CITY AND COUNTY OF SAN FRANCISCO

BOARD OF SUPERVISORS

BUDGET AND LEGISLATIVE ANALYST

1390 Market Street, Suite 1150, San Francisco, CA 94102

(415) 552-9292 FAX (415) 252-0461

Policy Analysis Report

To: Supervisor Mar

From: Budget and Legislative Analyst's Office

Re: Impact of Speed Limit Changes in San Francisco

Date: November 18, 2016

Summary of Requested Action

Your office requested that the Budget and Legislative Analyst: (1) report on recent traffic calming strategies, specifically, reducing speeding and speed limits on City streets; (2) provide an update on streets where the City recently reduced the speed limit such as Fulton Street and Sunset Boulevard; and (3) examine data on this strategy's effectiveness in slowing down traffic, preventing collisions, and improving pedestrian safety.

For further information about this report, contact Fred Brousseau at the Budget and Legislative Analyst's Office.

Executive Summary

Collisions and speed in San Francisco

- In San Francisco, there were 3,538 reported collisions resulting in injury or death in 2015, of which 759 involved pedestrians and 576 involved bicyclists. 38 of the 3,538 collisions resulted in a fatality. Speeding is the leading cause of death on City streets according to the San Francisco Municipal Transportation Agency (SFMTA).
- The number of total collisions in 2015 was lower than in 2000 though the number of collisions fluctuated inconsistenly up and down during that 15 year period. Bicyle collisions also fluctuated between 2000 and 2015, but there were more bicycle-invovled collisions in 2015 than in 2000 (576 in 2015 vs. 364 in 2000).
- Workers commuting by bicycle or walking experience more collisions per 1,000 commuters than the commuting population overall. However, reflecting growth in the number of workers commuting by bicycle or walking between 2006 and 2014, even though collision rates for both groups declined during that period, both still remained substantially higher than for commuters overall.
- The number of collisions resulting in fatalities has fluctuated year over year. Between 2000 and 2015, there was a high of 44 fatal collisions in 2000 and a low of 23 collisions in 2011. The average number of fatal collisions was 32.6 between 2000 and 2015.

Impact of changes in speed limits on arterial roadway collisions

- Data from SFMTA indicates that other factors and approaches may be needed in addition to speed limit reductions to reduce collisions in San Francisco. Collision data for three years before and three years after speed limits were reduced on nine arterial roadways in San Francisco between 2011 and 2013 shows that reducing speed limits did not result in an overall reduction in collisions.
- While injury severity and the likelihood of fatality are closely related to the speed at impact in vehicle-pedestrian collisions, the relationship between speed and the likelihood of a collision is complicated. Because collisions on many street segments or at particular intersections are infrequent, it is difficult to draw conclusions about traffic safety analyzing individual events, streets or intersections. In addition, factors other than speed limits can affect collision probability, such as traffic volume, alcohol and drug use, and weather.
- Overall, injury collisions on the nine studied arterial roadways increased by 31.7 percent after the speed limit reductions, although the share of collisions attributed to speed decreased slightly. Speeding-related collisions decreased on four of the nine roadways and increased on five of the nine roadways.
- Data is not available to determine if speeds driven on the nine arterial roadways were lower after speed limits were reduced. It is possible that without measures such as enhanced enforcement, drivers may not have adhered to the lowered speed limits.
- Increased traffic volume did not explain increases in collisions on four of the nine studied roadways for which traffic volume data is available. In fact, vehicle traffic volume on two of the nine roadways decreased significantly and increased only slightly on the two other roadways.
- Other factors that may have affected the overall increase in collisions on the nine arterial roadways include increases in the number of pedestrians and bicyclists and/or other road improvements implemented after speed limits were lowered that affect driver speed choices and traffic volume.
- According to State law, speed limits can only be changed by a municipality when a speed survey shows that the 85th percentile speed on a street is different than the posted limit. Speed limits are required to be rounded to the nearest 5 mph increment, although local authorities are allowed to round down to the nearest 5 mph increment due to safety conditions. Because of these State laws, the City and County of San Francisco's authority to lower speed limits is limited and such reductions can rarely be executed in San Francisco.

Impact of traffic calming installations on residential streets

- For residential streets, SFMTA administers a traffic calming program designed to reduce speeds with installations such as median islands, rubber speed humps, speed humps, and speed cushions. Under the current program, devices such as these are

installed on residential streets primarily on the basis of petitions from a majority of residents.

- SFMTA conducted before and after traffic counts and tracked vehicle speeds for eight non-arterial residential streets where residential traffic calming measures were installed between 2011 and 2015. On those streets:
  - Residential traffic calming features were successful at significantly decreasing speeds traveled, particularly the incidence of vehicles traveling at high rates of speed.
  - The 85th percentile speed decreased by 18.1 percent, and vehicles traveling over 30 mph decreased by 77.5 percent.
- While the data shows there were reductions in speed on residential streets where traffic calming measures were installed, SFMTA did not include data on the number of collisions or collision severity before and after traffic calming because collisions on particular residential streets are infrequent and speeds at the time of collision are generally low. In general, vehicle speeds at the time of collision are associated with severity of injury or likelihood of fatality.
- Collision data for these and other locations where traffic calming measures are installed should be analyzed in the future to measure program effectiveness at improving traffic safety.

Vision Zero

- The above described speed limit reductions and traffic calming installations by SFMTA to reduce vehicle speed occurred largely before SFMTA and the Board of Supervisors adopted Vision Zero in 2014. Vision Zero is a set of goals and policies and procedures aimed at improving traffic safety through a series of interdepartmental initiatives and programs, many to be executed by SFMTA. One of the goals of Vision Zero is to eliminate traffic fatalities and serious traffic-related injuries by 2024.
- Since Vision Zero was only adopted in 2014, more time is needed to measure and evaluate the impacts of its speed reduction initiatives on collisions and collision severity. Evaluation of outcomes is one of the five key elements of Vision Zero.
- SFMTA's Two-Year Action Strategy for Vision Zero outlines projects and policy changes for the City to implement between 2015 and 2017. The program's five elements are:
  1. **Engineering:** Safety treatments on High-Injury Corridors and at intersections and continued implementation of traffic calming measures on residential streets.
  2. **Enforcement**: Refocused and enhanced efforts by the San Francisco Police Department (SFPD) on High-Injury Corridors to address unsafe speeding.
  3. **Education**: Inter-departmental traffic safety campaigns, such as SFMTA's Safe Speed Campaign, to slow traffic and encourage bicycling and walking.
  4. **Evaluation:** The Department of Public Health (DPH) will evaluate the effectiveness of various Vision Zero programs after implementation. DPH launched TransBASE in 2014

which serves as a centralized repository of data for monitoring and evaluating Vision Zero program effectiveness.

5. **Policy:** SFMTA is currently working on legislation to make Automated Speed Enforcement (ASE) legal in California since it is currently prohibited by State law. ASE is a tool using fixed or mobile cameras and other equipment to detect and capture images of vehicles travelling above speed limits.

Future Speed Reduction Efforts

- SFMTA's schedule for conducting speed surveys has not changed since adoption of Vision Zero, as speed survey procedures are dictated by the State. Therefore, speed limit reductions that result from new speed surveys will likely continue to be infrequent.
- Other means of reducing speed such as traffic calming, speed reduction installations, increased enforcement, including Automated Speed Enforcement (ASE), and others stemming from the Vision Zero program could occur more quickly and may prove more effective than just speed limit reductions stemming from speed surveys.
- SFMTA is considering shifting to proactive traffic calming based on area-wide planning. Starting in FY 2019-20, SFMTA will allocate funding for both proactive traffic calming and its current application-based residential streets traffic calming program, which accepts applications from residents on an annual basis.

Project Staff: *Fred Brousseau, Jennifer Millman*

Traffic Speed and Safety

Vehicle speeds at the time of collision are associated with severity of injury or likelihood of fatality in vehicle-pedestrian collisions, so the goal of many traffic safety improvements is to reduce vehicle speeds. In vehicle-pedestrian collisions, 5 percent of pedestrians are likely to die if struck by a vehicle traveling 20 mph, and the fatality rate increases to 45 percent for pedestrians hit at 30 mph, and 85 percent at 40 mph.[1] Increased impact speed also results in a sharp increase in injury severity.

While the relationship between speed and collision severity is clear, the link between speed and the probability of collision is less straightforward. Collisions on many street segments or at particular intersections are infrequent events, so it is difficult to draw conclusions about traffic safety from a small number of events on particular streets or at certain intersections. Although the potential for conflict on urban streets is high due to numerous intersections and the presence of vehicles, pedestrians, and bicyclists, traffic congestion often restrains speed and reduces collision severity. Although speed dispersion, or the average speed difference between two neighboring vehicles, is associated with collision likelihood on urban streets, many other factors affect collision probability, such as changes in traffic volume, alcohol or drug use, and weather. Additionally, little is known about the role of speed in collision likelihood on residential streets.[2]

Collision Trends in San Francisco

Total Collisions

Between 2000 and 2015, the total annual number of collisions resulting in injury or death in San Francisco decreased from 4,226 to 3,538, a reduction of 16 percent. However, there was not a consistent trend during those years, with upward and downward fluctuations in the number of collisions year to year.

In spite of inconsistent trends over the fifteen-year period, collisions resulting in death and those resulting in injury were both lower in 2015 than in 2000. Collisions that resulted in fatalities decreased from 44 in 2000 to 38 in 2015; those resulting in injury decreased from 4,182 in 2000 to 3,500 in 2015.

Total collisions involving pedestrians that resulted in injury or death also decreased between 2000 and 2015, from 987 to 759, whereas those involving bicycles increased from 364 to 576 during the same period. Exhibit 1 presents data on collisions resulting in injury or death between 2000 and 2015, breaking out the number of collisions involving

[1] Transportation Research Board (TRB). Managing Speed: Review of Current Practice for Setting and Enforcing Speed Limits. Special Report 254. 1998.
[2] TRB, 1998.

bicyclists or pedestrians and the number resulting in fatalities.

Exhibit 1: Total Collisions Resulting in Death or Injury

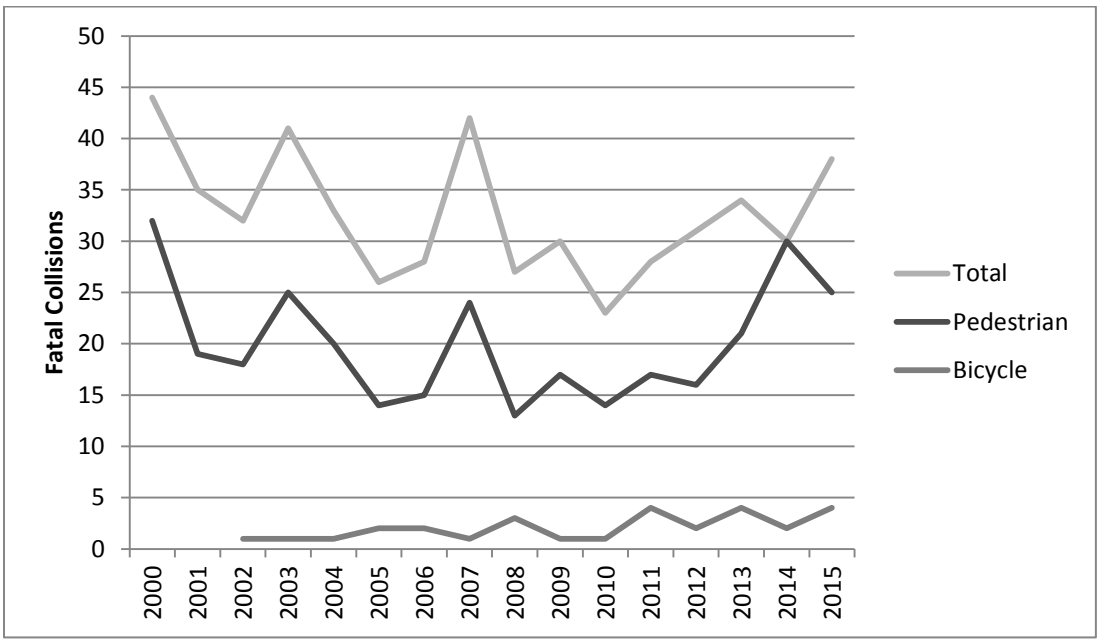
Year	Total Collisions	Bicycle Collisions	Pedestrian Collisions	Collisions Resulting in Fatalities
2000	4,226	364	987	44
2001	3,952	360	914	35
2002	3,809	308	880	32
2003	3,552	312	840	41
2004	3,071	317	747	33
2005	3,253	345	761	26
2006	2,897	345	741	28
2007	3,063	452	820	42
2008	3,037	471	812	27
2009	2,907	532	712	30
2010	3,104	600	798	23
2011	3,139	634	861	28
2012	3,771	660	958	31
2013	2,596	458	539	34
2014	3,733	659	877	30
2015	3,538	576	759	38

Sources: SFMTA 2010-2011 San Francisco Collisions Report; 2012-2015 SWITRS Collision Data
Bicycle Collisions = injury collisions involving a bicycle.
Pedestrian Collisions = injury collisions involving a pedestrian.

Fatal Injury Collisions

Though fatal injury collisions decreased from 44 in 2000 to 38 in 2015, there were more year-to-year fluctuations in this category of collisions than there were for non-injury collisions. Between 2000 and 2015, there was a high of 44 fatal collisions in 2000 and a low of 23 collisions in 2011. The average number of fatal collisions was 32.6, and the median was 31.5 collisions. The number of pedestrian and bicycle fatal collisions have also fluctuated between 2000 and 2015, as shown in Exhibits 1 and 2.

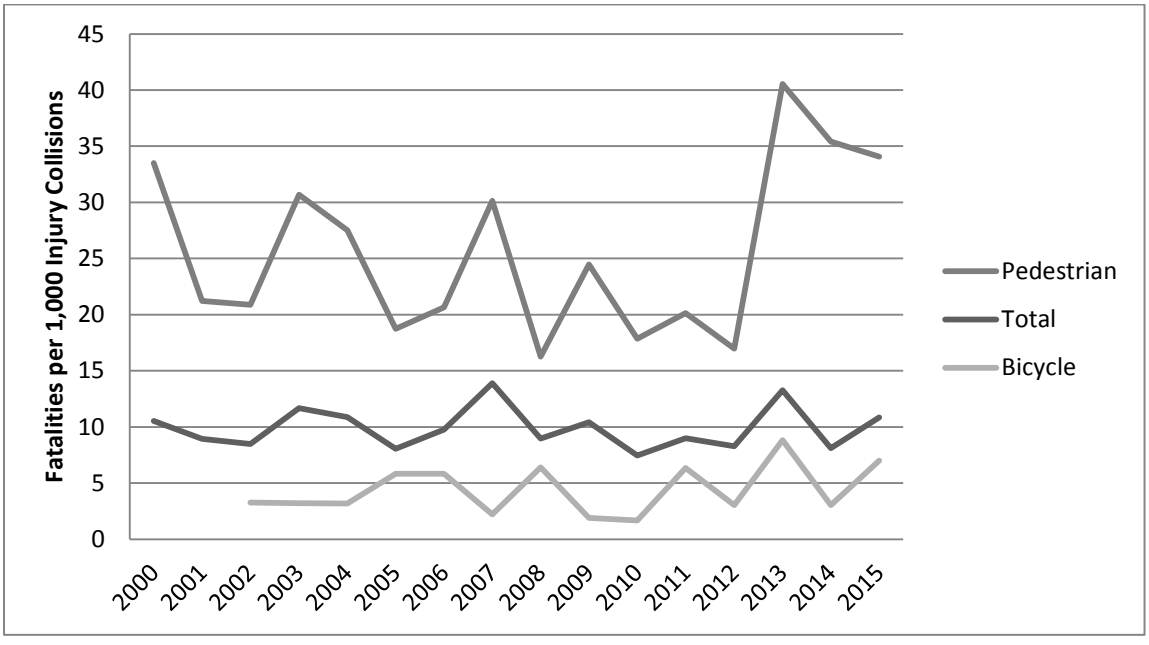
Exhibit 2: Fatal Injury Collisions in San Francisco, 2000 – 2015



Sources: SFMTA 2010-2011 San Francisco Collisions Report; 2012-2015 SWITRS Collision Data

The rate of collision severity (represented as the ratio of fatal collisions to non-fatal injury collisions), also fluctuated between 2000 and 2015, but not in a particular direction, as shown below in Exhibit 3. This indicates that the severity of collisions did not necessarily getting better or worse during those years.

Exhibit 3: Fatal Collisions per 1,000 Non-fatal Injury Collisions, 2000 – 2015



Sources: SFMTA 2010-2011 San Francisco Collisions Report; 2012-2015 SWITRS Collision Data

Non-fatal Injury Collisions

As mentioned above, total non-fatal injury collisions decreased from 4,182 in 2000 to 3,500 in 2015, a 16 percent reduction. While there were moderate fluctuations year to year, a general downward trend occurred between 2009 and 2011, at which point the total number of non-fatal injury collisions spiked upward. However, even with that spike, the number of non-fatal injury collisions in 2015 was still lower than in 2000. Details are presented in Exhibits 4 and 5.

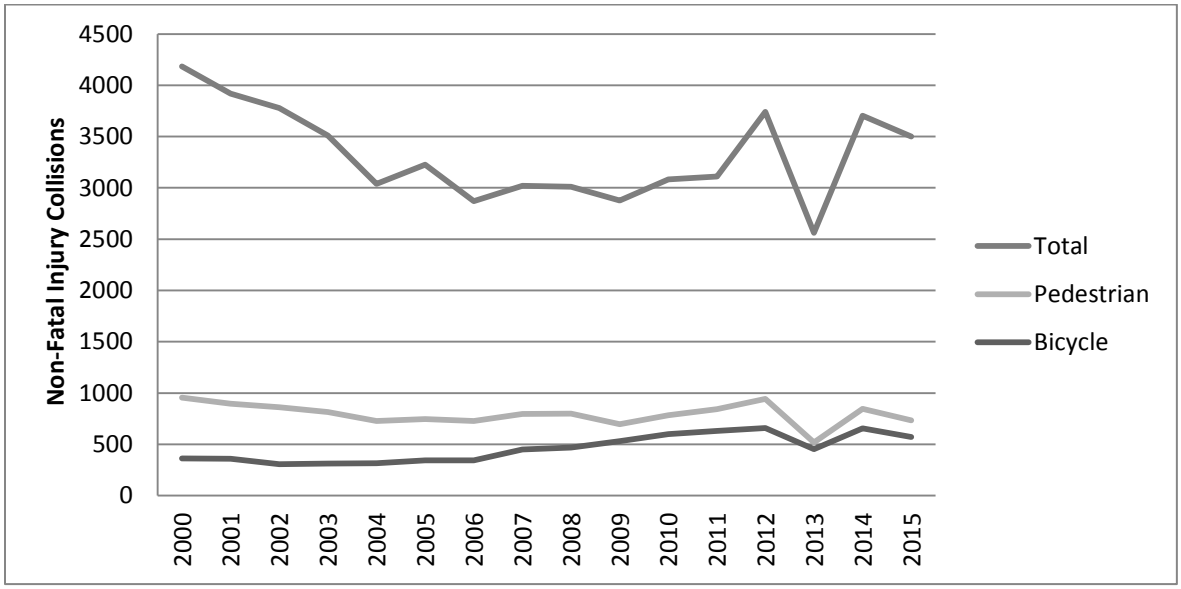
Similar to the statistics reported in Exhibit 1 for all collisions, non-fatal injury collisions involving pedestrians decreased from 955 in 2000 to 734 in 2015, a 23 percent reduction. During the same period, non-fatal injury collisions involving bicycles increased from 364 in 2000 to 572 in 2015, a 57 percent increase.

Exhibit 4: Total Non-fatal Injury Collisions in San Francisco, 2000 – 2015

Year	Total Non-fatal Injury Collisions	Bicycle Collisions	Pedestrian Collisions
2000	4,182	364	955
2001	3,917	360	895
2002	3,777	307	862
2003	3,511	311	815
2004	3,038	316	727
2005	3,227	343	747
2006	2,869	343	726
2007	3,021	451	796
2008	3,010	468	799
2009	2,877	531	695
2010	3,081	599	784
2011	3,111	630	844
2012	3,740	658	942
2013	2,562	454	518
2014	3,703	657	847
2015	3,500	572	734

Sources: SFMTA 2010-2011 San Francisco Collisions Report; 2012-2015 SWITRS Collision Data
Bicycle Collisions = injury collisions involving a bicycle.
Pedestrian Collisions = injury collisions involving a pedestrian.

Exhibit 5: Non-fatal Injury Collisions in San Francisco, 2000 – 2015



Sources: SFMTA 2010-2011 San Francisco Collisions Report; 2012-2015 SWITRS Collision Data

Non-fatal Injury Collision Rates by Type of Travel

To determine whether increases in the number of collisions in San Francisco reported above were affected by increases in population and/or the number of vehicles, bicyclists, and pedestrians on the streets during the years reviewed, U.S. Census Bureau American Community Survey data on transportation mode to work were collected and analyzed for 2006 to 2014, the most recent data available. Specifically, changes in transportation mode for San Francisco residents commuting to work between 2006 and 2014 was compared to collision data by mode of transportation. The results are shown in Exhibit 6.

Exhibit 6: Changes in Mode of Transportation to Work and Non-fatal Collision Rates for San Francisco Residents: 2006 and 2014

	2006	2014	Change	% Change
Workers 16 years +	394,646	480,997	86,351	21.9%
All				
Collisions	2,869	3,703	834	29.1%
# all workers	394,646	480,997	86,351	21.9%
Collisions/1000	7.3	7.7	0.4	5.9%
Bicycles				
# Collisions	343	657	314	91.5%
# workers commuting by bicycle	8,938	21,068	12,130	135.7%
Collisions/1000	38.4	31.2	(7)	-18.7%
Pedestrians				
# Collisions	726	847	121	16.7%
# workers commuting by walking	37,943	53,875	15,932	42.0%
Collisions/1000	19.1	15.7	(3)	-17.8%

Source: U.S. Census Bureau, American Community Survey (1-Year Estimates), 2005-2016; SFMTA 2010-2011 San Francisco Collisions Report; 2012-2015 SWITRS Collision Data

As can be seen in Exhibit 6, the number of City resident workers 16 years of age and over increased by 86,351 between 2006 and 2014, from 394,646 to 480,997. As a result, there was likely more traffic on City streets that could explain some of the increase in non-fatal collision injuries from 2,869 to 3,703 during that time period.

Though workers continued to use all modes of transportation to get to and from work over the nine-year period, growth in bicycling and walking to work eclipsed the percentage growth in total workers. Between 2006 and 2014, the number of workers walking to work increased by 42 percent and the number of commuters bicycling to work increased by 135.7 percent. In comparison, the total number of workers increased by 21.9 percent between 2006 and 2014.

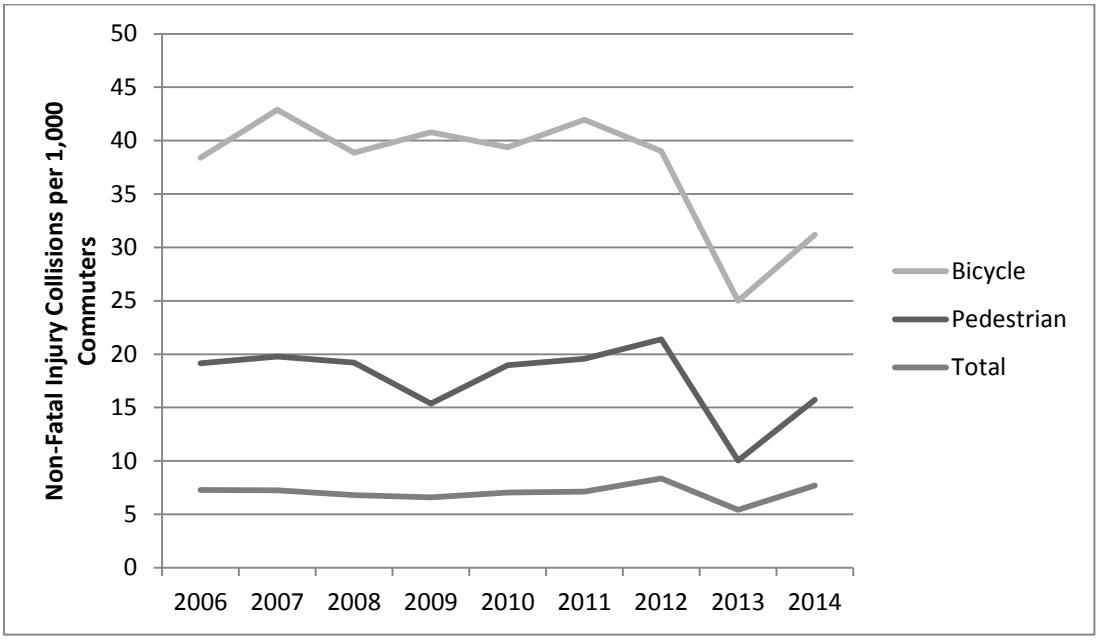
Exhibit 6 shows there were increases in the gross number of collisions between 2006 and 2014 for workers 1) using all modes of transportation, 2) commuting by bicycle, and 3) walking to work. However, some of the increases in collisions are explained by larger numbers of workers walking and bicycling to work during those years. In fact, while bicyclist and pedestrian commuters experienced more collisions per 1,000 commuters than the commuting population as a whole, this trend was blunted somewhat since the collision rates for both groups decreased between 2006 and 2014. The collision rate for all commuters, on the other hand, increased between 2006 and 2014, from 7.3 to 7.7 collisions per 1,000 commuters. These collision rates are based on transportation modes for workers only, so it must be assumed that the patterns reflect general transportation patterns in the City.

Exhibit 7 below shows in graphic form the slight increase in the rate of total collisions per 1,000 commuters (of any mode) between 2006 and 2014 from 7.3 collisions to 7.7 collisions per 1,000 commuters, the decrease in the rate of bicycle collisions from 38.5 collisions in 2006 to 31.2 collisions per 1,000 commuters and the decrease in the rate of pedestrian collisions from 19.1 collisions in 2006 to 15.7 collisions per 1,000 commuters in 2014.

Because the rate of non-fatal injury collisions for bicycle and pedestrian commuters decreased between 2006 and 2014, the increase in total non-fatal injury collision rate appears to be due to an unchanging or slightly higher number of collisions invovling vehicles or other modes of tranportation.

This analysis indicates that the rate of non-fatal injury collisisons involving vehicles has changed little in recent years and may warrant new approaches or tools to stem this trend. While there are still a great number of collisions occuring involving bicycles and pedestrians, the rate of non-fatal injury collisisons involving both groups has decreased, possibly indicating that some of the recent approaches to improving safety for these groups may have been effective and need to be further replicated and/or enhanced.

Exhibit 7: Rate of Non-Fatal Injury Collisions per Commuter, 2006 – 2014*



*Note: Commuter volumes are used to represent general patterns in transportation mode share in San Francisco. Data on collisions is not restricted to commute trips.
Sources: SFMTA 2010-2011 San Francisco Collisions Report; 2012-2015 SWITRS Collision Data; 2006-2014 American Community Survey 1-Year Estimates

Effectiveness of City Speed Reduction Strategies in Recent Years

Adopted in 2014 by the Board of Supervisors and SFMTA, Vision Zero is a set of goals and policies and procedures aimed at improving traffic safety in San Francisco though a series of interdepartmental policies and programs. One of the goals of Vision Zero is to eliminate traffic fatalities and serious traffic-related injuries by 2024.

Since Vision Zero policy was only adopted in 2014, more time is needed to measure and evaluate the outcomes of speed reduction treatments implemented as part of the program. Such evaluation requires analysis of before and after conditions. As mentioned above, SFMTA and DPH are collecting data on Vision Zero-related improvements and will present the results of their evaluations in the coming years. However, the Budget and Legislative Analyst obtained data on the impacts of speed limit reductions on certain City streets in recent years. Below, this report presents before and after conditions at locations where speed limits were reduced on arterial streets or traffic calming features were installed in residential areas prior to the adoption of Vision Zero. While these changes and installations were not specifically implemented as part of Vision Zero, they support the goal of Vision Zero to improve traffic safety.

Relationship between Speed Limits and Collisions on Arterial and Collector Roadways

Arterial Roadways with Lowered Speed Limits

Roadway classifications are indicated on the California Road System Maps maintained by Caltrans and approved by the Federal Highway Administration. SFMTA uses the California Road System Maps, which are updated continuously, to identify the collector and arterial roadways on which actual traffic speeds need to be surveyed on a seven- to ten-year cycle to determine if speed limit adjustments are warranted. Some surveys are updated prior to the seven-year expiration due to public or SFPD requests. For example, speed surveys are necessary for SFPD to be able to use LIDAR detectors for speed enforcement[3].

Speed surveys are generally conducted by SFMTA at a rate of one per week, or approximately 50 per year. Although it is uncommon for speed surveys to justify a change of speed limit, SFMTA pursues the lower speed limits when warranted.

According to SFMTA, there are nine roadways in the City where speed limits were reduced between mid-2011 and early 2013, and therefore collision data is available for

[3] LIDAR is a hand-held device used to measure vehicle speed.

three-year periods before and after the speed limit reduction. The nine roadways are presented below in Exhibit 8.

Exhibit 8: Nine San Francisco Roadways where Speed Limits were Reduced between 2011 and 2013

Roadway	Between:	Old speed limit	New speed limit
King Street	5th St. & The Embarcadero	35 mph	30 mph
The Embarcadero	Bay and King Streets	35 mph	30 mph
Folsom Street	13th Street & The Embarcadero	30 mph	25 mph
Howard Street	S. Van Ness Ave & The Embarcadero	30 mph	25 mph
Harrison Streeet	13th Street & The Embarcadero	30 mph	25 mph
Bryant Street	11th Street & The Embarcadero	30 mph	25 mph
John Muir Drive North	Skyline Blvd. & 2,500 feet southeasterly	35 mph	30 mph
John Muir Drive South	County Line and 3,300 feet northwesterly	45 mph	40 mph
8th Street	Market & Townsend Streets	30 mph	25 mph

Source: SFMTA

For all of the roadways shown in Exhibit 8, speed limits were lowered by 5 mph as justified by new speed surveys.

In California, 25 mph is the default speed limit that applies when no other speed limit is posted. In general, SFMTA does not conduct speed surveys on local residential streets with a default speed limit of 25 mph.

Speed limits on the roadways presented in Exhibit 8 were lowered to conform to speed-setting regulations established by the State rather than to meet a safety goal. In California, speed limits are normally set at the 85th percentile actual speed rounded to the nearest 5 mph increment, although local authorities are allowed to round down to the nearest 5 mph increment due to safety conditions. The 85th percentile speed is the speed at or below which 85 percent of the traffic is moving, as determined by a speed survey, and statistically represents one standard deviation above the average speed. SFMTA conducts speed surveys along collector and arterial streets on a seven- to ten-year cycle in accordance with State requirements. Although speed surveys are not conducted on local (residential) streets, some exceptions are made for school zones.

Results

Lowered speed limits were not associated with a consistent reduction in speeding-related collisions or injury collisions on the nine studied roadways. As presented in Exhibit 9, there were 586 injury collisions on the nine studied roadways in the three-year period before speed limits were lowered, and 772 injury collisions, or 186 more, in the three-year period after speed limit reductions.

There were 42 severe/fatal injury collisions in the period before speed limits were lowered, and 59 such collisions in the after period. As can be seen, the share of total collisions resulting in severe injuries or fatalities increased slightly from 7.2 to 7.6 percent of all collisions.

Exhibit 9: Highest Degree of Injury in Collisions before and after Speed Limit Reductions on Nine San Francisco Roadways with Speed Limits Lowered

	Complaint of Pain	Other Visible Injury	*Severe Injury*	*Fatal*	Severe Injury/ Fatal Subtotal	Total	% Severe/ Fatal
Before	353	191	*39*	*3*	42	586	7.2%
After	497	216	*51*	*8*	59	772	7.6%
Change	144	25	*12*	*5*	17	186	
% Difference	40.8%	13.1%	*30.8%*	*166.7%*	40.5%	31.7%	

Source: SFMTA

Collisions Attributed to Speed

Total injury collisions increased on seven of the nine roadways, and severe injury/fatal collisions increased on five of the nine roadways between the before and after periods. On the nine roadways analyzed, an increase was found in the overall number of collisions attributed to speed in the three-year period after the speed limit was lowered compared to the three-year period before the speed limit was reduced. Speeding-related collisions decreased on four of the nine roadways and increased on five of the nine roadways.

Although the share of collisions resulting in severe injuries or fatalities on the nine roadways analyzed increased slightly between the periods before and after speed limits were reduced, as shown in Exhibit 9 above, the share of collisions attributed to speed was less after speed limits were reduced. As shown in Exhibit 10 below, the share of reported speeding-related collisions relative to all collisions decreased slightly from 17.3 percent to 15.9 percent between the period before the speed limit reductions and the period after.

Exhibit 10: Share of Speeding-Related Collisions before and after Speed Limit Reductions, 2011 – 2013

	Speeding	Other Cause	Total	% Speeding
Before	102	486	588	17.3%
After	123	649	772	15.9%
Total	225	1,135	1,360	16.5%

Source: SFMTA

Although available data shows that speed was reported as less of a factor in the cause of collisions after speed limits were reduced, data is not available to determine if actual speeds driven on those roadways were, on average, lower after speed limits were

reduced. It is possible that, even though speed limits were reduced on the nine roadways, average actual speeds driven may not have been lower. This could possibly explain why the rate of collision severity and fatalities was not lower after the speed limit reductions, as shown in Exhibit 10 above.

Changes in Traffic Volumes

Increases in traffic volume do not appear to explain increases in collisions on at least four of the nine roadways where speed limits were lowered and collisions increased between mid-2011 and 2013. Based on SFMTA traffic count data collected between 2007 and 2015 for four of the nine roadways, vehicle traffic volumes on two of the nine roadways analyzed decreased significantly and increased, though only slightly, on the two other roadways between the before and after period. Exhibit 11 below presents the results for these four roadways.

Exhibit 11: Before and after Traffic Counts for Four Roadways where Speed Limits were Lowered

Street	Before Speed Limit Reduction		After Speed Limit Reduction		Difference
	Traffic Count	Date	Traffic Count	Date	
Embarcadero (btwn. Bay & King)	32,908	6/25/08	14,539	6/16/13	-18,369
Folsom Street (btwn. 13th & Embarcadero)	27,315	6/23/09	15,125	10/22/12	-12,190
Howard Street (btwn. S. Van Ness & Embarcadero)	17,743	1/18/11	18,078	10/29/12	335
Bryant Street (btwn. 11th & Embarcadero)	13,396	6/8/11	13,541	1/27/15	145

Source: SFMTA Traffic Count Data 1993-2015 for four of the nine roadways where speed limits were reduced between mid-2011 and 2013.

Note: Before and after traffic count data not available from SFMTA for the five other streets where speed limits were lowered during that time.

Although the comparative information is not available for all nine roadways, there does not seem to be a direct relationship between vehicle traffic volumes and the number of injury collisions on the roadways analyzed. For example, along the Embarcadero, where point-in-time counts show a substantial decrease in traffic volume between 2008 and 2013, the number of collisions increased from 85 in the before period to 116 in the after period. Severe/fatal injury collisions increased from 6 in the before period to 11 in the after period, and speeding-related collisions increased from 26 in the before period to 37 in the after period, as shown in Exhibit 12 below. Because the rate of injury collisions relative to traffic volumes increased after speed limits were reduced, speed limit reductions alone do not seem to be associated with improved traffic safety.

In addition to the Embarcadero, comparisons of changes in collisions and traffic volume for three other of the nine roadways for which speed limits were reduced between mid-2011 and 2013 are presented in Exhibit 12. As shown, injury collisions increased on all four roadways, even though traffic counts were lower after the speed limit reduction on two of the four roadways and slightly higher on the other two.

Exhibit 12: Number of Collisions in Periods Before and After Speed Limit Reduction*

	The Embarcadero		Folsom Street		Howard Street		Bryant Street	
	Before	After	Before	After	Before	After	Before	After
Traffic Count	32,908	14,539	27,315	15,125	17,743	18,078	13,396	13,541
Difference	-18,369 (↓ 56%)		-12,190 (↓ 45%)		335 (↑ 2%)		145 (↑ 1%)	
Total Injury Collisions	85	116	106	148	106	122	48	90
Difference	31 (↑ 36%)		42 (↑ 40%)		16 (↑ 15%)		52 (↑88%)	
Severe/Fatal Collisions	6	11	6	13	10	7	3	8
Difference	5 (↑ 83%)		7 (↑ 117%)		-3 (↓ 30%)		5 (↑ 167%)	
Speeding Collisions	26	37	15	20	16	17	8	17
Difference	11 (↑ 42%)		5 (↑ 33%)		1 (↑ 6%)		9 (↑ 113%)	

Source: SFMTA

* For roadways with traffic counts available for both before and after periods.

Changes in Means of Transportation in San Francisco

Although vehicle traffic volumes did not increase at the same rate as the number of collisions on the roadways analyzed, it is possible that an increased presence of pedestrians and bicyclists on the roadways analyzed could have contributed to the increase in injury collisions after the speed limit reductions. Before and after counts of pedestrian and bicycle volumes are not available for the nine roadways analyzed. However, citywide Census data about the means of transportation to work, presented above in Exhibit 6, shows that pedestrian and bicycle activity increased substantially on San Francisco streets between the before and after periods. Assuming that the worker travel modes discussed above are representative of travel trends on the nine roadways analyzed, the shift in travel mode could partially explain why the number of collisions on the roadways studied has gone up while vehicle travel has only increased slightly or decreased.

Other Considerations: Roadway Improvements and Enforcement

Evaluation of the effectiveness of lowered speed limits is complicated by other road improvements that affect driver choice of speed and traffic volumes. Six of the nine roadways analyzed had other traffic improvements implemented during the study period after their speed limits were lowered. These improvements included signal retiming on two roadways, road diets on two roadways, and new bike lanes on two roadways.

One of the many factors that contribute to driver speed is enforcement. Few studies have analyzed the effects of alternative enforcement levels in combination with speed limit changes to assess how enforcement interacts with a change in speed limit.

Although excessive speed is the leading cause of injury collisions on City streets, it is important to note that the number of speeding collisions could be overstated because

the default cause of collision is recorded as speeding or following too close when the responding officer cannot otherwise determine the cause. For example, distracted driving could be an under-reported cause of dangerous driving behavior and collisions because it is difficult to determine if a driver was distracted unless an officer or someone else witnessed it. The potential over-reporting of speeding-related collisions has policy implications for response mechanisms, particularly increased speeding enforcement, and education campaigns related to distracted driving.

Effect of Traffic Calming on Speed on Residential Roadways

SFMTA implements residential traffic calming projects based on a resident-application system. SFMTA conducted before and after traffic counts for eight locations where residential traffic calming measures were installed between 2011 and 2015. The traffic calming measures included a median island, rubber speed hump, speed humps, and speed cushions.

Overall, changes in average daily traffic on streets where traffic calming installations occurred were negligible, while the 85th percentile speeds decreased by 18.1 percent and vehicles traveling over 30 mph decreased by 77.5 percent.

At locations where speed humps were installed, the 85th percentile speed decreased by 22.7 percent, and vehicles traveling over 30 mph decreased by 86.6 percent. Therefore, residential traffic calming features were successful at significantly decreasing speeds traveled, particularly the incidence of vehicles traveling at high rates of speed. According to SFMTA staff, before and after collision data for the eight locations where traffic calming was implemented is unlikely to be meaningful because injury collisions on residential streets are very infrequent (i.e., no collision history in most cases). According to SFMTA staff, the primary goal of the traffic calming program is to reduce vehicle speeds, and a secondary goal is to improve livability and reinforce safe driving behavior, with a long-term goal of contributing to improved safety throughout the City as part of the goals of Vision Zero.

Vision Zero

The information above shows that reducing speed limits alone has had little apparent impact on reducing collisions, at least on nine arterial roadways in San Francisco. Further, under current State law, the City is limited in its ability to make speed limit reductions without a speed survey that must show that speeds being driven on the tested roadway are already lower than the posted speed limit. For streets where speed limits are routinely being exceeded, the City has limited authority to lower speed limits. For residential streets where speed limits are being exceeded, SFMTA's installation of traffic calming devices remains an effective option.

To address the rate of traffic fatalities that had not declined since 2010, the Board of Supervisors and SFMTA in 2014 adopted Vision Zero, a set of goals, policies, and procedures aimed at improving traffic safety. One of the goals of Vision Zero is to eliminate traffic fatalities and serious traffic-related injuries by 2024. Vision Zero serves as the City's inter-departmental guide for a variety of programs aimed at speed reduction and traffic safety. While some projects and programs were underway prior to the adoption of Vision Zero, traffic safety campaigns and projects already in place are now aligned under the policy.

In early 2015, SFMTA released a Two-Year Action Strategy outlining projects and policy changes for the City to implement between 2015 and 2017. Thirteen department heads and the Mayor pledged to work together in partnership with stakeholders to implement the Strategy. Actions fall within five main categories:

	Element	Actions
1.	**Engineering**	Annually implement safety treatments along at least 13 miles of the High-Injury Network, or corridors and intersections with a high number of injuries, and continue the Residential Traffic Calming program.
2.	**Enforcement**	Continue "Focus on the Five" enforcement targeting the top five violations associated with severe and fatal injuries: 1) not yielding to pedestrian right of way, 2) running red lights, 3) speeding, 4) running stop signs, and 5) not yielding while turning.
3.	**Education**	1) Implement a Citywide education campaign, 2) expand the mandatory large vehicle driver training programs for City employees, and 3) publicize the educational large vehicle driver training video on YouTube, which is available for all drivers to view.
4.	**Evaluation**	Integrate monitoring, evaluation, and injury data within TransBaseSF.org, which is an open platform database that links transportation injury-related data from multiple agencies with community and environmental factors.
5.	**Policy**	Advance State legislation to allow Automated Speed Enforcement (ASE) in California.

Each of these five areas is discussed further below.

Engineering: *High-Injury Network*

Vision Zero prioritizes the implementation of safety treatments along the City's High-Injury Network, which is made up of the corridors and intersections with a high density of injuries. The High-Injury Network was identified as part of the City's previous inter-

departmental WalkFirst[4] program, which is now a part of the Vision Zero program. WalkFirst developed a framework for prioritizing pedestrian improvements, including a map of high-injury corridors and intersections, in 2010 which, combined, now comprise the High-Injury Network. The City's High-Injury Network represents 6 percent of San Francisco's street miles (70 miles), but 55 percent of all severe and fatal injury collisions in the five-year period between 2005 and 2009.[5]

In 2013, the City's WalkFirst program used High-Injury Network data to identify locations where pedestrian safety improvements were most needed. This was done by scoring street segments and intersections by counting the number of pedestrian injuries that occurred at each street segment or intersection over the five-year period between 2005 and 2009, with severe and fatal injuries weighted more than minor injuries. Street segments and intersections with the highest injury scores that also had high levels of pedestrian activity[6] were designated as the highest priority corridors and intersections for safety improvements, as shown in the map below. The map of high-incident locations was further refined based on public input and technical analysis of locations with an imbalance between a pedestrian activity score and the actual level of activity, as shown in Exhibit 13 below.

Between January 2014 and March 2016, SFMTA installed 675 safety improvements at 333 locations. The types of features installed include advance stop or yield lines, continental crosswalks, corner bulb-outs, midblock crosswalks, leading pedestrian intervals, painted safety zone, red no-parking curbs, pedestrian countdown signals, pedestrian refuge islands, pedestrian warning signage, reduced lane widths, road diets, signal timing changes, and turn prohibitions.

[4] WalkFirst was a partnership among SFMTA, the SF Planning Department, DPH, Public Works, the Mayor's Office, SFPUC, and the Controller's Office. It is now part of the Vision Zero program.
[5] City and County of San Francisco. WalkFirst: Improving Safety & Walking Conditions in San Francisco, Final Report. October 2011.
[6] Pedestrian activity was scored based on the following categories that contribute to walking: 1) access/need to walk; 2) transit ridership; 3) density of people; 4) pedestrian generators (e.g., tourist destinations, schools, parks, etc.); 5) density of seniors, youth, and persons with disabilities; 6) income; and 7) street slope.

Exhibit 13: High-Injury Corridors and Key Safety Areas in San Francisco (2011)

Source: City and County of San Francisco. WalkFirst: Improving Safety & Walking Conditions in San Francisco, Final Report. October 2011.

Engineering: *Residential Traffic Calming*

The primary goal of SFMTA's Application-Based Residential Streets Traffic Calming Program is to reduce vehicle speeds. A secondary goal is to improve livability and reinforce safe driving behavior, with a long-term goal of contributing to improved safety throughout the City as part of the goals of Vision Zero.

Since the High-Injury Network tends to be located on arterial streets, Vision Zero projects tend to focus on commercial and mixed-use areas in the denser parts of the City where collisions occur more frequently. Therefore, SFMTA established the Application-Based Residential Streets Traffic Calming Program for ensuring engineering upgrades on relatively lower-volume residential streets. The measures on residential streets tend to differ from safety measures for arterials because residential features, such as speed humps and speed cushions,[7] are not appropriate for arterials.

For residential street traffic calming, a resident must submit an application and petition signed by at least 20 households on a block. In FY 2015-16, 102 applications were submitted, and 51 applications were approved.[8] For each submitted petition, SFMTA conducts a speed survey and traffic count along the blocks, reviews data on the number of collisions at the location, and considers the adjacent land uses. Ranking of applications is based predominantly on the prevalence of speeding in combination with average daily traffic volumes, as well as proximity of the block to schools, parks, commercial areas, bike routes, and high-frequency transit. For locations that are accepted into the program, SFMTA reviews the location to determine if a speed hump or other measure is appropriate. For blocks where a speed hump or speed cushion is recommended, SFMTA sends ballots to the residents of the block and residents vote on whether they favor the measure. Half of the returned ballots must be in favor of the measure for the project to move forward. Turnaround time between the application deadline and installation of the traffic calming feature is approximately 12 to 20 months.

Enforcement

The San Francisco Police Department (SFPD) conducts speed enforcement on City streets. The SFPD Traffic Company has approximately 45 motorcycle officers who are assigned to enforce dangerous driving behavior. Traffic Company officers are assigned by the Traffic Company captain for "Focus on the Five" enforcement to address the most dangerous driving behaviors: 1) not yielding to pedestrian right of way, 2) running red lights, 3) speeding, 4) running stop signs, and 5) not yielding while turning.

[7] A speed cushion is a speed hump that includes wheel cutouts to allow large vehicles, such as emergency vehicles, to pass unaffected while reducing passenger vehicle speeds.
[8] In the FY 2016-17 cycle, the traffic calming program received 84 applications, which were being evaluated by SFMTA staff at the time this report was prepared.

SFPD patrol officers are assigned by district captains at the ten district stations throughout the City to address enforcement-related community complaints. Traffic Company deployments are based primarily on the High-Injury Corridor[9] maps and, secondarily, on community input. According to SFPD, since June 2016, when two bicyclists were fatally struck by speeding vehicles, SFPD has refocused efforts on the High-Injury Corridors to address unsafe speeding. For example, in the first six months of 2016 (January to June), SFPD reports that it issued 689 citations for speeding, or an average of 115 per month. However, in July through September 2016, SFPD issued 4,432 citations for speeding, or an average of 1,477 citations per month. SFPD also plans to enhance its enforcement efforts in conjunctions with Vision Zero's education component, as detailed in the next section.

Education

Work that supports Vision Zero includes inter-departmental traffic safety campaigns, such as the Safe Speed SF campaign, to slow traffic and encourage bicycling and walking. The Safe Speed SF campaign includes a combination of education outreach and enforcement because, according to SFMTA staff, education and enforcement campaigns are often more effective when combined. The Safe Speed SF campaign, which will be directed to all drivers in San Francisco, began in September 2016, and the education component focuses on building respect for the speed limit and awareness that speeding is a leading cause of death on City streets.

SFPD's enhanced enforcement, to be rolled out in conjunction with the inter-departmental Safe Speed program, will involve approximately 132 hours of additional enforcement activities per week for one year on top of the current enforcement activities performed by SFPD personnel. About 72 of the additional 132 hours each week will be dedicated to routine enforcement, with about six officers using LIDAR (a hand-held device used to measure vehicle speed) on high-injury corridors or any other corridors at the discretion of SFPD. The remaining 60 hours each week will be dedicated to high-visibility enforcement with 12 officers conducting enforcement on high-injury corridors. High-visibility enforcement combines high-profile enforcement events with publicity to show the public that speeding is a concern and ticketing does occur, as well as why the law is being enforced and specifically what is being enforced.

As part of its support for Vision Zero, SFMTA also administers the Large Vehicle Urban Safety Program for people who drive large vehicles in the City. The program involves a training video available for streaming on YouTube as well as a stand-alone training curriculum. Viewing the training video is required of all large vehicle drivers who work

[9] The High-Injury Corridors are a subset of the High-Injury Network. The High-Injury Network also includes intersections with a high rate of injury collisions.

for the City or contract with SFMTA. The video is also available for the general public to view.

Evaluation

The effectiveness of various Vision Zero programs will be evaluated by the Department of Public Health (DPH) after implementation. For example, for the Safe Speed Campaign, outcome analysis measurements will be conducted at three points in time: 1) before intervention; 2) during the media campaign and targeted enforcement period; and 3) after intervention. Analysis of the outcome data over the three time periods will assess the extent to which travel behaviors, vehicle speeds, and public perceptions of safety are impacted by targeted enforcement and education.

Data on traffic safety measures (e.g., numbers and types of collisions) are collected by the DPH Program on Health, Equity and Sustainability. In 2014, DPH launched TransBASE (TransBASESF.org), which is an online database and analytical tool designed to address transportation problems in an effort to inform public and private efforts to improve transportation system safety and public health. TransBASE serves as a centralized system for accessing and visualizing data relating to transportation infrastructure, traffic volumes, demographics, high-injury intersections and corridors, collisions, traffic-related fatalities and injuries, and other features. TransBASE also serves an important role as a centralized repository of data for monitoring and evaluating Vision Zero program effectiveness.

Alternative Approach to Setting Speed Limits: incorporating presence of bicycle and pedestrian safety features

The City of Portland, Oregon, as part of their Vision Zero program, is pursuing a pilot program that would set speed limits based on the degree of separation between people driving, biking, and walking on non-arterial streets with posted speed limits greater than 25 mph. Maximum speeds would be based on whether the roadway has physical barriers (40 mph), bike lanes (30 mph), or shared space (20 mph). Oregon state statutes limit how cities set speed limits, so the City of Portland is currently seeking approval from the Oregon Department of Transportation to implement the alternative methodology for speed zones.

Policy

Automated Speed Enforcement (ASE) is a tool for addressing speeding on city streets that uses fixed or mobile cameras and other equipment to detect and capture images of vehicles traveling at excessive speeds. State law currently prohibits ASE in California but other states allow it to be used by local government jurisdictions for enforcement.

In support of Vision Zero, in 2015, the San Francisco Controller's Office administered a survey to six major cities that have implemented ASE, and reported on best practices and program effectiveness from the surveyed jurisdictions. Each jurisdiction measures

effectiveness in different ways, and all six cities found ASE to be an effective safety tool. For example, of the two jurisdictions that track fatalities, Washington D.C. reported a 70 percent reduction in fatalities and Portland, OR reported a 53 percent reduction in fatalities since ASE program inception.[10]

As mentioned above, ASE is not currently legal in California so a change to State law is required to implement the technology. SFMTA is currently working on a State bill to authorize an ASE pilot program in California that would mirror best practices from other jurisdictions that have already implemented ASE.

[10] City and County of San Francisco, Office of the Controller – City Services Auditor. Automated Speed Enforcement Implementation: Survey Findings and Lessons Learned From Around the Country. November 12, 2015.

Future Speed Reduction Efforts

Speed Surveys and Reductions

According to SFMTA staff, the schedule for conducting speed surveys has not changed since adoption of Vision Zero, as speed survey procedures are dictated by the State. Therefore, the schedule of surveying approximately 50 roadways each year is expected to continue, and speed limit reductions that result from new surveys will likely continue to be infrequent.

Residential Traffic Calming

As discussed above, traffic calming efforts are currently focused on residential streets with no more than one lane of travel in each direction and based on petitions to identify locations where there are speeding concerns. According to SFMTA staff, a Proactive Traffic Calming Program is currently in the planning stage. The Application-Based and Proactive programs are both funded in the Capital Improvement Program and will complement each other. Starting in FY 2019-20, both programs will receive funding to implement approximately 25 projects per year, but SFMTA approved 51 projects in the 2015-16 program cycle since additional funding was identified to accommodate the large number of applications that year.

As the traffic calming measures implemented on residential streets (e.g., speed cushions and raised crosswalks) have shown to be effective at reducing speeds traveled, SFMTA should consider the appropriateness and advantages and disadvantages of installing such features on collectors and arterials.

Autonomous Vehicles

Autonomous vehicle technology shows potential for reducing traffic deaths and serious injuries, but its potential for safety improvements is dependent on how cities design shared spaces for bicycles and pedestrians and regulation of speed. As discussed above, the likelihood of pedestrian death declines at lower vehicles speeds at impact. While autonomous vehicles can react faster than human drivers, the laws of physics still govern safety. For example, an autonomous vehicle may not be able to avoid a child running into the street after a ball, but a lower speed limit in areas where vehicles interact with pedestrians and bicycles would reduce the likelihood of death or serious injury in the event that an autonomous vehicle cannot stop in time. Federal and state governments will need to issue regulations about safe speeds for autonomous vehicles. Cities will also need to decide whether to re-prioritize space for vehicles, pedestrians, and bicycles since autonomous vehicles require less road space to maneuver. Consideration of this emerging technology and related matters should be incorporated in future Vision Zero planning efforts.

Conclusion

It is too early to evaluate the effectiveness of speed reduction strategies implemented as part of Vision Zero, therefore this report analyzed improvements implemented prior to the adoption of Vision Zero.

Although speed humps are effective at reducing travel speeds on residential streets, severe injury collisions tend to happen on arterials, not residential streets. Therefore, the contribution of residential traffic calming to collision prevention and improved pedestrian safety is small.

Speed limit reductions do not necessarily slow travel speeds and improve safety because speed limits reflect actual driver behavior at the time of the speed survey. As shown along the nine roadways analyzed before and after speed limits were reduced, injury collisions increased after the speed limit reduction even though traffic volumes did not increase significantly. It is not known why the rate of collisions increased over time, but the available evidence suggests there is no relationship between lower speed limits and the number of collisions.

Interpretation of the results is complicated by the fact that the mode share for pedestrians and bicyclists in San Francisco increased substantially over time. While collisions per pedestrian or cyclist went down, raw numbers of collisions went up, possibly due to the increased potential for conflict between vehicles and pedestrians or vehicles and bicyclists.