



# DON'T CUT CORNERS

LEFT TURN Pedestrian & Bicyclist Crash Study

August 2016





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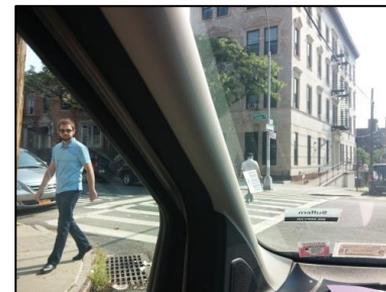
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New York City Department of Transportation (DOT) developed the Left Turn Pedestrian and Bicycle Crash Study to advance New York City's Vision Zero initiative to eliminate traffic deaths and serious injuries. Between 2010 and 2014, 108 pedestrians and bicyclists were killed by left turning vehicles (out of 859 pedestrian and bicyclist fatalities 2010-2014). In 2016, Mayor de Blasio prioritized the reduction of these failure to yield crashes, noting that left turns account for more than twice as many pedestrian and bicyclist fatalities as right turns and over three times as many serious injuries and fatalities.

Left turns are more dangerous than right turns for three main reasons: left turns can be taken at a wider radius, which leads to higher speeds and greater pedestrian exposure; the driver's visibility is partially obscured by parked cars and the vehicle's A-pillar; and left turns are more complicated than rights, and require more mental and physical effort ("driver workload") than right turns.

In line with the Vision Zero Pedestrian Safety Action Plans, this study utilizes a data-driven approach to examine crashes. DOT took an exhaustive look at the problem of left turn pedestrian and bicyclist injuries (including fatalities) in New York City, querying five years of citywide crash data, manually reviewing 1,105 crash reports drawn from the most problematic locations citywide, and analyzing 478 intersections where treatments were installed. The study relies on these findings to provide recommendations for additional engineering, planning, and education efforts to prevent and mitigate left turn failure to yield pedestrian and bicyclist injuries.

DOT prepared this study pursuant to Local Law 21 of 2014, one of several City Council bills signed by Mayor de Blasio to support Vision Zero.



Source: NYPD/NYCDOT (2010 – 2014); NYSDOT (2010 – 2014)

## KEY FINDINGS

**Citywide Analysis** (primarily utilized killed or severely injured (KSI) data where sample size was large enough to support robust analysis, otherwise total injuries were analyzed)

### How: Vehicular Movements

- Pedestrians and bicyclists are killed or severely injured (KSI) by a left-turning vehicle at over three times the rate (19%) of pedestrian and bicyclist KSI by a right-turning vehicle (6%)

### Who: Vehicle Type

- Nearly 80% of pedestrian and bicyclist KSI by a left-turning vehicle involve a passenger vehicle

### Who: Age

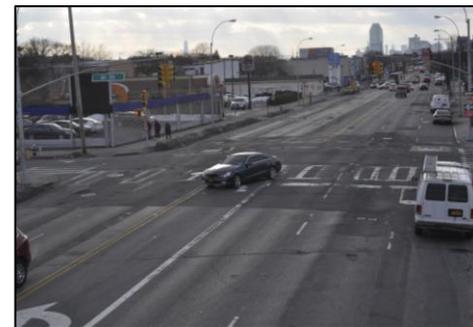
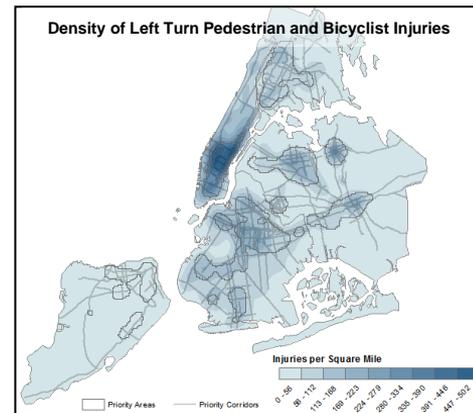
- Seniors are more at risk: pedestrians and bicyclists killed by a left-turning vehicle have a median age of 67; all other fatal crash types have a median age of 50

### Where: Geography

- Left turn pedestrian and bicyclist injuries are concentrated in the same locations as pedestrian KSI in general
- All left turn pedestrian and bicyclist injuries occur at 18% of total NYC intersections

### Where: Intersection Characteristics

- Most locations where left turn pedestrian and bicyclist injuries occurred:
  - involved a one-way street (70%)
  - had a signalized approach (80%)

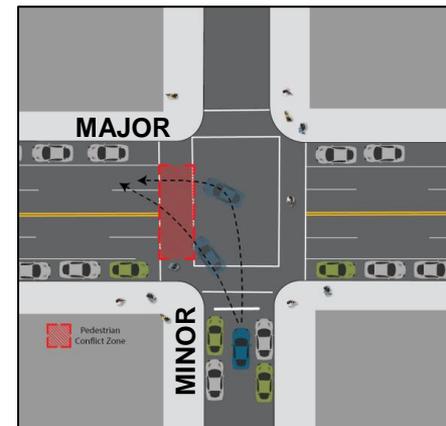


Source: NYSDOT (2010 – 2014)

## KEY FINDINGS

### Detailed Analysis

- DOT manually reviewed 1105 NYPD MV104 crash reports (2009-2013), drawn from locations with the highest concentration of left turn pedestrian and bicyclist injuries in NYC
- Injuries typically occurred where:
  - Vehicle was coming from the minor approach
  - Receiving street was 60' or wider
  - Vehicle was coming from a one-way street
  - Receiving street was a two-way street



## KEY FINDINGS

### Treatment Evaluation

- DOT conducted before/after crash analysis at 478 intersections (3 years of before vs. 3 years after data), using NYSDOT crash data (1996-2014)
- Left turn restrictions: 41% drop in left turn pedestrian and bicyclist injuries
- Left turn bays: 15% drop in left turn pedestrian and bicyclist injuries
- Protected bicycle lanes: 15% drop in in left turn pedestrian and bicyclist injuries, 53% drop in left turn pedestrian and bicyclist KSI
- Left turn only signals: 33% drop in left turn pedestrian and bicyclist injuries
- LPIs: 14% drop in in left turn pedestrian and bicyclist injuries, 56% drop in left turn pedestrian and bicyclist KSI

		Left Turn Restrictions	Left Turn Bays	Protected Bicycle Lanes	Left Turn Only Signals	LPIs
	<b>Study Sample (# of intersections)</b>	51	140	149	34	104
	<b>Years of crash data analyzed</b>	2005-2013	2006-2014	2004-2013	1996-2014	2000-2014
<b>Left Turn Pedestrian and Bicyclist Injuries</b>	<b>Before (3 years)</b>	113	117	295	55	282
	<b>After (3 years)</b>	67	100	250	37	243
	<b>Change</b>	-41%	-15%	-15%	-33%	-14%
<b>Left Turn Pedestrian and Bicyclist KSI</b>	<b>Before (3 years)</b>	10	11	32	6	41
	<b>After (3 years)</b>	3	9	15	4	18
	<b>Change</b>	NA*	NA*	-53%	NA*	-56%

\*The sample size provided by KSI in these cases was too small for robust analysis, so percent change was excluded

## ACTION PLAN

**Leading Pedestrian Intervals (LPIs):** Vision Zero has prioritized the study and installation of LPIs at Priority Intersections and at school intersections along Priority Corridors. DOT installed over 400 new LPIs citywide in 2015, and plans to install at least 500 in 2016.

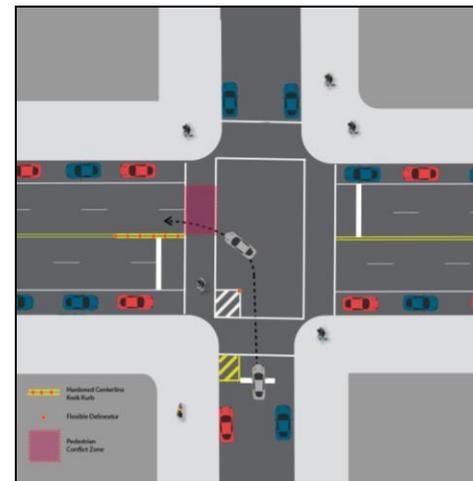
**Left Turn Traffic Calming Pilot:** DOT is undertaking a 100-intersection pilot initiative to test new safer, slower left-turn designs. Treatments will include the marking of a guiding radius, permanent plastic delineators and permanent rubber curbs with delineators on the double yellow centerline.

**Split LPIs:** Currently there are 28 Split LPIs and 9 Split LPIs w/ bicycle signals (pilot program) installed in NYC. DOT will continue to pilot and evaluate. If proven beneficial, DOT will seek to accelerate the rate of installation.

**Left Turn Restrictions and Left Turn Signals:** DOT will take every opportunity to incorporate either left turn restrictions or dedicated left turn signals into broader improvement projects based upon studies of individual locations.

**Protected Bicycle Lanes:** DOT will continue to implement new protected bicycle lanes, enhancing bicycle mobility as well as overall street safety, with at least 15 miles planned for 2016.

**Public Information Campaign:** The 3rd phase of the “Your Choices Matter” campaign will focus on pedestrian crashes at intersections. DOT will develop “Turn Speed” iconography to illustrate that turns should be taken at 5 mph. DOT will roll out a comprehensive failure to yield marketing effort in Fiscal Year 2017.



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## The Left Turn Problem



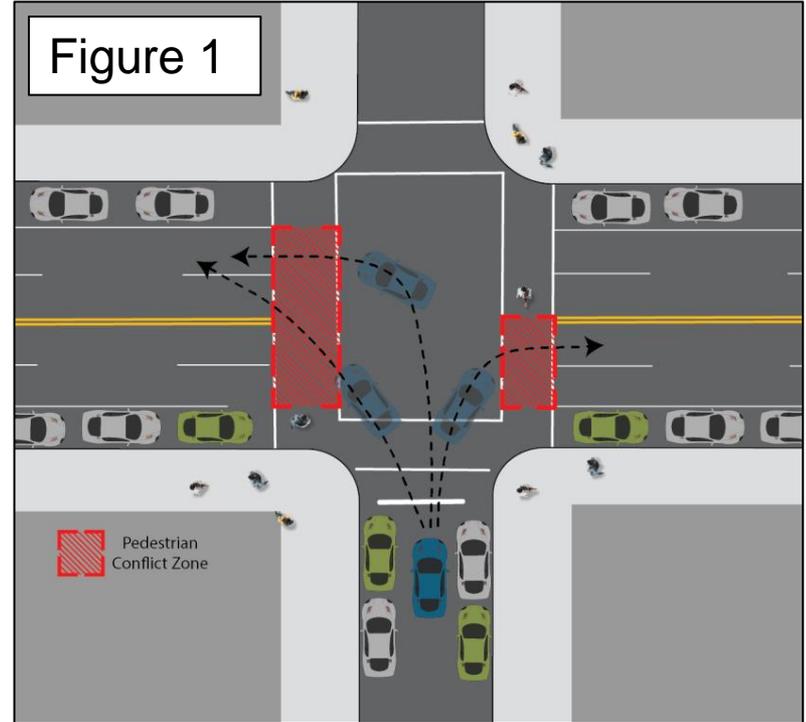
# 1. The Left Turn Problem

## HIGHER SPEEDS

- The larger possible turning radii and longer distance before the turn encourages drivers to take left turns at higher speeds than right turns
- Crash reconstruction analysis shows left turns occur at an average of 9.3 mph vs. right turns at 5.6 mph\*

## GREATER PEDESTRIAN EXPOSURE

- Larger area of exposure for pedestrians in the crosswalk
- Seen here in Figure 1 as the “Pedestrian Conflict Zone”



\*Roudsari, Bahman, Kaufman, Robert, and Koespell, Thomas; "Turning at Intersections and Pedestrian Injuries," 2006.

# 1. The Left Turn Problem

## DRIVER'S OBSCURED VISIBILITY

- **The vehicle's A-pillar** (the portion of the vehicle frame between the windshield and the driver's side window) obscures seven linear feet of the driver's view of pedestrians in the crosswalk\*\*\*. This blind spot can track with crossing pedestrians, dramatically obscuring the driver's view as compared to right turns (seen in Figure 2), if the driver fails to appropriately move their head and scan the crosswalk.
- Difficult for vehicles to stop in time
  - Sight stopping distance = 150 feet at 25MPH\*\*
  - Compounded by higher speed of left turning vehicle
- A left turning driver on a one-way street with **parked cars** on their left must take extra care to detect a pedestrian that is entering the adjacent crosswalk, because that pedestrian may not be readily visible until the vehicle is approximately 40 feet away.\*

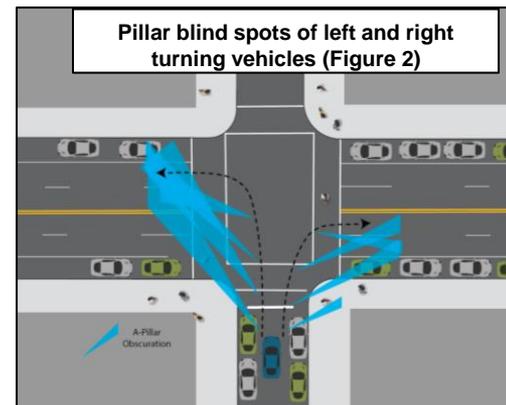


Image based on "Pedestrian Safety: The Hazards of Left-Turning Vehicles" by Philip A. Habib



Pedestrians in the crosswalk can disappear behind the vehicle's A-pillar

\* Based on NYCDOT estimates

\*\*AASHTO design stopping sight distance criteria is 155 ft at 25 mph. Found in *Speed Concepts: Informational Guide*, [http://safety.fhwa.dot.gov/speedmgt/ref\\_mats/fhwsa10001/#c4.2](http://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwsa10001/#c4.2)

\*\*\*Based on Reed, Matthew. "Intersection Kinematics: A Pilot Study of Driver Turning Behavior with Application to Pedestrian Obscuration by A-Pillars" November, 2008. University of Michigan Transportation Research Institute

# 1. The Left Turn Problem

## DRIVER WORKLOAD

Driver workload is the split-second decision-making based on a complex series of mental and physical tasks a driver must execute to perform a traffic maneuver. Left turns are more complex than other maneuvers with unique challenges.

- “Back Pressure”
  - Back pressure occurs when the left turning vehicle must yield to oncoming traffic while vehicles behind the left turning vehicle must wait
- “Find the Gaps”
  - The motorist must find the gaps in oncoming traffic in multiple streams (one or more lanes and the crosswalk) with those streams all having different moving speeds
  - The high numbers of pedestrians on the roadways makes this especially challenging in NYC

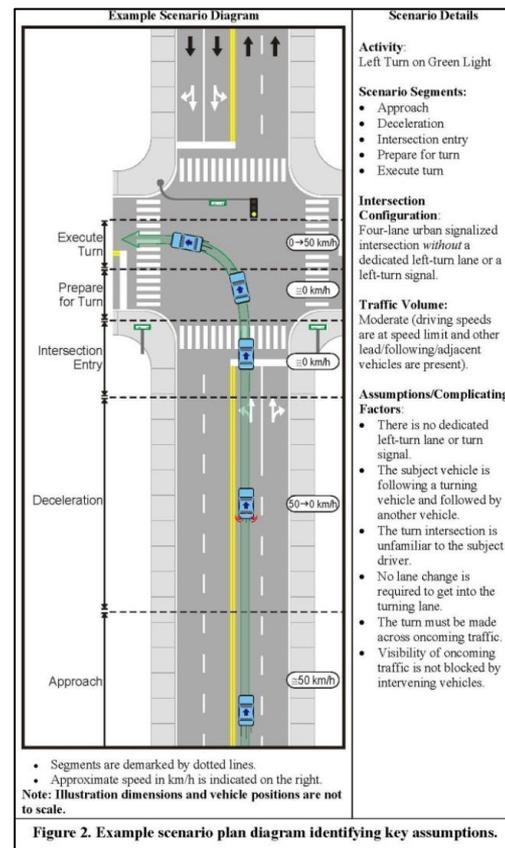


Figure 2. Example scenario plan diagram identifying key assumptions.

Image taken from: U.S. Department of Transportation Federal Highway Administration, “Task Analysis of Intersection Driving Scenarios: Information Processing Bottlenecks,” 2006

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## Citywide Analysis

# 2

### **METHODOLOGY**

For the citywide analysis, DOT utilized the last five years of available pedestrian and bicycle crash data (2010-2014), as supplied from New York State Department of Transportation (NYSDOT). This data covers all traffic crashes reported to the New York City Police Department (NYPD) from 2010 to 2014. This part of the study relies primarily on pedestrian and bicyclist killed or severely injured (KSI) data, as the sample size provided by citywide pedestrian and bicyclist KSI was large enough to support robust analysis. When injuries were analyzed, fatal injuries were included as well.

The dataset in this citywide analysis is comprehensive and covers all of the city's geography. However, it is missing certain key variables (vehicle location pre-crash (approach street), street width, directionality (one-way vs two-way)). For that reason, DOT supplemented the citywide analysis with a detailed analysis of individual locations (see Section 3 – Detailed Analysis).

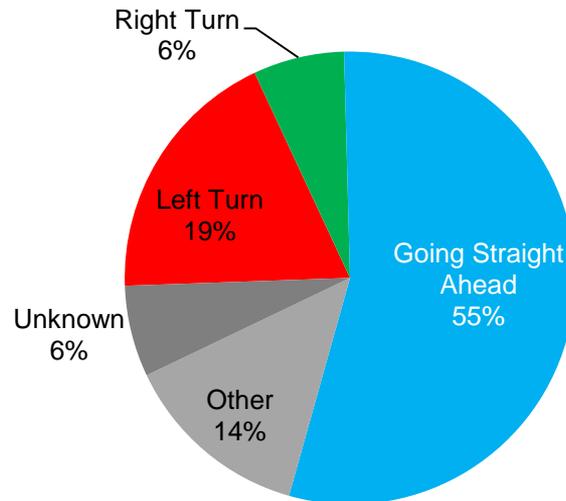
## 2. Citywide Analysis

### HOW

#### Vehicular Movements

- Pedestrians and bicyclists are killed or severely injured (KSI) by a left-turning vehicle at over three times the rate (19%) of pedestrian and bicyclist KSI by a right-turning vehicle (6%)

Total Pedestrian and Bicyclist KSI by Turning Movement



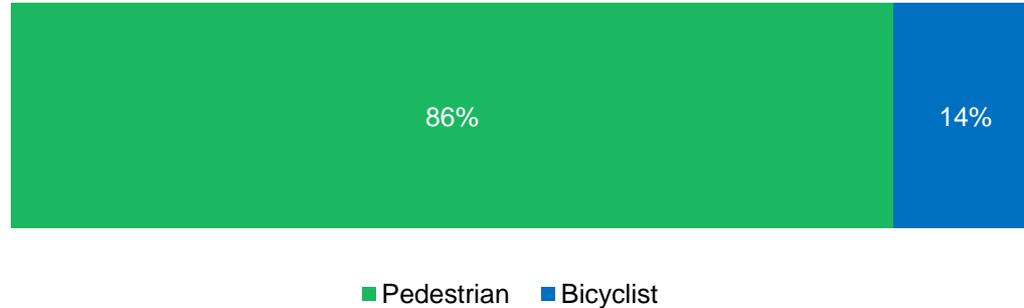
Source: NYSDOT (2010 – 2014)

### WHO

#### Pedestrians and Bicyclists

The vast majority of left turn pedestrian and bicyclist KSI involve pedestrians (86%), to a greater degree than all other KSI (75% pedestrian).

Distribution of Left Turn  
Pedestrian and Bicyclist KSI



Source: NYSDOT (2010 – 2014)

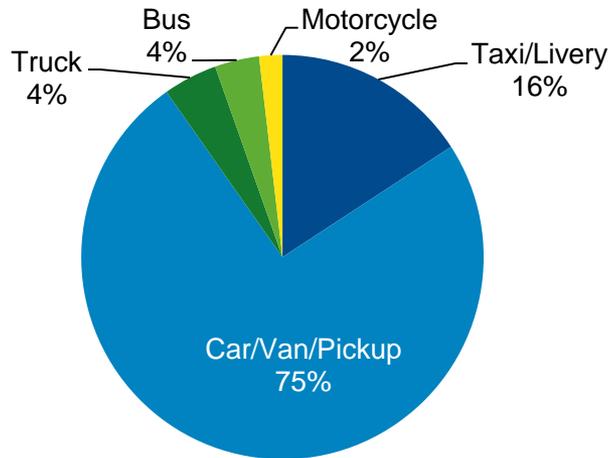
## 2. Citywide Analysis

### WHO

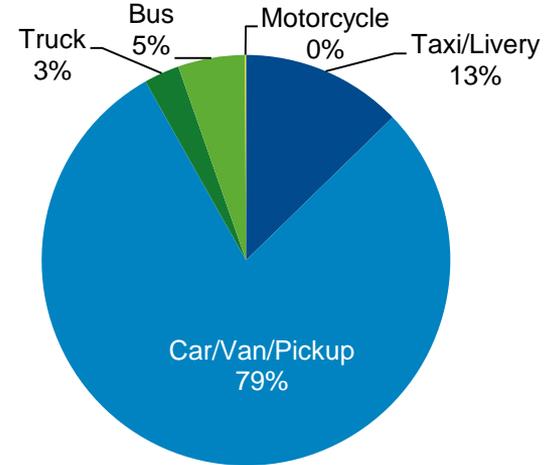
#### Vehicle Type

Nearly 80% of pedestrian and bicyclist KSI by a left-turning vehicle involve a passenger vehicle

**Non-Left Turn Pedestrian and Bicyclist KSI by Vehicle Type for Known Cases**



**Left Turn Pedestrian and Bicyclist KSI by Vehicle Type for Known Cases**



## 2. Citywide Analysis

### WHO

#### Pedestrian and Bicyclist Age

##### Seniors are more at risk:

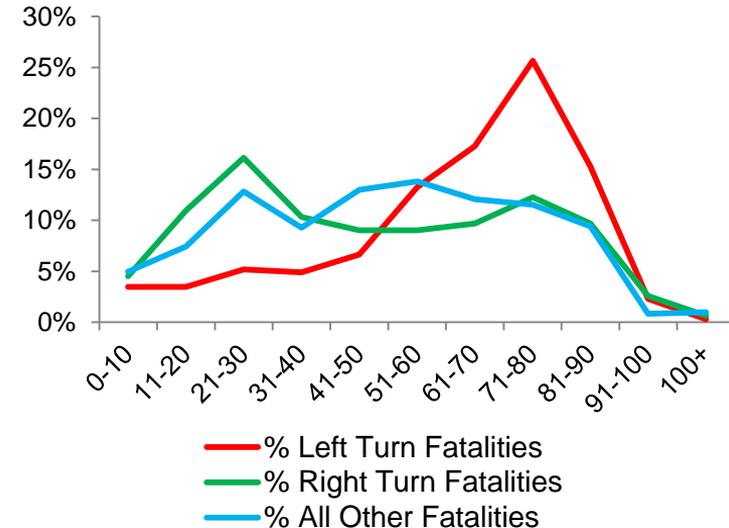
- The median age for left turn pedestrian and bicyclist fatalities is 67 as compared to right turn pedestrian and bicyclist fatalities, which is 50, and all other fatality types, also 50; the median age of NYC residents is 36
- Seniors are disproportionately represented in left turn pedestrian and bicyclist fatalities; 53% of all left turn pedestrian and bicyclist fatalities are aged 65 years or older, compared to 36% of all right turn pedestrian and bicyclist fatalities and 30% of all other pedestrian and bicyclist crash type fatalities
- Since left turns are taken at higher speeds than rights, it is likely that seniors are more vulnerable to left turn pedestrian and bicyclist fatalities than other demographics due to their increased frailty

Source: NYSDOT (2010 – 2014)

#### Median Age for Fatal Crash by Movement

Left Turn	67
Right Turn	50
All Other	50

Distribution of Fatal Left Turn Pedestrian and Bicyclist Crashes by Age



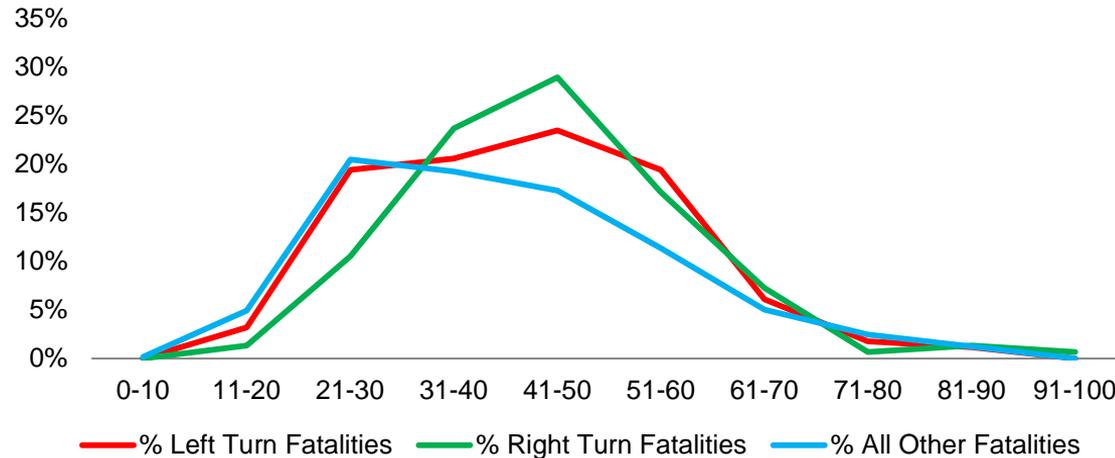
## 2. Citywide Analysis

### WHO

#### Motor Vehicle Driver Age

- No significant distinction between driver age for fatal crashes by left turn, right turn, and all other
- Unlike fatal left turn pedestrian and bicycle crash victims, the majority of these crashes involve young-adult and middle-aged drivers

**Distribution of Fatal Left Turn Pedestrian and Bicyclist Crashes by Driver Age**



Median Driver Age for Fatal Crash by Movement	
Left Turn	38
Right Turn	43
All Other	37

Source: NYSDOT (2010 – 2014)

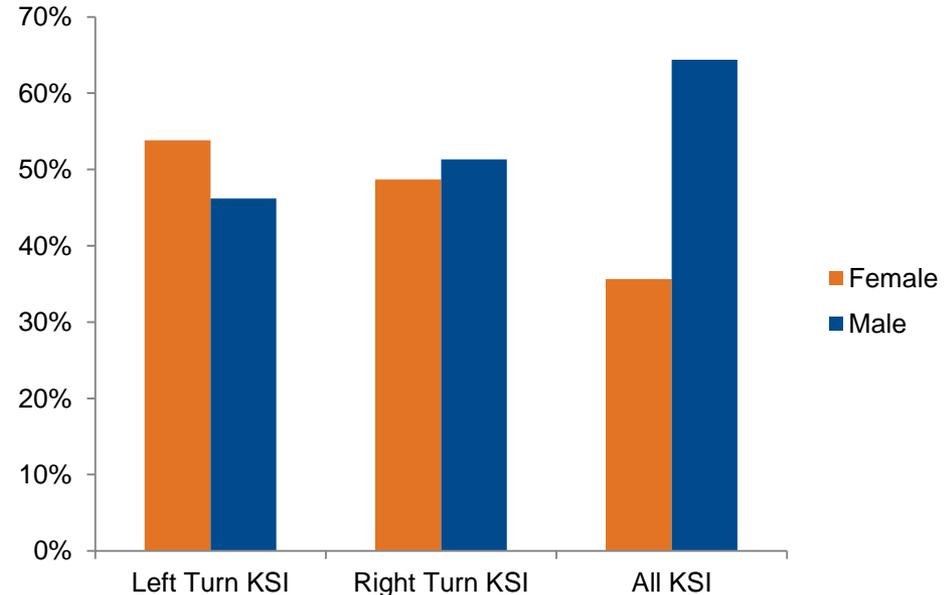
## 2. Citywide Analysis

### WHO

#### Gender

- The incidence of left and right turn pedestrian and bicyclist KSI between men and women are statistically similar to the population distribution of men and women in New York City, where women make up about 53% of the population
- A much higher percentage of males (72%) are involved in all pedestrian and bicyclist KSI at intersections. Crashes included in this category include failure to yield as well as crossing against the signal, crossing at an unsignalized location, emerging from behind parked car etc.

Pedestrian and Bicyclist KSI and Gender at Intersections



Source: NYSDOT (2010 – 2014)

Note: NYC population by gender from [http://www.nyc.gov/html/dcp/pdf/census/census2010/t\\_sf1\\_p6\\_p6h\\_nyc.pdf](http://www.nyc.gov/html/dcp/pdf/census/census2010/t_sf1_p6_p6h_nyc.pdf) ; KSI analysis is limited to cases in which 1 pedestrian or bicyclist was injured due to lack of ease in attributing gender to a severity in cases with multiple injured persons

## 2. Citywide Analysis

### WHEN

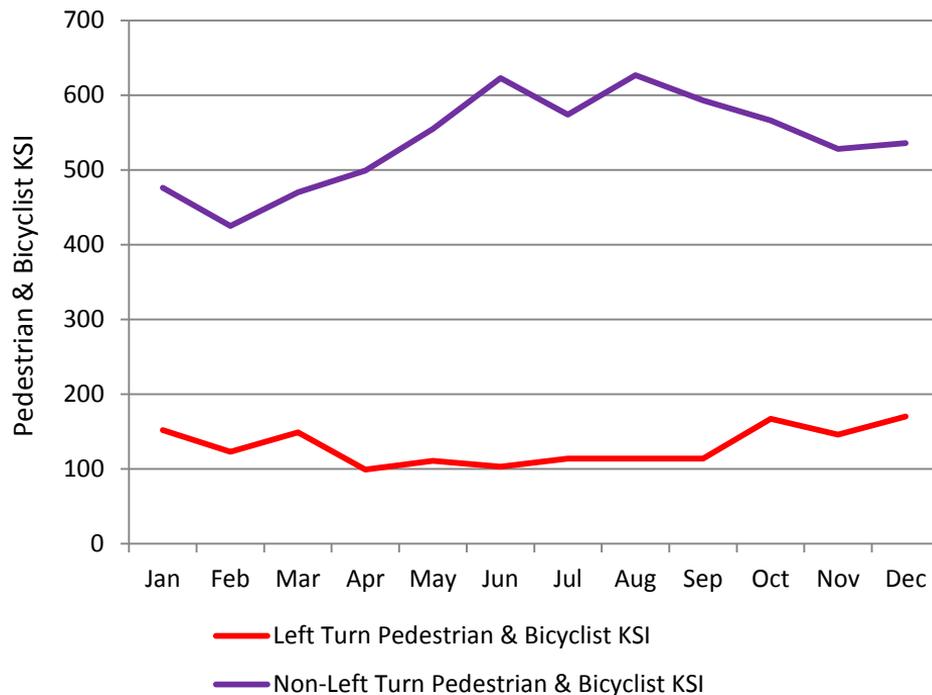
#### Seasonality

- Left turn pedestrian and bicyclist KSI rose by nearly 30% during the colder months.
- However, no significant correlation between left turn pedestrian and bicyclist KSI and presence of darkness
  - 31% of left turn pedestrian and bicyclist KSI occurred at night
  - 37% of all other crash types occurred at night
- Thus, increased KSI in fall and winter are not attributed to lack of visibility due to seasonal darkness

Pedestrian and Bicyclist Left Turn KSI		
	LTs	Non-LTs
October to March	58%	46%
April to September	42%	54%

Source: NYSDOT (2010 – 2014)

Pedestrian and Bicyclist Left Turn KSI by Month

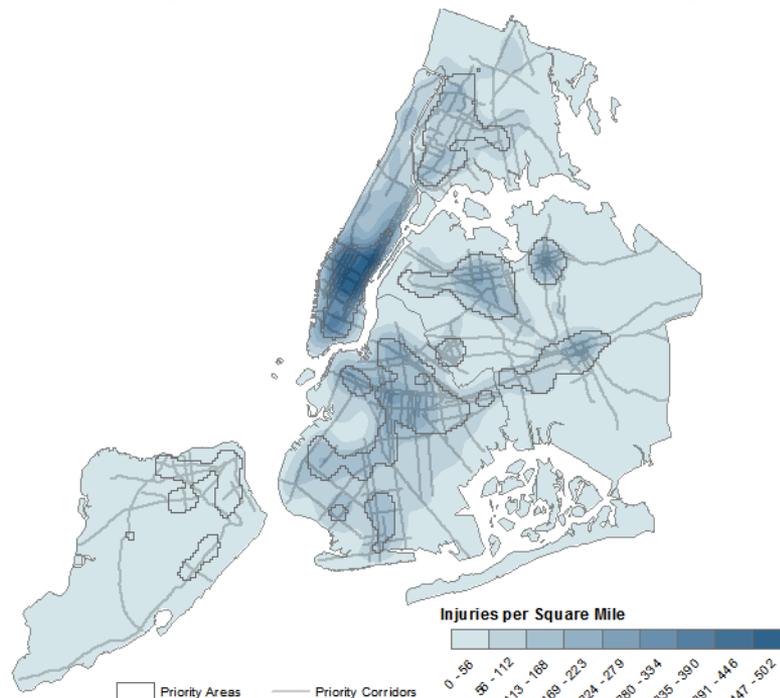


# WHERE

## Geography

- Left turn pedestrian and bicyclist injuries are concentrated in the same locations as pedestrian KSI in general, following the same pattern as the Vision Zero Priority Areas
- 55% of left turn pedestrian and bicyclist injuries are on Vision Zero Priority Corridors (similar to pedestrian KSI in general)

Density of Left Turn Pedestrian and Bicyclist Injuries



Source: NYSDOT (2010 – 2014)

# WHERE

## Geography

**Left turn pedestrian and bicyclist injuries are highly concentrated throughout New York City.**

**All left turn pedestrian and bicyclist injuries occurred at just 18% of NYC's ~39,000 intersections.**

Injuries per Intersection	Number of Intersections	% of All Intersections in NYC	% of Ped/Bike Left Turn Injuries
10+	91	0.2%	6%
5+	819	2%	31%
2+	3,915	8%	76%
1+	8,304	18%	100%

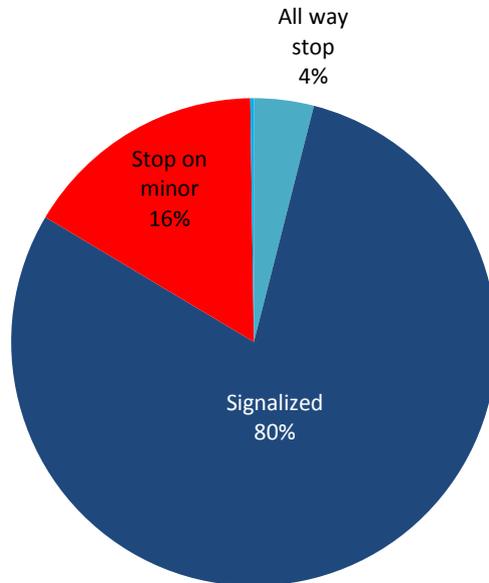
Source: NYSDOT (2010 – 2014)

# WHERE

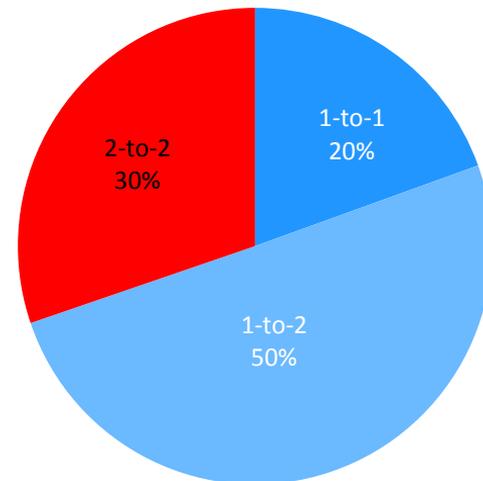
## Intersection Characteristics

- Signalized intersections
  - The overwhelming majority of intersections (80%) where a left turn pedestrian or bicyclist injury occurred had a signalized approach
- One-way streets
  - Over two thirds of all intersections (70%) where a left turn pedestrian and bicyclist injury occurred involved a one-way street

Traffic Control Type at Intersection for Citywide Left Turn Pedestrian and Bicyclist Injuries



Street Directionality at Intersections for Citywide Left Turn Pedestrian and Bicyclist Injuries



Source: NYSDOT (2010 – 2014)

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## Detailed Analysis

# 3

## 3. Detailed Analysis

# METHODOLOGY

DOT conducted a detailed manual review of NYPD MV104 crash reports (2009-2013) to discover important details of the crash locations that were missing from the NYSDOT dataset used in the Citywide Analysis (see Section 2 – Citywide Analysis). DOT reviewed 1105 crash reports, drawn from the locations with the highest concentration of left turn pedestrian and bicyclist injuries in New York City. Key details from reports include: vehicle location pre-crash (approach street), street width, and directionality (one-way vs two-way).

While the citywide analysis utilizes data from 2010-2014, this detailed analysis uses the most recent five years of available data at the start of the study; 2009-2013. Due to the manual nature of this review, DOT was unable to update this data to 2010-2014 as the study progressed.



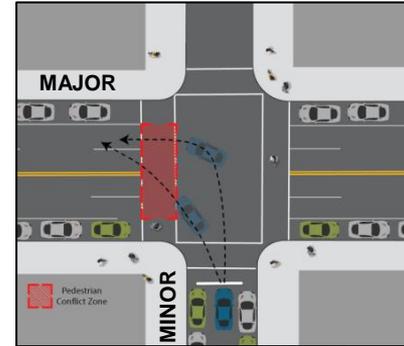
# MINOR TO MAJOR

In the study group, left turn pedestrian and bicyclist injury crashes occur when a vehicle is turning **from a minor street onto a major street at over double the rate** than when a vehicle is turning left from the major street to the minor street

## Major/Minor Approach



- Approach Street is Minor Street
- Approach Street is Major Street
- No Discernible Minor/Major Distinction



Source: NYPD MV-104 Reports (2009 – 2013)

From intersections with the highest concentration of left turn pedestrian and bicyclist injuries (with 10 or more left turn pedestrian and bicyclist injuries, 2009-13); .2% of total NYC intersections representing 6% of total left turn pedestrian and bicyclist injuries

## 3. Detailed Analysis

# STREET WIDTH

In the study group, DOT also found that the width of the receiving street is a significant factor; 69% of left turn pedestrian and bicyclist injury crashes occurred on receiving streets that were 60' or wider

Greater street width encourages vehicles to make left turns with wider radii, producing higher speeds

### Receiving Street Width

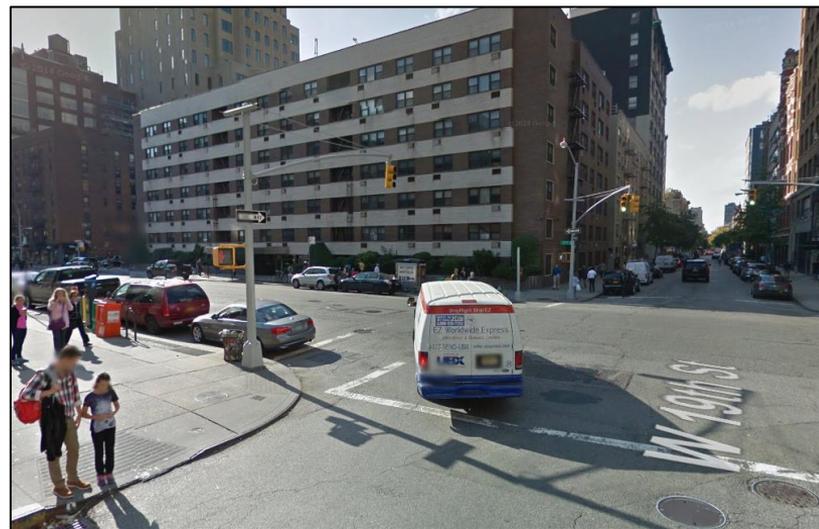
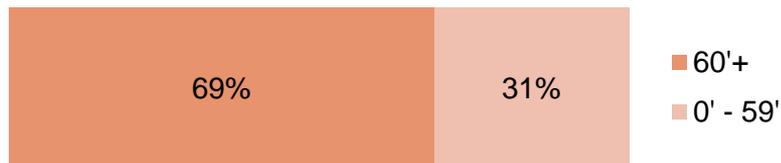


Image courtesy of Google Maps

Source: NYPD MV-104 Reports (2009 – 2013)

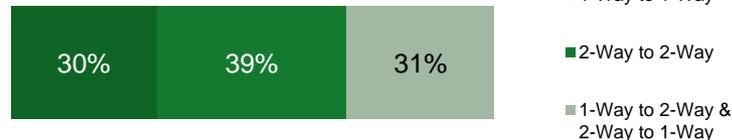
From intersections with the highest concentration of left turn pedestrian and bicyclist injuries (with 10 or more left turn pedestrian and bicyclist injuries, 2009-13); .2% of total NYC intersections representing 6% of total left turn pedestrian and bicyclist injuries

# SUMMARY OF FINDINGS

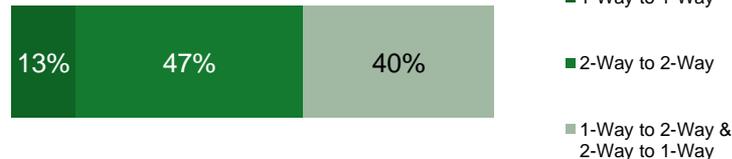
## Intersection Characteristics:

- In the study group, intersection directionality was a significant factor with 30% of left turn pedestrian and bicyclist injury crashes occurring at intersections that consist of a one-way to one-way configuration
  - In contrast, only 13% of intersections citywide are one-way to one-way
- Receiving direction was also shown to be a significant factor with the majority (61%) of left turn pedestrian and bicyclist injury crashes in the study group occurring where the vehicle was turning onto a two-way street
- All of the study group intersections were signalized

### Study Group Intersection Directionality



### Citywide Intersection Directionality



### Study Group Receiving Street Directionality



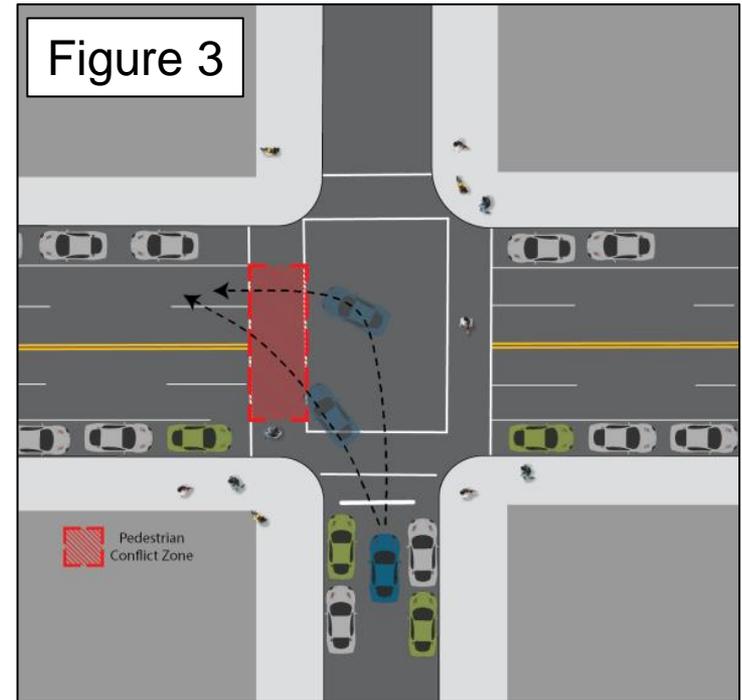
Source: NYPD MV-104 Reports (2009 – 2013)

From intersections with the highest concentration of left turn pedestrian and bicyclist injuries (with 10 or more left turn pedestrian and bicyclist injuries, 2009-13); .2% of total NYC intersections representing 6% of total left turn pedestrian and bicyclist injuries; directionality based on intersections where street directionality is known

### 3. Detailed Analysis

## SUMMARY OF FINDINGS

- DOT's analysis of locations with the greatest concentration of left turn and bicyclist injuries found that these crashes typically occurred where:
  - Vehicle was coming from the minor approach
  - Receiving street was 60' or wider
  - Vehicle was coming from a one-way street
  - Receiving street was a two-way street
- Figure 3 illustrates how turns made at intersections with most of these qualities are dangerous for pedestrians
- Results from the study group demonstrate a pedestrian and bicycle left turn problem unique to urban environments with dense one-way networks like NYC
  - **When the inherent complexity and risk in making a left turn with opposing traffic is eliminated, motorists can more easily be careless, taking left turns at a wider angle and faster speed**



Source: NYPD MV-104 Reports (2009 – 2013)

From intersections with the highest concentration of left turn pedestrian and bicyclist injuries (with 10 or more left turn pedestrian and bicyclist injuries, 2009-13); .2% of total NYC intersections representing 6% of total left turn pedestrian and bicyclist injuries; directionality based on intersections where street directionality is known

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## Treatment Toolbox

# 4

# BUILDING BLOCKS OF SAFER LEFT TURNS

NYCDOT currently has a number of left turn treatments in its toolbox to mitigate left turn pedestrian and bicyclist crashes

### Signs

**One-Way Streets:** Eliminates two-way left turn conflicts

**Left Turn Restrictions:** Eliminates left turn conflicts (assuming compliance)

**Daylighting:** Provides clear curb lane for improved visibility at approaches where one-way traffic turns left

### Markings

**Left Turn Bays and Lanes:** Better organizes traffic and eliminates “back pressure,” in many configurations including as part of a road diet, at curbside, or in a mixing zone with bicycles

**Protected Bicycle Lanes:** Creates protected space for bicyclists primarily using markings and elements for protection such as parked vehicles or lighter touch items, such as flexible delineators. Mitigates left turn speeds and conflicts via signal timing, turn lanes and changes to turn geometries. Typically includes pedestrian refuge islands at intersections



Curbside Left Turn Lane



Left Turn Bay



Mixing Zones

# BUILDING BLOCKS OF SAFER LEFT TURNS (CONT.)

### Islands

**Pedestrian Islands:** provides pedestrian refuge space, slows left turning vehicles turning from the minor street to the major street, often included as part of a road diet or a protected bicycle lane

### Signals

**Left Turn Only Signals:** Eliminates vehicle-pedestrian and vehicle-vehicle conflicts and provides higher left-turn throughput (assuming compliance)

**Leading Pedestrian Interval (LPI):** Holds traffic for several seconds at beginning of pedestrian “Walk” phase allowing pedestrians or cyclists to establish presence in the intersection before turning traffic is permitted to proceed

**Pedestrian and Bicycle Split Phase:** Splits pedestrian and bicycle signal with left turning vehicles on major urban one-way arterials with high pedestrian and bicycle volumes, high vehicular through volumes, and low left turning volumes from the major to the minor

**Split LPI & Split LPI w/ bicycle signals (pilot program):** Provides pedestrian or bicyclist with a leading interval, a conflict-free crossing while turning traffic is held with a red arrow, then displays a flashing amber advising caution for turning vehicles while pedestrians or bicyclists complete crossing



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## Project Examples

# 5

# **INTRODUCTION**

This section showcases elements from the treatment toolbox applied in safety engineering projects across New York City. DOT aims to make its projects comprehensive, addressing safety, mobility, accessibility, sustainability and other concerns. Accordingly, these project examples contain many combinations of different elements and treatments - some that address left turn safety concerns and others that bring additional benefits to the project.

## 5. Project Examples

# BROADWAY & W 96<sup>TH</sup> STREET, 2014

- Left Turn Restrictions
- Expanded Pedestrian Space
- Additional Crosswalk



Before



Banned left turns from southbound Broadway to eastbound W 96th St and westbound W 96th St to SB Broadway to reduce pedestrian and vehicle conflict

Expanded north mall at W 96th St into removed left turn bay

Removed median walls on north and south median tips and marked mall to mall crosswalk to accommodate pedestrian desire line

**Appropriate Design for:**  
Major urban two-way arterials with center mall and high pedestrian volumes

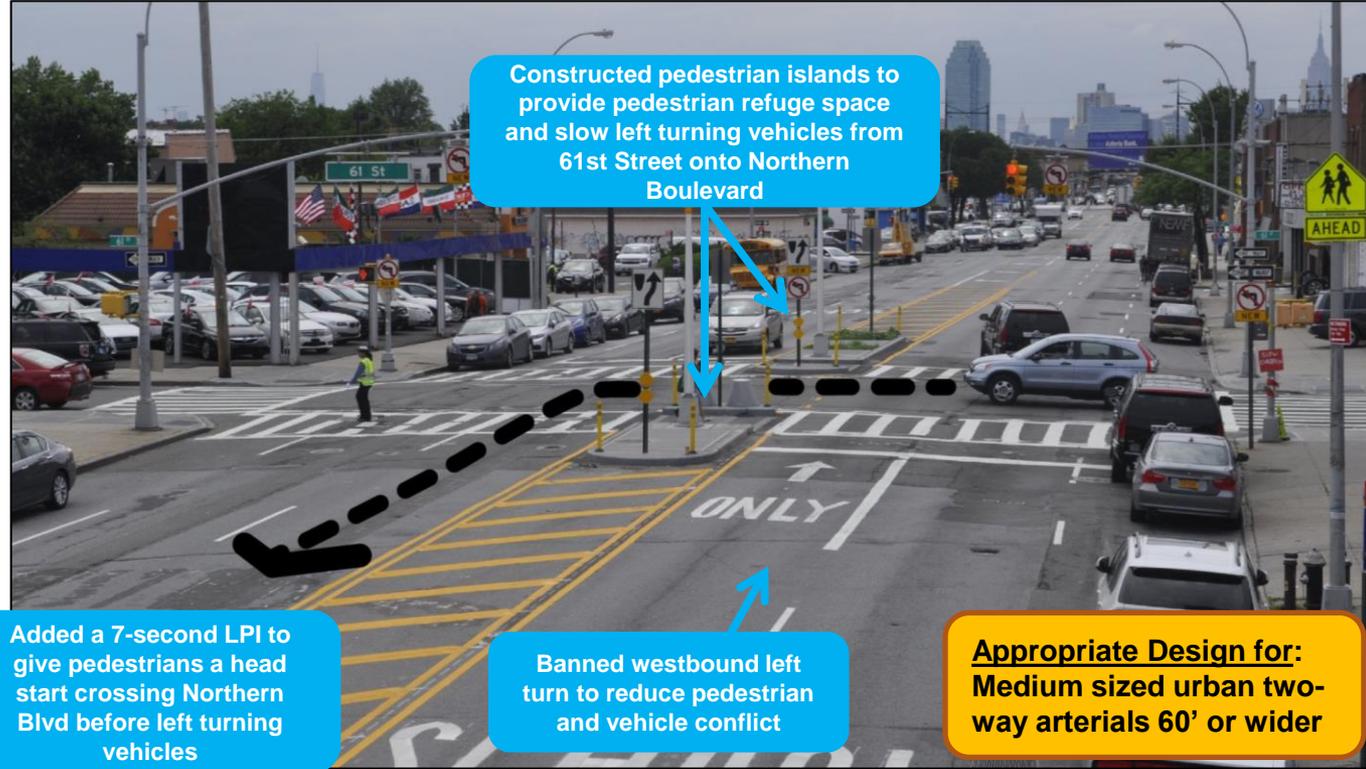
## 5. Project Examples

# NORTHERN BOULEVARD & 61<sup>ST</sup> STREET, 2014

- Left Turn Restriction
- Pedestrian Islands
- Leading Pedestrian Interval (LPI)



Before



Constructed pedestrian islands to provide pedestrian refuge space and slow left turning vehicles from 61st Street onto Northern Boulevard

Added a 7-second LPI to give pedestrians a head start crossing Northern Blvd before left turning vehicles

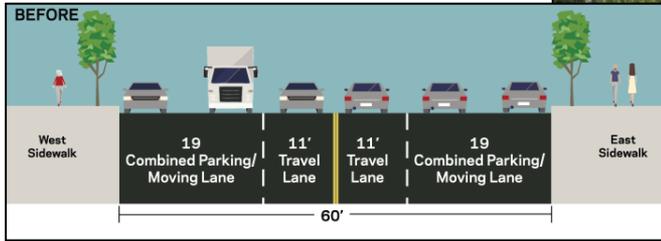
Banned westbound left turn to reduce pedestrian and vehicle conflict

**Appropriate Design for:**  
Medium sized urban two-way arterials 60' or wider

## 5. Project Examples

# AMSTERDAM AVENUE, 2015

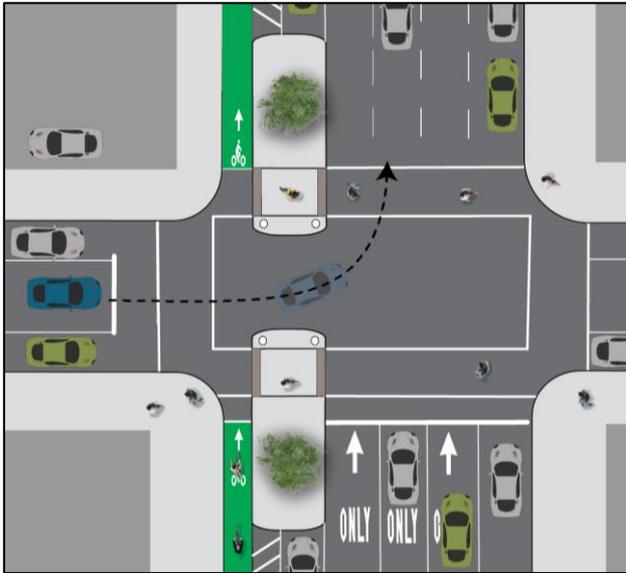
- Road Diet with Left Turn Bays, Flush Median, and Bicycle Lane
- Conversion from four lanes to two lanes plus left turn bays to better organize traffic and eliminate back pressure for left turning vehicles



## 5. Project Examples

# 9<sup>TH</sup> AVENUE & W. 17<sup>TH</sup> STREET, 2007

- Protected Bicycle Lane
- Pedestrian Islands
- Road Diet



**Protected Bicycle Lane w/ Pedestrian Island:** Slows left turning vehicles from the minor street onto the major street as pedestrians cross the major



Constructed wide pedestrian islands adjacent to curbside bicycle lane to provide pedestrian refuge space and slow left turning vehicles from W. 17<sup>th</sup> Street onto 9<sup>th</sup> Avenue

**Appropriate Design for:**  
Major urban one-way arterials with a protected bicycle lane and high volumes of pedestrians

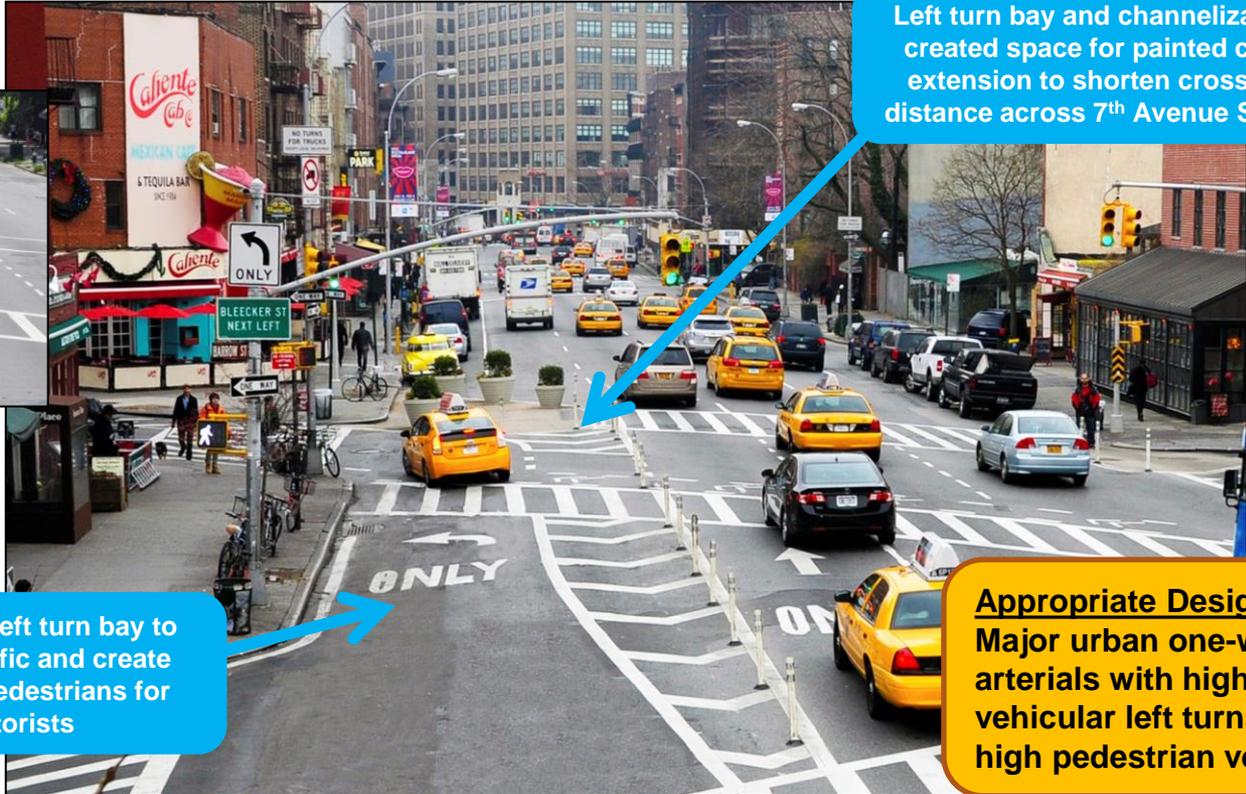
# 5. Project Examples

## 7<sup>TH</sup> AVENUE SOUTH & BLEECKER STREET, 2012

- Curbside Left Turn Bay
- Pedestrian Refuge Space



Before



Left turn bay and channelization created space for painted curb extension to shorten crossing distance across 7<sup>th</sup> Avenue South

Installed curb side left turn bay to better organize traffic and create more visibility of pedestrians for turning motorists

**Appropriate Design for:**  
Major urban one-way arterials with high vehicular left turns and high pedestrian volumes

# 5. Project Examples

## 7<sup>TH</sup> AVENUE & 23<sup>RD</sup> STREET, 2011

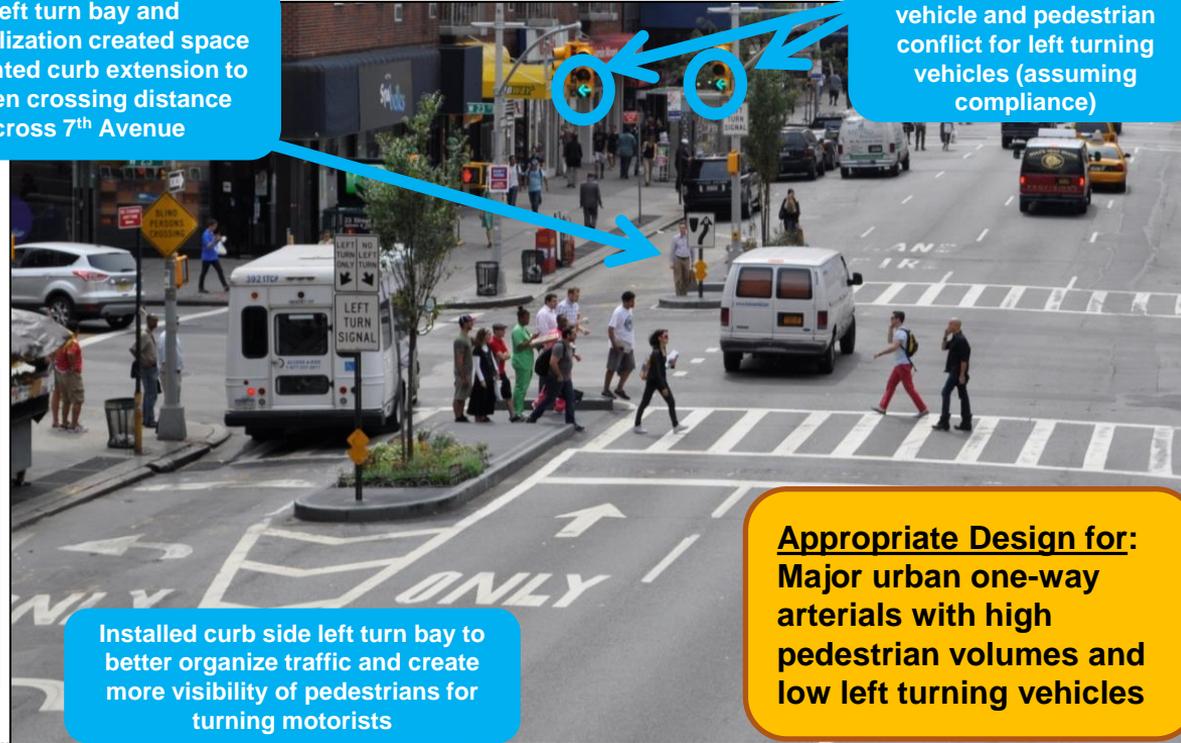
- Curbside Left Turn Bay
- Pedestrian Island
- Pedestrian Split Phase



Before

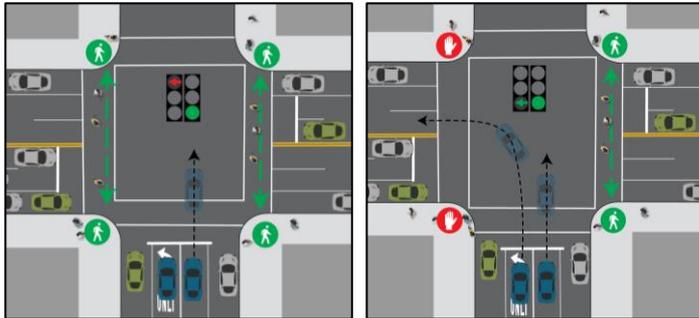
Left turn bay and channelization created space for painted curb extension to shorten crossing distance across 7<sup>th</sup> Avenue

Added pedestrian split phase to eliminate vehicle and pedestrian conflict for left turning vehicles (assuming compliance)



Installed curb side left turn bay to better organize traffic and create more visibility of pedestrians for turning motorists

**Appropriate Design for:**  
Major urban one-way arterials with high pedestrian volumes and low left turning vehicles



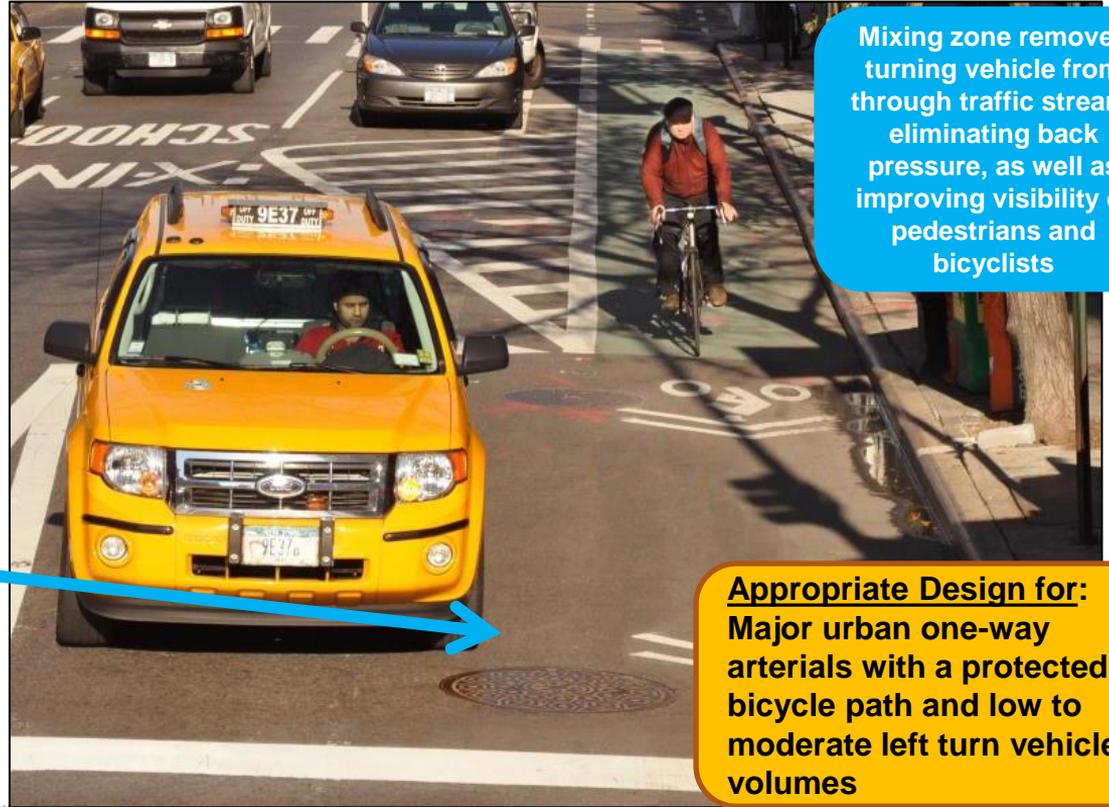
**Pedestrian Split Phase:** Pedestrians can cross while turning vehicles are held

# MANHATTAN AVENUES MIXING ZONES, 2010-PRESENT

- Protected bicycle path
- Left turn mixing zone

Mixing Zones have been installed on portions of 1<sup>st</sup> Ave, 2<sup>nd</sup> Ave, 8<sup>th</sup> Ave, 9<sup>th</sup> Ave, Columbus Ave, Hudson St, Lafayette St, Grand St, Broadway, and 4<sup>th</sup> Ave in Manhattan

Installed a curbside mixing zone which allows additional space for vehicles to detect then yield to cyclists before making a left turn



Mixing zone removes turning vehicle from through traffic stream, eliminating back pressure, as well as improving visibility of pedestrians and bicyclists

**Appropriate Design for:**  
Major urban one-way arterials with a protected bicycle path and low to moderate left turn vehicle volumes

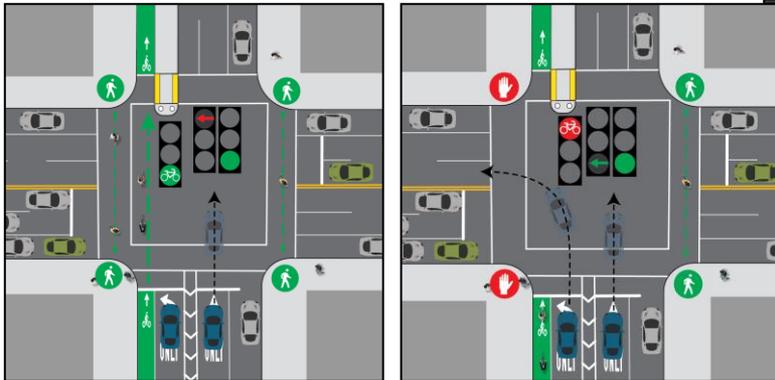
## 5. Project Examples

# COLUMBUS AVENUE & W 86<sup>TH</sup> STREET, 2010

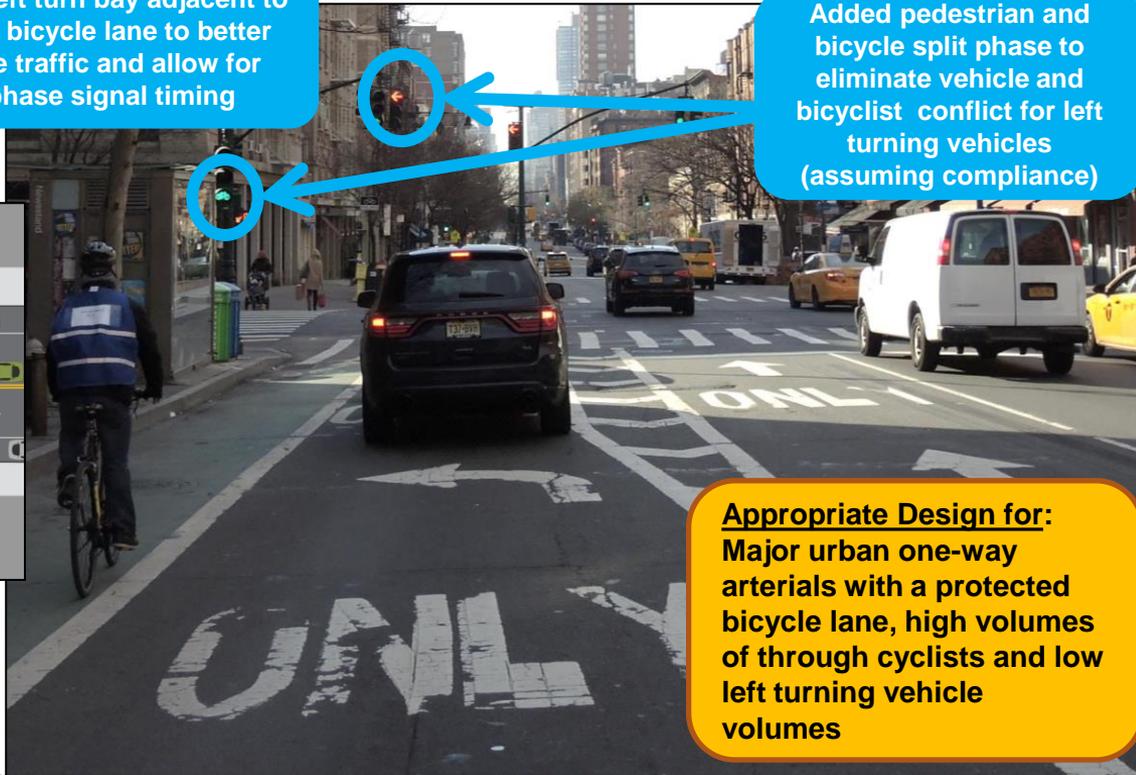
- Left Turn Bay
- Pedestrian and Bicycle Split Phase

Installed left turn bay adjacent to curbside bicycle lane to better organize traffic and allow for split phase signal timing

Added pedestrian and bicycle split phase to eliminate vehicle and bicyclist conflict for left turning vehicles (assuming compliance)



**Pedestrian and Bicycle Split Phase:** Pedestrians and bicyclists can cross while turning vehicles are held



**Appropriate Design for:**  
Major urban one-way arterials with a protected bicycle lane, high volumes of through cyclists and low left turning vehicle volumes

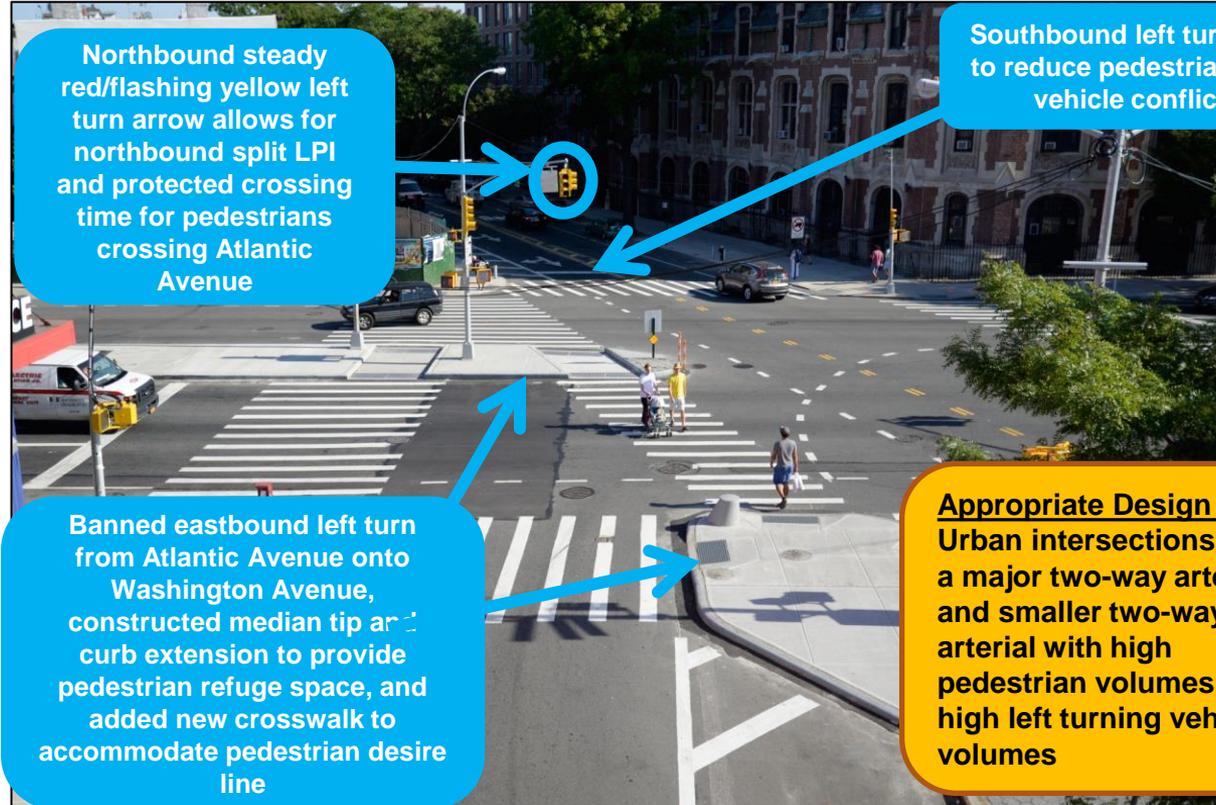
## 5. Project Examples

# WASHINGTON AVENUE & ATLANTIC AVENUE, 2015

- Left Turn Restrictions
- Median Tip and Curb Extension
- Split Leading Pedestrian Interval (Split LPI)



Before



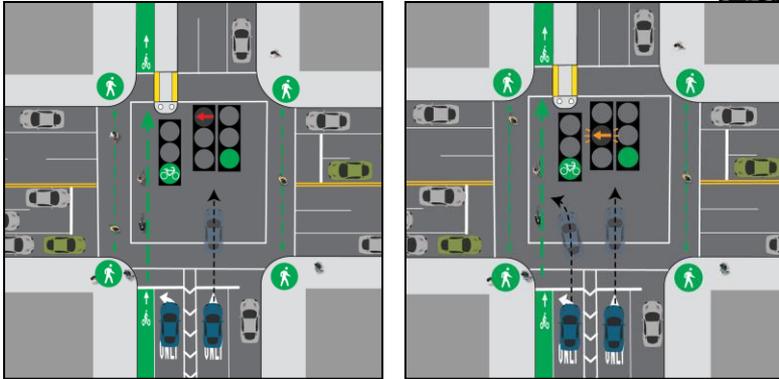
# 5. Project Examples

## 8<sup>TH</sup> AVENUE & W 29<sup>TH</sup> STREET, 2015

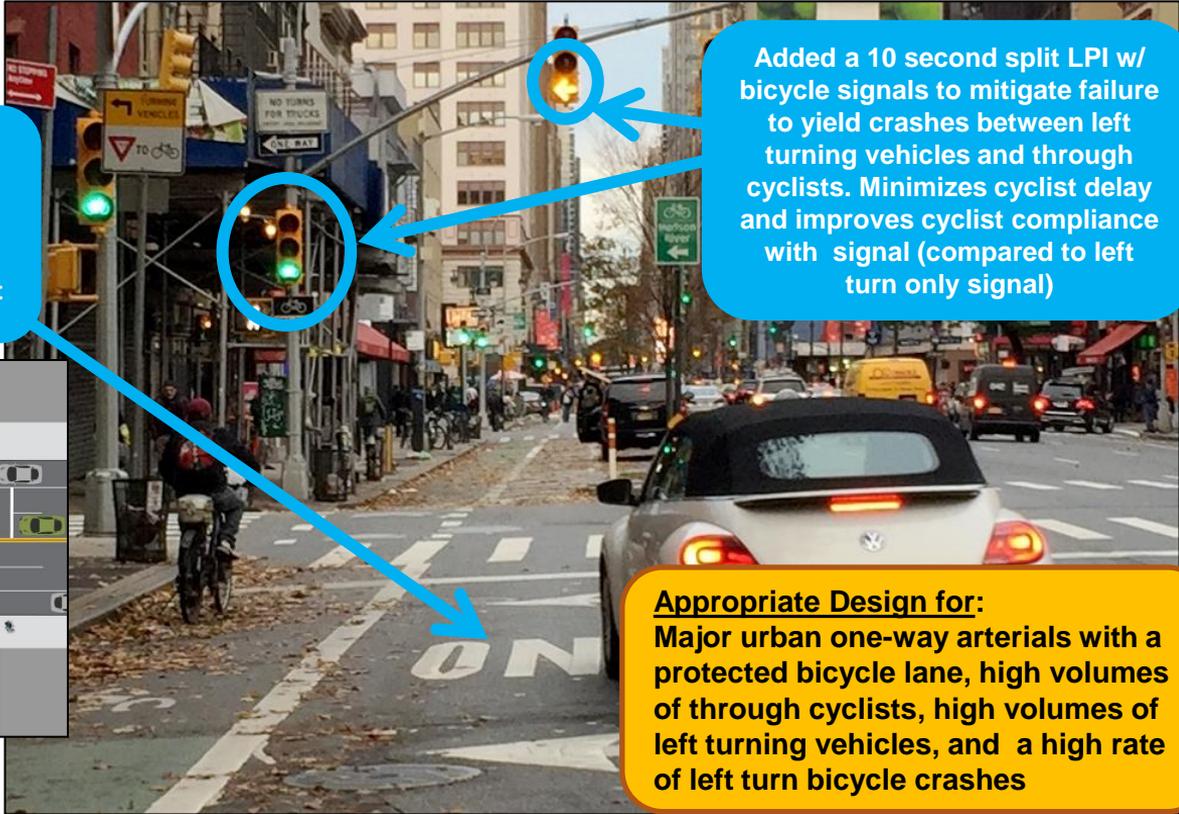
- Pilot program – under study with academic partners
- Left Turn Bay
- Split LPI w/ bicycle signals

Installed bay adjacent to curbside bicycle lane to better organize traffic and allow for split LPI signal timing

Added a 10 second split LPI w/ bicycle signals to mitigate failure to yield crashes between left turning vehicles and through cyclists. Minimizes cyclist delay and improves cyclist compliance with signal (compared to left turn only signal)



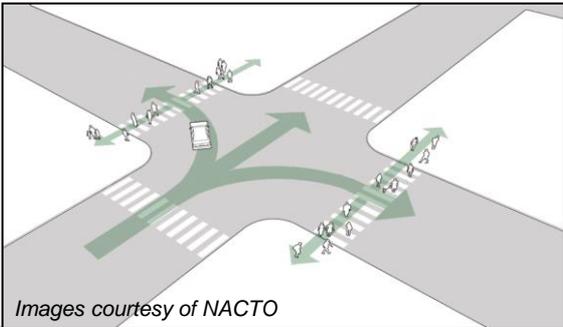
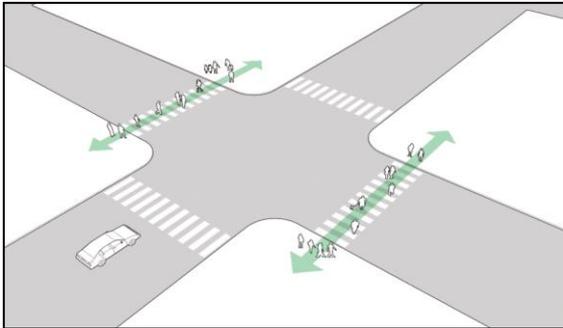
**Split LPI with Bicycle Signals:** Pedestrians and cyclists can cross while turning vehicles proceed with caution



**Appropriate Design for:** Major urban one-way arterials with a protected bicycle lane, high volumes of through cyclists, high volumes of left turning vehicles, and a high rate of left turn bicycle crashes

# CITYWIDE LEADING PEDESTRIAN INTERVALS (LPIs)

- Installed as standalone treatment or in conjunction with others
- Pedestrians are given a 7 second (minimum) head start to cross the street
- Pedestrians can establish right of way and are more visible to turning motor vehicles



Images courtesy of NACTO



Added a 7+ second LPI to mitigate failure to yield left turning crashes between left turning vehicles and pedestrians

**Appropriate Treatment for:**  
Longer crossings with substantial pedestrian volumes and frequent turning-vehicle/pedestrian conflicts

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## Treatment Evaluation

# 6

# METHODOLOGY

This section evaluates the effectiveness of specific safety treatments. DOT employed a simple before/after injury analysis, comparing three years of crash data before treatment installation to three years of crash data after installation.

For this task, DOT utilized comprehensive NYSDOT data which classifies injury crashes by severity. However, the availability and completeness of data for each treatment within this data set varies. Accordingly, DOT relied on varying sample sizes for the evaluation of each treatment, ranging from 34 intersections for left turn only signals to 149 intersections for protected bicycle lanes. This part of the study relies primarily on pedestrian and bicyclist injuries, as the sample size provided by pedestrian and bicyclist KSI was generally too small to support robust analysis. When injuries were analyzed, fatal injuries were included as well.

The findings demonstrate the effectiveness of the treatment type in mitigating left turn pedestrian and bicyclist injuries. Treatments tested include: signs (left turn restrictions); Markings (left turn bays, protected bicycle lanes); signals (left turn only, Leading Pedestrian Intervals (LPis)). One-way streets, pedestrian islands, pedestrian and bicycle split phases, and split LPI & split LPI w/ bicycle signals were not evaluated due to data availability issues. Daylighting was studied via a review of outside research, field observations and will be evaluated as part of the Left Turn Traffic Calming pilot.

Note: All evaluations, crashes, injuries, severe injuries are classified by motor vehicle movement. Certain crashes include multiple motor vehicle movements. These crashes are counted in each applicable movement column but only once in the Total column. For this reason, "Total" may not match the sum of the movement columns.

## 6. Treatment Evaluation

# SIGNS

## Left Turn Restrictions

**Purpose:** Eliminates conflict between left turning vehicles and pedestrians, bicyclists, and other vehicles (assuming compliance)

**Evaluation:**

- DOT performed before/after crash analysis of 21 left turn restrictions (51 intersections) from 2008-2010
- Preceding and succeeding intersections where a left turn is possible were also analyzed, to ensure that injuries were not migrating to a new location
- DOT implemented all the analyzed left turn restrictions as part of a Street Improvement Project or at a High Pedestrian Crash Location; in-depth study was integral to the decision to restrict the turn
- DOT analyzed injuries, as the sample size for KSI was too small for robust analysis
- **Left turn bicycle and pedestrian injuries fell by 41%; total left turn bicycle and pedestrian injuries fell by 21%**



Pedestrian and Bicyclist Injuries at Left Turn Restriction Locations (Includes preceding and succeeding intersections where a left turn is possible )					
	Left	Right	Through	Other*	Total
<b>Before (3 Years)</b>	113	41	121	70	331
<b>After (3 Years)</b>	67	40	105	54	262
<b>Change</b>	-41%	-2%	-13%	-23%	-21%

\* "Other" includes "U-Turn" and "Unknown"

Source: NYSDOT (2005 – 2013)

## 6. Treatment Evaluation

# MARKINGS

## Left Turn Bays

**Purpose:** Left turn bays improve traffic organization by allowing left turning vehicles their own space before turning left, which helps reduce “back pressure” from other vehicles

### Evaluation:

DOT performed a before and after crash analysis of left turn bays\* (without left turn only signals) installed from 2009-2011 at 140 intersections. DOT analyzed injuries, as the sample size for KSI was too small for robust analysis. At these locations:

- Left turn motor vehicle occupants injuries fell 45% and total motor vehicle occupants injuries fell 25%
- Left turn bicyclist injuries were too few to show any change of statistical significance
- Left turn pedestrian injuries fell 24% and total pedestrian injuries fell 9%
- Left turn pedestrian and bicyclist injuries fell 15% and total pedestrian and bicyclist injuries were relatively flat

Injuries on Two-Way Approaches with Left Turn Bays					
Motor Vehicle					
	Left	Right	Through	Other**	Total
Before (3 Years)	350	83	968	781	1,137
After (3 Years)	191	42	729	555	850
Change	-45%	-49%	-25%	-29%	-25%
Bicyclist					
	Left	Right	Through	Other**	Total
Before (3 Years)	10	11	20	9	48
After (3 Years)	19	7	44	11	80
Change	90%	-36%	120%	22%	67%
Pedestrian					
	Left	Right	Through	Other**	Total
Before (3 Years)	107	27	103	54	284
After (3 Years)	81	33	111	39	259
Change	-24%	22%	8%	-28%	-9%
Pedestrian + Bicyclist					
	Left	Right	Through	Other**	Total
Before (3 Years)	117	38	123	63	339
After (3 Years)	100	40	155	50	339
Change	-15%	5%	26%	-21%	2%

\* On two-way approaches only, installed as part of DOT Street Improvement Projects

\*\*“Other” includes “U-Turn” and “Unknown”

Source: NYSDOT (2006 – 2014)

## MARKINGS

### Protected Bicycle Lanes

**Purpose:** Creates protected space for bicyclists primarily using markings and elements for protection such as parked vehicles or lighter touch items, such as flexible delineators. Mitigates left turn speeds and conflicts via signal timing, turn lanes and changes to turn geometries. Typically includes pedestrian refuge islands at intersections

**Evaluation:** DOT performed a before and after crash analysis of 12 projects on six avenues covering 12 lane miles and 149 intersections (implemented 2008-2010)

- Specifically addresses the issue of one-way approaches in Manhattan
- **Protected bicycle lanes reduced left turn pedestrian and bicyclist KSI by 53% and total pedestrian and bicyclist KSI by 20%**

		Left	Right	Through	Other*	Total
Pedestrian and Bicyclist Injuries	Before (3 Years)	295	83	314	238	904
	After (3 Years)	250	79	329	172	817
	Change	-15%	-5%	5%	-28%	-10%
Pedestrian and Bicyclist KSI	Before (3 Years)	32	9	44	31	111
	After (3 Years)	15	7	51	18	89
	Change	-53%	-22%	16%	-42%	-20%

\* "Other" includes "U-Turn" and "Unknown"

Source: NYSDOT (2004 – 2013)



# SIGNALS

## Left Turn Only

**Purpose:** Left turn only signals allow left turning vehicles a conflict free turn.

- Reduces complexity by eliminating need to “find the gaps” by the driver

### Evaluation

- DOT performed a before and after crash analysis of 34 intersections (installed between 1999-2011)
- DOT analyzed injuries, as the sample size for KSI was too small for robust analysis
- **Left turn pedestrian and bicyclist injuries were reduced by 33% and total pedestrian and bicyclist injuries were reduced by 25%**

Pedestrian and Bicyclist Injuries					
	Left	Right	Through	Other*	Total
Before (3 Years)	55	23	59	23	158
After (3 Years)	37	22	49	11	119
Change	-33%	-4%	-17%	-52%	-25%

\* “Other” includes “U-Turn” and “Unknown”

Source: NYSDOT (1996 – 2014)

## SIGNALS

### Leading Pedestrian Intervals (LPIs)

**Purpose:** Give pedestrians and bicyclists a conflict-free head start in the crosswalk

**Evaluation:**

- DOT performed a before and after crash analysis of 104 intersections with LPIs (installed throughout NYC between 2003-2011)
- Total pedestrian and bicyclist KSI declined by 37%
- **Left turn pedestrian and bicycle injuries declined by 14% and left turn pedestrian and bicyclist KSI declined by 56%**

#### Pedestrian and Bicyclist Injuries at LPI Locations

		Left	Right	Through	Other*	Total
Pedestrian and Bicyclist Injuries	Before (3 Years)	282	113	304	137	839
	After (3 Years)	243	102	265	145	749
	Change	-14%	-10%	-13%	6%	-11%
Pedestrian and Bicyclist KSI	Before (3 Years)	41	19	40	16	115
	After (3 Years)	18	5	40	15	73
	Change	-56%	-74%	0%	-6%	-37%

\* "Other" includes "U-Turn" and "Unknown"

Source: NYSDOT (2000 – 2014)

## 6. Treatment Evaluation

# SIGNALS

### All Pedestrian Phase (aka Barnes Dance)

**Purpose:** Give pedestrians protected time to cross intersection in any direction, stop all traffic and require pedestrians to wait longer for signal

**Evaluation:**

All-pedestrian-phases (or Barnes Dances) have helped with pedestrian crash reductions in some urban environments

Only effective at intersections with about 20,000 pedestrians a day, high pedestrian signal compliance, and low vehicular traffic volumes\*

- Not feasible at most intersections in NYC due to concerns about excessive pedestrian wait time
- Installation dates are mainly very old or incomplete for All Pedestrian Phase locations in NYC and cannot be evaluated systematically via before/after crash analysis



All pedestrian phase, Broadway and Barclays St, Manhattan

\* Zegeer, Charles V., Kenneth S. Opiela, and Michael J. Cynecki. *Pedestrian Signalization Alternatives. Final Report.* No. FHWA-RD-83-102. 1985. <http://www.pedbikeinfo.org/cms/downloads/PedestrianSignalizationAlternatives1985.pdf>

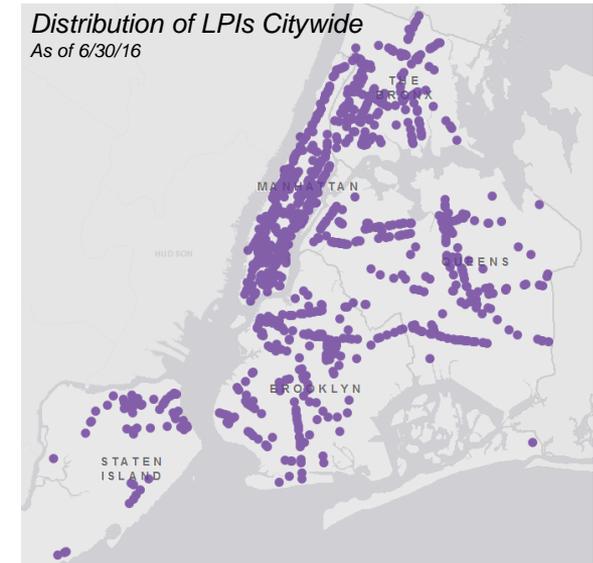
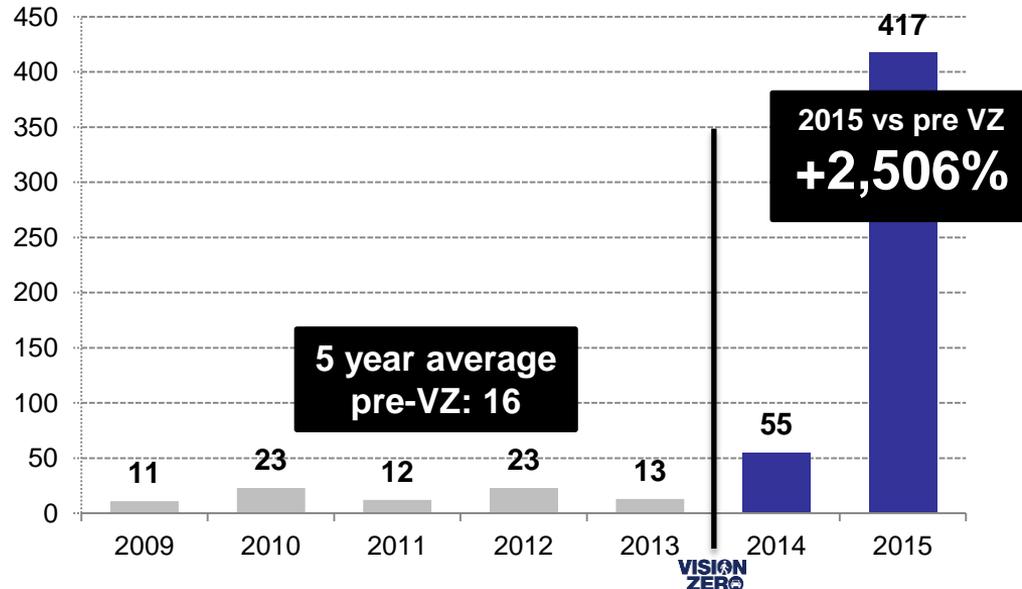
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## Action Plan

# 7

## LEADING PEDESTRIAN INTERVALS (LPIs)

- 56% decrease in left turn pedestrian and bicyclist KSI at locations in NYC where LPIs were installed (2003-2011)
- Vision Zero has prioritized study and installation of LPIs at Priority Intersections and at school intersections along Priority Corridors
  - As a result, DOT installed over 400 new LPIs citywide in 2015, doubling the citywide inventory
  - DOT plans to install at least 500 new LPIs in 2016



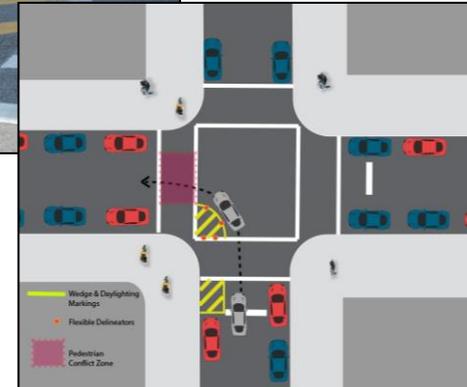
# LEFT TURN TRAFFIC CALMING PILOT

Enhanced Daylighting / Slow Turn Wedge  
(part of 100 location pilot program, currently being implemented and evaluated through 2016)

- One-way to one-way treatment
- Utilizes markings and plastic delineators
- Clears parking 10' from the crosswalk

### Benefits:

- Guiding radius tightens and calms left turn
- Increases visibility of pedestrians in the crosswalk for motorists, providing more stopping time
- Mitigates visibility issues caused by vehicle's A-pillar
- Modifies turning angle from cross street onto receiving roadway to create safer, slower left turns with no change in traffic capacity



# LEFT TURN TRAFFIC CALMING PILOT (CONT.)

## Hardened Centerline

(part of 100 location pilot program, currently being implemented and evaluated through 2016)

- One-way to two-way treatment
- Utilizes rubber curb with delineators on receiving centerline
- Utilizes markings and plastic delineators
- Clears parking 10' from the crosswalk

### Benefits:

- Hardened centerline and guiding radius tighten and calm left turns
- Increases visibility of pedestrians in the crosswalk for motorists
- Modifies turning angle from cross street onto receiving roadway to create safer, slower left turns with no change in traffic capacity



# SPLIT LPis

### Split Leading Pedestrian Intervals

Since 2011, DOT has installed 28 Split LPis in NYC

### Split Leading Pedestrian Intervals w/ bicycle signals (pilot program)

Since 2014, DOT has installed 9 Split LPis with bicycle signals in NYC

- Using before and after crash analysis, DOT will study the effectiveness of each treatment
- If shown to mitigate injuries, DOT will identify additional locations for implementation



Split LPI: Washington Avenue & Atlantic Avenue, 2015



Split LPI w/ bicycle signal: 8th Avenue & W 29th Street, 2015

# TURN RESTRICTIONS & LEFT TURN SIGNALS

- Banning left turns is effective and low cost, but can have negative effects on vehicle access
- Left turn only signals reduce injuries for pedestrians and bicyclists, as well as improving safety, comfort and mobility for motorists
- DOT will take every opportunity to incorporate either left turn restrictions or dedicated left turn signals into broader improvement projects based upon studies of individual locations, taking into account the road network, vehicle volumes, crash history, etc



# PROTECTED BICYCLE LANES

- In addition to expanding the bicycle network and access to safe cycling options, protected bicycle lanes have reduced left turn pedestrian and bicyclist:
  - Injuries by 15%
  - KSI by 53%
- DOT will continue to implement new protected bicycle lanes, with at least 15 miles planned for 2016

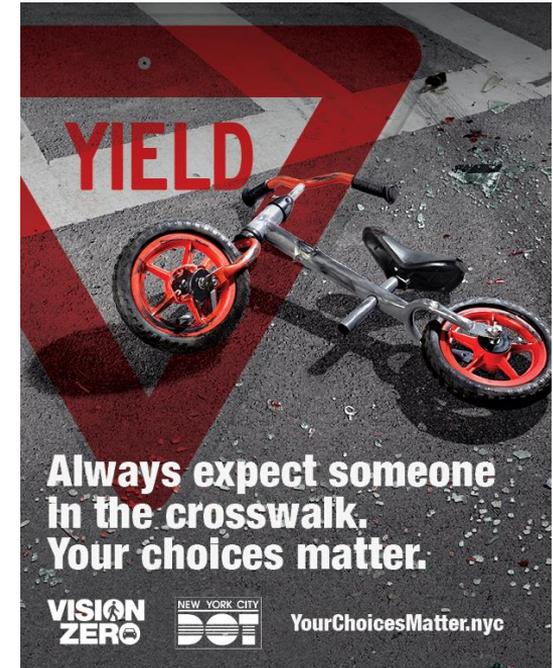
Protected bicycle lane on 1<sup>st</sup> Avenue in Manhattan



# PUBLIC INFORMATION CAMPAIGN

## A Comprehensive Owned, Earned, and Paid Media Approach

- The third phase of the “Your Choices Matter” will focus on pedestrian crashes at intersections by using general messaging – Traffic crashes are not accidents; Pause and look before you turn; Always expect someone in the crosswalk
- Turning Speed
  - DOT will develop “Turn-Speed” iconography to illustrate that turns should be taken at 5 mph, a speed safer for pedestrians. “Turn-Speed” will serve as a sub-brand for topic-specific Vision Zero communications
- Failure to Yield
  - DOT will roll out a comprehensive failure to yield marketing effort in Fiscal Year 2017. The commitment of NYPD's enforcement to deter failure to yield, and the institutionalization of left-turn engineering strategies can be bolstered a coordinated public information campaign across owned, earned, and paid media





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