



Trolley Crashes in Philadelphia and Delaware County

February 2013



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Executive Summary

Trolleys, also known as trams or streetcars, appeared in late-1880s America and were the first mass transit mode to run on electricity, essentially replacing horse-drawn vehicles. Until the early 1940s, trolleys dominated mass transit in cities large and small across the country, including the Pennsylvania cities of Scranton, Pittsburgh, and Philadelphia. History shows us that most municipal systems were dismantled in the mid-20th century, making way for the automobile.

Yet, the trolley has held on in some cities, including Philadelphia, and is experiencing a renaissance in others. The Southeastern Pennsylvania Transportation Authority (SEPTA) currently operates eight trolley lines, including the Girard Avenue trolley, which was restored in 2005 after a service suspension in the early 1990s. Today, SEPTA's trolley lines are an important part of Philadelphia's transit network, connecting neighborhoods with Center City and providing links to other transit modes.

An important characteristic separating trolleys from other rail modes is that they often operate side by side with vehicle traffic, in the roadway. This makes the trolley very much like a bus, but on a fixed guide way. Also like buses, their exposure to crashes with motor vehicles is greater than rail vehicles that only encounter traffic at at-grade crossings. This report examines trolley crashes as found in the Pennsylvania Department of Transportation's (PennDOT's) crash database.

In the first phase of this analysis, we examined crashes involving trains and motor vehicles (see *Crash Data Review of Rail At-Grade Crossings in the Delaware Valley*, October 2011, #10016). During this work, we discovered that the Pennsylvania AA 500 crash reporting form, and by extension the PennDOT crash database, uses a unique code for train-involved crashes and another for trolley-involved crashes, which is a subset of the train-involved crashes. Once the distinction between the two was understood, the analysis was broken into two phases. This report details the process and findings of the second phase: a database review of trolley crashes in the Delaware Valley Regional Planning Commission (DVRPC) region. The study area is predominantly Philadelphia but also includes Delaware County, where SEPTA's Routes 101 and 102 trolleys operate and the Routes 11 and 13 trolleys terminate. Trolley service is not currently available in the New Jersey portion of the region (*note*: the New Jersey Transit River LINE was included in the first analysis).

During the three-year analysis period (2008–2010), 144 crashes occurred between trolleys and motor vehicles on the eight active lines of SEPTA's trolley system. System-wide, trolley crashes increased from 40 in 2008 to 55 in 2009, then dipped to 49 in 2010. During this period, no fatalities were recorded. Only 13 percent of the crashes were property damage only, and the other 87 percent were injury crashes involving 433 people. Thankfully, these crashes resulted in low severity, most involving only minor injuries.

Regarding collision type, angle crashes were the leading type at 45 percent, followed by rear-end crashes at 22 percent. Although six pedestrian crashes occurred, each was on a different trolley

route, indicating the absence of a trend. No anomalies were discovered regarding roadway conditions, weather, or lighting.

An analysis of crash totals by trolley route identified the Routes 15, 10, and 36 trolleys as having the highest crash totals with 39, 26, and 25 respectively. These crash totals are more than two times higher than the total number of any of the other five trolley routes. Details of crashes per route are explored more closely in the report.

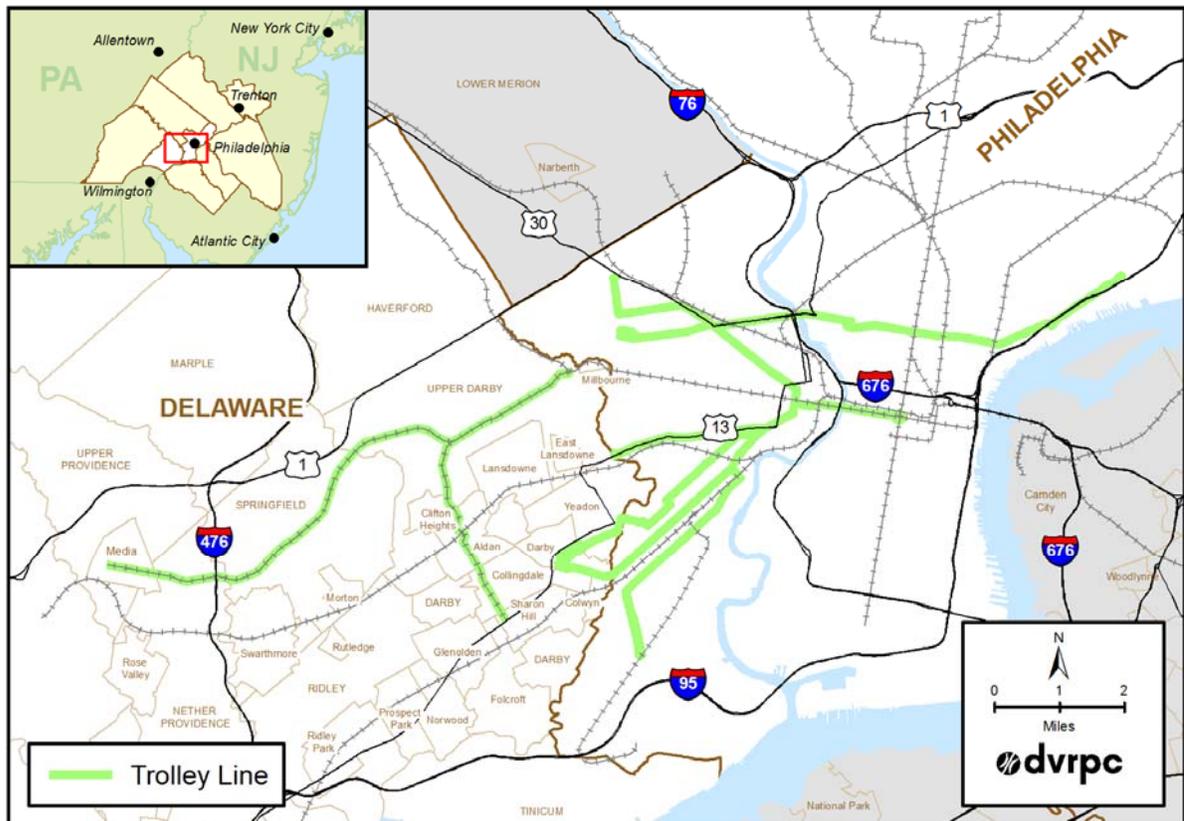
In summary, most crashes occurred at Center City locations, and very few occurred in suburban areas. Overall the most common location for crashes was at intersections. This is consistent with the finding that the most common contributing driver actions were making improper or careless turns, or making illegal U-turns. An important takeaway from these findings is that greater caution and vigilance are needed at intersections where trolleys cross.

Introduction

Background

Trolley lines were once common fixtures in many American cities. Thanks to their ability to transport large numbers of people farther and more quickly than many other transportation modes of the day, they enabled cities to grow farther horizontally, eventually contributing to suburban development. After the advent of the automobile and introduction of the bus, trolley lines fell out of favor in many places, and many were eventually removed. Recently, however, trolleys have been experiencing a renaissance, with new lines built or planned in many American cities. Philadelphia's trolley network once covered much of Center City and its surroundings. Today, eight lines remain, two of which are suburban (**Figure 1**). This also includes the recently restored Girard Avenue trolley line—a testament to the resurgence of trolley service nationwide.

Figure 1: Study Area



Why Trolleys Are Unique

Trolleys pose specific problems compared to other modes of transport. Like trains, they are fixed to a track. Like buses, they often run within the traffic of a road, however, they lack the flexibility of buses and cannot as easily avoid traffic congestion, road obstructions, or dangerous situations. When taking into account the high traffic volumes of both trolleys and the roads on which they operate, conflicts between trolleys and other vehicles are less common than vehicle–vehicle crashes. Somewhat attributable to their relatively slow speeds, trolley crashes often result in low injury severity. No fatalities were reported during the three-year analysis period for this study, and only a few instances of major injuries occurred. Still, trolley crashes remain somewhat common, despite laws meant to cut down on trolley-related accidents, such as the prohibition of passing a trolley while its lights are flashing, which is often ignored or misunderstood by motorists.

The Study

This report examines trolley crashes that involve motor vehicles or pedestrians, all of which were recorded by police using Pennsylvania’s AA 500 crash reporting form (no trolley–trolley, or trolley–bicyclist crashes were found during the analysis period). In 2010, there were 50 trolley–vehicle crashes in the study area (Philadelphia and Delaware counties), down 9 percent from 2009, but up 25 percent from 2008. In the same counties and during the same analysis period (2008–2010), approximately 45,000 total vehicle crashes occurred. Thus, trolley-involved vehicle crashes are a very small percentage of all crashes in the database but not insignificant. Very similar to when there is a bus crash, a trolley crash may cause congestion delays and involve many people.

This is the final report for the second phase of DVRPC’s crash data review of rail-related crashes. In the initial phase, crashes between trains and vehicles were addressed, as well as vehicle–vehicle crash trends in the immediate vicinity of train crossings. This effort identified the location and frequency of crashes involving trolleys, and considers summary information to attain a better understanding of trolley–vehicle crashes and concentration areas in the Philadelphia region. Crash details are examined for the trolley network as a whole and for each of SEPTA’s eight active trolley lines.

SEPTA and the Trolley Network

SEPTA

SEPTA owns and operates an extensive system of buses, trains, and trolleys throughout the Delaware Valley. It utilizes the infrastructure remaining from the Pennsylvania and Reading railroads for its Regional Rail services and operates subways, elevated trains, and at-grade trolleys on their own rights-of-way. These services, combined with its extensive bus system, make SEPTA one of the larger transportation authorities by ridership in the country.

SEPTA operates 14 Regional Rail lines connecting Philadelphia with its suburbs and International Airport. The lines reach into four suburban counties outside of Philadelphia: 1) Bucks, 2) Chester, 3) Delaware, and 4) Montgomery in Pennsylvania, Mercer County in New Jersey, and New Castle County in Delaware. Regional Rail is primarily used for commuting to and from Center City Philadelphia and operates on less frequent headways, with increased frequency during peak periods.

Along with Regional Rail, SEPTA operates two rapid transit train lines. The Market-Frankford Elevated Line (MFL; also known as “the El”) runs from Frankford Terminal in North Philadelphia, through Center City, to 69th Street Terminal just beyond the border of West Philadelphia in Upper Darby, Delaware County. The MFL runs grade separated: underground in Center City and elevated over major roads in peripheral areas. The Broad Street Line (BSL) subway runs north–south under Broad Street, connecting Center City Philadelphia to Fern Rock Transportation Center in North Philadelphia and the sports complex in South Philadelphia.

SEPTA operates many bus lines that interact with their rail network. Connections are available at major stations and transportation centers. Buses cover an extensive network throughout the region and are sometimes used to augment train and trolley service. In some cases, buses have been used to replace certain rail lines. Such was the case with the Route 15 Girard Avenue trolley, which was replaced with a bus from the 1990s until 2005 when trolley service was restored.



The Trolley Network

SEPTA's trolley lines run either underground or at-grade in Philadelphia and in Delaware County. All of the subway-surface trolley lines make stops at Philadelphia's 13th, 15th, 19th, and 22nd Street stations in Center City, before emerging above ground to serve points west. The Routes 15, 101, and 102 trolleys are not classified as subway-surface lines and run completely above ground. The Route 15 Trolley serves West and North Philadelphia, and the two latter routes serve the suburbs. Many lines operate 24 hours a day, though headways vary between day and night. Travel time also varies greatly depending on time of day because trolleys are not able to avoid peak-hour vehicular traffic. This difference is less pronounced on routes that operate partially or primarily on their own rights-of-way, such as the Routes 101 and 102 trolleys. Ridership varies between one million annual passengers for the least used line and five million annual passengers for the busiest.

Trackless Trolleys

Not included in this analysis are SEPTA's trackless trolleys. First put into service in 1923, the trackless trolley or "trolleybus" vehicles are actually electric buses that use the overhead catenary wires for power. Today, only three trackless trolley lines are operating, their service area restricted to North and Northeast Philadelphia. Unlike buses powered by fossil fuels, these lines are quiet and produce zero mobile source emissions, which typically makes them attractive in residential areas.

Route 10

The Route 10 Trolley operates between Center City and the Overbrook section of West Philadelphia. It follows Lancaster Avenue (US 30) for most of its route, a major east–west thoroughfare connecting Philadelphia to its western suburbs. Through Center City it utilizes a tunnel shared with other trolley lines. Seventy-four streets bisect the trolley's above-ground path, creating many points of potential conflict. The trolley runs 24 hours a day at headways of 5–10 minutes during the day, 10–15 minutes in the evening, and 30–40 minutes overnight. Depending on the time of day, the route takes between 29 and 39 minutes from start to finish. According to SEPTA's 2010 ridership estimates, the Route 10 Trolley transports approximately 15,900 persons daily and 4.6 million annually.

Route 11

The Route 11 Trolley runs southwest between Center City, where it travels underground, to the Darby Transportation Center in Delaware County. On its above-ground portion, the trolley follows Woodland Avenue for most of its route. Along this section, the line traverses 72 cross streets. During the day, the trolley operates at 5–10-minute headways, and 15–30-minute headways during the evening and night; hours of operation are from 5:00 AM to 2:00 AM. The trolley takes 31–41 minutes total to complete the route from start to finish. According to SEPTA's 2010 ridership estimates, The Route 11 Trolley transports approximately 16,100 persons daily and 4.8 million annually.

Route 13

The Route 13 Trolley also runs southwest, paralleling the Route 11 Trolley for most of its length. It operates between Center City and Yeadon, in Delaware County. Besides the underground portion in Center City, the line runs at street level primarily along Chester Avenue, Kingsessing Avenue, and 65th Street. Sixty-six cross streets are traversed along the trolley's above-ground length. Hours of operation are 24 hours a day, though the trolley only serves the Darby Transportation Center during peak hours. Headways range from 3–10 minutes during the day to 36 minutes overnight. Depending on the time of day, the trolley route takes between 27 and 34 minutes from end to end, plus an additional 5 minutes if it terminates at the Darby Transportation Center. According to SEPTA's 2010 ridership estimates, the Route 13 Trolley transported 16,700 persons daily and over five million annually—the highest of the lines studied.

Route 34

Following Baltimore Avenue (US 13) when above ground, the Route 34 Trolley operates between Center City and the Angora section of West Philadelphia. Like many other trolleys, it runs underground through Center City for the eastern portion of its length. The line traverses 37 cross streets along Baltimore Avenue, the shortest stretch of the lines studied. Hours of operation are 5:30 AM to 1:45 AM, with 3–10-minute headways during the day and up to 30-minute headways overnight. From start to finish, the route takes 25 to 28 minutes. According to SEPTA's 2010 ridership estimates, the Route 34 Trolley transported 16,200 persons daily and 4.8 million annually.

Route 36

The Route 36 Trolley splits off from Route 11 after briefly sharing track on Woodland Avenue. It operates between Center City and the Eastwick section of Southwest Philadelphia, not far from the Philadelphia International Airport. After running underground through Center City, it follows Elmwood Avenue and Island Avenue for most of its length, crossing 65 streets while above ground. Hours of operation are 24 hours a day, with 4–10-minute headways during the day and up to 32-minute headways overnight. When the trolley terminates at 73rd and Elmwood, the duration of the route is 25–33 minutes, and when terminating at Eastwick, the duration of the route is 32–41 minutes. According to SEPTA's 2010 ridership estimates, the Route 36 Trolley transported 15,900 persons daily and 4.7 million annually.

Route 15

The Route 15 Trolley is unique among the trolley lines in that it is not classified as a subway-surface trolley and is the only urban line that does not serve Center City. Instead, it connects the Haddington section of West Philadelphia with the Northern Liberties section of North Philadelphia. During the study period, the line terminated farther north in Port Richmond but was temporarily scaled back in 2012 due to construction. The Route 15 Trolley does not run underground at any point; it primarily follows Girard Avenue, then Richmond Street for approximately 1.25 miles to the eastern terminus.

Due to its extensive length completely above ground, it traverses 133 cross streets in total. Operation is 24 hours a day, with 10–15-minute headways during the day and up to 30 minutes overnight. The duration of the route from start to finish is between 42 and 67 minutes, depending on the time of day. According to SEPTA's 2010 ridership estimates, the Route 15 Trolley transported 10,900 persons daily and 3.2 million annually.

Route 101

The Route 101 Trolley is one of two trolley lines to operate wholly within the suburbs. Like the Route 15 Trolley, it is not classified as a subway-surface trolley line. It runs above ground for its entire length, connecting the 69th Street Terminal in Upper Darby to Media, the seat of Delaware County. No streets are followed at length; the Route 101 Trolley primarily operates on its own right-of-way. Because of this, it traverses only 41 cross streets, a small number considering its long length. Hours of operation are from 5:00 AM to 1:30 AM, with 10–20-minute headways during the day and up to 30 minutes at night. The duration of the route from start to finish is between 29 and 33 minutes. According to SEPTA's 2010 ridership estimates, the Route 101 Trolley transported 4,200 persons daily and 1.3 million annually.

Route 102

The Route 102 Trolley is the second line to operate wholly within the suburbs and is also not classified as a subway-surface trolley line. It runs above ground for its entire length, and like the Route 101 Trolley, it originates at the 69th Street Terminal in Upper Darby but terminates in Sharon Hill, also in Delaware County. The Route 102 Trolley primarily operates on its own right-of-way but uses Woodlawn Avenue for a considerable distance where it traverses 38 cross-streets. Hours of operations are from 5:00 AM to 2:00 AM, with 15– 20-minute headways during the day and up to an hour at night. The entire length takes 24–25 minutes to complete, depending on the time of day. According to SEPTA's 2010 ridership estimates, the Route 102 Trolley transported 3,400 persons daily and just over one million annual passengers.

Analysis Tools

Crash Data

All crash data used in this analysis came from PennDOT's crash database, for years 2008, 2009, and 2010. PennDOT's proprietary system is called the Crash Data Analysis and Retrieval Tool (CDART). This database contains only reportable crashes.

Reportable Crashes vs. Non-Reportable Crashes

Differentiating between reportable and non-reportable crashes is helpful in analyzing crash trends. In Pennsylvania, the threshold for a reportable crash requires that an involved vehicle need towing from the scene or that a person was injured. Fender-bender crashes in which no one was injured and no vehicles are disabled are excluded from the Pennsylvania database. Thus, a very high crash total in Pennsylvania may be an indication of high severity, but not always.

Other Tools

In completing the data verification and crash location work required in this effort, the following tools were utilized: ArcGIS, Microsoft Access, Microsoft Excel, and various internet-mapping applications. DVRPC also received police report narratives and diagrams for select crash records that were missing geo-reference information.

Crashes Involving Trolleys

The main objective of this study was to explore the universe of trolley crashes included in the PennDOT crash database, in search of concentration areas and trends. DVRPC's Office of Safety and Congestion Management has a large body of crash-related work, though none of it considers trolley crashes.

During the first phase of this effort, we discovered that trolley crashes are coded differently than train-vehicle crashes on Pennsylvania's AA 500 crash reporting form, and by extension in PennDOT's crash database. While parsing the data, we identified 141 trolley-vehicle crashes—nine times the number of train-vehicle crashes in the Pennsylvania counties of the DVRPC region for the 2007–2009 analysis period. Because trolleys operate in traffic and run predominantly at-grade, the number of crossings is higher and more densely concentrated. Due to these unique characteristics that set them apart from trains, as well as the greater number of trolley crashes, it was logical to focus on trolley crashes separately. At the time of this analysis a new year of data became available, making the analysis period 2008–2010.

Crash Data: 2008 to 2010

Originally, 145 crashes were identified as trolley crashes in the 2008–2010 analysis period. During the data verification process using geographic information systems (GIS), one crash was distinguished as a trackless-trolley crash that was miscoded as a trolley crash, apparent by its location. SEPTA's trackless trolleys are not trolleys, rather they are buses powered by overhead catenary power lines. Although their path is literally tethered to the power line structure, they have more freedom than trolleys and are also entirely different vehicles. For these reasons, this crash was omitted from the analysis. With that crash record removed, the new total for system-wide analysis became 144 crashes. The following sections consider statistics for trolley crashes system-wide as a whole, and for each of the eight routes that comprise the trolley network.

System-Wide Summary Statistics

Chronology

Between 2008 and 2010, 144 crashes occurred between trolleys and motor vehicles. They are distributed somewhat evenly by year, with 40 in 2008, 55 in 2009, and 49 in 2010. Concerning time

of year, crashes were most prevalent in the months of November and December and least prevalent during the summer months. The distribution of crashes by day of week reveals no clear pattern, with similar numbers each day. Wednesdays had the most crashes with 26 and Thursdays the fewest with 16 crashes. Crash patterns by time of day showed increases during the workday and decreases during the overnight hours (*note*: seven crashes were missing time-of-day information).

Severity

Table 1 below summarizes the crash severity details of the analysis period crashes. There were no fatalities resulting from the 144 trolley crashes recorded during years 2008, 2009, and 2010. Eighty-eight percent of the crashes (events) were injury crashes, and 12 percent were property damage only (PDO). Of the 126 injury crashes (events), the predominant category was minor injury (43 percent). Regarding the severity level of the 433 people involved, 42 percent reported minor injuries, four percent had moderate injuries, and only three people suffered major injuries (approximately one percent). Thirty-seven percent were described as having an injury of unknown severity, and 16 percent were listed as unknown if injured.

Table 1: Crash Severity Level (events) and Severity Count (people injured)

Crash Severity Level (events)	Total	Percent	Severity Count (people injured)	Total	Percent
Not injured	18	12%	Fatal	0	0%
Major injury	2	1%	Major injury	3	1%
Moderate injury	11	8%	Moderate injury	17	4%
Minor injury	62	43%	Minor injury	180	42%
Unknown injury or severity	51	36%	Unknown severity	163	37%
			Unknown if injured	70	16%
Total crashes	144	100%	Total people involved	433	100%

Source: DVRPC

Conservatively speaking, the trolley crashes examined in this analysis period resulted in very low severity overall, especially compared to vehicle–vehicle crashes. This may be related to the fact that trolleys generally operate at comparatively slower speeds. On balance, the trolleys’ stop frequency may be related to the number of total crashes.

Collision Type

A large variation in collision types was observed, most likely due to the high level of integration and interaction between trolleys and vehicle traffic. Angle crashes constituted a plurality of the total at 45 percent. According to Pennsylvania’s definition, an angle crash means that the two vehicles, or trolley and motor vehicle, struck each other at an angle, in T-bone fashion, but this definition does not indicate the direction of travel prior to the crash. A closer look at this data revealed that 67 percent of the 65 angle crashes involved a turning movement on the part of the motor vehicle operator: 21 left turns, 12 U-turns, and 11 right turns. This finding is important because it indicates a

judgment miscalculation most likely on the part of the driver and less likely on the part of the trolley operator, due to trolleys operating on a fixed guide way.

The next highest collision types were rear-end crashes at 22 percent, same-direction sideswipe at 16 percent, and opposite-direction sideswipe at 6 percent. Surprisingly, 5 percent of the crashes were head-on and 1 percent were rear-to-rear, suggesting irregular or erratic driving behavior. Six crashes or 4 percent of the total, involved pedestrians, with one pedestrian crash occurring on each of the following Routes: 10, 13, 15, 34, 36, and 101. There were no clear patterns concerning pedestrian crashes, as trolley lines of different ridership, frequency, geography, and level of integration in the road network were all represented. In addition, no bicyclists were involved in any of the trolley crashes.

Weather, Road Surface Condition, Lighting

Typically, motor vehicle crashes occur in ideal weather conditions. Sudden weather conditions, sun glare, or slippery road conditions accounted for only 20 percent of total crashes. Considering road surface condition, 76 percent of the crashes occurred on a dry road surface and 19 percent on wet roadways, with the remainder on snow, ice patches, or slush. Additionally, 69 percent occurred during daylight hours, which is typical as most travel occurs during the day.

Driver Actions

Driver actions describe things that the involved people did at the time of the crash, which may or may not have contributed to the crash. Because there are often multiple actions attributed to each driver, there are more driver actions than there are crashes. Almost half of the driver actions recorded were coded as “no contributing action.” This proportion is not uncommon in a crash report, nor is it an indication that driver error is insignificant because it also reflects underreporting by those involved in a crash. Often in a two-vehicle crash one driver is the victim who may have done nothing to contribute to the crash (e.g., rear-end crash). Two contributing actions worth noting in this analysis include “making an illegal U-turn” and “making an improper or careless turn.” “Tailgating” and “careless passing or lane changing” were also common. The database details did not provide enough information to determine if and how often a crash was caused by the trolley driver or the vehicle driver. However, as stated in the collision type discussion, 67 percent of the angle crashes involved a turning movement on the part of the motor vehicle operator.

Crash Summaries by Trolley Route

Introduction

The following section examines crash summary details for each line, including the following data items: chronology, collision and vehicle type, severity, environmental factors, driver actions, and crash concentrations (where applicable). A crash map of each line is also provided.

The driver actions total will always exceed the number of crashes because multiple actions can be recorded for each driver involved. As stated above, typically “no contributing action” is the most commonly cited action. In the route analyses that follow, the actions cited in addition to “no contributing action” are emphasized, as it is these details that help us to understand what may have caused the crash.

The following highlights were taken from the crash narratives.

- Routes 10, 15, and 36 had the highest crash totals of the lines studied.
- Route 102 had the fewest crashes, followed by Route 101 and Route 34.
- Routes with higher crash totals all follow busy arterials with frequent at-grade crossings.
- Routes with lower crash totals are generally located along roads with lower traffic volumes and fewer intersections.

Unassigned Crash Records

Crash records sometimes have missing or incomplete information. This analysis identified 144 trolley crashes system-wide, of which 140 contained enough location information to be assigned to individual trolley routes (**Table 2**). Although the remaining four records could not be assigned, the majority of the data fields were complete and provided adequate confirmation that they were in fact trolley crashes and should be included in the overall summaries. Therefore, the sum of all crashes by route equals 140, and not 144 as described in the system-wide summary statistics.

Table 2: Crash Totals by Trolley Route over Time

Trolley	2008	2009	2010	Crash Total
Route 10	10	10	6	26
Route 11	1	3	4	8
Route 13	4	5	6	15
Route 15	8	20	11	39
Route 34	2	2	2	6
Route 36	6	7	12	25
Route 101	1	3	0	4
Route 102	2	0	5	7
Routes 11 and 36 Trunk	2	1	1	4
Routes 101 and 102 Trunk	2	3	1	6
	38	54	48	140

Source: DVRPC

Trunk Line Crashes

There are two sets of trolley routes that share right-of-way for a portion of their above-ground alignments before diverging: the Routes 101 and 102 trolleys, and the Routes 11 and 36 trolleys. The GIS analysis performed to extract crashes per line for analysis did not provide a level of detail adequate to assign crashes to one line or the other on the shared right-of-way sections. In these cases, the trunk line crashes were analyzed separately from the route section crash analyses. Each route analysis was checked to ensure trunk line crashes were not included.

Routes 11 and 36 Trolley Trunk Line: Four Crashes

With only four crashes, the Routes 11 and 36 Trolley Trunk Line section was tied with the Route 101 Trolley for the fewest recorded crashes. The Route 11 and Route 36 trolleys have similar headways and annual ridership numbers. These routes start underground in Center City and, after emerging at the 40th Street portal, run parallel along Woodland Avenue through West Philadelphia for nine blocks. Woodland Avenue is mostly one lane per direction with on-street parking and bike lanes throughout. The trolley tracks are centered between the double yellow and the bike lanes in each direction. The two trolley lines diverge at 49th Street, where the Route 36 Trolley turns left, following 49th Street.

With so few crashes, it can be difficult to identify trends. All three years were represented, and each crash occurred in a different month, on a different day, and at different times. The two items of interest involve severity and collision type. Of the 13 people involved, two experienced major injuries which is a higher percentage than the system-wide trend. And there were two rear-end and two opposite-direction sideswipe crashes, whereas the predominant system-wide trend was angle crashes (45 percent). All other crash details were ordinary.

Regarding crash concentrations, the four crashes occurred at two locations: two were recorded very close to one another at the intersection of 41st Street, and the other two were recorded at the intersection of 47th Street.

Routes 101 and 102 Trolley Trunk Line: Six Crashes

There were six crashes along the Routes 101 and 102 Trolley Trunk Line during the study period. These routes have similar headways and annual ridership numbers. Their alignment begins at the 69th Street Terminal, and they travel approximately two miles along a dedicated right-of-way until they diverge at Shadeland Avenue in Upper Darby Borough. There are 11 cross streets along this trunk line.

Crashes declined over the three-year period, and only in December were two crashes recorded. Regarding day of week, two crashes were recorded on Sundays and Wednesdays, and the remaining two were on Tuesday and Thursday; no trend was identified by time of day.

Severity was low with only one moderate injury recorded of the six people involved; the remainder coded as unknown severity. Road condition, weather, and lighting conditions were predominantly favorable with 83 percent of the crashes occurring on dry roads, during favorable weather, and

during the daytime. Driver actions included turning and lane changing mistakes, red light running, and failure to obey the traffic control device.

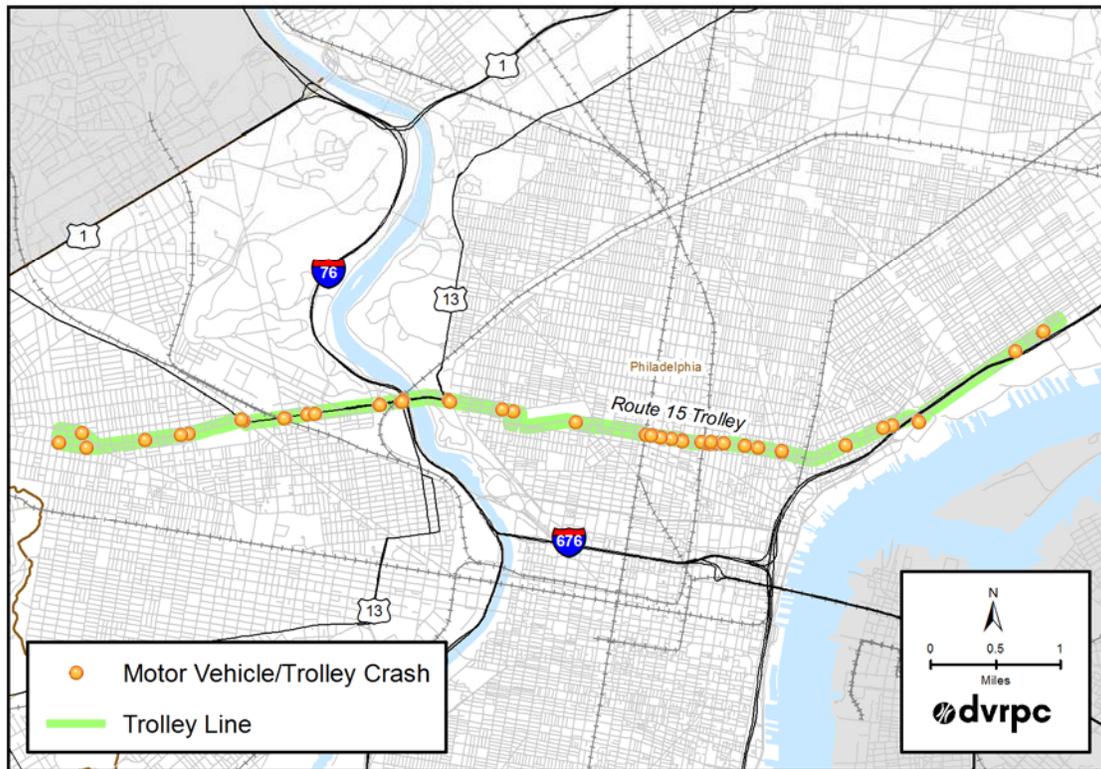
Regarding concentration areas, the six crashes occurred at four locations. Of those, three of the crashes were recorded at the Fairfax Road cross street crossing in Upper Darby Township, the only concentration area on the trunk line.

Route 15: 39 Crashes

Setting

During the study period, 39 crashes occurred involving the Route 15 Trolley, the highest number of crashes of the routes studied (**Figure 2**). This is the only line operating in North Philadelphia and the only urban trolley not using the underground main line under Center City. The line runs primarily on Girard Avenue, a major east–west thoroughfare, and is widely known as the Girard Avenue Trolley.

Figure 2: Route 15 Trolley Crashes



This trolley connects North and West Philadelphia over the Schuylkill River between 33rd and 34th streets. Girard Avenue cycles between two- and four-lane configurations along the route. West of the Schuylkill River, the road is either two lanes (both shared with trolleys) with bike lanes, or two or four lanes with trolleys in a dedicated median that may be exclusive or may be used for left turns or through traffic, depending on location. On-street parking is prevalent throughout. Girard Avenue is two-ways for its entire length, and where there is a median, the left turn lane is shared with the trolley right-of-way. The Route 15 Trolley operates 24 hours a day at 10–15-minute headways during the

day, and 30-minute intervals overnight. It crosses many other transit lines and offers useful connections to buses, the MFL, the BSL, and the Route 10 Trolley.

Chronology

Eight crashes were recorded in 2008, 20 in 2009, and 11 in 2010. There was an even distribution by month, where the crash totals were equally distributed with no anomalies. On average, there were about three crashes per month with February and December having the most at six and five, respectively; no crashes were recorded in January. Distribution of crashes by day of the week varied widely. Saturday had the most with nine, and Thursday had the least with two. Monday and Wednesday also had high numbers, with six and eight, respectively. There were no patterns by time of day. With the exception of 5:00 AM, 6:00 AM, 12:00 AM, and 1:00 AM when there were no crashes, each other hour of the day had between one and three (*note*: one crash was missing time-of-day information). No pattern was identified consistent with the morning and afternoon peak hours.

Collision and Vehicle Type

Crashes on the Route 15 Trolley showed some strong differences from other lines. There was a relatively low number of rear-end and same-direction sideswipe crashes (six and seven crashes, respectively), while the number of angle crashes (21) was disproportionately larger than the rest of the crash types, which is consistent with the finding that most crashes on the Route 15 Trolley took place at intersections. Rounding out the bottom, there were two head-on crashes, one non-collision (e.g., vehicle breakdown, etc.), one opposite-direction sideswipe, and one hit pedestrian. The large percentage of angle crashes and low percentage of rear-end crashes may be attributed to the line's partial right-of-way through much of the route, operating within the center lanes of the road that also accommodate left turns. Twenty-five automobiles were involved, along with seven vans, three sports utility vehicles (SUVs), three small trucks, and one bus. In addition, there was one pedestrian involved.

Severity

Crashes involving the Route 15 Trolley were of relatively low severity, with no fatalities. Of the total crashes, 21 resulted in minor injury, one in moderate injury, and one in major injury. Two crashes resulted in no injuries, one was unknown, and 13 resulted in an injury of unknown severity. Of the people involved, 44 sustained minor injuries, one sustained moderate injury, and one sustained major injury. Fifty-two people sustained injuries of an unknown severity, and it is unknown if the remaining 35 people were injured.

Environmental Factors

In keeping with the rest of the lines, most crashes occurred during favorable weather and environmental conditions. Six percent of crashes occurred on slippery road conditions and amid other weather conditions, while 68 percent of crashes occurred while there were no environmental or roadway factors. Similarly, 74 percent of the crashes occurred on a dry road surface, while 18 percent occurred on a wet surface, and 3 percent occurred on ice patches. Regarding weather, 77 percent of the crashes occurred in the absence of adverse conditions. Compared to other trolley lines and crash trends in general, a very high portion of crashes occurred during dark and dusk conditions. Only 54 percent of crashes were during daylight hours, a notable trend, while 38 percent

occurred in the dark with street lights on, and 3 percent occurred in the dark with no street lights. Another 3 percent happened during dusk, and the remainder was listed as other.

Driver Actions

The most prevalent driver actions involved turning: making an improper or careless turn (8 percent), turning from the wrong lane (7 percent), and making an illegal U-turn (6 percent). No contributing action accounted for 41 percent of the total, and another 22 percent were listed as unknown. The remaining actions were recorded only once, signifying no trend.

Crash Concentrations

Although crashes are spread out along the entire length of the Route 15 Trolley, they occurred mostly at intersections. Crashes were especially numerous on an 11-block stretch of Girard Avenue between Broad Street and Marshall Street to the east. In this section, there is at least one crash at nearly every intersection, coming to a total of 13. Conversely, directly west of this stretch there are very few crashes until the trolley crosses the Schuylkill River into West Philadelphia. Just after its crossing, the two adjacent intersections where Girard Avenue meets North 34th Street (US 13) and the on- and off-ramps for the Schuylkill Expressway (I-76) each had two crashes. In total, 12 crashes occurred west of the river and 27 on the east.

Route 10: 26 Crashes

Setting

During the study period, there were 26 crashes involving trolleys along Route 10 in West Philadelphia, the second highest number among the lines studied (**Figure 3**). The line follows Lancaster Avenue for most of its length. Other roads used include Lansdowne Avenue and 63rd Street, where it terminates. Lancaster and Lansdowne avenues are both two-lane, two-way streets with on-street parking throughout. They traverse dense residential neighborhoods and commercial corridors. Sixty-Third Street is a four-lane road through a less dense neighborhood. On this road, the trolleys use the inner lanes. The trolleys run at 5–10-minute headways during the day, 10–15-minute headways in the evening, and 30–40-minute headways overnight. The line operates 24 hours a day.

Chronology

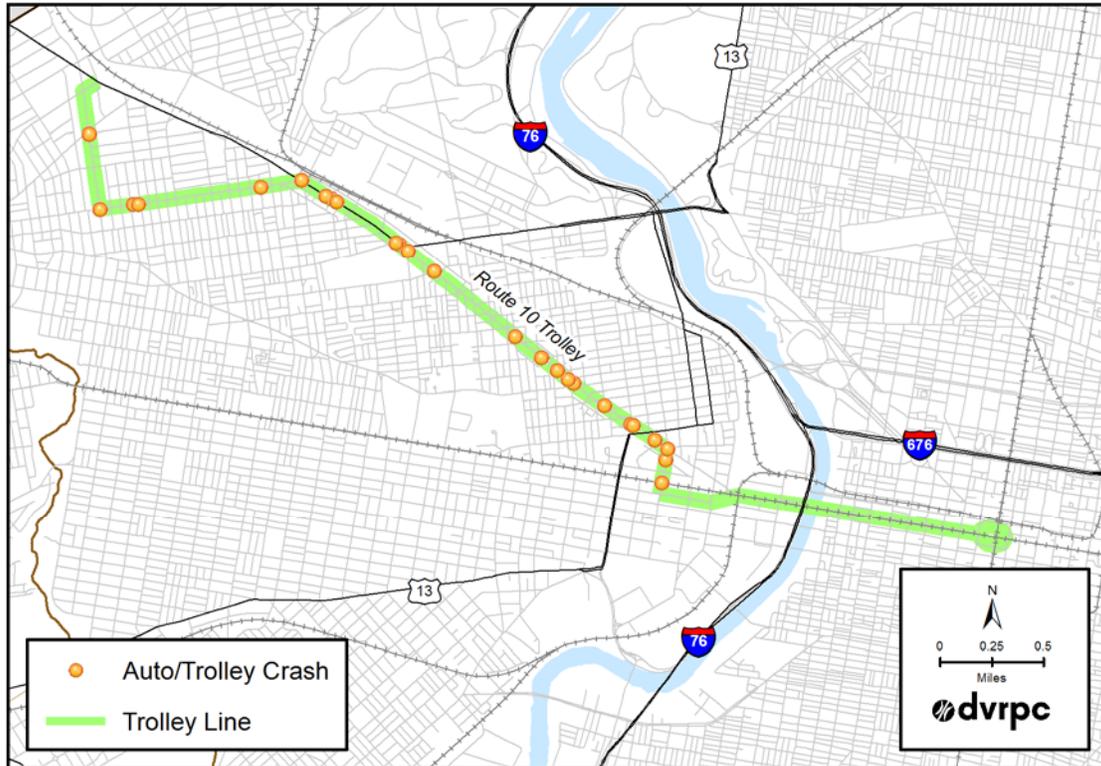
Ten crashes were recorded in both 2008 and 2009, dropping to six crashes in 2010. There was some variation in crashes by month, with the most crashes (five) occurring in December, and no crashes occurring in July. Crashes by day of the week were sporadic. Each weekday had between four and six crashes, while one crash occurred on Sunday and none on Saturday. By hour of the day, 19 occurred in the PM hours, with the highest numbers at 5:00 PM during the evening rush. There was no such spike during the AM hours, which saw just seven crashes. Three crashes were missing time-of-day information.

Collision and Vehicle Type

In keeping with the patterns of other trolley lines, there were many rear-end and same-direction sideswipe crashes: eight and nine, respectively. Angle crashes were close behind, with seven. Other crash types were much less numerous, with one opposite-direction sideswipe and one pedestrian

crash. The crashes involved 29 total automobiles. In much smaller numbers, there were also four SUVs, two small trucks, and one large truck.

Figure 3: Route 10 Trolley Crashes



Severity

Most of the crashes were of low severity; no crashes resulted in major injuries or fatalities. Of the total, two crashes resulted in moderate injury and nine in minor injury. Additionally, 14 crashes resulted in injuries of unknown severity. Of the people involved in the crashes, two sustained moderate injury, while 59 sustained minor injury. Forty-five people sustained injuries of unknown severity, and the remaining 14 people were described as unknown if injured.

Environmental Factors

As with many crashes, environmental and roadway conditions were often favorable. The majority of the crashes occurred with no extraordinary environmental factors in effect (85 percent). Sun glare and slippery road conditions were each a factor in 3 percent of the crashes. Sixty-nine percent of crashes occurred on a dry road surface, 27 percent on a wet road surface, and 4 percent on a snow-covered surface. Seventy-seven percent of crashes occurred in daylight, while 23 percent occurred in the dark with street lights on.

Driver Actions

“Other improper driving actions” was the most common action with 5 percent of the total, followed by making illegal U-turns and careless passing or lane changing, each with 4 percent of the total.

Driving while using a hand-held phone and parking carelessly accounted for 2 percent each. No contributing action accounted for 61 percent of the total, and another 16 percent were listed as unknown. The remaining actions were recorded only once, signifying no trend.

Crash Concentrations

Crashes on the Route 10 Trolley were concentrated at isolated intersections. The immediate area around the intersection of Lancaster Avenue and 51st Street saw three crashes over the study period, while the intersection of Lancaster Avenue and 41st Street had two. The other 21 crashes were widely distributed at various intersections and did not form any concentrations.

Route 36: 25 Crashes

Setting

With 25 crashes, the Route 36 Trolley was involved in the third most crashes of the lines studied (**Figure 4**). The route starts underground in Center City and continues into Southwest Philadelphia. It first runs integrated in traffic on Elmwood Avenue and then turns onto Island Avenue. At one point, Island Avenue is a full ten lanes wide, divided into four separate roads and a trolley median. Traffic moves at high speeds, and the trolleys frequently cross traffic both on Island Avenue and its cross streets. The trolley operates 24 hours a day at 4–10-minute headways during the day and up to 30-minute headways overnight. There are 20 vehicles operating on the Route 36 Trolley, which carries over 15,000 passengers a day and over four million passengers annually.

Chronology

In total, there were six crashes in 2008, seven in 2009, and 12 in 2010. Crash distribution by month showed no clear pattern. January, June, and July saw the most crashes, with six each; February, August, and September had no crashes. The rest of the months had between one and three crashes. Distribution by day of the week was even: between two and five crashes per day, the highest being on Fridays and the lowest on Thursdays. Most crashes occurred in the PM hours, and no crashes occurred before 7:00 AM. Small spikes in crashes were observed at 8:00 AM and 6:00 PM, although crash totals were highest around noon and in the early afternoon. One crash was missing time-of-day information.

Collision and Vehicle Type

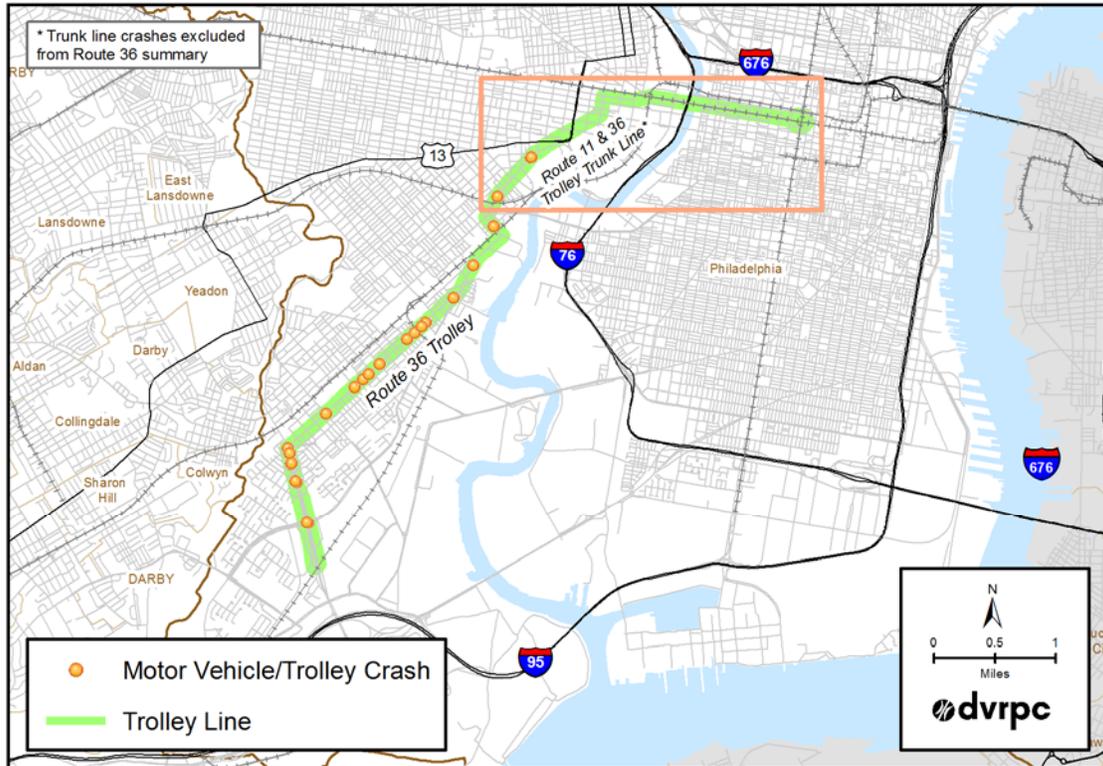
Ten of the crashes, or 40 percent, were angle crashes, making up the largest share. This was followed by five rear-end crashes, three head-on crashes, three same-direction sideswipes, and two opposite-direction sideswipes. There was one rear-to-rear (backing) crash and one crash involving a pedestrian. A total of 20 automobiles were involved in the crashes, along with three SUVs, one bus, one large truck, and one van.

Severity

Of the 25 total crashes, there were no fatalities. Nine were of unknown severity, 12 resulted in minor injury, and two crashes did not result in injury. There were no crashes that resulted in major injury, so the most severe outcomes were two crashes that led to moderate injury. Of the people involved in

the crashes, 31 had injuries of unknown severity, and 14 others were described as unknown if injured. Thirty-five people sustained minor injuries, and three people sustained moderate injuries.

Figure 4: Route 36 Trolley Crashes



Environmental Factors

Crashes involving the Route 36 Trolley occurred predominantly during favorable environmental conditions, more so than many other lines. Ninety-one percent of crashes occurred under clear skies, while 6 percent occurred in other weather conditions, and 3 percent are unknown. Regarding road condition, 80 percent of crashes occurred on dry road surfaces, while 20 percent occurred while roads were wet. Eighty-eight percent of crashes occurred with no adverse weather conditions, and 12 percent occurred in the rain. Illumination was more in line with the rest of the trolley lines, with 76 percent of crashes occurring in the daylight and 24 percent in the dark with street lights on.

Driver Actions

Improper or careless turning was the most common action, accounting for 6 percent of the total, followed by tailgating at 4 percent. The following actions each accounted for 2 percent of the total: making an illegal U-turn, turning from the wrong lane, proceeding without clearance after a stop, running a red light, carelessly passing or changing lanes, and carelessly parking or unparking. No contributing action accounted for 45 percent of the total, and another 24 percent were listed as unknown. The remaining actions were recorded only once, signifying no trend.

Crash Concentrations

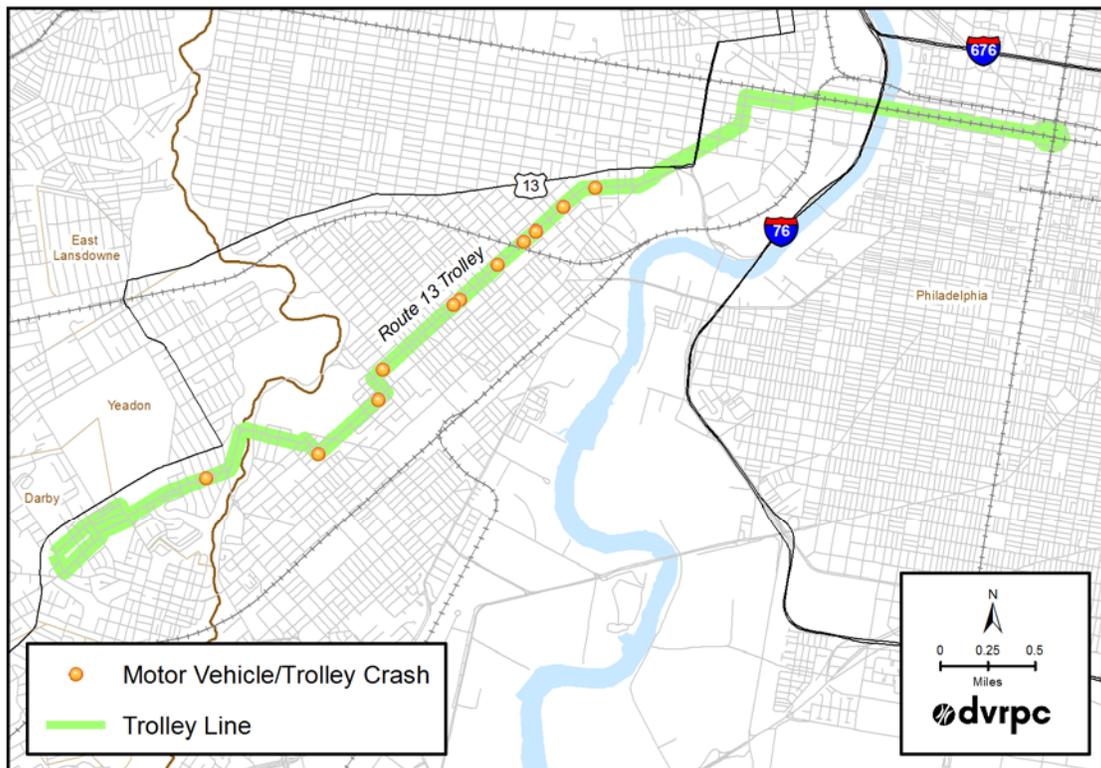
Although crashes were mostly spread out along the line, three concentrations were identified. On Elmwood Avenue between 59th and 61st streets there were five crashes in close proximity. The same is true for the stretch of Elmwood Avenue between 64th and 67th streets. There were also two crashes at each intersection where Island Avenue crosses Buist Avenue, Tanager Street, and Lindbergh Boulevard.

Route 13: 15 Crashes

Setting

During the study period, the Route 13 Trolley was involved in 15 crashes (**Figure 5**). It begins underground in Center City, runs above ground in Southwest Philadelphia, and terminates in Darby, Delaware County. Roads used include Chester Avenue, Kingsessing Avenue, and 65th Street. The route runs primarily through residential areas, with on-street parking available intermittently throughout. All roads traversed are two lanes with the exception of a brief portion in Darby, where the line splits in order to use one-way roads. Along with the other trolley lines that run underground through Center City, the Route 13 Trolley makes connections with numerous buses, the MFL, the BSL, SEPTA Regional Rail, and other trolley lines. Ridership on the Route 13 Trolley is the highest among the trolley lines, with 16,700 passengers daily and about five million passengers annually, running 24 hours a day with 3–10-minute headways and up to 36 minutes overnight.

Figure 5: Route 13 Trolley Crashes



Chronology

The number of crashes involving the Route 13 Trolley steadily increased throughout the study period. In 2008 it was involved in four crashes, followed by five in 2009, and six in 2010. By month, November had the highest number of crashes with three and no crashes recorded during February, March, July, and August. There were no clear patterns by day of the week, with all days ranging between one and four crashes. With the exception of two crashes in the early morning hours, crashes were mainly concentrated in the morning rush hour, noon/mid-afternoon, and the evening rush hour.

Collision and Vehicle Type

The most prevalent collision types were angle crashes (eight) and rear-end crashes (three). Also represented were two opposite-direction sideswipe crashes, one head-on crash, and one hit pedestrian. There were 13 passenger cars, two small trucks, and one van involved.

Severity

The crash severity level was low, with no major injuries or fatalities. Overall, there was one PDO crash, nine minor injury crashes, and two that caused moderate injuries. Additionally, there were three crashes that resulted in an injury of unknown severity. Concerning people involved in the crashes, 12 sustained minor injuries and four sustained moderate injuries. There were thirteen people who sustained injury of an unknown severity, and it is unknown if the remaining three people were injured.

Environmental Factors

Environmental factors followed usual patterns, with most crashes occurring in favorable conditions. Seventy-eight percent of the crashes occurred with no special environment or roadway factors, compared to 4 percent on slippery road conditions and 4 percent in other weather conditions. Eighty-seven percent of crashes occurred on a dry road surface, compared to 7 percent on a wet surface and 7 percent on slush. Concerning weather, the vast majority (93 percent) took place with no adverse conditions present, while 7 percent occurred during rainy weather. Statistics regarding illumination were less consistent with prevailing trends. Sixty-seven percent of crashes occurred during daylight hours, a slightly lower number, while 33 percent of crashes were during darkness with street lights on.

Driver Actions

The most common driver actions were making an illegal U-turn, making improper or careless turns, and tailgating (6 percent each), followed by proceeding without clearance after a stop (4 percent). No contributing action accounted for 40 percent of the total, and another 22 percent were listed as unknown. The remaining actions were recorded only once, signifying no trend.

Crash Concentrations

Crashes were distributed throughout the entire line with no major concentrations; however, similar to the Route 11 Trolley, crashes become more dispersed as the line stretches out of the city center. The location with the most crashes was the intersection of 48th Street and Chester Avenue, with

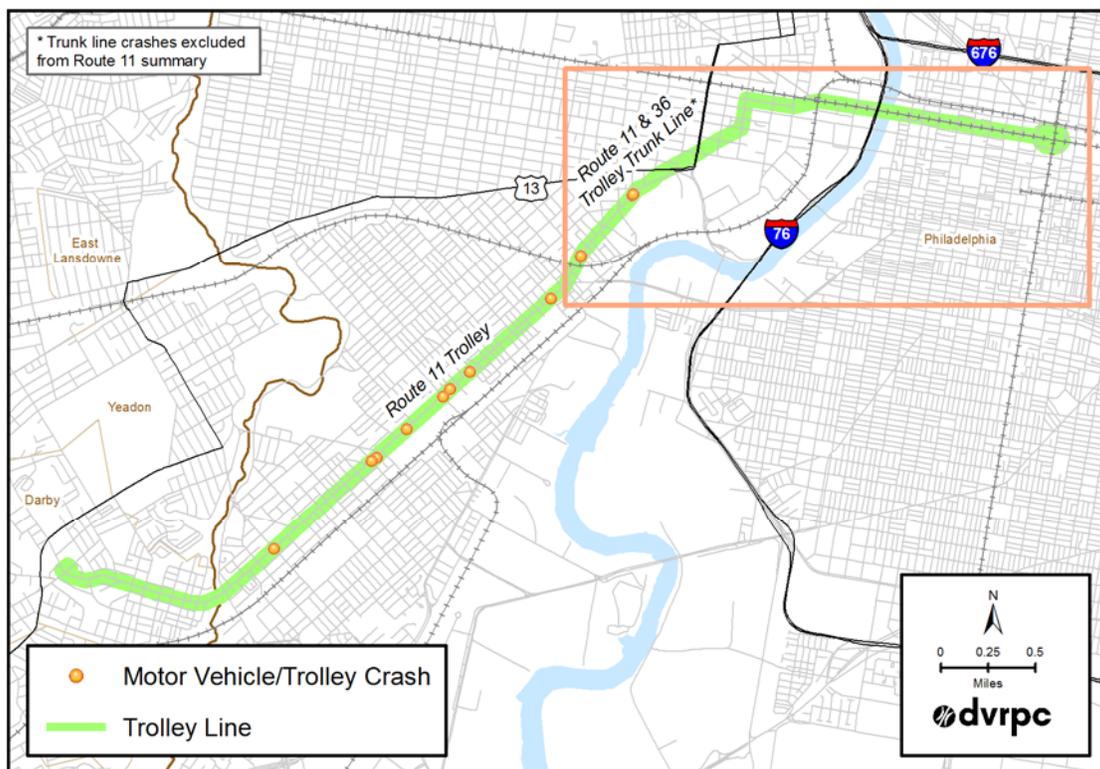
three crashes. Other locations with multiple crashes were the intersections of 49th Street and Chester Avenue, with two crashes, and 65th Street and Kingsessing Avenue, also with two crashes. The latter intersection is where the trolley line makes a turn onto a different road, creating a potential point of conflict with other vehicles. Despite the considerable distance the Route 13 Trolley travels in Delaware County, it was only involved in one crash outside of Philadelphia city limits.

Route 11: 8 Crashes

Setting

The Route 11 Trolley was involved in eight crashes during the study period (**Figure 6**). The line follows Woodland Avenue in Southwest Philadelphia to Darby, in Delaware County. Woodland Avenue is an important corridor in Southwest Philadelphia, with one lane per direction, on-street parking along its entire length, and a bike lane on either side. Easy connections can be made from the line's leg in Center City to many transit lines, including buses, the MFL, the BSL, SEPTA Regional Rail, and other trolley lines. The Route 11 Trolley also meets with the Route 13 Trolley at the Darby Terminal in Delaware County. It operates from 5:00 AM to 2:00 AM, with headways of 5–10 minutes during the day and 15–20 minutes at night.

Figure 6: Route 11 Trolley Crashes



Chronology

The Route 11 Trolley was involved in one crash in 2008, three crashes in 2009, and four crashes in 2010: a steady increase during the study period, for a total of eight. By month of year, there were two crashes in February and one crash each in April, June, August, October, November, and December.

The remaining months saw no crashes. Half of the crashes occurred on Saturdays, none on Sundays or Thursdays, and one each on the remaining days. The Route 11 Trolley runs through a lively commercial and residential corridor with retail stores and restaurants. The Saturday crashes may be attributed to the influx of people in the area for weekend activities. By time of day, the only concentration of significance was that two crashes occurred at 5:00 PM. There was no observable trend regarding rush-hour peak times.

Collision and Vehicle Type

The two most prevalent crash types were angle (three crashes) and rear-end (two crashes). A concentration of angle and rear-end crashes is a consistent pattern among the trolley lines. Other collision types represented are one head-on, one rear-to-rear (backing), and one same-direction sideswipe. There were eight trolleys involved in the eight crashes, plus seven automobiles, two vans, and one SUV.

Severity

Crash severity level was low; only one crash resulted in moderate injury, four in minor injuries, and one unknown injury, while two were property damage only. Of the 19 people involved, there were no fatalities. However, two people sustained major injuries, four sustained moderate injuries, and 15 sustained minor injuries; one was considered unknown severity. There was more than double the number of people with injuries than there were crash events.

Environmental Factors

Sudden weather and slippery conditions were factors in only one crash each, and the remaining crashes had none. Regarding weather, two crashes were influenced by rainy conditions, while the remaining crashes occurred in good weather. Lighting was a factor in half of the crashes: 50 percent during daylight and 50 percent at night with streetlights on. As crashes are more common under daylight conditions, there is cause for investigation as to why half of these crashes occurred at night.

Driver Actions

With lower crash totals, it can be difficult to identify driver action trends as many actions were recorded just once, including: driving using a hand-held phone, proceeding without clearance after a stop, driving on the wrong side of the roadway, carelessly parking or unparking, failing to maintain proper speed, tailgating, and being affected by a physical condition. Making an illegal U-turn and other improper driving action were each recorded twice. No contributing action accounted for 32 percent of the total, and another 9 percent were listed as unknown.

Crash Concentrations

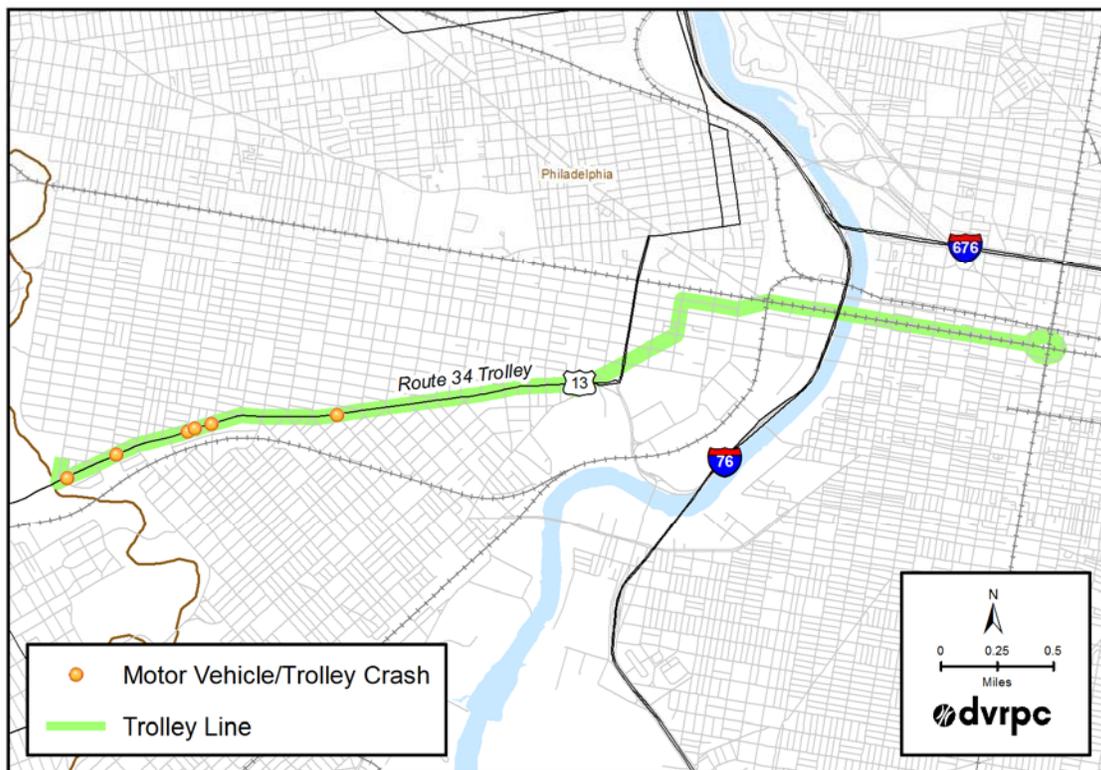
Crashes are spread out on the Route 11 Trolley line, with no clear concentrations. Unlike other trolley lines, most crashes on the Route 11 Trolley are not located directly at intersections. Of the intersections that did have crashes, none had more than one. However, crashes steadily become more dispersed as the line stretches farther from the city center. Despite traveling a good distance in Delaware County, there are no crashes outside of Philadelphia city limits. This is most likely due to lower density and reduced traffic in Delaware County compared to Philadelphia.

Route 34: Six Crashes

Setting

Trolleys on Route 34 were involved in six crashes during the study period (**Figure 7**). This line stretches from Center City, where it runs underground, and along Baltimore Avenue to the neighborhood of Angora, where it terminates just before Philadelphia's border with Delaware County. For the entire length of the trolley line, Baltimore Avenue is a two-lane, two-way street with frequent lights and on-street parking. Along with the other trolley lines that run underground through Center City, the Route 34 Trolley makes connections with numerous buses, the MFL, the BSL, SEPTA Regional Rail, and other trolley lines. Nineteen vehicles operate on the Route 34 Trolley, carrying upwards of 15,000 passengers a day and about four million passengers annually. The service runs from 5:30 AM to 1:45 AM and operates at headways of 3–10 minutes during the day and up to 30 minutes at night.

Figure 7: Route 34 Trolley Crashes



Chronology

There were two crashes each in 2008, 2009, and 2010. Crashes were evenly distributed by month, with six months having one crash each and six months having no crashes. The analysis by day revealed no clear patterns. Sunday and Thursday each had one crash, while Wednesday and Friday each had two crashes. Crash distribution by hour was similar to that of other trolley lines. With the exception of one early-morning crash, one crash occurred during the morning rush hour, two in the early afternoon, and two during the evening rush hour.

Collision and Vehicle Type

The most prevalent crash type was angle with three crashes, followed by rear-end with two crashes, and one hit-pedestrian crash. There were four automobiles, one large truck, one SUV, and one van also involved in the crashes.

Severity

Crash severity involving the Route 34 Trolley is unclear. One crash resulted in a minor injury and one crash in no injuries. The remaining four crashes were categorized as unknown if injured. Regarding people involved, one person sustained minor injury, while six people sustained injuries of unknown severity.

Environmental Factors

As with the other trolley lines in the study, the majority of crashes involving the Route 34 Trolley occurred during favorable environmental conditions; 90 percent of crashes occurred with no environmental or roadway factors. In the case of the remaining 10 percent of crashes, whether they were influenced by an environmental or roadway factor is unknown. Concerning roadway conditions, all of the crashes occurred on a dry road surface. Similarly, no crashes occurred during adverse weather conditions. Eighty-three percent of crashes were during daylight hours, which is about the average. The remaining 17 percent were at night with the streetlights on.

Driver Actions

Tailgating and driving too fast for conditions were each recorded twice (6 percent each). Running a red light, parking or unparking carelessly, and being affected by a physical condition were each recorded once (3 percent each). No contributing action accounted for 46 percent of the total, and another 12 percent were listed as unknown.

Crash Concentrations

Half of the crashes were concentrated on Baltimore Avenue between 55th and 56th streets, where conflict is probable given the multiple roads intersecting Baltimore Avenue at this location. Unlike Routes 11 and 13, the crashes become denser as the line moves away from the city center; there are no crashes on the line until 50th street, which is well west of downtown.

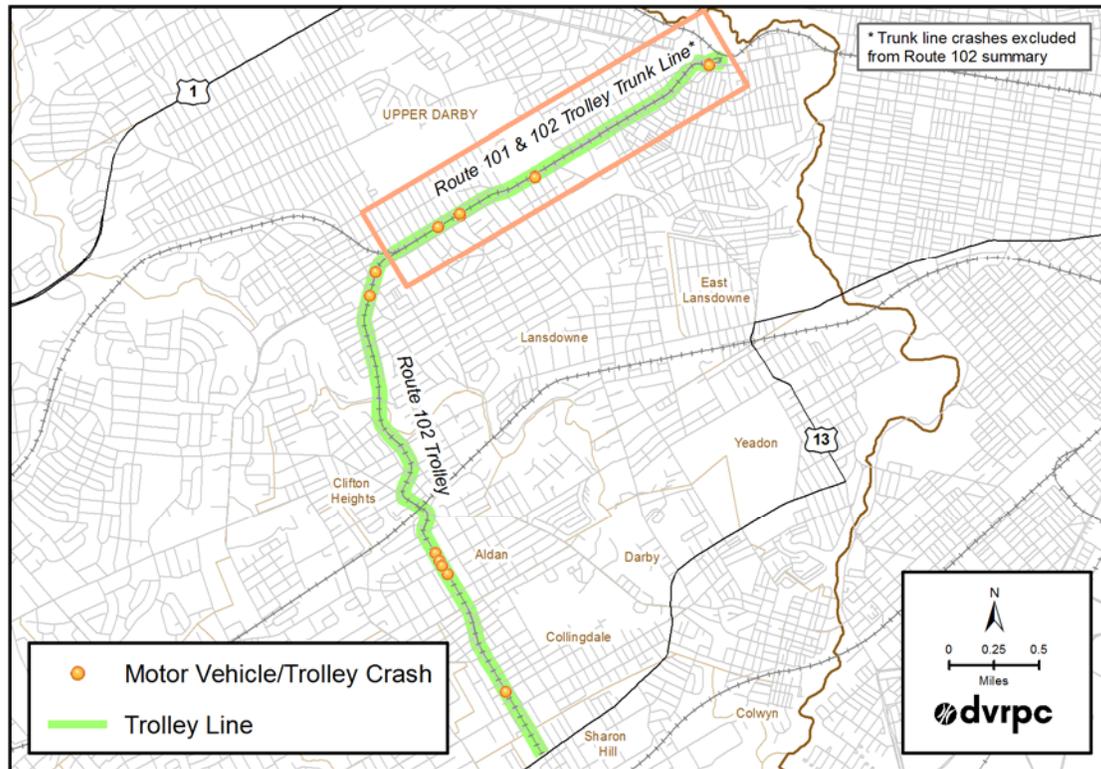
Route 102: Seven Crashes

Setting

During the study period, there were seven crashes involving the Route 102 Trolley (**Figure 8**). The line connects 69th Street Terminal in Upper Darby to Sharon Hill to the south. Like the Route 101 Trolley, its suburban setting has allowed the trolley to run predominantly on its own right-of-way. The two trolley lines share tracks paralleling Garrett Avenue after leaving Upper Darby, splitting in Drexel Hill. The Route 102 Trolley briefly shares its right-of-way with Woodlawn Avenue in Aldan Borough. At 69th Street Terminal, connections are available to the MFL to Center City or to the Norristown High Speed Line. The hours of operation are 5:00 AM to 2:00 AM, with operating headways of 15–20

minutes during the day and up to an hour at night. Ridership is the lowest of the trolleys studied, carrying 3,400 passengers daily and one million annually.

Figure 8: Route 102 Trolley Crashes



Chronology

Crash totals were not distributed equally by year. There were two crashes in 2008, none in 2009, and five in 2010. Concerning month of the year, most crashes occurred in December with three, followed by two in August, and one each in February and November. Tuesday had the highest crash total with two, while all other days except Sunday each had one crash. Crashes were very evenly spread out over the course of the day. One crash each occurred at 6:00 AM, 9:00 AM, 10:00 AM, 2:00 PM, and 3:00 PM, while two crashes occurred at noon.

Collision and Vehicle Type

There were four angle crashes during the study period, a similar amount and percentage to the Route 101 Trolley. Two same-direction sideswipe crashes and one opposite-direction sideswipe crash also occurred. Seven trolleys were involved in the seven crashes, meaning that no crash involved multiple trolleys. There were five automobiles, one bus, one SUV, and one van also involved.

Severity

The severity of the crashes was relatively low, and there were a small number of unknown injuries. In total, two crashes resulted in minor injuries, three crashes resulted in no injuries, and two crashes

resulted in an injury of unknown severity. Concerning the people involved, six people sustained minor injury, while two people sustained an injury of unknown severity.

Environmental Factors

There were few environmental or roadway factors involved in the seven crashes. Regarding road condition, one crash (14 percent) occurred on a wet road surface and six crashes on dry. Weather conditions were also not a factor in most crashes. One crash occurred during snow, and the remaining six occurred during no adverse conditions. Similarly, all seven crashes occurred in the daylight.

Driver Actions

In two cases each, proceeding without clearance after a stop and carelessly passing or changing lanes were recorded (11 percent each). The following actions were each recorded once (6 percent each): making an illegal U-turn, making an improper or careless turn, running a red light, carelessly passing or changing lanes, carelessly parking or unparking, or making other improper driving actions. No contributing action accounted for 39 percent of the total and another 6 percent (one record) were listed as unknown.

Crash Concentrations

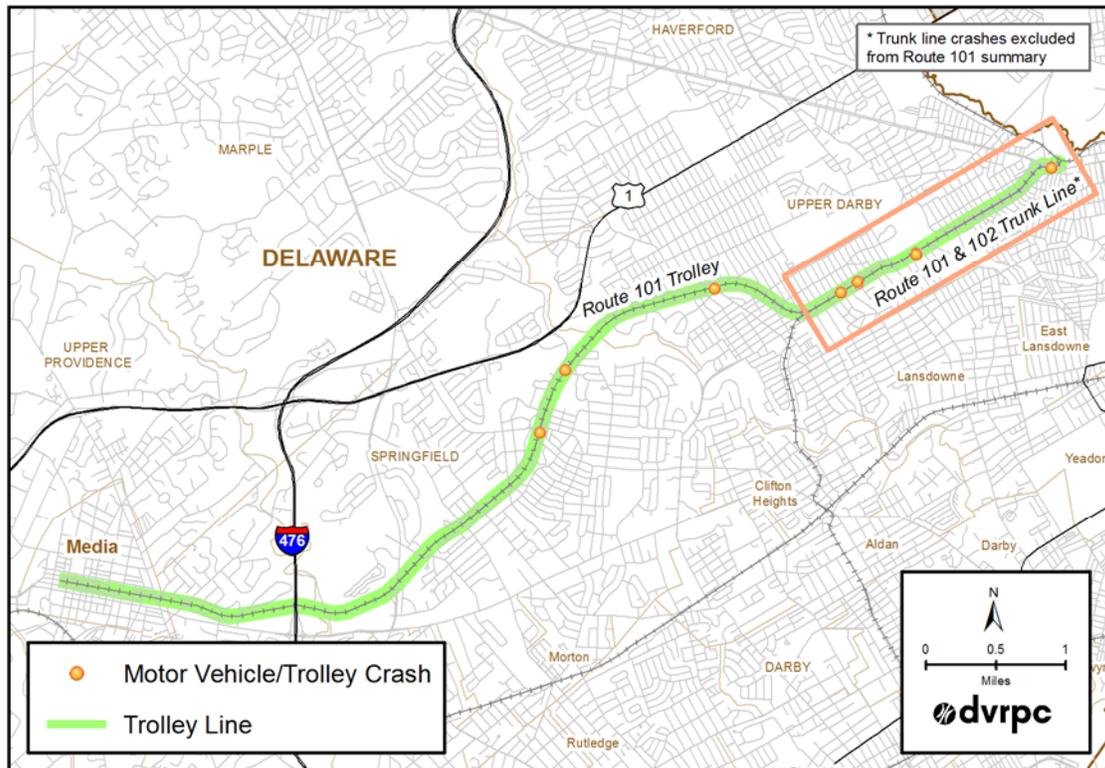
Most of the crashes involving the Route 102 Trolley were concentrated in Aldan Borough. These three crashes were within close proximity, located in the short stretch of track that operates on Woodlawn Avenue. The three crashes are not within intersections, but are located in front of a school. The remaining two crashes are at separate ends of the line and are located where roads cross the trolley's right-of-way.

Route 101: 4 Crashes

Setting

The Route 101 Trolley was involved in four crashes (**Figure 9**). The line connects the 69th Street Terminal in Upper Darby to Media, the seat of Delaware County. The entire line runs on the surface; there are no underground portions. Being in a more suburban setting than the other trolleys studied, it largely runs on its own right-of-way. Beginning at 69th Street, it parallels Garrett Avenue until Drexel Hill, while sharing tracks with the similar Route 102 Trolley. After Drexel Hill, the lines split and the Route 101 Trolley makes stops in Springfield, including at the Springfield Mall, before reaching Media. The right-of-way ends when entering Media, where the trolleys run on the local street grid. At 69th Street Terminal, there are connections available to the MFL to Center City and bus connection to the Norristown High Speed Line. Hours of operation are 5:00 AM to 1:30 AM, with headways of 10–20 minutes during the day, and up to 30 minutes at night. Ridership is lower than the more urban trolley lines, with just over 4,000 people daily and over one million annually.

Figure 9: Route 101 Trolley Crashes



Chronology

By year, there was one crash in 2008, three in 2009, and none in 2010. There was one crash each in January and July, and two in October. One crash occurred every day but Monday, Tuesday, and Thursday. Concerning time of day, two crashes occurred between 11:00 AM and noon, and no other concentrations were noted.

Collision and Vehicle Type

All four were angle crashes that occurred at intersections. Thirteen vehicles were involved in the four crashes, of which four were trolleys.

Severity

Three people were injured in the four crashes. Two were categorized as moderate injuries, and one was a minor injury.

Environmental Factors

One crash occurred on slippery road conditions, and one involved an obstructed traffic control device. The remaining two occurred under typical conditions.

Driver Actions

In addition to no contributing action, four additional actions were recorded, including: proceeding without clearance after a stop, failing to respond to a traffic control device, distracted driving, and

being affected by a physical condition (recorded twice). No contributing action accounted for 55 percent (six records) of the total.

Crash Concentrations

The four crashes occurred at three locations, with two crashes recorded at the Springfield Road cross street crossing in Springfield Township. The last third of the Route 101 line toward Media does not have any crashes. As the Route 101 heads west, density decreases and the trolley runs through a wooded area for a considerable distance before arriving in Media. Though the trolley joins the road network in Media, there were no reported crashes there.

Interpretation and Conclusion

The main findings from this analysis are

- injury severity was low with no fatalities;
- crashes were less frequent farther away from Center City;
- even though trolleys operate in the median—essentially in traffic—that was not a major contributor to crash frequency;
- most crashes occurred at intersections in Center City locations;
- angle crashes (45 percent) and rear-end crashes (21 percent) were the most common collision types; and
- by year, the crash trend was mostly stable during the 2008–2010 analysis period.

Despite on-street trolleys being relatively prevalent in the Philadelphia area, there were no fatalities and only a few major injuries resulting from the crashes reported during the 2008–2010 analysis period. It can be surmised that trolley crashes typically result in lower severity and pose less of a safety risk to motorists, bikers, and pedestrians. This is especially true when compared to train crashes, which, although far fewer, resulted in more severe injuries and at a higher rate.

The one circumstance that was common among the highest number of crashes involves location, specifically at intersections. Thus, greater caution should be exercised at intersections where trolleys pass, as the most prevalent driver actions involved turns, and the most common crash type was angle: characteristics common to at-intersection crashes.

External influences on crashes were few. Weather did not seem to have much of an effect, as on all lines the large majority of crashes occurred under ideal conditions. The percentage of crashes that occurred on wet or icy roads was negligible. These findings, plus the slight variability in crash frequency by year, raise questions about causation. They suggest that while many crashes were due to driver error, crashes between trolleys and vehicles will continue to be probable as long as they operate side by side in traffic. Trolleys that run on partial rights-of-way over segments of their routes had fewer crashes between intersections but elevated numbers at intersections.

Trolleys traveling in the roadway median, partially separated from most traffic, were found to be no safer than those completely immersed in traffic. Two roads with trolleys operating within the median, Girard Avenue and Island Avenue, had the largest crash concentrations of the roads studied. In these cases, crashes between intersections were reduced, but crashes at intersections were more frequent.

Crash frequency was not necessarily a function of a line's ridership or service frequency. None of the trolleys with the highest ridership or most frequent headways were among the three lines with the

most crashes; however, those that mix with higher volumes of automobile traffic did have more crashes. Given crash findings, initiatives to educate drivers and pedestrians about trolley safety should be explored. Also, conducting a field visit to busy intersections where trolleys cross frequently would provide the opportunity to examine conditions like driver behavior, which typically differ by location. This is a proactive approach for reducing fatalities.

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Abstract: This report details the process and findings of phase two of the database review of train and trolley crashes in the Delaware Valley Regional Planning Commission region. The study area is predominantly Philadelphia but also examines Delaware County, where SEPTA's Routes 101 and 102 trolleys operate and the Routes 11 and 13 trolleys terminate. Using the Pennsylvania Department of Transportation crash records database, crashes involving trolleys were extracted and examined both as a system, and as they occurred per trolley route for years 2008–2010. One finding is that crash frequency was not necessarily a function of a trolley's ridership or service frequency.

Staff Contact:

Kevin S. Murphy
Principal Transportation Planner
☎ (215) 238-2864
✉ kmurphy@dvrpc.org

Delaware Valley Regional Planning Commission
190 N. Independence Mall West, 8th Floor
Philadelphia PA 19106
Phone: (215) 592-1800
Fax: (215) 592-9125
Internet: www.dvrpc.org

