included information for each collision record indicating the number of fatalities, number of injuries, or property damage. It was then possible to determine the cost for each collision record using these assumptions. Table 5-16 depicts a summary of collision costs by category. As shown in the table, motor bus collisions with motor vehicles at intersections have the highest total cost associated to them. The cost estimate related to motor bus collisions is estimated to be $1,958,416,787 in year 2013 dollars.

Table 5-16: Summary of Average Collision Costs by Category

Category	Average Number of Collisions	Cost
Motor Bus Collisions with Pedestrians at Intersections, Mid-Block, or Bus Stops	436	$435,891,299
Motor Bus Collisions with Motor Vehicles at Intersections	1,448	$746,445,807
Motor Bus Collisions with Motor Vehicles at Mid-Block	865	$450,873,305
Motor Bus Collisions with Motor Vehicles at Bus Stops	581	$325,206,376
Other	206	N/A
Total	**3,535**	**$1,958,416,787**

Table 5-17 is sorted according to collision types by cost. Sorting in this manner yields different results than sorting the data by frequency. The three highest costs were for motor bus rear-ended by motor vehicles at a bus stop (No. 1), at mid-block (No. 2), and at an intersection (No. 3). The rest of the top 10 fall into three general categories – collisions with pedestrians, collisions in which a motor bus rear-ended a motor vehicle, and collisions in which both vehicles are going straight.

Table 5-17: 2009-2014 Average Collision Types Sorted by Average Cost

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions	Average Cost per year
1	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	422	$241,856,704
2	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-13	238	$123,363,322
3	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-4	266	$121,867,107
4	Mid-Block Collisions	Motor Bus Going Straight	Pedestrian	Figure 5-2	103	$120,344,533
5	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-4	208	$119,676,273
6	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Going Straight	Motor Vehicle	Figure 5-10	138	$87,741,630
7	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-14	200	$83,293,519
8	Collisions at Intersections	Motor Bus Turning Left	Pedestrian	Figure 5-1	77	$81,775,124
9	Collisions at Intersections	Motor Bus Going Straight	Pedestrian	Figure 5-1	101	$80,971,600
10	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-13	167	$75,031,569
11	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-15	57	$71,086,530
12	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	103	$69,730,780
13	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-5	138	$52,225,569
14	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-11	64	$46,728,883
15	Bus Stop Collisions	Motor Bus Leaving a Stop	Pedestrian	Figure 5-3	42	$43,630,200

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions	Average Cost per year
16	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-6	109	$43,503,456
17	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	75	$34,211,446
18	Intersection - Bus Stop	Motor Bus Leaving a Stop	Motor Vehicle	Figure 5-12	72	$32,160,678
19	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-11	36	$29,170,380
20	Collisions at Intersections	Motor Bus Turning Right	Pedestrian	Figure 5-1	33	$29,082,057
21	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-6	25	$27,739,731
22	Intersection - Bus Stop	Motor Bus Making a Stop	Motor Vehicle	Figure 5-12	47	$25,304,336
23	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	52	$24,154,515
24	Mid-Block - Bus Stop	Motor Bus Leaving a Stop	Motor Vehicle	Figure 5-18	41	$21,302,041
25	Mid-Block Collisions	Motor Bus Leaving a Stop	Pedestrian	Figure 5-2	14	$20,583,467
26	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-14	41	$20,375,570
27	Mid-Block Collisions	Motor Bus Making a Turn	Pedestrian	Figure 5-2	11	$17,651,384
28	Collisions at Intersections	Motor Bus Making a Stop	Pedestrian	Figure 5-1	5	$17,474,000
29	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	23	$15,609,529
30	Mid-Block - Bus Stop	Motor Bus Making a Stop	Motor Vehicle	Figure 5-18	38	$14,938,279
31	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-16	35	$14,288,068
32	Intersection - Motor Bus Turning Left	Motor Vehicle Driving in Same Direction - Turning Left	Motor Vehicle	Figure 5-7	36	$11,610,911
33	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the	Motor Vehicle	Figure 5-15	16	$11,515,807

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions	Average Cost per year
		Opposite Direction - Turning Left				
34	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	6	$8,567,398
35	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	7	$7,920,953
36	Bus Stop Collisions	Motor Bus Making a Stop	Pedestrian	Figure 5-3	18	$7,915,800
37	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-16	17	$7,065,782
38	Bus Stop Collisions	Motor Bus Going Straight or Turning	Pedestrian	Figure 5-3	12	$6,700,800
39	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Turning Right	Motor Vehicle	Figure 5-10	16	$6,584,389
40	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	23	$6,556,342
41	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-22	19	$6,214,757
42	Intersection - Motor Bus Turning Left	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	Figure 5-7	23	$6,206,503
43	Collisions at Intersections	Motor Bus Leaving a Stop	Pedestrian	Figure 5-1	9	$6,080,267
44	Intersection - Motor Bus Turning Right	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	Figure 5-8	21	$5,930,331
45	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Turning Left	Motor Vehicle	Figure 5-10	6	$5,586,116
46	Mid-Block - Motor Bus Making a Turn	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-17	3	$4,788,433
47	Bus Stop - Motor Bus Other Movement (Going Straight, Making Turn, etc.)	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	N/A	9	$4,576,699
48	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	10	$3,992,969

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions	Average Cost per year
49	Mid-Block - Motor Bus Making a Turn	Motor Vehicle Driving in Same Direction	Motor Vehicle	Figure 5-17	11	$3,824,386
50	Intersection - Motor Bus Turning Right	Motor Vehicle Driving in Same Direction - Turning Right	Motor Vehicle	Figure 5-8	13	$3,545,261
51	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Right - Going Straight	Motor Vehicle	Figure 5-10	9	$2,974,887
52	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	9	$2,819,409
53	Mid-Block Collisions	Motor Bus Making a Stop	Pedestrian	Figure 5-2	7	$2,715,067
54	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	1	$2,712,595
55	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Left- Turning Left	Motor Vehicle	Figure 5-9	6	$2,179,604
56	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	8	$2,117,268
57	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-22	6	$1,576,605
58	Intersection - Motor Bus Turning Right	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	5	$1,433,862
59	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Right	Motor Vehicle	Figure 5-11	4	$1,430,584
60	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	2	$979,530
61	Bus Stop Collisions	Motor Bus Stopped	Pedestrian	Figure 5-3	5	$967,000
62	Intersection - Motor Bus Turning Right	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	3	$762,012
63	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	1	$685,622
64	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and	Motor Vehicle	Figure 5-22	2	$660,589

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions	Average Cost per year
		Turning Right in Front of Bus				
65	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	2	$637,110
66	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left- Turning Left	Motor Vehicle	Figure 5-9	1	$605,203
67	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	1	$524,476
68	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	1	$263,702
69	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	1	$108,894
70	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	1	$106,081
71	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0	$100,502
72	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left- Turning Right	Motor Vehicle	N/A	0	$0
73	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Right - Turning Left	Motor Vehicle	Figure 5-10	0	$0
74	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	0	$0
75	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	0	$0
76	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	0	$0
77	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0	$0
78	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and	Motor Vehicle	Figure 5-22	0	$0

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions	Average Cost per year
		Turning Left in Front of Bus				
79	Miscellaneous Pedestrian Collisions	Miscellaneous Pedestrian Collisions	Pedestrian	N/A	25	N/A
80	Miscellaneous Motor Vehicle Collisions	Miscellaneous Motor Vehicle Collisions	Motor Vehicle	N/A	46	N/A
81	Collisions with Fixed Objects	Collisions with Fixed Objects	Fixed Object	N/A	76	N/A
82	Collisions with Transit Vehicles	Collisions with Transit Vehicles	Transit Vehicle	N/A	30	N/A
83	Collisions with Other	Collisions with Other	Other	N/A	29	N/A

5.7.3 Analysis of Collision Types by Average Cost per Collision

A third way of looking at collision types is to sort the data by the average cost per collision, shown in Table 5-18. Sorting the data this way allows the collision types to be analyzed by average severity (i.e., average cost per collision) so that collisions that result in more fatalities, injuries, or property damage are ranked higher than collisions that may occur more frequently but results in minor fender benders with minimal property damage, no injuries, or fatalities. It should be noted, however, that the average cost per collision rankings can variate significantly due to the high costs of severe injuries or fatalities. The average cost per collision can be influenced by a few number of collisions that resulted in severe injuries or fatalities. A certain type of collision may occur infrequently, but a single accident with unusually high injury or fatality counts can drive the average cost per collision upwards. This is evident in the top collision below – a motor bus rear-ending a motor vehicle at a bus stop occurs an average of one time a year, but has the highest average cost per collision. Since these costs are highly variable, it is recommended that the average cost per collision be used as only a rough indication of average severity or cost. However, the table below does indicate that many of the incidents with a high average cost per collision involve collisions with pedestrians. This is due to the fact that most pedestrian collisions involve some type of injury or fatality.

Table 5-18: 2009-2014 Average Collision Types Sorted by Average Cost per Collision

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions	Average Cost per Collision
1	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	1	$4,831,082
2	Collisions at Intersections	Motor Bus Making a Stop	Pedestrian	Figure 5-1	5	$3,382,065
3	Mid-Block Collisions	Motor Bus Making a Turn	Pedestrian	Figure 5-2	11	$1,681,084
4	Mid-Block - Motor Bus Making a Turn	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-17	3	$1,556,116

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions	Average Cost per Collision
5	Mid-Block Collisions	Motor Bus Leaving a Stop	Pedestrian	Figure 5-2	14	$1,487,961
6	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	6	$1,441,368
7	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-15	57	$1,256,905
8	Mid-Block Collisions	Motor Bus Going Straight	Pedestrian	Figure 5-2	103	$1,166,506
9	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-6	25	$1,103,864
10	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	7	$1,078,699
11	Collisions at Intersections	Motor Bus Turning Left	Pedestrian	Figure 5-1	77	$1,065,487
12	Bus Stop Collisions	Motor Bus Leaving a Stop	Pedestrian	Figure 5-3	42	$1,051,330
13	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Turning Left	Motor Vehicle	Figure 5-10	6	$920,896
14	Collisions at Intersections	Motor Bus Turning Right	Pedestrian	Figure 5-1	33	$874,624
15	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-11	36	$818,306
16	Collisions at Intersections	Motor Bus Going Straight	Pedestrian	Figure 5-1	101	$800,378
17	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-11	64	$730,864
18	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-15	16	$720,814
19	Collisions at Intersections	Motor Bus Leaving a Stop	Pedestrian	Figure 5-1	9	$715,325
20	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	103	$678,535
21	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	23	$664,929

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions	Average Cost per Collision
22	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Going Straight	Motor Vehicle	Figure 5-10	138	$635,447
23	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	1	$593,754
24	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-4	208	$576,531
25	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	422	$573,527
26	Bus Stop Collisions	Motor Bus Going Straight or Turning	Pedestrian	Figure 5-3	12	$570,281
27	Intersection - Bus Stop	Motor Bus Making a Stop	Motor Vehicle	Figure 5-12	47	$539,094
28	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-13	238	$517,888
29	Mid-Block - Bus Stop	Motor Bus Leaving a Stop	Motor Vehicle	Figure 5-18	41	$516,341
30	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-14	41	$493,243
31	Bus Stop - Motor Bus Other Movement (Going Straight, Making Turn, etc.)	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	N/A	9	$485,122
32	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left-Turning Left	Motor Vehicle	Figure 5-9	1	$465,990
33	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	2	$463,909
34	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	52	$461,314
35	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-4	266	$458,714
36	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	75	$454,312
37	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-13	167	$449,909
38	Intersection - Bus Stop	Motor Bus Leaving a Stop	Motor Vehicle	Figure 5-12	72	$445,885
39	Bus Stop Collisions	Motor Bus Making a Stop	Pedestrian	Figure 5-3	18	$433,742

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions	Average Cost per Collision
40	Mid-Block Collisions	Motor Bus Making a Stop	Pedestrian	Figure 5-2	7	$417,703
41	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-14	200	$416,868
42	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Turning Right	Motor Vehicle	Figure 5-10	16	$409,491
43	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-16	17	$409,264
44	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-16	35	$402,549
45	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-6	109	$399,062
46	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	10	$394,194
47	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-22	2	$393,155
48	Mid-Block - Bus Stop	Motor Bus Making a Stop	Motor Vehicle	Figure 5-18	38	$390,087
49	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-5	138	$379,180
50	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	2	$369,056
51	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0	$368,800
52	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	1	$368,264
53	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Left-Turning Left	Motor Vehicle	Figure 5-9	6	$351,721
54	Mid-Block - Motor Bus Making a Turn	Motor Vehicle Driving in Same Direction	Motor Vehicle	Figure 5-17	11	$348,033
55	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Right - Going Straight	Motor Vehicle	Figure 5-10	9	$345,260
56	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and	Motor Vehicle	Figure 5-22	19	$327,302

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions	Average Cost per Collision
		Turning Right in Front of Bus				
57	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Right	Motor Vehicle	Figure 5-11	4	$323,476
58	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	9	$322,998
59	Intersection - Motor Bus Turning Left	Motor Vehicle Driving in Same Direction - Turning Left	Motor Vehicle	Figure 5-7	36	$322,398
60	Intersection - Motor Bus Turning Right	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	5	$291,810
61	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	23	$290,625
62	Intersection - Motor Bus Turning Right	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	Figure 5-8	21	$285,516
63	Intersection - Motor Bus Turning Right	Motor Vehicle Driving in Same Direction - Turning Right	Motor Vehicle	Figure 5-8	13	$278,097
64	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-22	6	$277,887
65	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	8	$277,505
66	Intersection - Motor Bus Turning Left	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	Figure 5-7	23	$266,148
67	Intersection - Motor Bus Turning Right	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	3	$244,104
68	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	1	$235,074
69	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	1	$188,800
70	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	1	$184,412
71	Bus Stop Collisions	Motor Bus Stopped	Pedestrian	Figure 5-3	5	$184,190
72	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left-Turning Right	Motor Vehicle	N/A	0	$0

No.	Category	Collision Type	Collision With	Figure #	Average Number of Collisions	Average Cost per Collision
73	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Right - Turning Left	Motor Vehicle	Figure 5-10	0	$0
74	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	0	$0
75	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	0	$0
76	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	0	$0
77	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0	$0
78	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0	$0
79	Miscellaneous Pedestrian Collisions	Miscellaneous Pedestrian Collisions	Pedestrian	N/A	25	N/A
80	Miscellaneous Motor Vehicle Collisions	Miscellaneous Motor Vehicle Collisions	Motor Vehicle	N/A	46	N/A
81	Collisions with Fixed Objects	Collisions with Fixed Objects	Fixed Object	N/A	76	N/A
82	Collisions with Transit Vehicles	Collisions with Transit Vehicles	Transit Vehicle	N/A	30	N/A
83	Collisions with Other	Collisions with Other	Other	N/A	29	N/A

6 Motor Bus Making and Leaving a Stop: Collisions with Pedestrians

While collisions between motor buses and pedestrians do not constitute a large percentage of collisions, as shown in Section 5, they do lead to a high percentage of injuries and fatalities. The USDOT tasked the analysis team with conducting further analysis at specific types of collisions between motor buses and pedestrians – specifically collisions occurring while the motor bus is making or leaving a stop. The making a stop and leaving a stop categories account for a combined 20.4% of all collisions with pedestrians. This vehicle movement may cause potential conflicts between the motor bus and pedestrians because of the close proximity between pedestrians and the motor bus near bus stops. Between 2009 and 2014 there were a normalized average of 461 collisions between motor buses and pedestrians in all locations, i.e., intersections, bus stops and mid-block. As shown in Table 6-1, the highest percentages of collisions with pedestrians were instances where the motor bus was going straight (46.9%), making a turn (26.2%), leaving a stop (13.9%), and making a stop (6.5%).

The analysis team chose to aggregate the data into the categories 'making a stop' and 'leaving a stop' to conduct an in-depth analysis of collisions at a bus stop. These two collision categories are provided in the NTD and reported by the transit agencies, thus do not require normalization. Since the fields were provided by the NTD, the analysis team was able to use the actual numbers as reported by the agencies for the analysis presented in Sections 6.1 and 6.2.

Table 6-1: 2009-2014 Average Number of Pedestrian Collisions with Motor Bus

Category and Collision Type	Average Number	% of Category	% of All Collisions
Motor Bus Going Straight	216	46.9%	6.1%
Motor Bus Making a Turn	121	26.2%	3.4%
Motor Bus Leaving Bus Stop	64	13.9%	1.8%
Motor Bus Making a Bus Stop	30	6.5%	0.8%
Other Motor Bus Collision	30	6.5%	0.9%
Total	**461**	**100%**	**13.0%**

6.1 Motor Bus and Pedestrian Strikes while Making a Bus Stop and Leaving a Stop

NTD data from 2009 through 2014 was analyzed for all collisions between motor buses and pedestrians while the motor bus was either **'making a stop'** or **'leaving a stop.'** These two motor bus actions are provided by the NTD under the "Vehicle Action" field. Over the six year time frame there were an average of 82 collisions per year (a total of 494 combined collisions over the six years) while the motor bus was specifically 'making or leaving a stop' and struck a pedestrian. Between 2009 and 2014, amongst all motor bus collisions with pedestrians there was an average

of 435 collisions a year, which means that approximately 19% of all motor bus and pedestrian collisions occur while the motor bus is specifically 'making a stop' or 'leaving a stop.' While these two collision types only make up 2% of all collisions types reported in the NTD each year, they represent nearly a fifth of all pedestrian strikes.

A greater understanding of these types of collisions was warranted due to the frequency of the collisions and the fact that the USDOT has a vast interest in improving the safety of transit facilities, including bus stops. From 2009-2014, there was an average of 1 fatality and 27 injuries per year while the Motor Bus was making a stop, and an average of 5 fatalities and 51 injuries per year while the Motor Bus was leaving a stop. On average, 82.6% of all reported motor bus making a stop or leaving a stop collisions reported at least one injury and 6.0% of those collisions result in a fatality each year. One of the areas of focus under the USDOT's Connected Vehicle Research Program involves V2I Pedestrian Safety Applications. An understanding of actions that take place while buses are entering or leaving bus stops is important and could help the USDOT identify potential solutions to prevent this type of collision.

6.2 Analysis of Motor Bus Making a Stop and Leaving a Stop Pedestrian Collisions

The analysis team analyzed all motor bus collisions with pedestrians while the motor bus was making a stop or leaving a stop and manually categorized each incident by identifying basic collision types and characteristics using the NTD provided free-form description fields. The collision categories that were categorized are shown below:

- Mirror Strike
- Pedestrian made contact with the side of the Motor Bus
- Pedestrian was rushing to catch the Motor Bus
- Pedestrian walked in front of the Motor Bus
- Bicycle Strike
- Other Pedestrian Strike
- Other Pedestrian Event
- Pedestrian was pushed into the Motor Bus
- Pedestrian removing Bicycle from front rack of Motor Bus
- NA: Description does not include pedestrian strike detail

The analysis was based on the collision descriptions provided by the NTD free-form descriptions field. The analyst determined what occurred in each particular event and then categorized the information into a new field. The motor bus movements of 'leaving a stop' and 'making a stop' were chosen for further analysis because this movement clearly describes the action of the motor bus as both being in the proximity of a bus stop and involving pedestrians. Until 2011 the NTD did not provide a 'Bus Stop' location, as described in Section 5. As a result, the only way to determine if the motor bus was servicing a bus stop was to use the 'leaving a stop' and 'making a stop' fields. In order to provide an accurate comparison between all 6 years, the team focused specifically on the collisions identified as leaving or making a bus stop, regardless of the location of the motor bus.

6.2.1 Motor Bus Making a Stop or Leaving a Stop Collisions with Pedestrian: Frequency

Table 6-2 and Figure 6-1 below provide a breakdown by frequency of the various collision types that were identified as making a stop. Table 6-3 and Figure 6-2 show a breakdown by frequency of the various collision types that were identified as leaving a stop. The numbers presented in the table are the actual counts as reported in the NTD as well as the averages. When the motor bus was making a stop, the most frequent collision type that was identifiable based on the NTD description fields was a mirror strike (24.8%) followed by a bicycle strike (18.6%) and situations where a pedestrian walked in front of the motor bus (17.4%). When the motor bus was leaving a stop, the most frequent collision type was when pedestrians were rushing to catch the motor bus (26.1%). These collisions generally involved the intending passengers rushing after a motor bus that was pulling out of the bus stop or a person running alongside the motor bus attempting to get the driver's attention, but ending up tripping or being run over. The second most frequent collision type while leaving a stop involved pedestrians making contact with the side of the motor bus (22.8%). This category involved pedestrians running into the side of the bus or pedestrians who had just alighted from the bus, but still made contact with the side – either by falling backwards or standing too close as the motor bus pulled away. The third highest category was 'other pedestrian strike' at 20.4% of the collisions while the motor bus was leaving a stop. This category represents all collisions with injuries that could not be fully categorized due to NTD description fields with limited descriptions. The majority of these included unclear descriptions such as "Bus v Ped" or details that did not describe what type of collision took place.

Table 6-2: 2009-2014 Motor Bus Making a Stop Characteristics

Categorized Collision Type	2009-2014 Total	Yearly Average	% of Category
Mirror Strike	40	7	24.8%
Bicycle Strike	30	5	18.6%
Pedestrian walked in front of the Motor Bus	28	5	17.4%
Other Pedestrian Strike	25	4	15.5%
Pedestrian made contact with the side of the Motor Bus	15	3	9.3%
Pedestrian was rushing to catch the Motor Bus	8	1	5.0%
Other Pedestrian Event	7	1	4.3%
Pedestrian was pushed into the Motor Bus	4	1	2.5%
Pedestrian removing Bicycle from front of Motor Bus	2	0	1.2%
N/A	2	0	1.2%
Total	**161**	**27**	**100%**

Table 6-3: 2009-2014 Motor Bus Leaving a Stop Characteristics

Categorized Collision Type	2009-2014 Total	Yearly Average	% of Category
Pedestrian was rushing to catch the Motor Bus	87	15	26.1%
Pedestrian made contact with the side of the Motor Bus	76	13	22.8%
Other Pedestrian Strike	68	11	20.4%
Pedestrian walked in front of the Motor Bus	49	8	14.7%
Bicycle Strike	23	4	6.9%
Pedestrian removing Bicycle from front of Motor Bus	11	2	3.3%
Other Pedestrian Event	7	1	2.1%
N/A	6	1	1.8%
Mirror Strike	5	1	1.5%
Pedestrian was pushed into the Motor Bus	1	0	0.3%
Total	**333**	**56**	**100%**

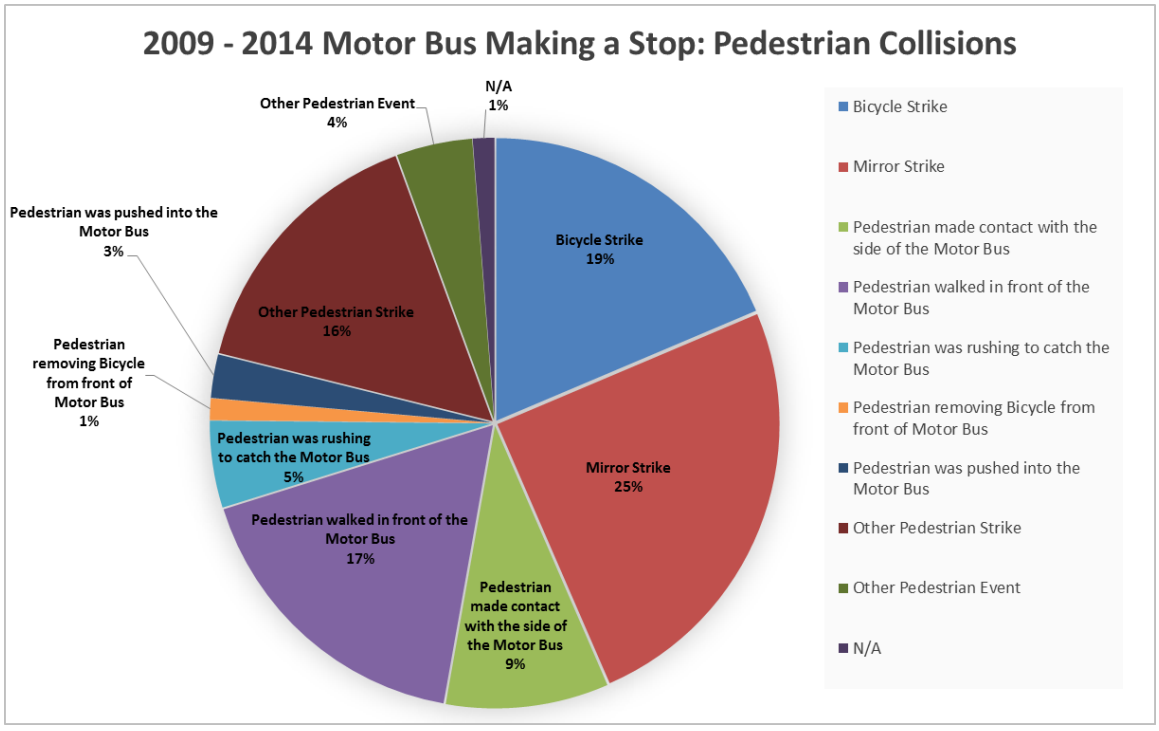


Figure 6-1: 2009-2014 Motor Bus Making a Stop: Pedestrian Collisions

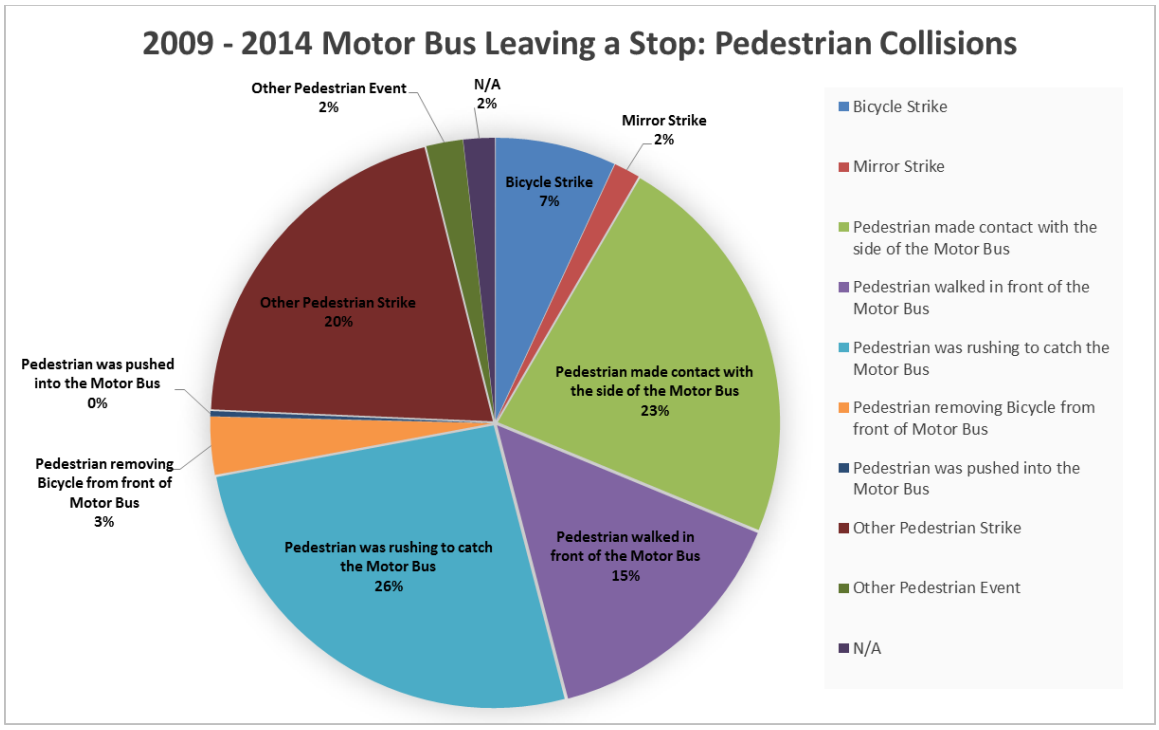


Figure 6-2: 2009-2014 Motor Bus Leaving a Stop: Pedestrian Collisions

6.2.2 Motor Bus Making a Stop or Leaving a Stop Collisions with Pedestrian: Injuries

Table 6-4 provides a breakdown of the number of injuries within each of the collision categories when the motor bus was making a stop. Table 6-5 shows the number of injuries when the motor bus was leaving a stop. The tables provide the total injuries that occurred between 2009 and 2014, along with the yearly average of injuries occurred by motor bus collisions. The highest percentage of injuries when the motor bus was making a stop occurred with a mirror strike collision (24.8%), followed by pedestrians walking in front of the motor bus and bicycle strikes tied for second (18.6% each.) When the motor bus was leaving a stop, the highest percentage of injuries occurred when the pedestrian was rushing to catch the motor bus (27.0%), followed by pedestrians making contact with the side of the motor bus (22.1%) and other pedestrian strikes (18.9%). These results point to the need for increased situational awareness to increase safety around areas where motor buses make stops.

Table 6-4: 2009-2014 Motor Bus Making a Stop Collisions with Pedestrian: Injuries

Categorized Collision Type	2009-2014 Injuries	Yearly Average	% of Category
Mirror Strike	40	7	24.8%
Pedestrian walked in front of the Motor Bus	30	5	18.6%
Bicycle Strike	30	5	18.6%
Other Pedestrian Strike	24	4	14.9%
Pedestrian made contact with the side of the Motor Bus	15	3	9.3%
Other Pedestrian Event	8	1	5.0%
Pedestrian was rushing to catch the Motor Bus	7	1	4.3%
Pedestrian was pushed into the Motor Bus	3	1	1.9%
Pedestrian removing Bicycle from front of Motor Bus	2	0	1.2%
N/A	2	0	1.2%
Total	**161**	**27**	**100%**

Table 6-5: 2009-2014 Motor Bus Leaving a Stop Collisions with Pedestrian: Injuries

Categorized Collision Type	2009-2014 Injuries	Yearly Average	% of Category
Pedestrian was rushing to catch the Motor Bus	83	14	27.0%
Pedestrian made contact with the side of the Motor Bus	68	11	22.1%
Other Pedestrian Strike	58	10	18.9%
Pedestrian walked in front of the Motor Bus	46	8	15.0%
Bicycle Strike	23	4	7.5%
Pedestrian removing Bicycle from front of Motor Bus	11	2	3.6%
Other Pedestrian Event	6	1	2.0%
N/A	6	1	2.0%
Mirror Strike	5	1	1.6%
Pedestrian was pushed into the Motor Bus	1	0	0.3%
Total	**307**	**51**	**100%**

6.2.3 Motor Bus Making a Stop or Leaving a Stop Collisions with Pedestrian: Fatalities

There are on average six (6) fatalities a year while the motor bus is making or leaving a stop, 1 while making a stop and 5 while leaving a stop. Out of an average of 83 motor bus making or leaving a stop collisions a year, this means that 7.2% of all collisions while the motor bus is leaving or making a stop result in a fatality. Table 6-6 provides a breakdown of the number of fatalities that occurred within each of the collision categories when the motor bus was making a stop, and Table 6-7 shows the breakdown when the motor bus was leaving a stop. Similar to the section above, the tables show the total number of fatalities between 2009 and 2014 as well as the yearly average. When the motor bus was making a

stop, only three fatalities occurred across the six years, one each for 'pedestrian was rushing to catch the motor bus,' 'other pedestrian strike,' and 'pedestrian pushed into the motor bus.'

When the motor bus was leaving a stop, the top two categories for fatalities were 'other pedestrian strikes' and collisions where pedestrians made contact with the side of the motor bus, with both categories at 32.3%. The third highest collision type is when the pedestrian was rushing to catch the motor bus (19.4%). An important observation is that for collisions when a motor bus was leaving a stop, the top 3 categories for injuries were also the top categories for fatalities but in a different order. There could be more of these frequent types of collisions due to pedestrians and motor bus riders being unaware of the motor busses movements or an issue with situational awareness that the USDOT should study further since these collisions represent the highest categories in both injuries and fatalities.

Table 6-6: 2009-2014 Motor Bus Making a Stop Collisions with Pedestrian: Fatalities

Categorized Collision Type	2009-2014 Fatalities	Yearly Average	% of Category
Pedestrian was rushing to catch the Motor Bus	1	0	33.3%
Other Pedestrian Strike	1	0	33.3%
Pedestrian was pushed into the Motor Bus	1	0	33.3%
Pedestrian made contact with the side of the Motor Bus	0	0	0.0%
Pedestrian walked in front of the Motor Bus	0	0	0.0%
Bicycle Strike	0	0	0.0%
Mirror Strike	0	0	0.0%
Other Pedestrian Event	0	0	0.0%
Pedestrian removing Bicycle from front of Motor Bus	0	0	0.0%
N/A	0	0	0.0%
Total	**3**	**1**	**100%**

Table 6-7: 2009-2014 Motor Bus Leaving a Stop Collisions with Pedestrian: Fatalities

Categorized Collision Type	2009-2014 Fatalities	Yearly Average	% of Category
Other Pedestrian Strike	10	2	32.3%
Pedestrian made contact with the side of the Motor Bus	10	2	32.3%
Pedestrian was rushing to catch the Motor Bus	6	1	19.4%
Pedestrian walked in front of the Motor Bus	3	1	9.7%
Bicycle Strike	1	0	3.2%
Other Pedestrian Event	1	0	3.2%
Mirror Strike	0	0	0.0%
Pedestrian removing Bicycle from front of Motor Bus	0	0	0.0%
N/A	0	0	0.0%
Pedestrian was pushed into the Motor Bus	0	0	0.0%
Total	**31**	**5**	**100%**

6.2.4 Motor Bus Making a Stop or Leaving a Stop: Costs per Category

Table 6-8 and Table 6-9 provide the costs for each category based on fatalities, injuries and property damage as reported to the NTD, for 'making a stop' and 'leaving a stop' collisions, respectively. The cost calculations were conducted using the same method and values for statistical life as presented in Section 5.7.2. The costs are presented with both the totals from 2009 through 2014 and the averages for each year. The costs are approximate and should only be viewed as such. They are useful in providing a way to categorize collision types using costs and allowed the analysis team a way of quantifying collisions based on associated fatalities, injuries and property damage. When the motor bus is making a stop, the highest costs on average each year are other pedestrian strikes at $2,256,267, followed by pedestrians rushing to catch the motor bus at $1,746,267 and pedestrians pushed into the motor bus $1,623,333. When the motor bus is leaving a stop, the costs were generally higher due to higher numbers of injuries and fatalities. The highest costs when the bus was leaving a stop were collisions where the pedestrian made contact with the side of the motor bus at $17,382,133 each year, followed by other pedestrian strikes at $17,090,933 and pedestrians rushing to catch the motor bus at $11,695,867. These categories represent the highest overall costs, and are consistent with the categories having the highest numbers of injuries and fatalities. It should be noted that some categories, such as pedestrian walking in front of the motor bus, have relatively high numbers of injuries (13 each year) but have limited numbers of fatalities, which bring the costs down overall.

Table 6-8: 2009-2014 Motor Bus Making a Stop Pedestrian Collisions Costs per Category

Categorized Collision Type	2009-2014 Cost	Yearly Average	% of Category
Other Pedestrian Strike	$13,537,600	$2,256,267	23.8%
Pedestrian was rushing to catch the Motor Bus	$10,477,600	$1,746,267	18.4%
Pedestrian was pushed into the Motor Bus	$9,740,000	$1,623,333	17.1%
Mirror Strike	$7,235,200	$1,205,867	12.7%
Bicycle Strike	$5,505,600	$917,600	9.7%
Pedestrian walked in front of the Motor Bus	$5,435,200	$905,867	9.6%
Pedestrian made contact with the side of the Motor Bus	$2,717,600	$452,933	4.8%
Other Pedestrian Event	$1,475,200	$245,867	2.6%
N/A	$368,800	$61,467	0.6%
Pedestrian removing Bicycle from front of Motor Bus	$360,000	$60,000	0.6%
Total	**$56,852,800**	**$9,475,467**	**100%**

Table 6-9: 2009-2014 Motor Bus Leaving a Stop Pedestrian Collisions Costs per Category

Categorized Collision Type	2009-2014 Cost	Yearly Average	% of Category
Pedestrian made contact with the side of the Motor Bus	$104,292,800	$17,382,133	30.6%
Other Pedestrian Strike	$102,545,600	$17,090,933	30.1%
Pedestrian was rushing to catch the Motor Bus	$70,175,200	$11,695,867	20.6%
Pedestrian walked in front of the Motor Bus	$35,915,200	$5,985,867	10.5%
Bicycle Strike	$13,436,800	$2,239,467	3.9%
Other Pedestrian Event	$10,306,400	$1,717,733	3.0%
Pedestrian removing Bicycle from front of Motor Bus	$1,988,800	$331,467	0.6%
N/A	$1,080,000	$180,000	0.3%
Mirror Strike	$900,000	$150,000	0.3%
Pedestrian was pushed into the Motor Bus	$180,000	$30,000	0.1%
Total	**$340,820,800**	**$56,803,467**	**100%**

7 Light Rail Collisions

The NTD defines a light rail vehicle as a transit mode, typically an electric railway, with a light volume traffic capacity compared to heavy rail. Light rail collisions make up only a small fraction of all transit collisions (4.0%), and account for 3.4% of all transit injuries and 15.5% of all fatalities. The following sections of the report discuss light rail collisions in more detail. It should be noted that the numbers used for the analysis are the normalized / extrapolated numbers from 2009-2014 combined. **Due to a small total number of light rail collisions, the frequencies provided in this section are a sum of all six years, not a yearly average.** Both total cost and yearly average cost figures are provided.

- Section 7.1 breaks down the number of light rail collisions by location.
- Section 7.2 provides a summary of light rail collisions categorized by the other object involved.
- Section 7.3 breaks down the number of light rail collisions by the collision type.
- Section 7.4 discusses light rail collisions with pedestrians. These collisions account for 407 of the 1,013 light rail collisions or approximately 40.2% of all light rail collisions.
- Section 7.5 discusses light rail collisions with motor vehicles. These collisions account for 543 of the 1,013 light rail collisions or approximately 53.6% of all light rail collisions.
- Section 7.6 presents a more in-depth analysis of the collision types by frequency, cost, and cost per collision.

7.1 Light Rail Collisions Categorized by Location

For light rail collisions, the NTD defines five categories for location: (1) Non-Revenue Facility, (2) Revenue Facility: Transit Station, (3) Right-of-way: Grade Crossing, (4) Right-of-way: Not a Grade Crossing, and (5) Other. Table 7-1 includes a breakdown of 2009-2014 NTD data by the collision location. These data show that Right-of-way: Grade Crossing had the highest number of collisions from 2009-2014 with 690 or 68.1% of all light rail collisions. Revenue Facility: Transit Station and Right-of-way: Not a Grade Crossing had similar numbers of collisions – 15.1% (153) and 13.6% (138) of all light rail collisions, respectively. The remaining locations accounted for a little more than three percent of all light rail collisions combined.

Table 7-1: 2009-2014 Light Rail Collisions by Location

Location	Total Number of Collisions (2009-2014)	Percentage
Right-of-way: Grade Crossing	690	68.1%
Revenue Facility: Transit Station	153	15.1%
Right-of-way: Not a Grade Crossing	138	13.6%
Other	29	2.9%
Non-Revenue Facility	3	0.3%
Total	**1,013**	**100%**

7.2 Light Rail Collisions Categorized by Object Involved

Collision data can also be categorized by the other party involved in the collision (see Table 7-2). When analyzed by collision object, the highest percentage of light rail collisions occurred with motor vehicles, accounting for 53.6% of all motor bus collisions. The second highest percentage of collisions occurred between light rail vehicles and pedestrians (40.2%). Light rail collisions with other rail vehicles, non-rail transit vehicles, fixed objects, and other accounted for less than 7% of light rail collisions.

Table 7-2: 2009-2014 Light Rail Collisions by Object Involved

Collision With	Total Number of Collisions (2009-2014)	Percentage
Motor Vehicle	543	53.6%
Pedestrian	407	40.2%
Other	31	3.1%
Rail Vehicle	24	2.4%
Fixed Object	5	0.5%
Non-Rail Transit Vehicle	3	0.3%
Total	**1,013**	**100%**

7.3 Light Rail Collisions Categorized by Collision Type

Table 7-3 shows a breakdown of light rail collisions by NTD collision type. The NTD includes eight collision types: angle, head-on, other front impact, rear-ended, rear-ending, side impact, sideswipe, and other. Definitions for these collision types are included in Appendix B. For 2009-2014, front-related collisions were most common, with other front impact collisions accounting for 29.7% of collisions and head-on collisions accounting for 28.3% of collisions. Following these collisions, side impact collisions were 20.1% and angle collisions were 9.7% of all light rail collisions. Rear-ended, rear-ending, sideswipe, and other collisions each accounted for around 2-4% of all light rail collisions.

Table 7-3: 2009-2014 Light Rail Collisions by Collision Type

NTD Collision Type	Total Number of Collisions (2009-2014)	Percentage
Other Front Impact	301	29.7%
Head-On	287	28.3%
Side Impact	204	20.1%
Angle	98	9.7%
Other	41	4.0%
Sideswipe	34	3.4%
Rear-Ended	26	2.6%
Rear-Ending	22	2.2%
Total	**1,013**	**100%**

7.4 Light Rail Collisions with Pedestrians

For 2009-2014, there were 407 light rail collisions with pedestrians accounting for 40.2% of all light rail collisions. As previously discussed, light rail collisions account for 3.4% of all transit injuries and 15.5% of all fatalities. Most of these injuries and fatalities are due to pedestrian collisions – these 407 collisions account for 19% of light rail injuries and 84% of light rail fatalities. 46.9% of the injuries and 61% of the fatalities occurred when the pedestrian was 'in or along the track.'[4]

Table 7-4 provides a summary of light rail collisions with pedestrians. The NTD specifies that the light rail vehicle is going straight in all of these collisions. Of the 407 collisions, 42.8% occurred at a grade crossing, 33.7% at a transit station, and 23.1% at a right-of-way: not a grade crossing. There was only one collision each for non-revenue facilities and other locations across all six years.

Table 7-4: 2009-2014 Light Rail Collisions with Pedestrians by Location

Location	Total Number of Collisions (2009-2014)	Percentage
Right-of-way: Grade Crossing	174	42.8%
Revenue Facility: Transit Station	137	33.7%
Right-of-way: Not a Grade Crossing	94	23.1%
Non-Revenue Facility	1	0.2%
Other	1	0.2%
Total	**407**	**100%**

[4] 'In or along the track' is language used in the NTD injury and fatality tables, not the incident descriptions, and may correspond to either 'Right-of-way: Grade Crossing' or 'Right-of-way: Not a Grade Crossing' in Table 7-4.

7.5 Light Rail Collisions with Motor Vehicles

Light rail collisions with motor vehicles account for 543 or 53.6% of all light rail collisions. Of these 543 collisions, 498 (91.7%) occurred at the Right-of-way: Grade Crossing location and only 45 (8.3%) occurred at Right-of-way: Not a Grade Crossing. Analysis of light rail collisions with motor vehicles at gate crossings showed that traffic violations were by far the most common cause of motor vehicle collisions. These violations include motor vehicles running red lights or stop signs, ignoring traffic signs, or going around gates.

Table 7-5 shows light rail collisions at grade crossings. Category and collision type was determined using the filtering method described in Section 4 to identify the motor vehicle movement and spatial relationship. The light rail vehicle was going straight in all of these collisions. As shown in the table, 231 (46.4%) occurred when the motor vehicle turns left in front of the light rail vehicle while driving in the same direction. Ninety-four (94) (18.8%) occurred when the motor vehicle was going straight and approaching from the right, 76 (15.3%) when the motor vehicle was going straight and approaching from the left, and 41 (8.2%) when the motor vehicle was going straight and driving in the same direction as the light rail vehicle (for example, a rear-ending that occurs on embedded tracks.) The other collision types each represented less than 4% of all light rail collisions at grade crossings.

Table 7-5: 2009-2014 Light Rail Collisions with Motor Vehicles at Grade Crossings

Category and Collision Type	Total Number of Collisions (2009-2014)	% of Grade Crossing Collisions
Motor Vehicle Driving in Same Direction - Turned Left in Front of Light Rail	231	46.4%
Motor Vehicle Approaching from Right - Going Straight	94	18.8%
Motor Vehicle Approaching from Left - Going Straight	76	15.3%
Motor Vehicle Driving in Same Direction - Going Straight	41	8.2%
Motor Vehicle Driving in Same Direction - Turned Right in Front of Light Rail	17	3.5%
Motor Vehicle Driving Towards Light Rail - Going Straight	14	2.7%
Motor Vehicle Driving Towards Light Rail - Turning Left	9	1.9%
Motor Vehicle Approaching from Right - Turning Left	9	1.9%
Motor Vehicle Driving Towards Light Rail - Turning Right	3	0.7%
Motor Vehicle Approaching from Left - Turning Left	3	0.6%
Total	**498**	**100%**

Figure 7-1 uses an image to depict light rail collisions with motor vehicles at grade crossings when both the motor vehicle and light rail vehicle are traveling in the same direction. Figure 7-2 and Figure 7-3 show light rail collisions with motor vehicles at grade crossings when the motor vehicle is approaching from the left and from the right, respectively. Figure 7-4 depicts light rail collisions with motor vehicles at grade crossings when the motor vehicle is approaching the light rail vehicle from the opposite direction.

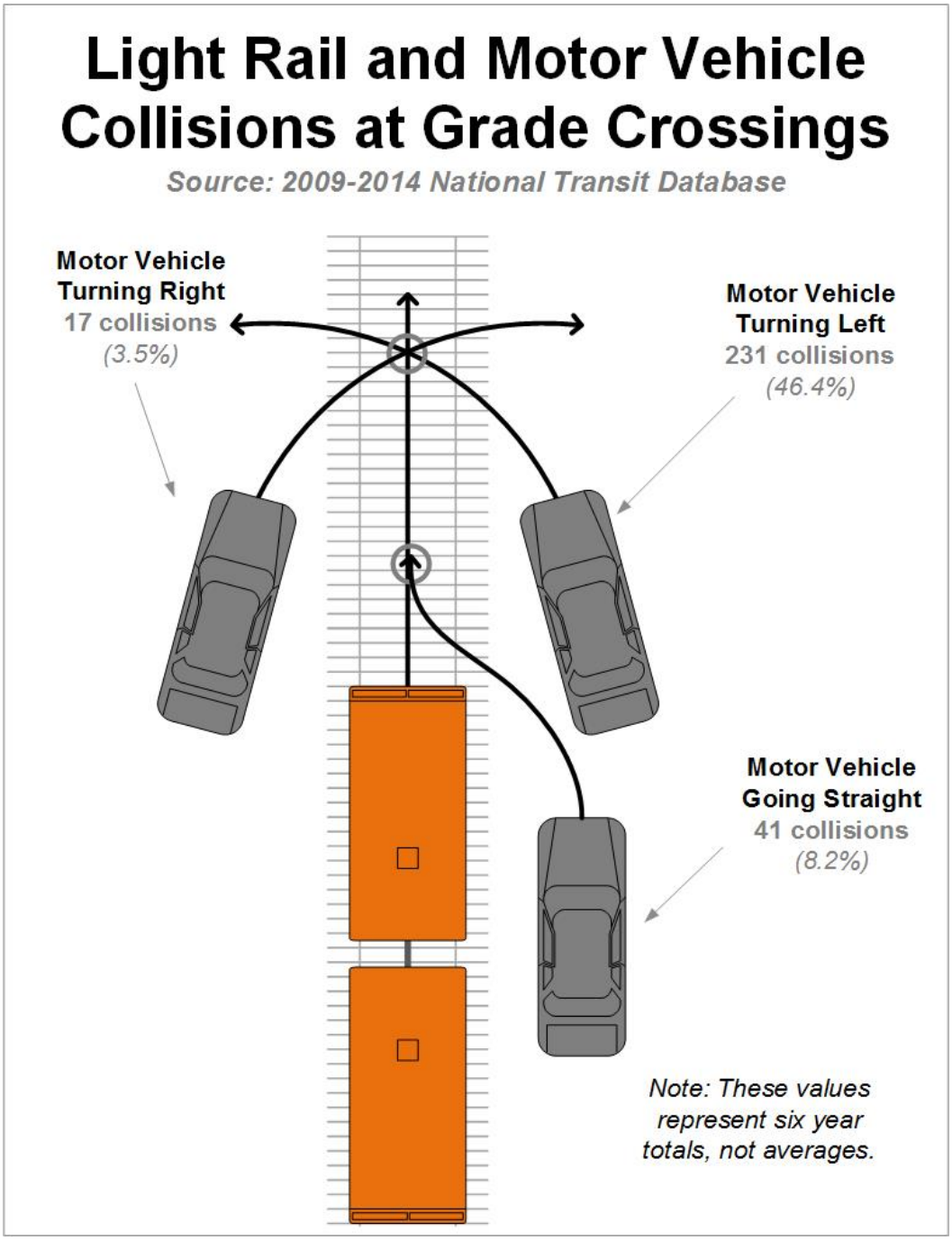


Figure 7-1: Motor Vehicle Driving in Same Direction as Light Rail Vehicle

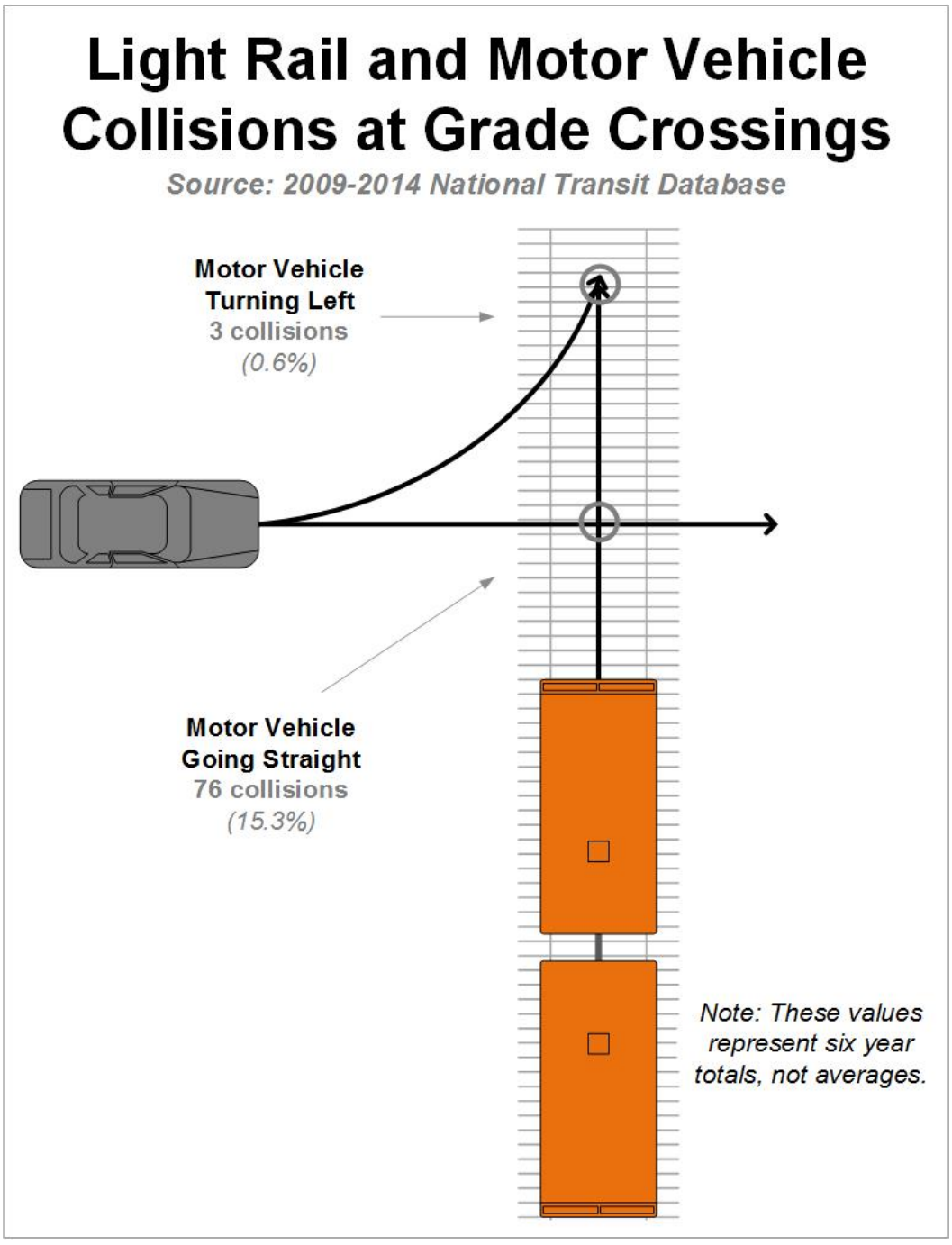


Figure 7-2: Motor Vehicle Approaching the Light Rail Vehicle from the Left

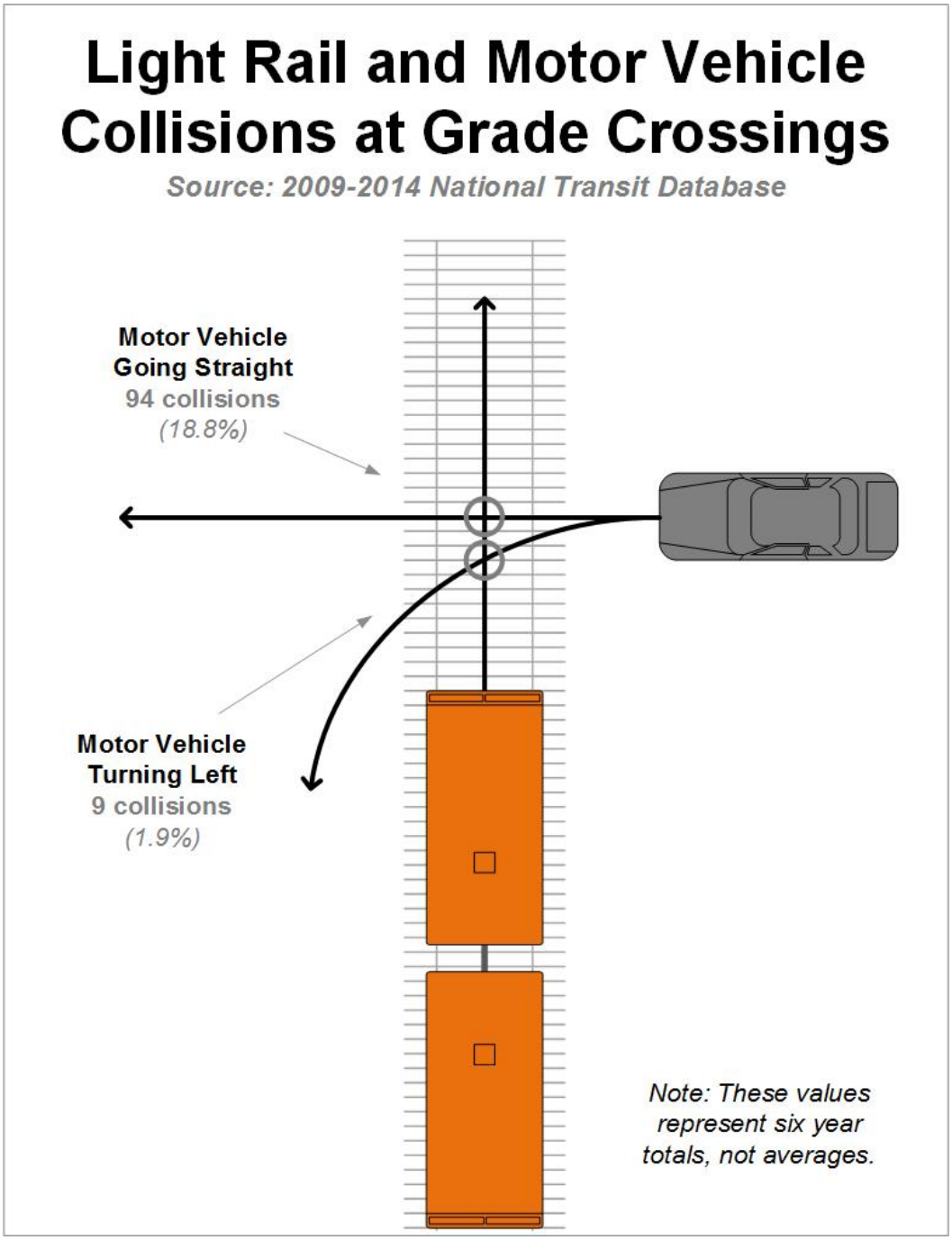


Figure 7-3: Motor Vehicle Approaching the Light Rail Vehicle from the Right

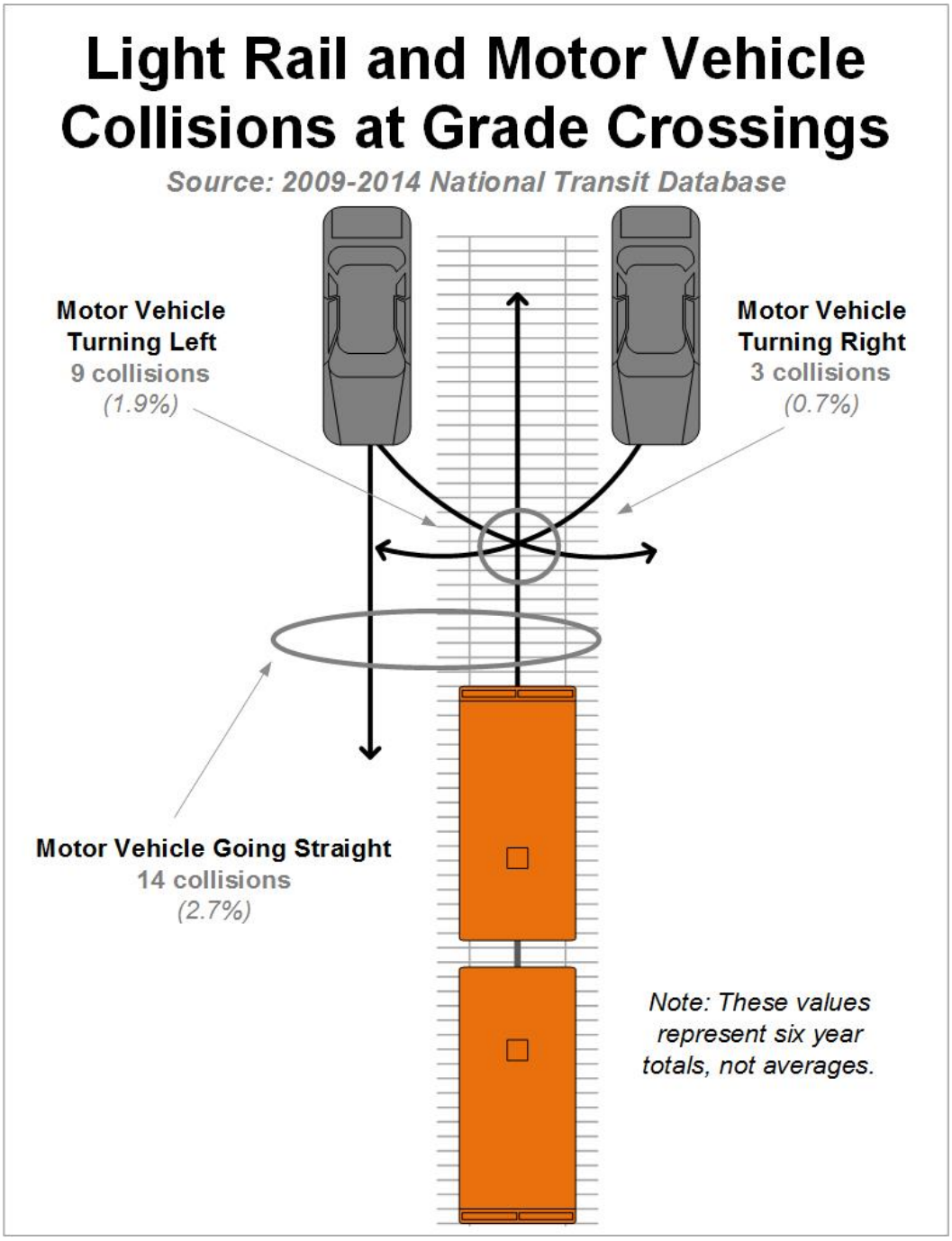


Figure 7-4: Motor Vehicle Approaching the Light Rail Vehicle from the Opposite Direction

7.6 Light Rail Collision Analysis

7.6.1 Analysis of Collision Types by Frequency

Table 7-6 depicts the collision types sorted by the frequency of collisions. The types of collisions occurring the most were collisions in which a motor vehicle traveling in the same direction turned left in front of the light rail vehicle while at a grade crossing, followed by the top three collisions with pedestrians, as described in Section 7.4.

Table 7-6: 2009-2014 Light Rail Collision Types Sorted by Frequency

No.	Collision With	Location	Collision Type	Total Number of Collisions (2009-2014)
1	Motor Vehicle	Grade crossing	Motor Vehicle Driving in Same Direction - Turned Left in Front of Light Rail	231
2	Pedestrian	Grade crossing	N/A	174
3	Pedestrian	Transit station	N/A	137
4	Pedestrian	Not a grade crossing	N/A	94
5	Motor Vehicle	Grade crossing	Motor Vehicle Approaching from Right - Going Straight	94
6	Motor Vehicle	Grade crossing	Motor Vehicle Approaching from Left - Going Straight	76
7	Motor Vehicle	Not a grade crossing	N/A	45
8	Motor Vehicle	Grade crossing	Motor Vehicle Driving in Same Direction - Going Straight	41
9	Other	N/A	N/A	31
10	Rail Vehicle	N/A	N/A	24
11	Motor Vehicle	Grade crossing	Motor Vehicle Driving in Same Direction - Turned Right in Front of Light Rail	17
12	Motor Vehicle	Grade crossing	Motor Vehicle Driving Towards Light Rail - Going Straight	14
13	Motor Vehicle	Grade crossing	Motor Vehicle Driving Towards Light Rail - Turning Left	9
14	Motor Vehicle	Grade crossing	Motor Vehicle Approaching from Right - Turning Left	9
15	Fixed Object	N/A	N/A	5
16	Motor Vehicle	Grade crossing	Motor Vehicle Driving Towards Light Rail - Turning Right	3
17	Motor Vehicle	Grade crossing	Motor Vehicle Approaching from Left - Turning Left	3
18	Non-rail transit vehicle	N/A	N/A	3
19	Pedestrian	Non-Revenue Facility	N/A	1
20	Pedestrian	Other	N/A	1

7.6.2 Analysis of Collision Types by Cost

Cost estimates of fatalities and injuries were derived using the method described in Section 5.7.2. An average property damage estimate of $52,000 was determined by taking an average of NTD-provided property damage costs for light rail collisions. The costs in Table 7-7 below reflect the sum of injury, fatality, and property damage costs for each collision type. The average yearly cost represents an arithmetic average across the six years. Collisions with pedestrians were by far the most expensive and were the top three collisions by total cost. The next highest cost was for collisions in which a motor vehicle was driving in the same direction and turned left in front of the light rail vehicle. Overall, the top four collision types by cost are the same as the top four collision types by frequency but in a slightly different order.

Table 7-7: 2009-2014 Light Rail Collision Types Sorted by Cost

No.	Collision With	Location	Collision Type	Total Number of Collisions (2009-2014)	Total Cost	Average Yearly Cost
1	Pedestrian	Grade crossing	N/A	174	$413,716,000	$68,952,667
2	Pedestrian	Not a grade crossing	N/A	94	$316,656,000	$52,776,000
3	Pedestrian	Transit station	N/A	137	$252,488,000	$42,081,333
4	Motor Vehicle	Grade crossing	Motor Vehicle Driving in Same Direction - Turned Left in Front of Light Rail	231	$111,784,495	$18,630,749
5	Motor Vehicle	Grade crossing	Motor Vehicle Approaching from Right - Going Straight	94	$54,064,113	$9,010,685
6	Motor Vehicle	Grade crossing	Motor Vehicle Approaching from Left - Going Straight	76	$36,508,296	$6,084,716
7	Motor Vehicle	Grade crossing	Motor Vehicle Driving in Same Direction - Turned Right in Front of Light Rail	17	$36,151,111	$6,025,185
8	Other	N/A	N/A	31	$33,968,000	$5,661,333
9	Rail Vehicle	N/A	N/A	24	$30,356,000	$5,059,333
10	Motor Vehicle	Not a grade crossing	N/A	45	$16,560,000	$2,760,000
11	Motor Vehicle	Grade crossing	Motor Vehicle Driving in Same Direction - Going Straight	41	$16,525,875	$2,754,313
12	Non-rail transit vehicle	N/A	N/A	3	$7,896,000	$1,316,000
13	Motor Vehicle	Grade crossing	Motor Vehicle Driving Towards Light Rail - Going Straight	14	$2,465,617	$410,936

No.	Collision With	Location	Collision Type	Total Number of Collisions (2009-2014)	Total Cost	Average Yearly Cost
14	Motor Vehicle	Grade crossing	Motor Vehicle Driving Towards Light Rail - Turning Left	9	$2,145,197	$357,533
15	Motor Vehicle	Grade crossing	Motor Vehicle Approaching from Right - Turning Left	9	$2,145,197	$357,533
16	Motor Vehicle	Grade crossing	Motor Vehicle Approaching from Left - Turning Left	3	$715,066	$119,178
17	Fixed Object	N/A	N/A	5	$260,000	$43,333
18	Pedestrian	Other	N/A	1	$232,000	$38,667
19	Motor Vehicle	Grade crossing	Motor Vehicle Driving Towards Light Rail - Turning Right	3	$181,453	$30,242
20	Pedestrian	Non-Revenue Facility	N/A	1	$180,000	$30,000

7.6.3 Analysis of Collision Types by Cost per Collision

Table 7-8 shows the collision types sorted by average cost per collision. As mentioned in Section 5.7.3, cost per collision is a highly variable number so it should only be used as a rough indication of collision severity. Collisions with pedestrians occurring at Right-of-way: Not a Grade Crossing have the highest cost per collision at $3,368,681 due to a high number of collisions, injuries, and fatalities. While few in number, collisions with non-rail transit vehicles have the second highest cost per collision at $2,632,000 because of the high number of fatalities.

Table 7-8: 2009-2014 Light Rail Collision Types Sorted by Cost per Collision

No.	Collision With	Location	Collision Type	Total Number of Collisions (2009-2014)	Cost per Collision
1	Pedestrian	Not a grade crossing	N/A	94	$3,368,681
2	Non-rail transit vehicle	N/A	N/A	3	$2,632,000
3	Pedestrian	Grade crossing	N/A	174	$2,377,678
4	Motor Vehicle	Grade crossing	Motor Vehicle Driving in Same Direction – Turned Right in Front of Light Rail	17	$2,072,000
5	Pedestrian	Transit station	N/A	137	$1,842,978
6	Rail Vehicle	N/A	N/A	24	$1,264,833
7	Other	N/A	N/A	31	$1,095,742

No.	Collision With	Location	Collision Type	Total Number of Collisions (2009-2014)	Cost per Collision
8	Motor Vehicle	Grade crossing	Motor Vehicle Approaching from Right - Going Straight	94	$577,417
9	Motor Vehicle	Grade crossing	Motor Vehicle Driving in Same Direction - Turned Left in Front of Light Rail	231	$483,573
10	Motor Vehicle	Grade crossing	Motor Vehicle Approaching from Left - Going Straight	76	$479,897
11	Motor Vehicle	Grade crossing	Motor Vehicle Driving in Same Direction - Going Straight	41	$403,429
12	Motor Vehicle	Not a grade crossing	N/A	45	$368,000
13	Motor Vehicle	Grade crossing	Motor Vehicle Driving Towards Light Rail - Turning Left	9	$232,000
14	Motor Vehicle	Grade crossing	Motor Vehicle Approaching from Right - Turning Left	9	$232,000
15	Motor Vehicle	Grade crossing	Motor Vehicle Approaching from Left – Turning Left	3	$232,000
16	Pedestrian	Other	N/A	1	$232,000
17	Motor Vehicle	Grade crossing	Motor Vehicle Driving Towards Light Rail – Going Straight	14	$180,571
18	Pedestrian	Non-Revenue Facility	N/A	1	$180,000
19	Motor Vehicle	Grade crossing	Motor Vehicle Driving Towards Light Rail - Turning Right	5	$52,000
20	Fixed Object	N/A	N/A	3	$52,000

8 Next Steps

This report provides a detailed and thorough analysis of transit collisions using 2009 through 2014 NTD data. Feasible next steps might use the analysis in a productive way that promotes deployment and adoption of ITS and connected vehicle safety applications within public transportation operations and, more specifically, in transit vehicles. Below are recommended actions for consideration as the USDOT further deploys ITS strategies and related connected vehicle programs.

Further Understanding of Transit Collisions

There is an opportunity to bring all relevant stakeholders to the table in a collaborative effort to further explore and review this work. There is a need to bring both internal USDOT offices and external transit agencies together to expand the knowledge base and incorporate user needs. Collaborating externally with both state and local DOTs as well as local transit providers would provide greater clarity of the top collision types this report identified and would provide greater understanding of these collisions and others, especially incidents that do not meet the federal requirements of NTD report, such as collisions which do not involve injuries/fatalities and those with costs under the $25,000 threshold. There is also a need to gain additional understanding and insight regarding the full costs and payouts involved with transit collisions and the overarching indemnification process. This report provides estimations and approximations based on the statistical values of life and injury thresholds, however by working with state insurance pools, for instance, and other transit professional organizations USDOT could enhance its understanding of the actual full costs of collisions and costs associated with long term disability payouts and other detailed figures.

Internal collaboration with other USDOT offices as well as with other stakeholders might also allow for increased opportunities to take advantage of other data that the USDOT already has, such as safety statistics and Geographic Information Systems (GIS) mapping files with latitude and longitude coordinates. The analysis used in this report involved NTD provided data sets. Other data sets might provide additional information or provide greater detail. For example, as detailed in Section 4, the data received from NTD is informative, but there are potential improvements that could be made to the NTD S&S-40 reporting which would increase the USDOT's ability to analyze transit vehicle collisions. Working with internal offices such as the FTA Office of Safety and Oversight as well as the program managers in charge of the NTD database could allow for increased coordination on both reporting transit collisions as well as collaboration on working to avoid collisions all together. Additional and expanded data fields that might be included in NTD reporting could enable greater depth of transit vehicle collision understanding. Likewise, other data sets might provide a greater level of detail and perspective on actually specifics of a collision. The analysis team believes that by adding additional information, or considering other data sets for comparison, would enhance the usefulness of the NTD. Such examples include:

a. **Provide Additional Details in the "Vehicle Action" Field:** The "Vehicle Action" field currently describes transit vehicles' movement when the vehicle collided with another object. Currently, users can select whether the transit vehicle was going straight or making a turn. The analysis team sees additional value in understanding whether the transit vehicle was making a left turn or making a right turn. It is thus recommended that the drop down menu for the "Vehicle Action" field to include options for "Turning Right", "Turning Left", and "Making a U-Turn".
b. **Include a New Field for the "Other Vehicle Movement" Field:** Currently, the NTD does not include a field describing the other vehicle's movement at the time of the collision. An understanding of the opposing vehicle's movement such as "Turning Right", "Turning Left",

"Going Straight", or "Stopped" would be beneficial for a comprehensive understanding of the collision. To obtain this information currently, researchers must extract this type of information from the non-uniform, free text "Event Description" field.

c. **Include a New Field to Document the Spatial Relationship between the Transit Vehicle and the Other Vehicle – Expand the Collision Type Field:** The NTD does not include a standardized field that describes the spatial relationship between two vehicles that were involved in the collision. To obtain this information, researchers currently have to extract information from the non-uniform, free text "Event Description" field. The research team thus recommends a new field be added to the NTD that categorizes the spatial relationship between the vehicles including information such as "Motor Vehicle Approaching from the Right", "Motor Vehicle Approaching from the Left", and "Motor Vehicle Driving toward the Transit Vehicle".

d. **Include a New Field Identifying the Traffic Control Device (e.g., Traffic Light, Stop Sign, Crosswalk):** The analysis team sees value in understanding if the collisions at intersections occurred at a traffic signal or a stop sign. The NTD does not have a field for this data, thus requiring researchers to extract this type of information from the non-uniform, free text "Event Description" field. Including a field that identifies the type of traffic control device (e.g., stop sign, yield sign, or traffic signal) present would provide valuable information on potential causes of collisions. Further defining the traffic control device to correspond to whether the traffic control device applied to the transit vehicle or other vehicle (e.g., motor vehicle) may be beneficial to account for intersections that have stop signs on the cross street, but not the mainline – and other intersection configurations.

Support Development, Testing, Evaluation, and Deployment of Transit Safety Applications

Due to its unique characteristics and behaviors, such as vehicle size and frequent stops/starts, transit often deals with safety challenges and priorities that are different from those for light vehicles. Based on an analysis of data from the NHTSA Fatality Reporting System, information from the 2013 "Transit Vehicle Collision Characteristics for Connected Vehicle Applications Research" report (FHWA-JPO-13-116), and collaboration with transit industry stakeholders, the USDOT identified several priority transit connected vehicle safety applications. Among these safety applications, two were selected for development and testing in the USDOT's Transit Safety Retrofit Package (TRP) research and development project, which was a part of the Safety Pilot Model Deployment. These transit safety applications are Pedestrian in Signalized Crosswalk Warning (PCW) and Vehicle Turning Right in Front of Bus Warning (VTRW). These two applications are currently being enhanced and improved. Also included in the Model Deployment for transit were the basic safety applications of Forward Collision Warning (FCW), Emergency Electronic Brake Lights (EEBL), and Curve Speed Warning (CSW). In 2015 the USDOT began work to develop and test another transit vehicle safety application: Transit Stop Bus Pedestrian Warning (TSPW). This V2I application provides alerts to bus drivers and pedestrians (via roadside infrastructure and registered mobile devices) when pedestrians are at risk of being struck by a bus as it approaches or departs from an equipped bus stop.

The next step for the Transit Connected Vehicle Research Program is to further explore applications that can enhance transit safety using connected vehicle technologies. These application areas could significantly reduce the number of transit collisions as well as collisions caused indirectly by the presence of a transit vehicle. Using the collision statistics, characteristics, and rankings identified in this report, potential application areas for transit safety include the following:

- Pedestrian Crossing Warning Applications: These applications could warn bus drivers of a pedestrian's presence in a crosswalk – at intersections and mid-block – such as the PCW application.

- Bus Stop Pedestrian Warning Applications: These applications could warn bus drivers and pedestrians of pedestrians in harm's way of bus movements at bus stops, such as the TSPW application.
- Left Turn Warning Applications: These applications could provide information to drivers performing unprotected left turns to judge the gaps in oncoming traffic and to inform them of hazards to completing a safe left turn.
- Forward Collision Warning Applications: These applications could warn drivers if they fail to brake when a vehicle in their path is stopped or traveling substantially slower, such as the FCW and EEBL applications.
- Angle Collisions at Intersections Warning Applications: These applications could provide warnings to drivers of imminent angle or T-bone collisions at intersections, including highway-rail intersections (HRI).
- Blind Spot Warning/Lane Change Warning Applications: These applications could warn drivers when they try to change lanes if there is a vehicle in the blind spot of an overtaking vehicle.

Developing limited pilots or demonstrations on specific fleets of transit vehicles with transit agencies or within testbeds could provide opportunities to collect additional data for analysis. These types of environments would allow for opportunities to evaluate the effectiveness of deployed safety technologies and their impacts on providing a greater safety environment. By partnering with local transit providers and working towards implementing these transit safety applications on a pilot or demonstration basis, the USDOT will analyze effectiveness and usefulness of the various applications. These pilots and demonstrations would provide an environment to accelerate the connected vehicle program and towards greater acceptance and deployment.

It is foreseeable that USDOT would work to assess future pilots and demonstrations of transit safety applications. The analysis team believes in performing additional collision analysis once transit safety applications are piloted or deployed by transit agencies in revenue service. Expanded evaluations will be needed when these safety applications are implemented and deployed. The USDOT could initiate a more detailed analysis using NTD data from particular transit agencies that implemented specific safety applications. Once these safety applications have been implemented for an extended period of years, USDOT could conduct a longitudinal study and compare the frequencies of collisions types both before and after the transit vehicle safety application deployment.

This report may be used by USDOT and the Connected Vehicle Transit Program as input for defining future transit safety applications and prioritizing those applications through phases of ITS implementation. This report should serve as an informed resource as USDOT moves towards ensuring that collisions occurring more frequently, and which are more costly, are given a higher priority as the transit industry continues defining, prototyping, and implementing safety applications for transit vehicles.

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APPENDIX A. List of Acronyms

Acronym	Meaning
AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
AIS	Abbreviated Injury Scale
BSM	BASIC Safety Message
CPI	Consumer Price Index
DOT	Department of Transportation
DSRC	Dedicated Short Range Communications
EEBL	Emergency Electronic Brake Light
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GPS	Global Positioning System
HOV	High Occupancy Vehicle
HRI	Highway Rail Intersection
I2P	Infrastructure-to-Pedestrian
I2V	Infrastructure-to-Vehicle
IMA	Intersection Movement Assist
ITS	Intelligent Transportation Systems
JPO	Joint Program Office
NHTSA	National Highway Traffic Safety Administration
NTD	National Transit Database

Acronym	Meaning
PCW	Pedestrian in Signalized Crosswalk Warning
RLVW	Red Light Violation Warning
ROW	Right-of-Way
RSU	Roadside Unit
SAE	Society of Automotive Engineers
SSGA	Stop Sign Gap Assist
SSVW	Stop Sign Violation Warning
TRP	Transit Retrofit Package
USDOT	United States Department of Transportation
V2I	Vehicle-to-Infrastructure
V2P	Vehicle-to-Pedestrian
V2V	Vehicle-to-Vehicle
VSL	Value of a Statistical Life
VTRW	Vehicle Turning Right in Front of Bus Warning
X2D	Vehicle of Infrastructure-to-Device

APPENDIX B. Terms and Definitions

The following terms and definitions were taken from the 2009 - 2014 NTD Glossary provided in the S&S-40 reporting manuals.

- **Angle Collision.** A collision type involving an impact to anywhere on the side of a vehicle with the exception of a sideswipe.
- **At Grade, Exclusive Right-of-Way.** Railway right-of-way from which all other traffic, mixed and cross, is excluded. Median strip ROW is included provided all crossings of the right-of-way pass over or under the median.
- **Automated Guideway.** A transit mode that is an electric railway (single or multi-car trains) of guided transit vehicles operating without vehicle operators or other crew onboard the vehicle. Service may be on a fixed schedule or in response to a passenger activated call button. Automated Guideway transit includes personal rapid transit, group rapid transit, and people mover systems.
- **Bicyclist.** A person who rides a bicycle.
- **Bus Stop.** Pre-defined location for passengers to board and/or alight the transit vehicle, typically on-street, at the curb, or in a median, sometimes with a shelter, sign, or lighting.
- **Cable Car.** A transit mode that is an electric railway with individually controlled transit vehicles attached to a moving cable located below the street surface and powered by engines or motors at a central location, not onboard the vehicle.
- **Commuter Rail.** A transit mode that is an electric or diesel propelled railway for urban passenger train service consisting of local short distance travel operating between a central city and adjacent suburbs. Service must be operated on a regular basis by or under contract with a transit operator for the purpose of transporting passengers within urbanized areas (UZAs), or between urbanized areas and outlying areas. Such rail service, using either locomotive hauled or self-propelled railroad passenger cars, is generally characterized by multi-trip tickets, specific station to station fares, railroad employment practices, and usually only one or two stations in the central business district. It does not include: heavy rail rapid transit, or light rail/streetcar transit service. Intercity rail service is excluded, except for that portion of such service that is operated by or under contract with a public transit agency for predominantly commuter services. Predominantly commuter service means that for any given trip segment (i.e., distance between any two stations), more than 50 percent of the average daily ridership travels on the train at least three times a week. Only the predominantly commuter service portion of an intercity route is eligible for inclusion when determining commuter rail route miles.
- **Demand Response.** A transit mode comprised of passenger cars, vans or small buses operating in response to calls from passengers or their agents to the transit operator, who then dispatches a vehicle to pick up the passengers and transport them to their destinations. A demand response operation is characterized by the following: (a) the vehicles do not operate over a fixed route or on a fixed schedule except, perhaps, on a temporary basis to satisfy a special need, and (b) typically, the vehicle may be dispatched to pick up several passengers at different pick-up points before taking them to their

respective destinations and may even be interrupted en route to these destinations to pick up other passengers. The following types of operations fall under the above definitions provided they are not on a scheduled fixed route basis:

  - Many origins — many destinations
  - Many origins — one destination
  - One origin — many destinations, and
  - One origin — one destination.

- **Employee.** An individual who is compensated by the transit agency as follows: (a) for directly operated services, the labor expense for the individual is reported in object class labor or (b) for purchased transportation service; the labor expense for the individual meets the same criteria as object class labor.
- **Fatality.** A death or suicide confirmed within 30 days of a reported incident. Does not include deaths in or on transit property that are a result of illness or other natural causes.
- **Ferryboat.** A transit mode comprised of vessels carrying passengers and/or vehicles over a body of water that are generally steam or diesel powered. Intercity ferryboat service is excluded, except for that portion of such service that is operated by or under contract with a public transit agency for predominantly commuter services. Predominantly commuter service means that for any given trip segment (i.e., distance between any two piers), more than 50 percent of the average daily ridership travels on the ferryboat on the same day. Only the predominantly commuter service portion of an intercity route is eligible for inclusion when determining ferryboat route miles.
- **Fixed Object.** A collision in which the primary collision involved a single vehicle and a fixed object.
- **Fixed Route Service.** Transit service using rubber tired passenger vehicles operating on fixed routes and schedules, regardless of whether a passenger actively requests a vehicle.
- **Grade Crossing.** An intersection of roadways, railroad tracks, or dedicated transit rail tracks that run across mixed traffic situations with: motor vehicles, rail modes, and pedestrian traffic.
- **Guideway.** A public transportation facility using and occupying a separate right-of-way or rail for the exclusive use of public transportation including the buildings and structures dedicated for the operation of transit vehicles such as at grade, elevated and subway structures, tunnels, bridges, track and power systems for rail modes, and paved highway lanes dedicated to bus mode. Guideway does not include passenger stations and transfer facilities, bus pull-ins or communication systems (e.g., cab signaling and train control).
- **Head-on Collision.** A collision type where two vehicles coming from opposite directions impact each other straight on in the front; or in a T-bone or broadside collision, where the front of a vehicle (head-on) impacts the side (angle) of another vehicle.
- **Heavy Rail.** A transit mode that is an electric railway with the capacity for a heavy volume of traffic. It is characterized by: (a) high speed and rapid acceleration passenger rail cars operating singly or in multi-car trains on fixed rails, (b) separate rights-of-way from which all other vehicular and foot traffic are excluded, (c) Sophisticated signaling, and (d) high platform loading.

- **Injury.** Any physical damage or harm to persons as a result of an incident that requires immediate medical attention away from the scene.
- **Jitney.** A transit mode comprised of passenger cars or vans operating on fixed routes (sometimes with minor deviations) as demand warrants without fixed schedules or fixed stops.
- **Light Rail.** A transit mode that typically is an electric railway with a light volume traffic capacity compared to heavy rail. It is characterized by: (a) passenger rail cars operating singly (or in short, usually two car, trains) on fixed rails in shared or exclusive right-of-way, (b) low or high platform loading, and (c) vehicle power drawn from an overhead electric line via a trolley or a pantograph.
- **Mode.** A system for carrying transit passengers described by specific right-of-way, technology and operational features.
- **Motor Bus.** A transit mode comprised of rubber-tired passenger vehicles operating on fixed routes and schedules over roadways. Vehicles are powered by diesel, gasoline, battery, or alternative fuel engines contained within the vehicle.
- **Motor Vehicle.** A self-propelled wheeled vehicle that does not operate on rails, such as trains or trolleys. The vehicle propulsion is provided by an engine or motor, usually by an internal combustion engine, or an electric motor, or some combination of the two, such as hybrid electric vehicles and plug-in hybrids.
- **Non-Revenue Facility.** A facility or an area that is not used to enable individuals to board or alight transit vehicles, and that is primarily staffed by transit employees.
- **Other Collision.** Any collision that is not defined by the NTD. Includes collisions with vehicles or objects not included in the S&S-40.
- **Other Front Impact Collision.** Any collision type that impacts the front of the vehicle and that would not be described as head-on.
- **Other Vehicle Occupant.** A person who is inside the other vehicle than a transit vehicle collided with.
- **Paratransit.** Types of passenger transportation which are more flexible than conventional fixed-route transit but more structured than the use of private automobiles. Paratransit includes demand response transportation services, shared-ride taxis, car-pooling and vanpooling, and jitney services. Most often refers to wheelchair-accessible, demand response service.
- **Parking Facility.** A transit-owned parking lot; a type of Revenue Facility.
- **Passenger.** An individual on board, boarding, or alighting from a revenue transit vehicle. Excludes operators, transit employees, and contractors.
- **Passenger Stations.** A passenger boarding/de-boarding facility with a platform, which may include: stairs, elevators, escalators, passenger controls (e.g., fare gates or turnstiles), canopies, wind shelters, lighting, or signs. It also may include buildings with a waiting room, ticket office or machines, restrooms, or concessions. Includes all fixed guideway passenger facilities (except for on-street cable car and light rail stops), including bus way passenger facilities; underground, at grade, and elevated rail stations; and ferryboat terminals. It includes transportation/transit/transfer centers, park-and-ride facilities, and transit malls

with the above components, including those only utilized by motor buses. It does not include stops (which are typically on-street locations at the curb or in a median, sometimes with a shelter, signs, or lighting) for bus, light rail, or cable car.

- **Property Damage.** The estimated dollar value of all property that is damaged in a Reportable Incident. Property damage considers transit-owned property and other vehicles property involved in the incident that are not owned by the transit agency. It excludes personal property such as cell phones and computers. Property damage also includes the cost of clearing wreckage.
- **Rear-ended.** A collision type where a vehicle is impacted on its back end by the front of another vehicle.
- **Rear-ending.** A collision type where the front of a vehicle impacts the back end of another vehicle.
- **Revenue Facility.** A location or an area within a location that is used to enable individuals to board or alight transit vehicles and that is controlled by the transit system. Includes terminal centers.
- **Revenue Facility Occupant.** An occupant at a location or an area within a location that is used to enable individuals to board or alight transit vehicles and that is controlled by the transit system.
- **Side Impact Collision.** A collision type in which a vehicle was impacted on one of its sides, including being T-boned or broadsided, or sustaining impact to a side mirror.
- **Sideswipe Collision.** A collision type in which two vehicles traveling in the same direction or opposite directions contact each other along the side in a scraping-type action, or a moving vehicle scraping its side against a stationery object.
- **Transit Employee/Contractor.** An individual who is compensated by the transit agency as follows: (a) for directly operated services, the labor expense for the individual is reported in object class 501 labor or (b) for purchased transportation service; the labor expense for the individual meets the same criteria as object class 501 labor.
- **Transit Facility Occupant.** A person who is inside the public passenger area of a transit revenue facility. Employees, other workers, or trespassers are not transit facility occupants.
- **Transit Passenger.** A person who is on board, boarding, or alighting from a transit vehicle for the purpose of travel. Operators, transit employees, and contractors are excluded.
- **Trolleybus.** A transit mode comprised of electric rubber-tired passenger vehicles, manually steered and operating singly on city streets. Vehicles are propelled by a motor drawing current through overhead wires via trolleys, from a central power source not onboard the vehicle.
- **Vanpool.** A transit mode comprised of vans, small buses and other vehicles operating as a ride sharing arrangement, providing transportation to a group of individuals traveling directly between their homes and a regular destination within the same geographical area. The vehicles shall have a minimum seating capacity of seven persons, including the driver. Vanpool(s) must also be in compliance with mass transit rules including Americans with Disabilities Act (ADA) provisions, and be open to the public and that availability must be

made known. Other forms of public participation to encourage ridesharing arrangements, such as:

- The provision of parking spaces
- Use of high occupancy vehicle (HOV) lanes
- Coordination or clearing house service, do not qualify as public vanpools.

APPENDIX C. Summary of 2009-2014 NTD Transit Collisions

The tables in Appendix C provide the detailed breakdown of all 2009-2014 NTD transit collisions. Tables C-1 through C-8 provide the normalized number of collisions in each category by year, as well as the averages for each collision type. Included in this table is the percentage of those collisions by category, and the percentage of the total number of collisions. As shown in the tables 13.0% of collisions involved motor buses and pedestrians, 41.0% of collisions occurred between motor buses and motor vehicles at intersections, 24.5% of collisions occurred mid-block between motor buses and motor vehicles and 16.4% of collisions occurred between motor busses and motor vehicles at bus stops.

Table C-9 provides the total number of collisions in order of frequency. Table C-10 provides the collision types based on average costs and Table C-11 provides the collision types based on cost per collision.

Table C-1: Summary of Average 2009-2014 NTD Motor Bus – Pedestrian Collisions

Category	Collision Type	2009*	2010*	2011*	2012*	2013*	2014*	Average Number of Collisions 2009-2014	% Category of Average Data	% Total of Average Data
Collisions at Intersections	Motor Bus Going Straight	114	113	94	87	100	99	101	22.0%	2.9%
Collisions at Intersections	Motor Bus Turning Left	80	76	74	68	72	90	77	16.7%	2.2%
Collisions at Intersections	Motor Bus Turning Right	42	31	40	29	27	31	33	7.2%	0.9%
Collisions at Intersections	Motor Bus Leaving a Stop	23	15	3	0	5	5	9	1.8%	0.2%
Collisions at Intersections	Motor Bus Making a Stop	11	11	2	1	3	3	5	1.1%	0.1%
Mid-Block Collisions	Motor Bus Going Straight	81	110	102	113	108	105	103	22.4%	2.9%
Mid-Block Collisions	Motor Bus Making a Turn	14	6	10	11	5	17	11	2.3%	0.3%
Mid-Block Collisions	Motor Bus Leaving a Stop	27	33	6	4	5	8	14	3.0%	0.4%
Mid-Block Collisions	Motor Bus Making a Stop	10	24	1	3	0	1	7	1.4%	0.2%
Bus Stop Collisions	Motor Bus Leaving a Stop	--	--	41	38	48	39	42	9.0%	1.2%
Bus Stop Collisions	Motor Bus Making a Stop	--	--	16	20	18	19	18	4.0%	0.5%
Bus Stop Collisions	Motor Bus Stopped	--	--	5	5	6	5	5	1.1%	0.1%
Bus Stop Collisions	Motor Bus Going Straight or Turning	--	--	8	13	11	15	12	2.6%	0.3%
Other Locations	N/A	25	27	25	20	21	32	25	5.4%	0.7%
Total		**427**	**446**	**427**	**412**	**429**	**469**	**461**	**100.0%**	**13.0%**

** Represents the normalized number of collisions for each year*

Table C-2: Summary of Average 2009-2014 NTD Motor Bus - Motor Vehicle Collisions at Intersections

Category	Collision Type	2009*	2010*	2011*	2012*	2013*	2014*	Average Number of Collisions 2009-2014	% Category of Average Data	% Total of Average Data
Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left - Going Straight	11	50	0	29	17	28	23	1.6%	0.6%
Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left- Turning Left	0	3	0	3	0	2	1	0.1%	0.0%
Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left- Turning Right	0	0	0	0	0	0	0	0.0%	0.0%
Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Right	4	0	15	0	0	8	4	0.3%	0.1%
Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	45	59	74	37	104	64	64	4.4%	1.8%
Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	4	6	0	3	0	0	2	0.1%	0.1%
Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Right - Going Straight	23	12	0	11	0	6	9	0.6%	0.2%
Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Right - Turning Left	0	0	0	0	0	0	0	0.0%	0.0%
Intersection - Motor Bus Turning Left	Motor Vehicle Driving in Same Direction - Turning Left	56	34	49	24	20	32	36	2.5%	1.0%
Intersection - Motor Bus Turning Left	Motor Vehicle Driving in Same Direction - Going Straight	15	31	30	27	13	24	23	1.6%	0.7%
Intersection - Motor Bus Turning Right	Motor Vehicle Approaching from Left - Going Straight	0	0	0	9	15	6	5	0.3%	0.1%
Intersection - Motor Bus Turning Right	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	4	3	10	0	0	2	3	0.2%	0.1%

Category	Collision Type	2009*	2010*	2011*	2012*	2013*	2014*	Average Number of Collisions 2009-2014	% Category of Average Data	% Total of Average Data
Intersection - Motor Bus Turning Right	Motor Vehicle Driving in Same Direction - Turning Right	15	16	10	4	18	14	13	0.9%	0.4%
Intersection - Motor Bus Turning Right	Motor Vehicle Driving in Same Direction - Going Straight	23	16	15	24	23	24	21	1.4%	0.6%
Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Left - Going Straight	58	129	39	98	127	165	103	7.1%	2.9%
Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Left- Turning Left	5	13	0	14	5	0	6	0.4%	0.2%
Intersection - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	28	13	22	57	35	59	36	2.5%	1.0%
Intersection - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	53	71	68	65	121	75	75	5.2%	2.1%
Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Going Straight	71	139	68	188	186	177	138	9.5%	3.9%
Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Turning Right	4	30	5	13	37	9	16	1.1%	0.5%
Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Turning Left	5	6	5	8	3	9	6	0.4%	0.2%
Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	202	117	85	173	119	132	138	9.5%	3.9%
Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	55	85	131	89	149	146	109	7.5%	3.1%
Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	5	14	29	27	28	47	25	1.7%	0.7%

Category	Collision Type	2009*	2010*	2011*	2012*	2013*	2014*	Average Number of Collisions 2009-2014	% Category of Average Data	% Total of Average Data
Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	405	164	261	100	159	156	208	14.3%	5.9%
Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	218	406	334	192	234	210	266	18.3%	7.5%
Intersection - Bus Stop	Motor Bus Leaving a Stop	94	96	75	60	45	63	72	5.0%	2.0%
Intersection - Bus Stop	Motor Bus Making a Stop	119	93	31	8	13	17	47	3.2%	1.3%
Total		**1521**	**1606**	**1354**	**1262**	**1472**	**1474**	**1448**	**100.0%**	**41.0%**

** Represents the normalized number of collisions for each year*

Table C-3: Summary of Average 2009-2014 NTD Motor Bus – Motor Vehicle Collisions at Mid-Block

Category	Collision Type	2009*	2010*	2011*	2012*	2013*	2014*	Average Number of Collisions 2009-2014	% Category of Average Data	% Total of Average Data
Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	150	158	264	135	148	145	167	19.3%	4.7%
Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	472	378	208	129	116	126	238	27.5%	6.7%
Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	168	160	114	257	233	267	200	23.1%	5.7%
Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	48	51	49	75	52	64	57	6.5%	1.6%
Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	4	21	2	10	35	24	16	1.8%	0.5%
Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	4	26	38	31	51	63	35	4.1%	1.0%
Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	4	11	15	14	27	32	17	2.0%	0.5%
Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching from Left or Right	12	58	6	56	58	58	41	4.8%	1.2%
Mid-Block - Motor Bus Making a Turn	Motor Vehicle Driving in Same Direction	11	11	13	16	4	11	11	1.3%	0.3%
Mid-Block - Motor Bus Making a Turn	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	1	4	6	3	3	2	3	0.4%	0.1%
Mid-Block - Bus Stop	Motor Bus Leaving a Stop	64	54	32	27	38	32	41	4.8%	1.2%

Category	Collision Type	2009*	2010*	2011*	2012*	2013*	2014*	Average Number of Collisions 2009-2014	% Category of Average Data	% Total of Average Data
Mid-Block - Bus Stop	Motor Bus Making a Stop	64	96	23	22	13	11	38	4.4%	1.1%
Total		**1003**	**1029**	**769**	**775**	**777**	**837**	**865**	**100.0%**	**24.5%**

** Represents the normalized number of collisions for each year*

Table C-4: Summary of Average 2009-2014 NTD Motor Bus – Motor Vehicle Collisions at Bus Stops

Category	Collision Type	2009*	2010*	2011*	2012*	2013*	2014*	Average Number of Collisions 2009-2014	% Category of Average Data	% Total of Average Data
Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	--	--	3	0	2	1	2	0.3%	0.0%
Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	--	--	1	11	7	10	7	1.3%	0.2%
Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	--	--	5	17	3	15	10	1.7%	0.3%
Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	--	--	0	0	2	0	1	0.1%	0.0%
Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	--	--	0	0	0	0	0	0.0%	0.0%
Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	--	--	20	22	16	18	19	3.3%	0.5%
Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	--	--	0	1	0	0	0	0.0%	0.0%
Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching from Left or Right	--	--	0	2	2	0	1	0.2%	0.0%
Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	--	--	2	1	0	2	1	0.2%	0.0%
Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	--	--	22	31	16	25	23	4.0%	0.7%
Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Going	--	--	6	14	9	6	9	1.5%	0.2%

Category	Collision Type	2009*	2010*	2011*	2012*	2013*	2014*	Average Number of Collisions 2009-2014	% Category of Average Data	% Total of Average Data
	Straight - Non Rear-Ending/Ended									
Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	--	--	0	0	0	0	0	0.0%	0.0%
Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	--	--	0	0	0	0	0	0.0%	0.0%
Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	--	--	2	3	0	1	2	0.3%	0.0%
Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	--	--	0	0	0	0	0	0.0%	0.0%
Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching from Left or Right	--	--	1	0	1	0	1	0.1%	0.0%
Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	--	--	0	1	0	1	1	0.1%	0.0%
Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	--	--	408	389	428	461	422	72.6%	11.9%
Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	--	--	41	47	53	68	52	9.0%	1.5%
Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	--	--	3	8	6	7	6	1.0%	0.2%
Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	--	--	0	0	2	2	1	0.2%	0.0%

Category	Collision Type	2009*	2010*	2011*	2012*	2013*	2014*	Average Number of Collisions 2009-2014	% Category of Average Data	% Total of Average Data
Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	--	--	2	7	6	8	6	1.0%	0.2%
Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	--	--	0	0	0	0	0	0.0%	0.0%
Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching from Left or Right	--	--	1	11	12	7	8	1.3%	0.2%
Bus Stop - Motor Bus Other Movement (Going Straight, Making Turn, etc.)	Motor Vehicle Driving in Same Direction - Going Straight	--	--	18	4	5	10	9	1.6%	0.3%
Total		**--**	**--**	**537**	**569**	**571**	**645**	**581**	**100.0%**	**16.4%**

** Represents the normalized number of collisions for each year*

Table C-5: Summary of Average 2009-2014 NTD Motor Vehicle Collisions with Fixed Objects

Category	Collision Type	2009*	2010*	2011*	2012*	2013*	2014*	Average Number of Collisions 2009-2014	% Category of Average Data	% Total of Average Data
Collisions with Fixed Objects	N/A	64	69	66	77	81	97	76	100.0%	2.1%
Total		**64**	**69**	**66**	**77**	**81**	**97**	**76**	**100.0%**	**2.1%**

** Represents the normalized number of collisions for each year*

Table C-6: Summary of Average 2009-2014 NTD Motor Vehicle Collisions with Transit Vehicles

Category	Collision Type	2009*	2010*	2011*	2012*	2013*	2014*	Average Number of Collisions 2009-2014	% Category of Average Data	% Total of Average Data
Collisions with Transit Vehicles	N/A	0	0	46	43	33	59	30	100.0%	0.9%
Total		**0**	**0**	**46**	**43**	**33**	**59**	**30**	**100.0%**	**0.9%**

** Represents the normalized number of collisions for each year*

Table C-7: Summary of Average 2009-2014 NTD Other Collisions

Category	Collision Type	2009*	2010*	2011*	2012*	2013*	2014*	Average Number of Collisions 2009-2014	% Category of Average Data	% Total of Average Data
Collisions with Other	N/A	40	27	28	28	28	22	29	100.0%	0.8%
Total		**40**	**27**	**28**	**28**	**28**	**22**	**29**	**100.0%**	**0.8%**

** Represents the normalized number of collisions for each year*

Table C-8: Summary of Average 2009-2014 NTD Miscellaneous Motor Vehicle Collisions (locations other than intersection, mid-block, or bus stop)

Category	Collision Type	2009*	2010*	2011*	2012*	2013*	2014*	Average Number of Collisions 2009-2014	% Category of Average Data	% Total of Average Data
Miscellaneous Motor Vehicle Collisions	N/A	77	47	33	31	50	39	46	100.0%	1.3%
Total		**77**	**47**	**33**	**31**	**50**	**39**	**46**	**100.0%**	**1.3%**

** Represents the normalized number of collisions for each year*

Table C-9: 2009-2014 Average NTD Collision Categories by Frequency

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
1	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	422	$241,856,704	$573,527
2	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-4	266	$121,867,107	$458,714
3	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-13	238	$123,363,322	$517,888
4	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-4	208	$119,676,273	$576,531
5	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-14	200	$83,293,519	$416,868
6	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-13	167	$75,031,569	$449,909
7	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Going Straight	Motor Vehicle	Figure 5-10	138	$87,741,630	$635,447
8	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-5	138	$52,225,569	$379,180
9	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-6	109	$43,503,456	$399,062
10	Mid-Block Collisions	Motor Bus Going Straight	Pedestrian	Figure 5-2	103	$120,344,533	$1,166,506
11	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	103	$69,730,780	$678,535
12	Collisions at Intersections	Motor Bus Going Straight	Pedestrian	Figure 5-1	101	$80,971,600	$800,378
13	Collisions at Intersections	Motor Bus Turning Left	Pedestrian	Figure 5-1	77	$81,775,124	$1,065,487
14	Collisions with Fixed Objects	Collisions with Fixed Objects	Fixed Object	NA	76	N/A	N/A
15	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	75	$34,211,446	$454,312
16	Intersection - Bus Stop	Motor Bus Leaving a Stop	Motor Vehicle	Figure 5-12	72	$32,160,678	$445,885
17	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-11	64	$46,728,883	$730,864

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
18	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-15	57	$71,086,530	$1,256,905
19	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	52	$24,154,515	$461,314
20	Intersection - Bus Stop	Motor Bus Making a Stop	Motor Vehicle	Figure 5-12	47	$25,304,336	$539,094
21	Miscellaneous Motor Vehicle Collisions	Miscellaneous Motor Vehicle Collisions	Motor Vehicle	NA	46	N/A	N/A
22	Bus Stop Collisions	Motor Bus Leaving a Stop	Pedestrian	Figure 5-3	42	$43,630,200	$1,051,330
23	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-14	41	$20,375,570	$493,243
24	Mid-Block - Bus Stop	Motor Bus Leaving a Stop	Motor Vehicle	Figure 5-18	41	$21,302,041	$516,341
25	Mid-Block - Bus Stop	Motor Bus Making a Stop	Motor Vehicle	Figure 5-18	38	$14,938,279	$390,087
26	Intersection - Motor Bus Turning Left	Motor Vehicle Driving in Same Direction - Turning Left	Motor Vehicle	Figure 5-7	36	$11,610,911	$322,398
27	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-11	36	$29,170,380	$818,306
28	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-16	35	$14,288,068	$402,549
29	Collisions at Intersections	Motor Bus Turning Right	Pedestrian	Figure 5-1	33	$29,082,057	$874,624
30	Collisions with Transit Vehicles	Collisions with Transit Vehicles	Transit Vehicle	NA	30	N/A	N/A
31	Collisions with Other	Collisions with Other	Other	NA	29	N/A	N/A
32	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-6	25	$27,739,731	$1,103,864
33	Miscellaneous Pedestrian Collisions	Miscellaneous Pedestrian Collisions	Pedestrian	NA	25	N/A	N/A
34	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	23	$15,609,529	$664,929
35	Intersection - Motor Bus Turning Left	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	Figure 5-7	23	$6,206,503	$266,148

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
36	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	23	$6,556,342	$290,625
37	Intersection - Motor Bus Turning Right	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	Figure 5-8	21	$5,930,331	$285,516
38	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-22	19	$6,214,757	$327,302
39	Bus Stop Collisions	Motor Bus Making a Stop	Pedestrian	Figure 5-3	18	$7,915,800	$433,742
40	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-16	17	$7,065,782	$409,264
41	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Turning Right	Motor Vehicle	Figure 5-10	16	$6,584,389	$409,491
42	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-15	16	$11,515,807	$720,814
43	Mid-Block Collisions	Motor Bus Leaving a Stop	Pedestrian	Figure 5-2	14	$20,583,467	$1,487,961
44	Intersection - Motor Bus Turning Right	Motor Vehicle Driving in Same Direction - Turning Right	Motor Vehicle	Figure 5-8	13	$3,545,261	$278,097
45	Bus Stop Collisions	Motor Bus Going Straight or Turning	Pedestrian	Figure 5-3	12	$6,700,800	$570,281
46	Mid-Block - Motor Bus Making a Turn	Motor Vehicle Driving in Same Direction	Motor Vehicle	Figure 5-17	11	$3,824,386	$348,033
47	Mid-Block Collisions	Motor Bus Making a Turn	Pedestrian	Figure 5-2	11	$17,651,384	$1,681,084
48	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	10	$3,992,969	$394,194
49	Bus Stop - Motor Bus Other Movement (Going Straight, Making Turn, etc.)	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	NA	9	$4,576,699	$485,122
50	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	9	$2,819,409	$322,998
51	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Right - Going Straight	Motor Vehicle	Figure 5-10	9	$2,974,887	$345,260
52	Collisions at Intersections	Motor Bus Leaving a Stop	Pedestrian	Figure 5-1	9	$6,080,267	$715,325

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
53	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	8	$2,117,268	$277,505
54	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	7	$7,920,953	$1,078,699
55	Mid-Block Collisions	Motor Bus Making a Stop	Pedestrian	Figure 5-2	7	$2,715,067	$417,703
56	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Left- Turning Left	Motor Vehicle	Figure 5-9	6	$2,179,604	$351,721
57	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Turning Left	Motor Vehicle	Figure 5-10	6	$5,586,116	$920,896
58	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	6	$8,567,398	$1,441,368
59	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-22	6	$1,576,605	$277,887
60	Bus Stop Collisions	Motor Bus Stopped	Pedestrian	Figure 5-3	5	$967,000	$184,190
61	Collisions at Intersections	Motor Bus Making a Stop	Pedestrian	Figure 5-1	5	$17,474,000	$3,382,065
62	Intersection - Motor Bus Turning Right	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	5	$1,433,862	$291,810
63	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Right	Motor Vehicle	Figure 5-11	4	$1,430,584	$323,476
64	Intersection - Motor Bus Turning Right	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	3	$762,012	$244,104
65	Mid-Block - Motor Bus Making a Turn	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-17	3	$4,788,433	$1,556,116
66	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	2	$979,530	$463,909
67	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	2	$637,110	$369,056
68	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-22	2	$660,589	$393,155
69	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	1	$524,476	$368,264
70	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left- Turning Left	Motor Vehicle	Figure 5-9	1	$605,203	$465,990

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
71	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	1	$685,622	$593,754
72	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	1	$263,702	$235,074
73	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	1	$108,894	$188,800
74	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	1	$106,081	$184,412
75	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	1	$2,712,595	$4,831,082
76	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0	$100,502	$368,800
77	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left- Turning Right	Motor Vehicle	NA	0	$0	$0
78	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Right - Turning Left	Motor Vehicle	Figure 5-10	0	$0	$0
79	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	0	$0	$0
80	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	0	$0	$0
81	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	0	$0	$0
82	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0	$0	$0
83	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0	$0	$0

Table C-10: 2009-2014 Average NTD Collision Categories by Cost

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
1	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	422	$241,856,704	$573,527

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
2	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-13	238	$123,363,322	$517,888
3	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-4	266	$121,867,107	$458,714
4	Mid-Block Collisions	Motor Bus Going Straight	Pedestrian	Figure 5-2	103	$120,344,533	$1,166,506
5	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-4	208	$119,676,273	$576,531
6	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Going Straight	Motor Vehicle	Figure 5-10	138	$87,741,630	$635,447
7	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-14	200	$83,293,519	$416,868
8	Collisions at Intersections	Motor Bus Turning Left	Pedestrian	Figure 5-1	77	$81,775,124	$1,065,487
9	Collisions at Intersections	Motor Bus Going Straight	Pedestrian	Figure 5-1	101	$80,971,600	$800,378
10	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-13	167	$75,031,569	$449,909
11	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-15	57	$71,086,530	$1,256,905
12	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	103	$69,730,780	$678,535
13	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-5	138	$52,225,569	$379,180
14	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-11	64	$46,728,883	$730,864
15	Bus Stop Collisions	Motor Bus Leaving a Stop	Pedestrian	Figure 5-3	42	$43,630,200	$1,051,330
16	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-6	109	$43,503,456	$399,062
17	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	75	$34,211,446	$454,312
18	Intersection - Bus Stop	Motor Bus Leaving a Stop	Motor Vehicle	Figure 5-12	72	$32,160,678	$445,885
19	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-11	36	$29,170,380	$818,306

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
20	Collisions at Intersections	Motor Bus Turning Right	Pedestrian	Figure 5-1	33	$29,082,057	$874,624
21	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-6	25	$27,739,731	$1,103,864
22	Intersection - Bus Stop	Motor Bus Making a Stop	Motor Vehicle	Figure 5-12	47	$25,304,336	$539,094
23	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	52	$24,154,515	$461,314
24	Mid-Block - Bus Stop	Motor Bus Leaving a Stop	Motor Vehicle	Figure 5-18	41	$21,302,041	$516,341
25	Mid-Block Collisions	Motor Bus Leaving a Stop	Pedestrian	Figure 5-2	14	$20,583,467	$1,487,961
26	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-14	41	$20,375,570	$493,243
27	Mid-Block Collisions	Motor Bus Making a Turn	Pedestrian	Figure 5-2	11	$17,651,384	$1,681,084
28	Collisions at Intersections	Motor Bus Making a Stop	Pedestrian	Figure 5-1	5	$17,474,000	$3,382,065
29	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	23	$15,609,529	$664,929
30	Mid-Block - Bus Stop	Motor Bus Making a Stop	Motor Vehicle	Figure 5-18	38	$14,938,279	$390,087
31	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-16	35	$14,288,068	$402,549
32	Intersection - Motor Bus Turning Left	Motor Vehicle Driving in Same Direction - Turning Left	Motor Vehicle	Figure 5-7	36	$11,610,911	$322,398
33	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-15	16	$11,515,807	$720,814
34	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	6	$8,567,398	$1,441,368
35	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	7	$7,920,953	$1,078,699
36	Bus Stop Collisions	Motor Bus Making a Stop	Pedestrian	Figure 5-3	18	$7,915,800	$433,742
37	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-16	17	$7,065,782	$409,264

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
38	Bus Stop Collisions	Motor Bus Going Straight or Turning	Pedestrian	Figure 5-3	12	$6,700,800	$570,281
39	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Turning Right	Motor Vehicle	Figure 5-10	16	$6,584,389	$409,491
40	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	23	$6,556,342	$290,625
41	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-22	19	$6,214,757	$327,302
42	Intersection - Motor Bus Turning Left	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	Figure 5-7	23	$6,206,503	$266,148
43	Collisions at Intersections	Motor Bus Leaving a Stop	Pedestrian	Figure 5-1	9	$6,080,267	$715,325
44	Intersection - Motor Bus Turning Right	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	Figure 5-8	21	$5,930,331	$285,516
45	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Turning Left	Motor Vehicle	Figure 5-10	6	$5,586,116	$920,896
46	Mid-Block - Motor Bus Making a Turn	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-17	3	$4,788,433	$1,556,116
47	Bus Stop - Motor Bus Other Movement (Going Straight, Making Turn, etc.)	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	N/A	9	$4,576,699	$485,122
48	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	10	$3,992,969	$394,194
49	Mid-Block - Motor Bus Making a Turn	Motor Vehicle Driving in Same Direction	Motor Vehicle	Figure 5-17	11	$3,824,386	$348,033
50	Intersection - Motor Bus Turning Right	Motor Vehicle Driving in Same Direction - Turning Right	Motor Vehicle	Figure 5-8	13	$3,545,261	$278,097
51	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Right - Going Straight	Motor Vehicle	Figure 5-10	9	$2,974,887	$345,260
52	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	9	$2,819,409	$322,998
53	Mid-Block Collisions	Motor Bus Making a Stop	Pedestrian	Figure 5-2	7	$2,715,067	$417,703
54	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	1	$2,712,595	$4,831,082

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
55	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Left- Turning Left	Motor Vehicle	Figure 5-9	6	$2,179,604	$351,721
56	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	8	$2,117,268	$277,505
57	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-22	6	$1,576,605	$277,887
58	Intersection - Motor Bus Turning Right	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	5	$1,433,862	$291,810
59	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Right	Motor Vehicle	Figure 5-11	4	$1,430,584	$323,476
60	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	2	$979,530	$463,909
61	Bus Stop Collisions	Motor Bus Stopped	Pedestrian	Figure 5-3	5	$967,000	$184,190
62	Intersection - Motor Bus Turning Right	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	3	$762,012	$244,104
63	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	1	$685,622	$593,754
64	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-22	2	$660,589	$393,155
65	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	2	$637,110	$369,056
66	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left- Turning Left	Motor Vehicle	Figure 5-9	1	$605,203	$465,990
67	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	1	$524,476	$368,264
68	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	1	$263,702	$235,074
69	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	1	$108,894	$188,800
70	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	1	$106,081	$184,412
71	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0	$100,502	$368,800
72	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left- Turning Right	Motor Vehicle	N/A	0	$0	$0

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
73	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Right - Turning Left	Motor Vehicle	Figure 5-10	0	$0	$0
74	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	0	$0	$0
75	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	0	$0	$0
76	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	0	$0	$0
77	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0	$0	$0
78	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0	$0	$0
79	Miscellaneous Pedestrian Collisions	Miscellaneous Pedestrian Collisions	Pedestrian	N/A	25	N/A	N/A
80	Miscellaneous Motor Vehicle Collisions	Miscellaneous Motor Vehicle Collisions	Motor Vehicle	N/A	46	N/A	N/A
81	Collisions with Fixed Objects	Collisions with Fixed Objects	Fixed Object	N/A	76	N/A	N/A
82	Collisions with Transit Vehicles	Collisions with Transit Vehicles	Transit Vehicle	N/A	30	N/A	N/A
83	Collisions with Other	Collisions with Other	Other	N/A	29	N/A	N/A

Table C-11: 2009-2014 Average NTD Collisions by Cost per Collisions

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
1	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	1	$2,712,595	$4,831,082
2	Collisions at Intersections	Motor Bus Making a Stop	Pedestrian	Figure 5-1	5	$17,474,000	$3,382,065
3	Mid-Block Collisions	Motor Bus Making a Turn	Pedestrian	Figure 5-2	11	$17,651,384	$1,681,084

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
4	Mid-Block - Motor Bus Making a Turn	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-17	3	$4,788,433	$1,556,116
5	Mid-Block Collisions	Motor Bus Leaving a Stop	Pedestrian	Figure 5-2	14	$20,583,467	$1,487,961
6	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	6	$8,567,398	$1,441,368
7	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-15	57	$71,086,530	$1,256,905
8	Mid-Block Collisions	Motor Bus Going Straight	Pedestrian	Figure 5-2	103	$120,344,533	$1,166,506
9	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-6	25	$27,739,731	$1,103,864
10	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	7	$7,920,953	$1,078,699
11	Collisions at Intersections	Motor Bus Turning Left	Pedestrian	Figure 5-1	77	$81,775,124	$1,065,487
12	Bus Stop Collisions	Motor Bus Leaving a Stop	Pedestrian	Figure 5-3	42	$43,630,200	$1,051,330
13	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Turning Left	Motor Vehicle	Figure 5-10	6	$5,586,116	$920,896
14	Collisions at Intersections	Motor Bus Turning Right	Pedestrian	Figure 5-1	33	$29,082,057	$874,624
15	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-11	36	$29,170,380	$818,306
16	Collisions at Intersections	Motor Bus Going Straight	Pedestrian	Figure 5-1	101	$80,971,600	$800,378
17	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-11	64	$46,728,883	$730,864
18	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-15	16	$11,515,807	$720,814
19	Collisions at Intersections	Motor Bus Leaving a Stop	Pedestrian	Figure 5-1	9	$6,080,267	$715,325
20	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	103	$69,730,780	$678,535
21	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	23	$15,609,529	$664,929

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
22	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Going Straight	Motor Vehicle	Figure 5-10	138	$87,741,630	$635,447
23	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	1	$685,622	$593,754
24	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-4	208	$119,676,273	$576,531
25	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-19	422	$241,856,704	$573,527
26	Bus Stop Collisions	Motor Bus Going Straight or Turning	Pedestrian	Figure 5-3	12	$6,700,800	$570,281
27	Intersection - Bus Stop	Motor Bus Making a Stop	Motor Vehicle	Figure 5-12	47	$25,304,336	$539,094
28	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-13	238	$123,363,322	$517,888
29	Mid-Block - Bus Stop	Motor Bus Leaving a Stop	Motor Vehicle	Figure 5-18	41	$21,302,041	$516,341
30	Mid-Block - Motor Bus Going Straight	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-14	41	$20,375,570	$493,243
31	Bus Stop - Motor Bus Other Movement (Going Straight, Making Turn, etc.)	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	N/A	9	$4,576,699	$485,122
32	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left- Turning Left	Motor Vehicle	Figure 5-9	1	$605,203	$465,990
33	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	2	$979,530	$463,909
34	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	52	$24,154,515	$461,314
35	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ended	Motor Vehicle	Figure 5-4	266	$121,867,107	$458,714
36	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	75	$34,211,446	$454,312
37	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-13	167	$75,031,569	$449,909
38	Intersection - Bus Stop	Motor Bus Leaving a Stop	Motor Vehicle	Figure 5-12	72	$32,160,678	$445,885

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
39	Bus Stop Collisions	Motor Bus Making a Stop	Pedestrian	Figure 5-3	18	$7,915,800	$433,742
40	Mid-Block Collisions	Motor Bus Making a Stop	Pedestrian	Figure 5-2	7	$2,715,067	$417,703
41	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-14	200	$83,293,519	$416,868
42	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Right - Turning Right	Motor Vehicle	Figure 5-10	16	$6,584,389	$409,491
43	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-16	17	$7,065,782	$409,264
44	Mid-Block - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-16	35	$14,288,068	$402,549
45	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-6	109	$43,503,456	$399,062
46	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	10	$3,992,969	$394,194
47	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-22	2	$660,589	$393,155
48	Mid-Block - Bus Stop	Motor Bus Making a Stop	Motor Vehicle	Figure 5-18	38	$14,938,279	$390,087
49	Intersection - Motor Bus Going Straight	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-5	138	$52,225,569	$379,180
50	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	2	$637,110	$369,056
51	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0	$100,502	$368,800
52	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction - Motor Bus Rear-Ending	Motor Vehicle	Figure 5-19	1	$524,476	$368,264
53	Intersection - Motor Bus Going Straight	Motor Vehicle Approaching from Left- Turning Left	Motor Vehicle	Figure 5-9	6	$2,179,604	$351,721
54	Mid-Block - Motor Bus Making a Turn	Motor Vehicle Driving in Same Direction	Motor Vehicle	Figure 5-17	11	$3,824,386	$348,033
55	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Right - Going Straight	Motor Vehicle	Figure 5-10	9	$2,974,887	$345,260
56	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-22	19	$6,214,757	$327,302

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
57	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Right	Motor Vehicle	Figure 5-11	4	$1,430,584	$323,476
58	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Going Straight - Non Rear-Ending/Ended	Motor Vehicle	Figure 5-20	9	$2,819,409	$322,998
59	Intersection - Motor Bus Turning Left	Motor Vehicle Driving in Same Direction - Turning Left	Motor Vehicle	Figure 5-7	36	$11,610,911	$322,398
60	Intersection - Motor Bus Turning Right	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	5	$1,433,862	$291,810
61	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left - Going Straight	Motor Vehicle	Figure 5-9	23	$6,556,342	$290,625
62	Intersection - Motor Bus Turning Right	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	Figure 5-8	21	$5,930,331	$285,516
63	Intersection - Motor Bus Turning Right	Motor Vehicle Driving in Same Direction - Turning Right	Motor Vehicle	Figure 5-8	13	$3,545,261	$278,097
64	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Turning Right in Front of Bus	Motor Vehicle	Figure 5-22	6	$1,576,605	$277,887
65	Bus Stop - Motor Bus Stopped	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	8	$2,117,268	$277,505
66	Intersection - Motor Bus Turning Left	Motor Vehicle Driving in Same Direction - Going Straight	Motor Vehicle	Figure 5-7	23	$6,206,503	$266,148
67	Intersection - Motor Bus Turning Right	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-11	3	$762,012	$244,104
68	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	1	$263,702	$235,074
69	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	1	$108,894	$188,800
70	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching from Left or Right	Motor Vehicle	Figure 5-20	1	$106,081	$184,412
71	Bus Stop Collisions	Motor Bus Stopped	Pedestrian	Figure 5-3	5	$967,000	$184,190
72	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Left- Turning Right	Motor Vehicle	N/A	0	$0	$0
73	Intersection - Motor Bus Turning Left	Motor Vehicle Approaching from Right - Turning Left	Motor Vehicle	Figure 5-10	0	$0	$0
74	Bus Stop - Motor Bus Leaving a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	0	$0	$0

No.	Category	Collision Type	Collision With	Figure #	Number of Collisions	Cost	Average Cost per Collision
75	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Going Straight	Motor Vehicle	Figure 5-21	0	$0	$0
76	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Approaching the Motor Bus from the Opposite Direction - Turning Left	Motor Vehicle	Figure 5-21	0	$0	$0
77	Bus Stop - Motor Bus Making a Stop	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0	$0	$0
78	Bus Stop - Motor Bus Stopped	Motor Vehicle Driving in Same Direction and Turning Left in Front of Bus	Motor Vehicle	Figure 5-22	0	$0	$0
79	Miscellaneous Pedestrian Collisions	Miscellaneous Pedestrian Collisions	Pedestrian	N/A	25	N/A	N/A
80	Miscellaneous Motor Vehicle Collisions	Miscellaneous Motor Vehicle Collisions	Motor Vehicle	N/A	46	N/A	N/A
81	Collisions with Fixed Objects	Collisions with Fixed Objects	Fixed Object	N/A	76	N/A	N/A
82	Collisions with Transit Vehicles	Collisions with Transit Vehicles	Transit Vehicle	N/A	30	N/A	N/A
83	Collisions with Other	Collisions with Other	Other	N/A	29	N/A	N/A

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