

APPENDIX

CYCLING AT A CROSSROADS

The Design Future of New York City
Intersections

September 2018



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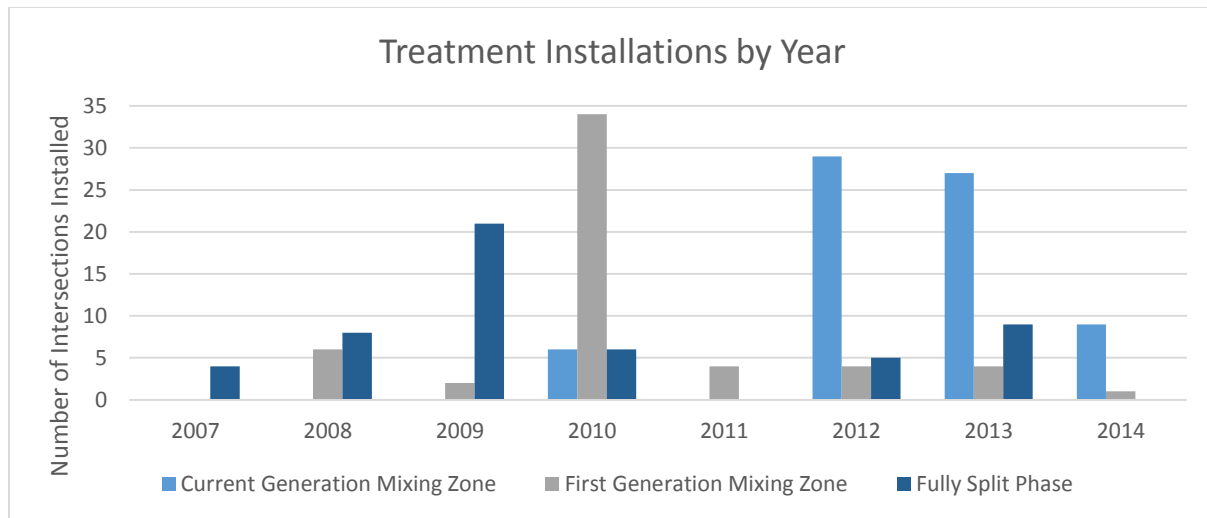
Crash Analysis

Study Corridors

| Street | From | To | Number of Study Intersections | Installation Year |
|----------------------------|-----------------|-----------------|-------------------------------|---------------------|
| 1st Avenue | E 3rd Street | E 45th Street | 25 | 2010/2011 |
| 1st Avenue | E 61st Street | E 124th Street | 34 | 2012/2013 |
| 2nd Avenue | E 2nd Street | E 30th Street | 14 | 2010/2013 |
| 2nd Avenue | E 104th Street | E 122nd Street | 9 | 2012 |
| 8th Avenue | Jane Street | W 55th Street | 23 | 2008/2009/2010/2012 |
| 9th Avenue | W 14th Street | W 58th Street | 24 | 2007/2008/2012 |
| Allen Street / Pike Street | Cherry Street | Houston Street | 9 | 2009 |
| Broadway | W 19th Street | W 38th Street | 8 | 2008/2009/2010 |
| Broadway | W 48th Street | W 57th Street | 6 | 2009 |
| Columbus Avenue | W 70th Street | W 108th Street | 18 | 2010/2013 |
| Grand Street | Thompson Street | Chrystie Street | 7 | 2008 |
| Hudson Street | Leroy Street | W 14th Street | 7 | 2014 |
| Lafayette Street | Houston Street | Astor Place | 3 | 2014 |

Study Sample Size by Treatment Type, Years of Data and Total Bicycle Injury Crashes

| Intersection Treatment | Number of Study Intersections | Sites x Years Before PBL | Sites x Years After PBL | Crashes Before PBL | Crashes After PBL |
|--------------------------------|-------------------------------|--------------------------|-------------------------|--------------------|-------------------|
| Current Generation Mixing Zone | 71 | 855.0 | 305.9 | 322 | 143 |
| First Generation Mixing Zone | 55 | 523.6 | 323.0 | 302 | 257 |
| Fully Split Phase | 53 | 448.0 | 363.5 | 347 | 255 |
| Lateral Shift | 3 | 30.1 | 17.4 | 26 | 30 |
| None | 2 | 16.4 | 18.3 | 3 | 7 |
| TOTAL | 184 | 1899.3 | 1051.6 | 1000 | 692 |



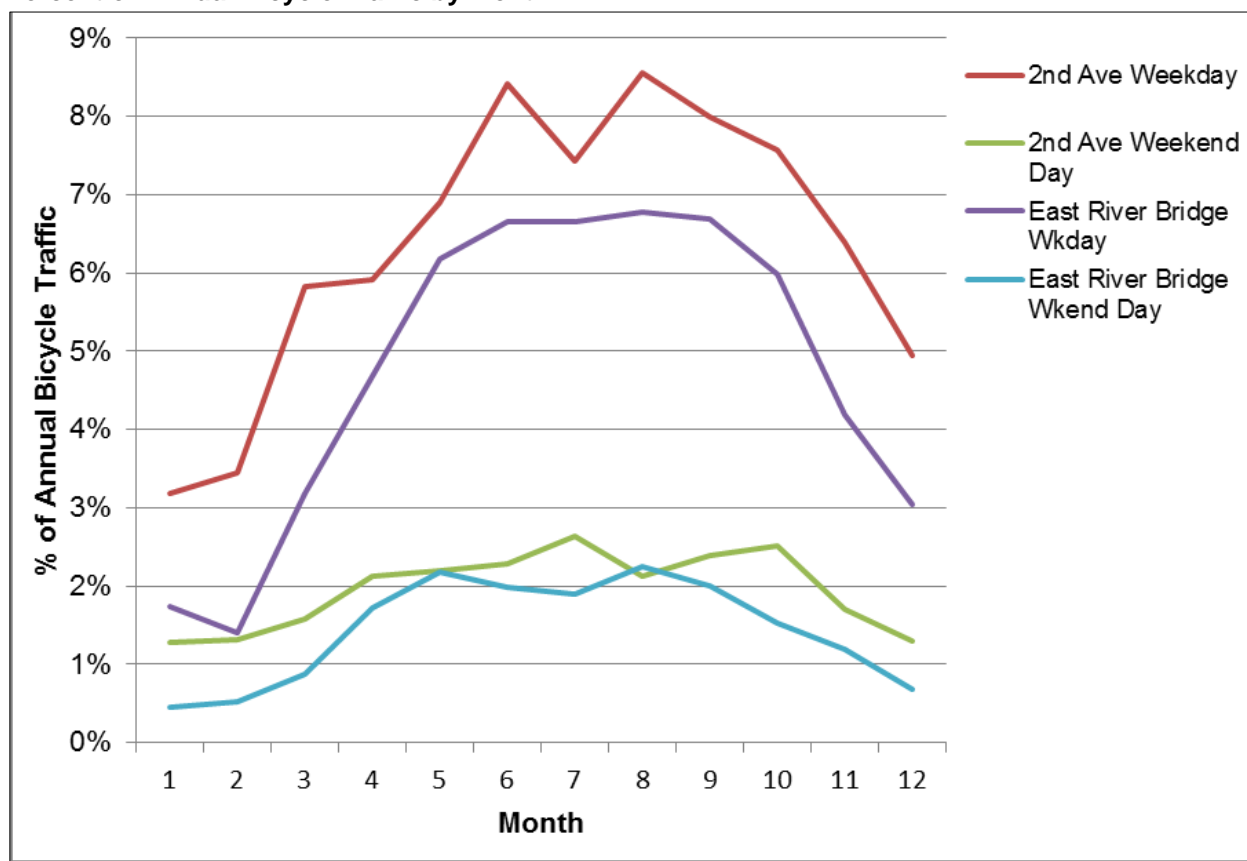
Bicycle Volume Estimation

Two different traffic volumes are used in this analysis. The first, **bicycle volume**, is used to account for the large increase in cycling volumes after Protected Bike Lanes (PBLs) are installed and to better assess individual risk at each intersection.

NYC DOT collects bicycle volume counts via continuously monitoring count stations (machines) on the four East River Bridges and at 2nd Avenue & E 26th Street in Manhattan. These count stations provide data on the hourly, daily, and seasonal variations of bicycling volumes in the city. In addition, short-duration counts of bicycle volumes (human observers) are typically collected before and after each bicycle project is implemented to capture any changes related to the project.

For each study site, an average annual daily bicyclists (AADB) is calculated for each year. To arrive at the AADB for each study intersection, the short-duration project counts need to be factored such to take into consideration the time of year that the counts were collected. The factors need to account for the typical cycling behaviors at the study sites and thus the permanent bicycle counters on the East River bridges and 2nd Avenue were compared to study sites with several short-duration counts throughout the year. Based on the slightly different cycling profiles between the bridge and 2nd Avenue counters, the 2nd Avenue profile was identified as the best match of the study area cycling profile throughout the year when compared to the short-duration counts. The monthly averages from 2nd Avenue is used in this study to adjust the single-day counts at each study site to develop an AADB that accurately accounts for the variations in cycling volume throughout the year.

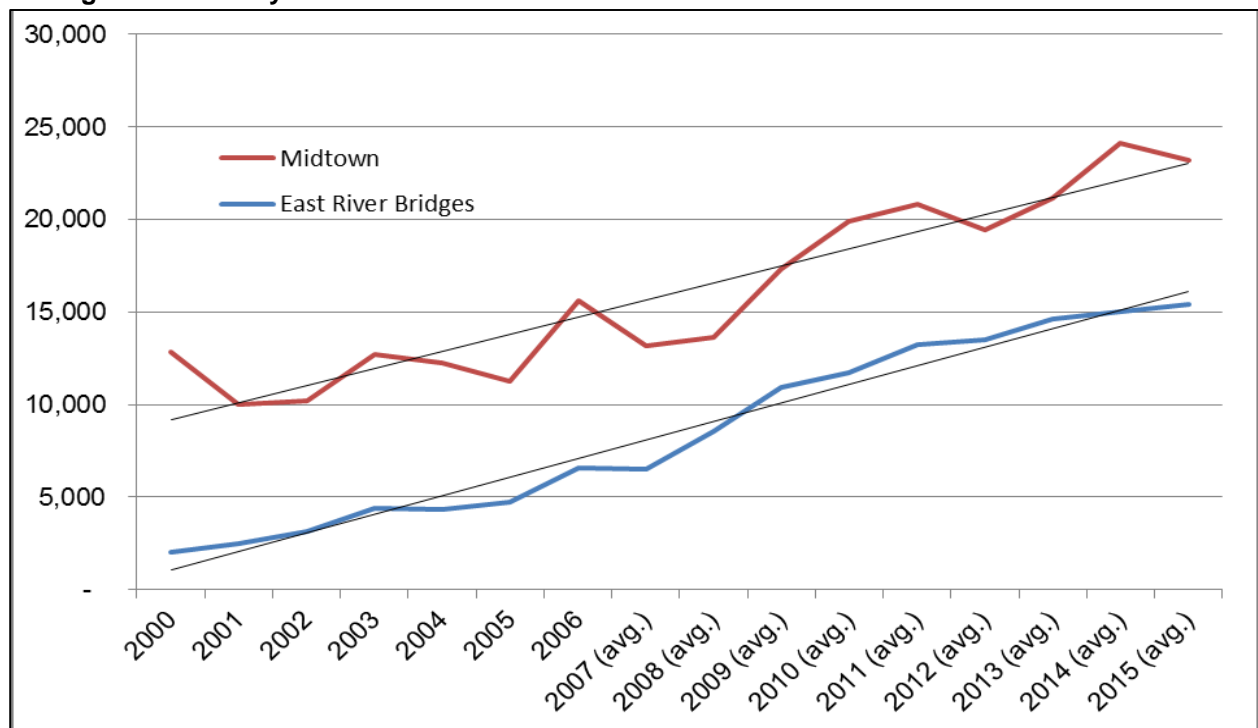
Percent of Annual Bicycle Traffic by Month



Because the short-duration bicycle counts for each project are only conducted at a few locations along a corridor, not every study intersection has a bicycle volume count. Thus, to assign volumes to each intersection it is assumed that cycling volumes along a corridor remain relatively consistent at nearby intersections. Therefore, the *same AADB* was used for each intersection along a *short section of the corridor*. Where sections included several counts at different locations or times, the counts were averaged to develop a single section AADB.

The AADB values are also adjusted for each year of the study based on annual growth rates based on bicycle counts on the East River bridges and Midtown.

Average 12-Hour Bicycle Counts



Motor Vehicle Turning Volumes

Turning movements are also incorporated into this study to account for the different levels of exposure that cyclists encounter to turning vehicles at each intersection. Because turning movements cannot easily be estimated the study only uses intersections where turning movement counts are available. This results in approximately 1/3 of the total number of study sites.

The turning movement counts have been adjusted to account for seasonal changes and modest changes in traffic volumes between the before and after study periods.

Study Sample Size by Turning Movement Count Sites

| Treatment | Sites | % of Total Study Sites |
|----------------------------------|-----------|------------------------|
| Mixing Zone (current generation) | 20 | 28% |
| Mixing Zone (first generation) | 13 | 24% |
| Mixing Zone (all) | 33 | 26% |
| Fully Split Phase | 30 | 57% |
| Lateral Shift | 1 | 33% |
| No Treatment | 1 | 50% |
| TOTAL | 65 | 35% |

Crash Analysis Results

Overall Crashes by Treatment Type (Before-After)

The first analysis examines all study sites and treatment types and compares the intersections before and after the Protected Bike Lane (PBL) installation. The Site Years category is a measure of sample size by simply multiplying the number of sites by the number of years of data for that site.

The Average Annual Bicycle Crashes (AABC) values provide a measure of the average number of annual injury bicycle crashes that occur at each study intersection. As presented, the total number of bicycle-involved intersection crashes increased an average 25% with PBLs.

While this increase in total crashes may appear to be alarming, it is important to consider the context. During the study period, the number of cyclists grew considerably, particularly along PBL corridors, thus considering only the total number of crashes does not provide a full picture of the safety for each individual cyclist. By normalizing the crashes by the number of bicyclists, the study intersections can be compared using crash rates that take into account this change in volume.

The final set of columns presents this crash rate as crashes per million cyclists. Looking at the intersections as a whole reveals a 30% decrease in the bicyclist crash rate after PBLs are installed. This result reinforces that findings from NYC DOT's 2017 Safer Cycling study that the rise in cycling trips contributes to a drop in cycling risk likely through high quality infrastructure that is safe and through the increased attentiveness paid to cyclists due to their greater numbers.

In addition to looking at the before and after crash rates, it is interesting to compare the rates between different treatments. For example, the crash rate at Mixing Zones (current generation) is lower than that of Fully Split Phase locations (1.4 and 2.0, respectively). However, as demonstrated by the before crash rates (1.9 and 4.3), the street context in which these two treatments are applied is often quite different where Fully Split Phase intersections appear to be installed at higher risk locations. This is important to bear in mind as the study attempts to identify the attributes that increase cyclist risk at intersections (i.e. turning volumes and street width) and to directly compare treatments to mitigate that risk.

Average Intersection Crashes and Crashes per Cyclist

| Treatment | Sites | Site Years [^] | | Avg Annual Bicycle Crashes (AABC)* | | | AABC per Million Entering Bicyclists* | | |
|-----------------------------------|------------|-------------------------|-------------|------------------------------------|-------------------|------------|---------------------------------------|-------------------|-------------|
| | | Before | After | Before | After | Change | Before | After | Change |
| Mixing Zone (current generation*) | 71 | 855 | 306 | 0.4 ± 0.03 | 0.5 ± 0.23 | 24% | 1.9 ± 0.05 | 1.4 ± 0.16 | -27% |
| Mixing Zone (first generation*) | 55 | 524 | 323 | 0.6 ± 0.06 | 0.8 ± 0.29 | 38% | 2.1 ± 0.08 | 1.7 ± 0.22 | -21% |
| Fully Split Phase | 53 | 448 | 364 | 0.8 ± 0.09 | 0.7 ± 0.40 | -9% | 4.3 ± 0.11 | 2.0 ± 0.25 | -54% |
| Lateral Shift [^] | 3 | 30 | 17 | 0.9 ± 1.02 | 1.7 ± 12.77 | 99% | 6.6 ± 0.91 | 6.0 ± 3.13 | -9% |
| None [^] | 2 | 16 | 18 | 0.2 ± 0.17 | 0.4 ± 1.25 | 109% | 1.3 ± 0.25 | 1.2 ± 0.61 | -9% |
| TOTAL | 184 | 1899 | 1052 | 0.5 ± 0.04 | 0.7 ± 0.28 | 25% | 2.5 ± 0.05 | 1.7 ± 0.13 | -30% |

[^]Study years for the before-after analysis are from January 2000 – June 2017

*Mean ± SEM

Since one of the largest threats to cyclists at intersections is turning traffic, an additional intersection safety metric is to consider the number of conflicting turns at each site. It should be noted that while the number of intersections with turning movement volumes is lower (see the Sites column), it still yields interesting results. Calculating a rate of cyclist crashes that incorporates both turning vehicles and cyclists provides an indicator that best accounts for the opportunity for collision between these two movements. Note that due to the low starting sample size, this rate is not calculated for all of the analyses in this study.

Since this rate also normalizes for turn volume, one of the highest intersection risk factors for cyclists, it allows for a more direct comparison between treatment types. The current generation (shorter) Mixing Zone has a lower crash rate than the Fully Split Phase treatment and the previous generation (longer) Mixing Zone. This suggests that from a safety perspective (though perhaps not an operational or comfort perspective) Mixing Zones are a reasonable treatment at higher turn volume locations. The higher crash rate at Fully Split Phase locations may be partially explained by risky behavioral issues such as red-light running that are amplified by the fact that the split phase treatment is typically used at wider intersecting streets. Especially since cyclists and turning vehicles should not be interacting at a fully split phase intersection.

It is also worth considering whether the turning movement count (TMC) sub-sample of intersections matches the characteristics of the full sample set. *Comparing the average crashes and crash rates between these two sets indicates that the TMC group has a higher number of crashes, particularly the first generation Mixing Zone and Fully Split Phase groups, which may slightly skew the comparisons.*

The bicyclist crash rates per turning vehicle volume and per turning vehicle volume and bicycle volume are calculated as follows:

$$\frac{\text{AABC}}{\text{Average Annual Turning Vehicle Volume}} \quad \frac{\text{AABC}}{\text{Average Annual Turning Vehicle Volume} \times \text{Average Annual Bicycle Volume}}$$

Average Crashes per Bicyclist Exposure to Turning Vehicles After PBL Installation

| Treatment | Sites | Bicycle Crash Rate per Million Turning Vehicles | Bicycle Crash Rate per [Million Turning Vehicles x Million Entering Bikes] |
|----------------------------------|-------|---|--|
| Mixing Zone (current generation) | 20 | 1.5 | 3.2 |
| Mixing Zone (first generation) | 13 | 2.5 | 5.0 |
| Fully Split Phase | 30 | 2.0 | 5.9 |

Finally, comparing the bicycling facility type pre-PBL installation (before-after) shows the change in crash rates to be quite similar for each of the before conditions even though there are some individual differences between the crash rates for each treatment and before condition. *These differences are more likely related to the slight differences in street types and contexts that led to the pre-PBL bicycling facilities being present or not rather than the PBL intersection design itself.*

Cyclist Crashes and Crash Rates by Bicycle Facility Before PBL

| Treatment | Before Bike Facility | Sites | Avg Annual Bicycle Crashes (AABC)* | | | AABC per Million Bicyclists* | | | Avg Annual Bicycle Crashes (AABC) | AABC per Million Bicyclists |
|--------------------------------|----------------------|-------|------------------------------------|------------|--------|------------------------------|------------|--------|-----------------------------------|-----------------------------|
| | | | Before | After | Change | Before | After | Change | After (2014-2016) | After (2014-2016) |
| Mixing Zone (current) | None | 34 | 0.4 ± 0.04 | 0.5 ± 0.08 | 16% | 2.7 ± 0.31 | 1.4 ± 0.24 | -48% | 0.57 | 1.51 |
| | Bike Lane | 28 | 0.4 ± 0.06 | 0.5 ± 0.08 | 40% | 2.2 ± 0.41 | 1.4 ± 0.27 | -38% | 0.43 | 1.30 |
| | Buffered Bike Lane | 9 | 0.4 ± 0.10 | 0.4 ± 0.14 | 9% | 2.1 ± 0.62 | 0.9 ± 0.28 | -59% | 0.42 | 0.93 |
| Mixing Zone (first generation) | None | 28 | 0.5 ± 0.05 | 0.8 ± 0.10 | 58% | 2.0 ± 0.19 | 1.5 ± 0.18 | -27% | 0.77 | 1.63 |
| | Bike Lane | 17 | 0.6 ± 0.12 | 0.8 ± 0.21 | 41% | 3.4 ± 0.77 | 2.1 ± 0.63 | -38% | 0.70 | 1.62 |
| | Buffered Bike Lane | 10 | 0.9 ± 0.17 | 0.9 ± 0.15 | -4% | 3.0 ± 0.58 | 1.4 ± 0.24 | -53% | 0.98 | 1.49 |
| Fully Split Phase | None | 21 | 0.9 ± 0.09 | 0.8 ± 0.17 | -15% | 5.7 ± 0.54 | 1.8 ± 0.35 | -68% | 0.92 | 2.16 |
| | Bike Lane | 24 | 0.6 ± 0.07 | 0.6 ± 0.12 | -1% | 5.6 ± 0.74 | 2.0 ± 0.33 | -64% | 0.61 | 1.93 |
| | Buffered Bike Lane | 8 | 1.3 ± 0.37 | 0.9 ± 0.38 | -27% | 3.8 ± 0.79 | 1.7 ± 0.60 | -54% | 1.08 | 1.84 |
| All | None | 85 | 0.5 ± 0.04 | 0.7 ± 0.06 | 23% | 3.2 ± 0.24 | 1.6 ± 0.14 | -51% | 0.73 | 1.74 |
| | Bike Lane | 73 | 0.5 ± 0.06 | 0.6 ± 0.08 | 35% | 3.7 ± 0.64 | 2.0 ± 0.26 | -47% | 0.58 | 1.66 |
| | Buffered Bike Lane | 29 | 0.7 ± 0.15 | 0.7 ± 0.13 | 11% | 2.5 ± 0.40 | 1.3 ± 0.22 | -49% | 0.80 | 1.38 |

*Mean ± SEM

Treatment Evaluation by Street Characteristics (Cross-Sectional)

*****Because not all of the treatment types were installed at the same time and cycling volumes changed dramatically over time, the comparative crash analysis between treatments uses crashes from the most recent three full years of crash data available (2014-2016), the results in this subsection are analyzed using this limit*****

To achieve a more nuanced understanding of intersection turning volumes on bicyclist safety, the sample intersections are categorized as low turn volume (under 120 peak hour turns per hour) and high turn volume for each type of treatment. The low turning volume intersections with a Fully Split Phase design are further parsed by 8th Ave, 9th Ave, and Broadway since these all feature slightly different designs.

These results suggest similar safety benefits between Mixing Zones and Fully Split Phases at intersections with lower turn volumes. At higher turn volume locations, the current (shorter) Mixing Zones have the lowest crash rates using both measures, while the longer Mixing Zones have the highest.

When comparing the rates of the combined Mixing Zones at high and low volume locations, the crash rate per cyclist remains roughly the same while the crash rate that also includes turning movements is lower at high volume intersections.

For the Fully Split Phase study sites, there is quite a bit of variation between the different corridors, with 8th Ave standing out as needing further investigation due to its higher crash rates.

Cyclist Crashes and Crash Rates at High and Low Turning Movement Intersections After PBL Installation

| Treatment | Subset^ | Sites | Avg Annual Bicycle Crashes (AABC) | AABC / Million Cyclists | Sites | Bicycle Crash Rate per Million Turning Vehicles | Bicycle Crash Rate per [Million Turning Vehicles x Million Entering Bikes] |
|--|-------------|-------|-----------------------------------|-------------------------|-------|---|--|
| Mixing Zone (current) | Low volume | 10 | 0.7 | 1.5 | 10 | 2.5 | 5.9 |
| Mixing Zone (first gen) | | 5 | 0.9 | 2.1 | 5 | 4.6 | 12.3 |
| Fully Split Phase: 8 th Ave | | 6 | 1.2 | 2.4 | 2 | - | - |
| Fully Split Phase: 9 th Ave | | 6 | 0.8 | 1.7 | 2 | - | - |
| Fully Split Phase: 8 th + 9 th Ave | | 12 | 1.0 | 2.0 | 4 | 3.3 | 7.1 |
| Fully Split Phase: Broadway | | 7 | 0.3 | 1.1 | 3 | 1.4 | 5.2 |
| Mixing Zone (current) | High volume | 10 | 0.6 | 1.3 | 10 | 1.2 | 2.5 |
| Mixing Zone (first gen) | | 8 | 0.9 | 1.6 | 8 | 1.8 | 3.7 |
| Fully Split Phase | | 34 | 0.8 | 2.2 | 23 | 1.5 | 4.3 |

^Low Volume Subsets (<120 peak hour turns)

Split - 8th Ave 14,15*,17*,19*,21*,23 Streets

Split - 9th Ave 16*,20*,22*,28*,34,57 Streets

Split - Broadway 26,28,36,48*,50*,54*,56* Streets

MZ Current Gen 1 Av / 85 St, 8 Av / 35 St, 8 Av / 37 St, 8 Av / 49 St, 8 Av / 51 St, 9 Av / 36 St, 9 Av / 54 St, 9 Av / 56 St, Columbus Ave / 70 St, Hudson St / Leroy St

MZ First Gen (long) 1 Av / 34 St, 2 Av / 24 St, Broadway / 30 St, Broadway / 32 St, Grand St / Chrystie St

*TMC unavailable, categorized as low volume by local knowledge and judgment

Treatment Evaluation by Cross-Street Width

The crash risk to bicyclists as relating to cross-street width is well documented in the research literature. This is due to a multitude of issues including the distance and length of time that cyclists are exposed to conflicting traffic and the speed at which turning traffic is able to turn. In fact, NYC DOT's 2016 Left Turn Pedestrian & Bicycle Crash Study found that left turn pedestrian and bicyclist injuries typically occur where the receiving street is 60' or wider and/or the receiving street is two-way. This next set of analyses attempts to identify how Mixing Zones and Fully Split Phase intersections compare under these different types of cross-street conditions.

Consistent with the previous findings, the Mixing Zone and Fully Split Phase intersection design appear to have a similar safety performance at the narrow cross-street locations. **At wider cross-streets, Fully Split Phase intersections have a lower crash rate**, particularly when accounting for the turning movements at each site.

It is also interesting to compare the crash rates as a whole between the narrow and wide cross-streets. While the bicycle facility treatments are similar for each type of location, **the crash rates for the wider cross-streets are considerably higher**. This is even the case when normalizing for the higher number of turns that likely occur onto these wider streets. This reinforces the findings from the Left Turn study that higher turn speeds and greater exposure distances contribute to a higher crash risk at wide streets. The previous speculation that red-light violations are considerably riskier on wider streets appears to also have merit, particularly considering that conflicts between cyclists and turning traffic should be non-existent at Fully Split Phase locations.

This Table also highlights that 60% of the Fully Split Phase sites are at locations with 2+ cross-street lanes compared with 16% of the Mixing Zone locations, this is consistent with NYC DOT's practice of typically using the split phase as a treatment at larger intersections.

Finally, attention should be drawn again to the low sample sizes for some of these groups, in particular the current Mixing Zone at wide cross-streets.

Cyclist Crashes and Crash Rates at by Cross-Street Width After PBL Installation

| Treatment | Cross-Street Lanes | Sites | Avg Annual Bicycle Crashes (AABC)* | AABC per Million Entering Cyclists* | Sites | Bicycle Crash Rate per Million Turning Vehicles | Bicycle Crash Rate per [Million Turning Vehicles x Million Entering Bikes] |
|-------------------------|--------------------|-------|------------------------------------|-------------------------------------|-------|---|--|
| Mixing Zone (current) | 1 | 63 | 0.4 ± 0.07 | 1.2 ± 0.17 | 19 | 1.1 | 2.4 |
| Mixing Zone (first gen) | | 43 | 0.7 ± 0.11 | 1.3 ± 0.17 | 7 | 1.6 | 3.7 |
| Fully Split Phase | | 21 | 0.4 ± 0.11 | 0.9 ± 0.23 | 5 | 1.0 | 3.3 |
| Mixing Zone (current) | 2 | 7 | 1.0 ± 0.14 | 2.7 ± 0.87 | 1 | - | - |
| Mixing Zone (first gen) | | 8 | 1.1 ± 0.37 | 2.3 ± 0.77 | 1 | - | - |
| Fully Split Phase | | 9 | 0.2 ± 0.10 | 0.6 ± 0.25 | 4 | 0.5 | 2.0 |
| Mixing Zone (current) | 2+ | 8 | 0.9 ± 0.12 | 2.7 ± 0.73 | 1 | - | - |
| Mixing Zone (first gen) | | 12 | 1.2 ± 0.25 | 2.7 ± 0.57 | 6 | 3.2 | 7.4 |
| Fully Split Phase | | 32 | 1.1 ± 0.21 | 2.8 ± 0.45 | 25 | 2.2 | 5.9 |
| Fully Split Phase | 3+ | 23 | 1.4 ± 0.23 | 3.5 ± 0.51 | 21 | 2.7 | 6.9 |

*Mean ± Standard Error of the Mean

The following two tables continue the analysis of cross-street width and safety by adding directionality to the study sites. While nearly all (93%) of the Mixing Zone study sites occur where the intersecting street is one-way, those at two-way streets have a greater crash rate. When accounting for the cross-street width, Mixing Zone locations with two-way cross streets still have a generally higher crash rate.

The Fully Split Phase locations present a similar trend where the crash rates are nearly three times greater at two-way intersections. However, when accounting for cross-street widths, the number of crossing lanes, rather than the street directionality appears to be more important; while the crash rates are similar for one-way and two-way streets with two lanes, the crash rate is considerably higher at locations with four lanes.

Cyclist Crashes and Crash Rates by One-Way and Two-Way Cross-Streets After PBL Installation

| Treatment | Cross-Street Directionality | Sites | Avg Annual Bicycle Crashes (AABC) | AABC / Cyclists x 1,000,000 |
|--------------------------------|-----------------------------|-------|-----------------------------------|-----------------------------|
| Mixing Zone (current) | One-Way | 68 | 0.5 | 1.3 |
| | Two-Way | 3 | 0.7 | 3.0 |
| Mixing Zone (first generation) | One-Way | 49 | 0.7 | 1.4 |
| | Two-Way | 6 | 1.8 | 4.0 |
| Fully Split Phase | One-Way | 25 | 0.3 | 0.9 |
| | Two-Way | 28 | 1.2 | 3.0 |
| All | One-Way | 146 | 0.5 | 1.2 |
| | Two-Way | 41 | 1.3 | 3.1 |

Cyclist Crashes and Crash Rates by One-Way and Two-Way Cross-Streets and Number of Crossing Lanes After PBL Installation

| Treatment | Cross-Street Characteristics | Sites | Avg Annual Bicycle Crashes (AABC) | AABC / Cyclists x 1,000,000 |
|--------------------------------|--|-------|-----------------------------------|-----------------------------|
| Mixing Zone (current) | 2 cross-street lanes, 1-way cross-street | 5 | 1.1 | 2.5 |
| | 2 cross-street lanes, 2-way cross-street | 2 | 0.7 | 3.2 |
| Mixing Zone (first generation) | 2 cross-street lanes, 1-way cross-street | 6 | 0.7 | 1.6 |
| | 2 cross-street lanes, 2-way cross-street | 2 | 2.9 | 6.5 |
| Fully Split Phase | 2 cross-street lanes, 1-way cross-street | 4 | 0.2 | 0.6 |
| | 2 cross-street lanes, 2-way cross-street | 5 | 0.3 | 0.6 |
| | 4 cross-street lanes, 2-way cross-street | 18 | 1.5 | 3.4 |

Crash Analysis: Key Findings

- Following the installation of PBLs, the rate of crashes per cyclist decreased an average of 30%
- Overall, Mixing Zones have a slightly lower crash rate than Fully Split Phases
- By all measures, the current, shorter, Mixing Zone design has a lower crash rate than the longer, first generation Mixing Zone
- There are similar safety benefits between Mixing Zones and Fully Split Phases at intersections with lower turn volumes. At higher turn volume locations, the current (shorter) Mixing Zones have the lowest crash rates
- Fully Split Phase intersections have a lower crash rate at multilane cross-streets and at two-way cross-streets
- Overall, the crash rates are higher for the wider cross-streets

Bicyclist Intercept Survey

To receive direct feedback on different PBL intersection designs, NYC DOT conducted a survey at several different PBL locations in 2017. The locations were selected to include a mix of downtown and uptown sites and focused on the Mixing Zone treatment to the Delayed Turn treatments. One of the Mixing Zone locations was also converted into a pilot Offset Crossing treatment, providing the opportunity to conduct the survey again with this new treatment and to compare the results.

To conduct the survey, the Street Ambassador teams set up midblock following the specific study intersections. This allowed for a view of the intersection while not creating a distraction. To keep the surveys brief, the questionnaire was limited to 10 questions and cyclists were encouraged to stop for through signs announcing a DOT survey and 'Free Bike Lights'.

NOTE: Because the survey focused on the understanding of intersection designs where bicyclists and turning drivers must interact, no locations of the Fully Split Phase design, with the two movements completely separated in time, are included in the survey.

Survey Locations

Table #: Cyclist Intercept Survey Sites

| Location | Treatment | Responses | % of Total | Survey Date (2017) |
|---|-----------------|-----------|------------|--------------------|
| 1 st Ave & E 7 th St | Mixing Zone | 95 | 18% | May 24 |
| Columbus Ave & W 70 th St | Mixing Zone | 100 | 19% | May 31 |
| Columbus Ave & W 70 th St | Offset Crossing | 43 | 8% | November 4 & 8 |
| 1 st Ave & E 85 th St | Mixing Zone | 70 | 13% | June 7 |
| 2 nd Ave & E 26 th St | Delayed Turn | 94 | 18% | June 14 |
| 1 st Ave & E 55 th St | Delayed Turn | 128 | 24% | July 5 |

Survey Questions

Hello! I'm from the New York City Department of Transportation. We are currently studying the intersection treatments at various protected bike lanes and we would like your feedback!

1. What type of bike?

- Personal bike
- Citi Bike
- Rental
- Working

2. How often do you ride through this intersection?

- At least once a week
- A couple times a month
- Once a month
- Rarely/First time

3. How would you rate your level of comfort riding a bicycle in New York City?

- Comfortable riding in off-street paths, greenways, and parks
- Comfortable riding in protected bike lanes
- Comfortable riding in any bike lane
- Comfortable riding on most streets
- Comfortable riding on any street

4. The next set of questions pertain to the intersection you just crossed:

Please rate the following statements: [1 – Strongly Disagree -> 5 – Strongly Agree]

4a. This intersection design makes it clear how cars should turn

4b. This intersection design makes it clear how cyclists should travel through

4c. This design makes it clear who must yield (the driver or cyclist) at the intersection

4d. I feel safe cycling through this intersection

5. Do you have any additional comments about the design of this intersection?

- Car blocks bike path
- Car cuts off
- Unsure what signs/markings mean
- Prefer to cross on red
- Prefer to leave the bike lane
- Drivers don't look
- Drivers do look
- Drivers yield
- Other (please specify)

6. The NYC DOT recently changed the design of this intersection. Have you noticed a difference?

(Question 6 is for the Offset Crossing location ONLY)

- Yes
- No

6a. If yes, which intersection design do you prefer? **(Question 6 is for the Offset Crossing location ONLY)**

- Strongly prefer old design
- Somewhat prefer old design
- Neutral
- Somewhat prefer new design
- Strongly prefer new design

6b. Why? **(Question 6 is for the Offset Crossing location ONLY)**

- I have more control over where I ride
- It is more comfortable
- Drivers behave better
- It's faster
- It feels safer
- I can't move out of the lane
- Drivers don't look
- Other (please specify)

7. Gender Identity

- Female
- Male
- Transgender FTM
- Transgender MTF
- Non-binary/gender fluid/genderqueer
- Prefer not to say
- Prefer to self describe (please identify):

8. Age

- Under 18
- 18 to 24
- 25 to 44
- 45 to 64
- 65 +

Survey Results

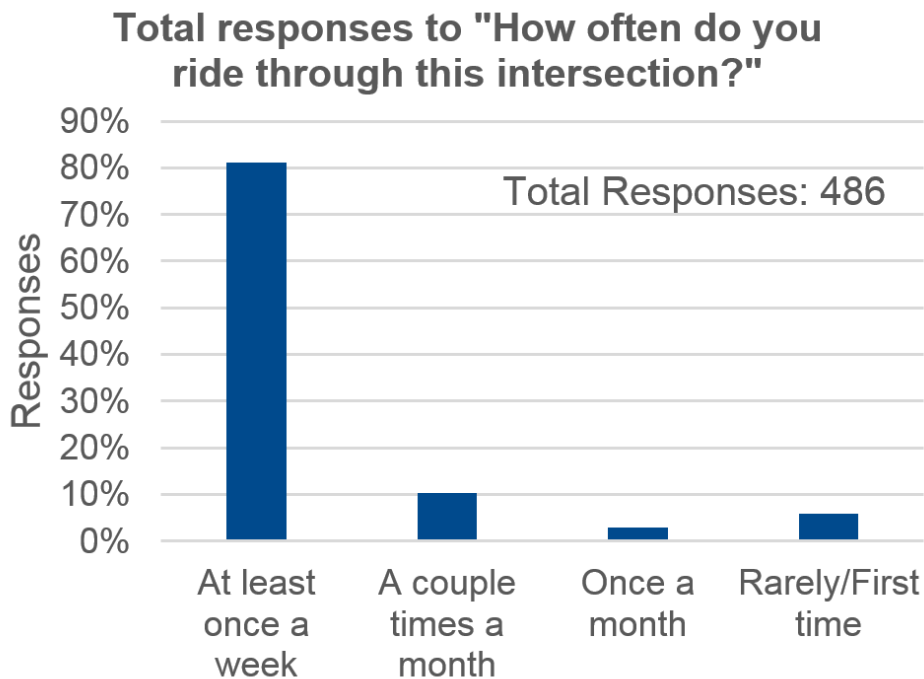
*****The following set of results pertains to the Mixing Zone and Delayed Turn locations ONLY*****

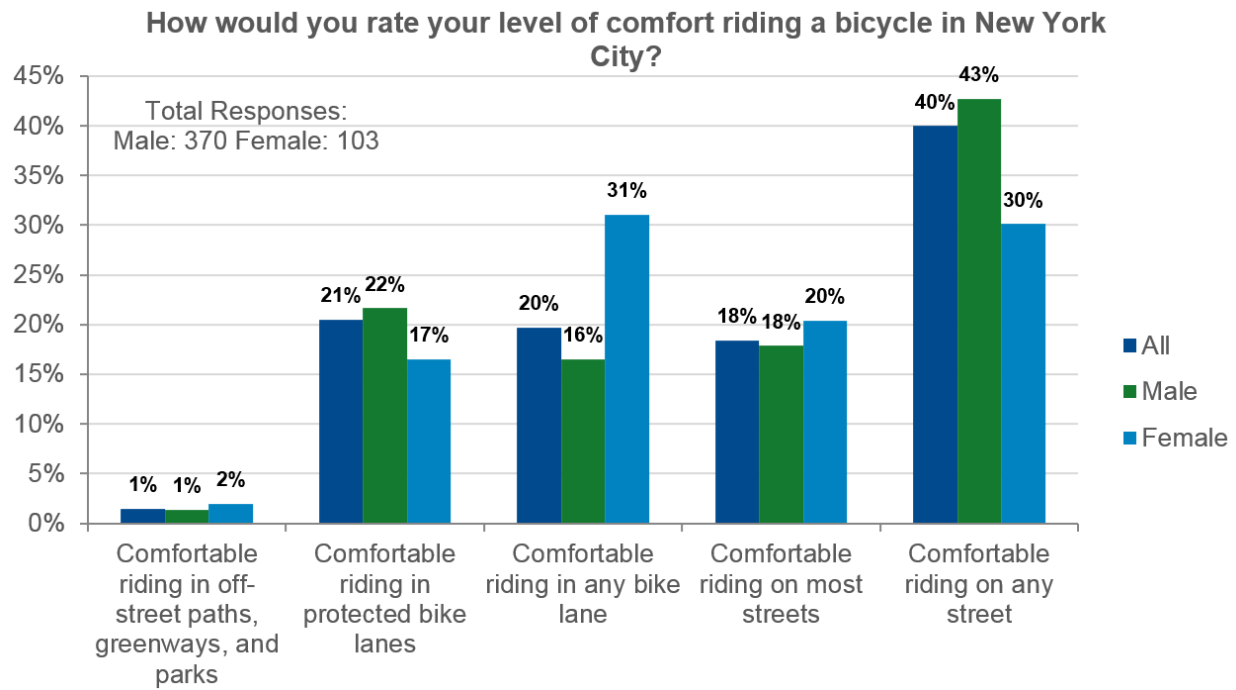
Of the total number of cyclists surveyed, 81% of them responded that they ride through the particular survey intersection at least once a week, indicating a familiarity with the treatment type.

To achieve a sense of how comfortable these respondents are in riding on NYC streets, they were asked to state their upper limit of comfort based on facility types. The respondents that selected the PBL option are saying that they are generally only comfortable while biking on streets with PBLs or on off-street paths or in parks.

These responses have been analyzed by gender revealing that nearly 40% of male respondents and 50% of female respondents feel most comfortable with at least a bike lane on the street. The greatest discrepancy between responses is the difference in between comfort in a bike lane and those comfortable riding on any street where male respondents expressed a higher tolerance for riding on any street type regardless of bike facility.

Since these surveys were conducted with cyclists who were already riding on PBLs, the low numbers of those who responded that they only feel comfortable on paths and parks is unsurprising.



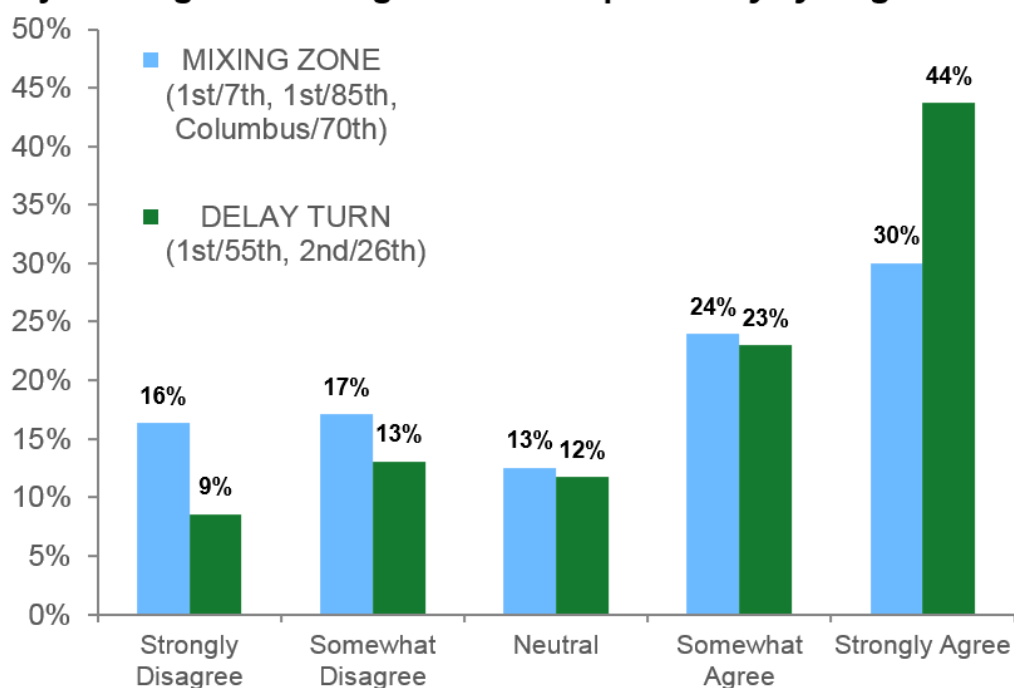


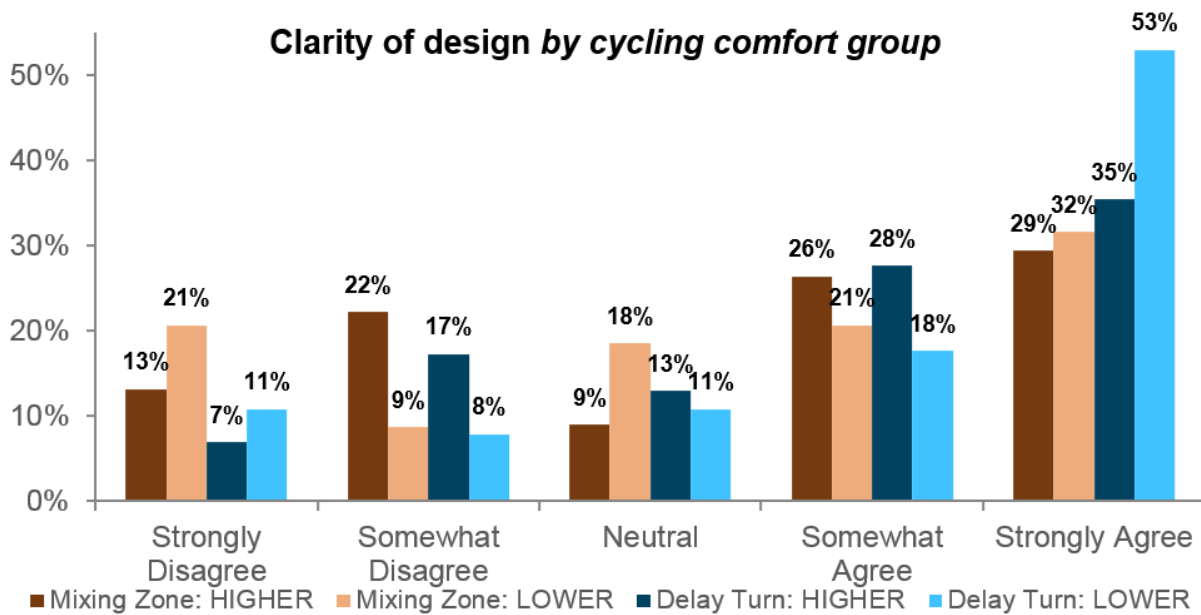
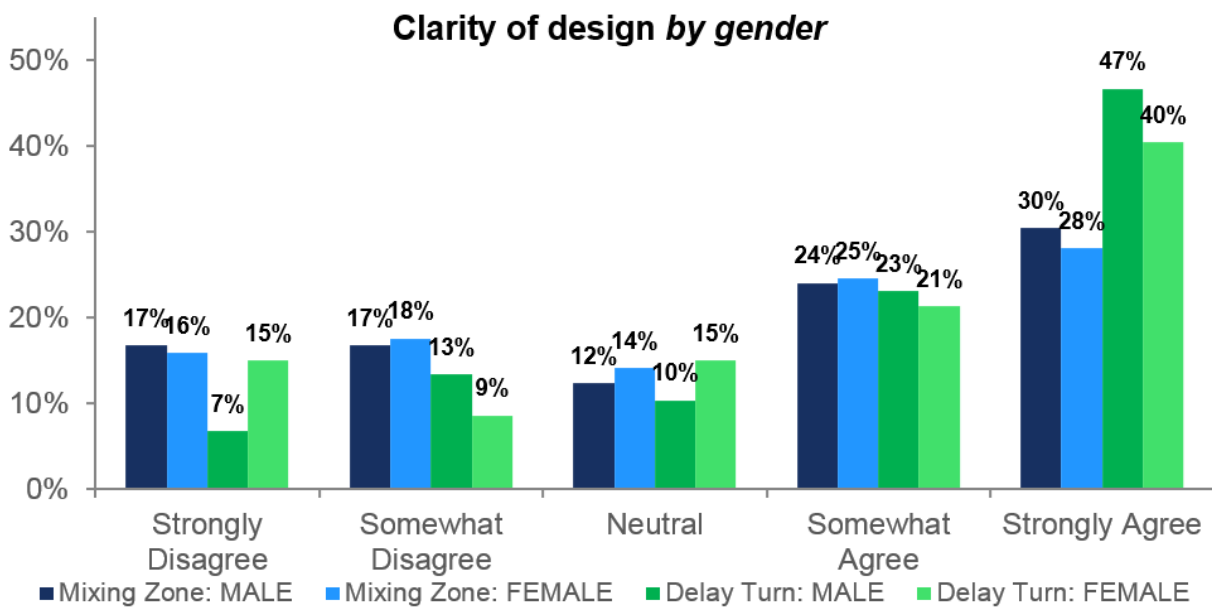
Survey Question: This intersection design makes it clear how cars should turn

Four questions on the cyclists' perception of the intersection design are asked with the first being whether it's clear how turning vehicles should use the intersection. Overall, neither the mixing zones nor the delay turn locations received overwhelming agreement that the design makes it clear how vehicles should turn but the mixing zone in particular had a high (33%) amount of disagreement.

The results of each design question are further evaluated by two groups: gender and comfort. The cycling comfort groups are defined by whether a respondent said that they were comfortable in bike lanes and other facilities (low) or comfortable in most to all streets in NYC (high). The largest discrepancies in responses between groups occurred between cycling comfort groups with most comfortable on all street types not agreeing that the delayed turn is a clear design for turning vehicles.

Clarity of design for turning vehicles: responses by cycling comfort group

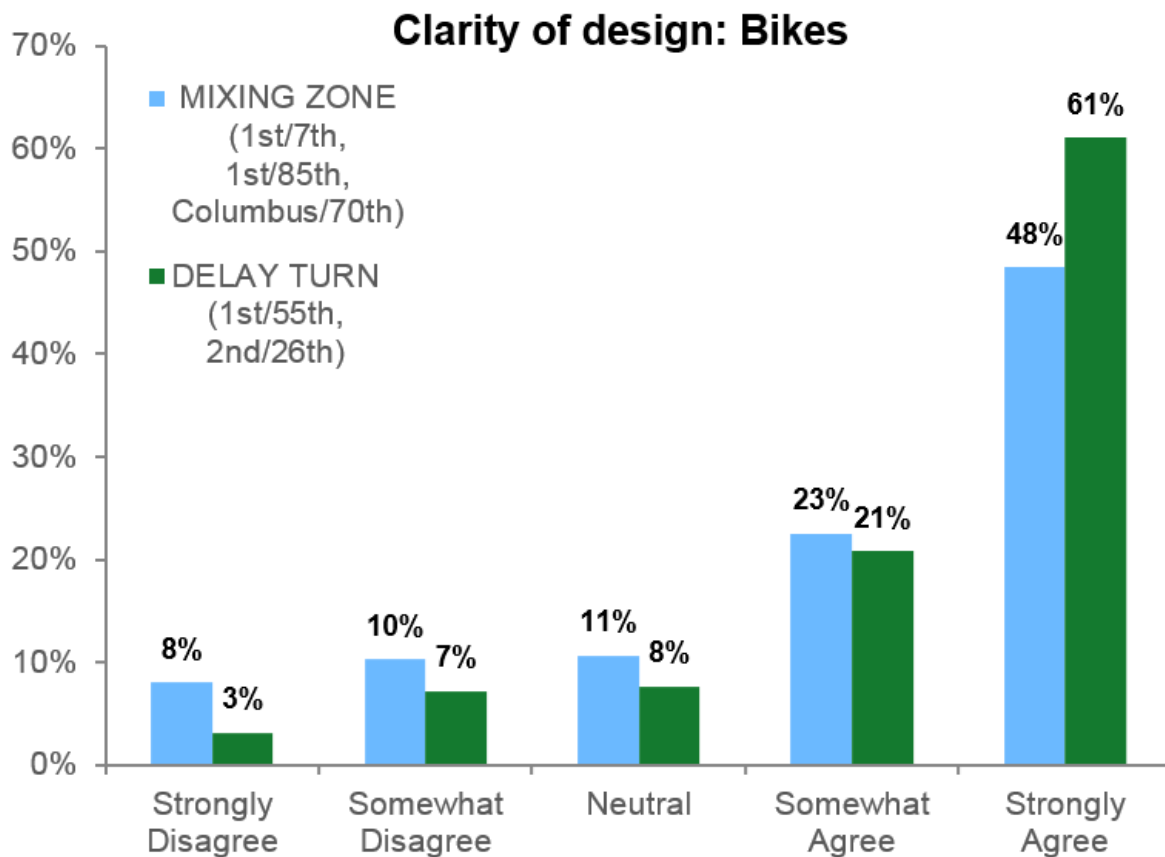


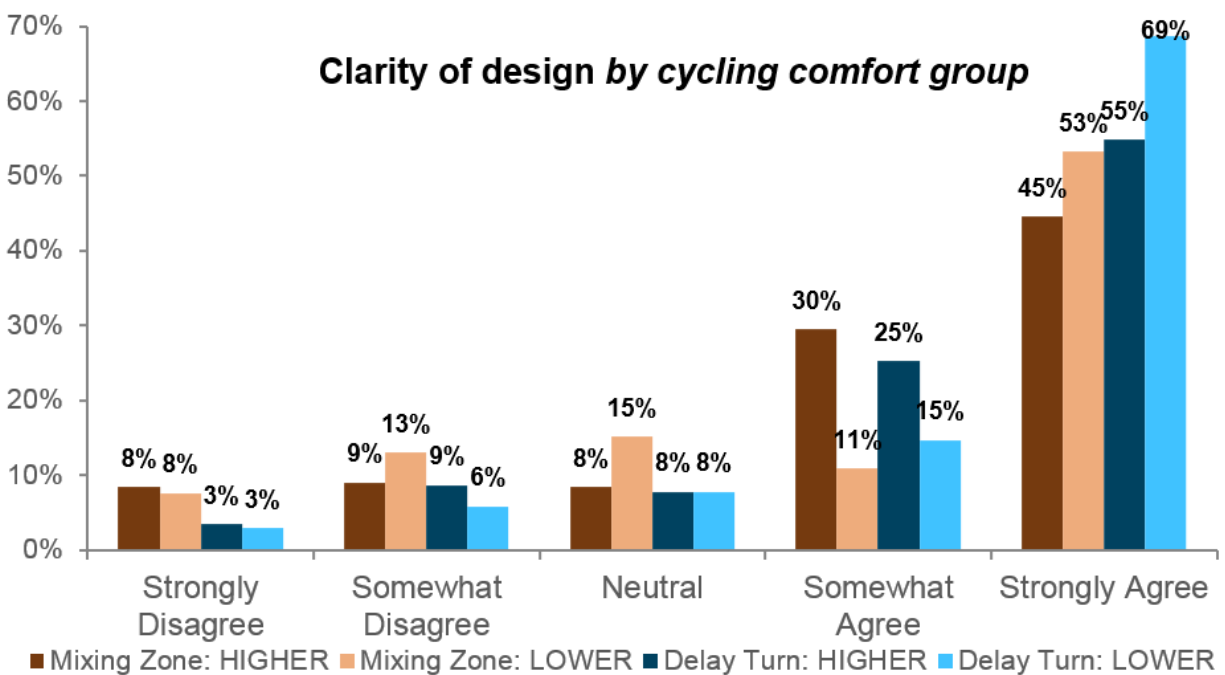
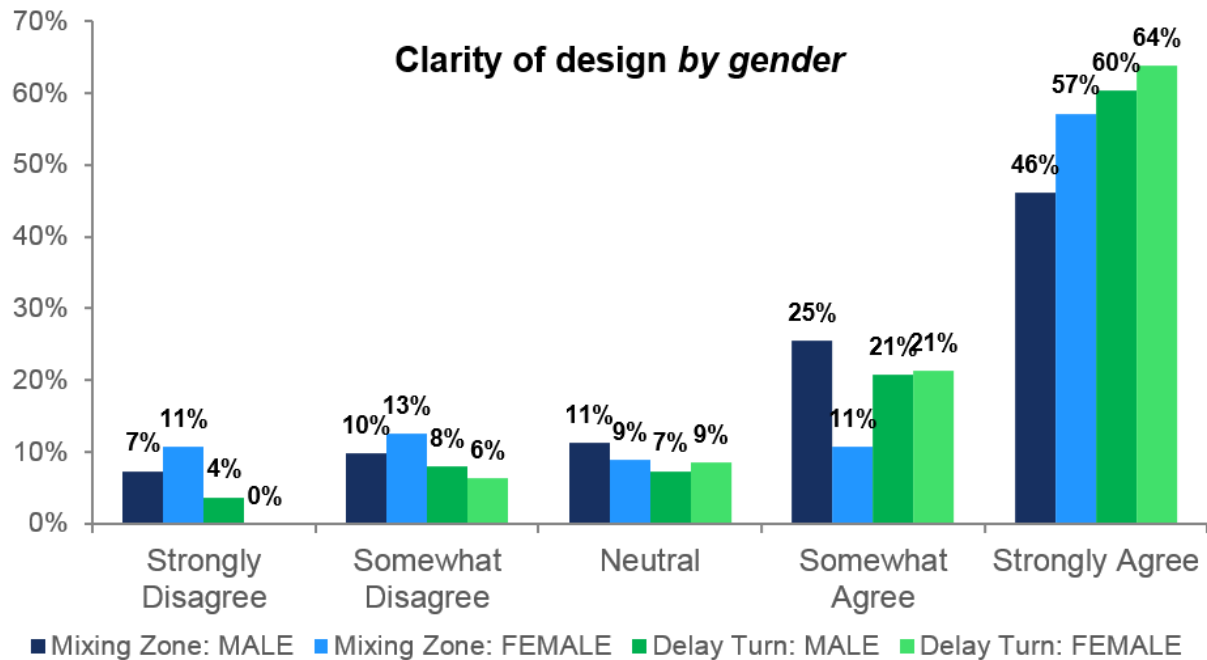


Survey Question: This intersection design makes it clear how cyclists should travel through

The next intersection design question asks whether it's clear how bicyclists are intended to navigate through the intersection. Overall, both of the designs appear to clear for the majority of the respondents.

The greatest discrepancies in responses between groups are with lower comfort cyclists and male respondents reporting a lower rate of agreement for understanding how bikes should travel through Mixing Zones.

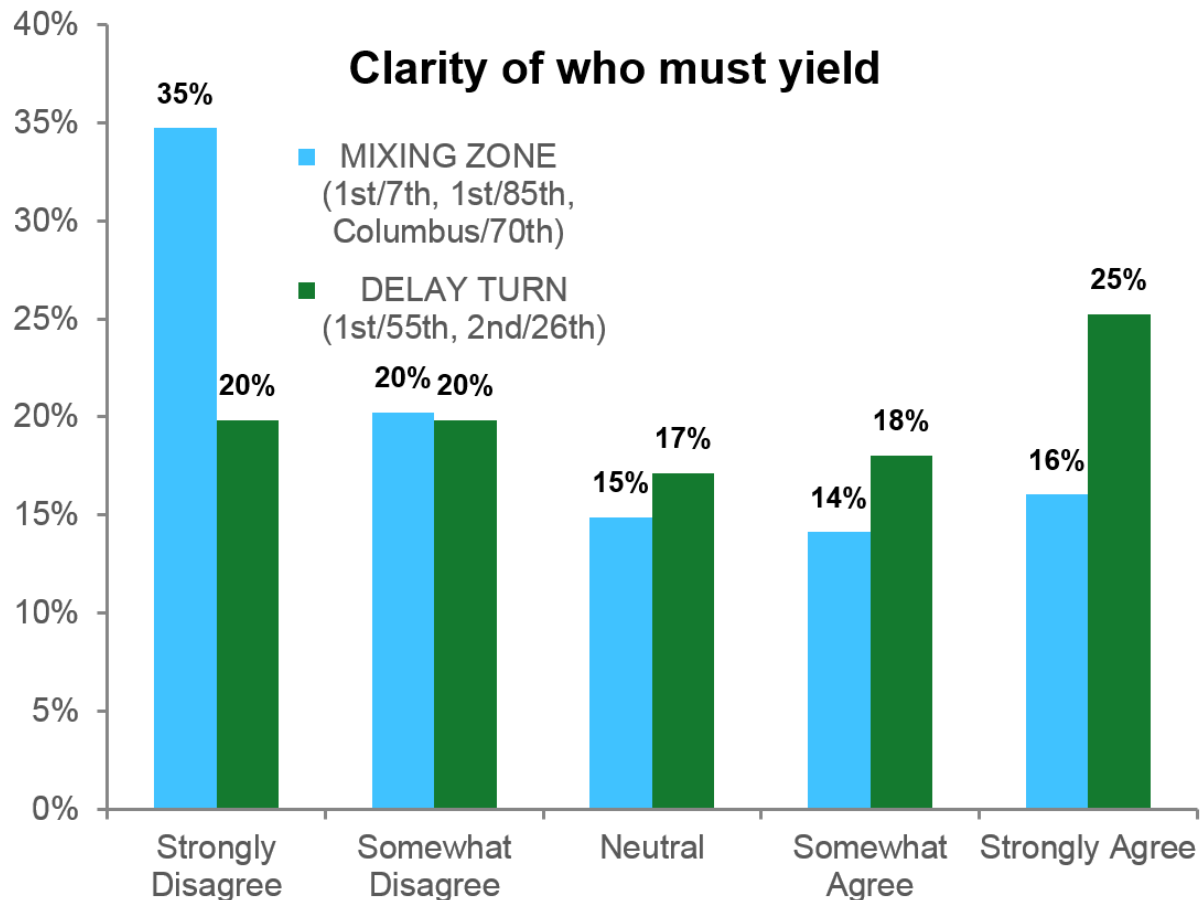


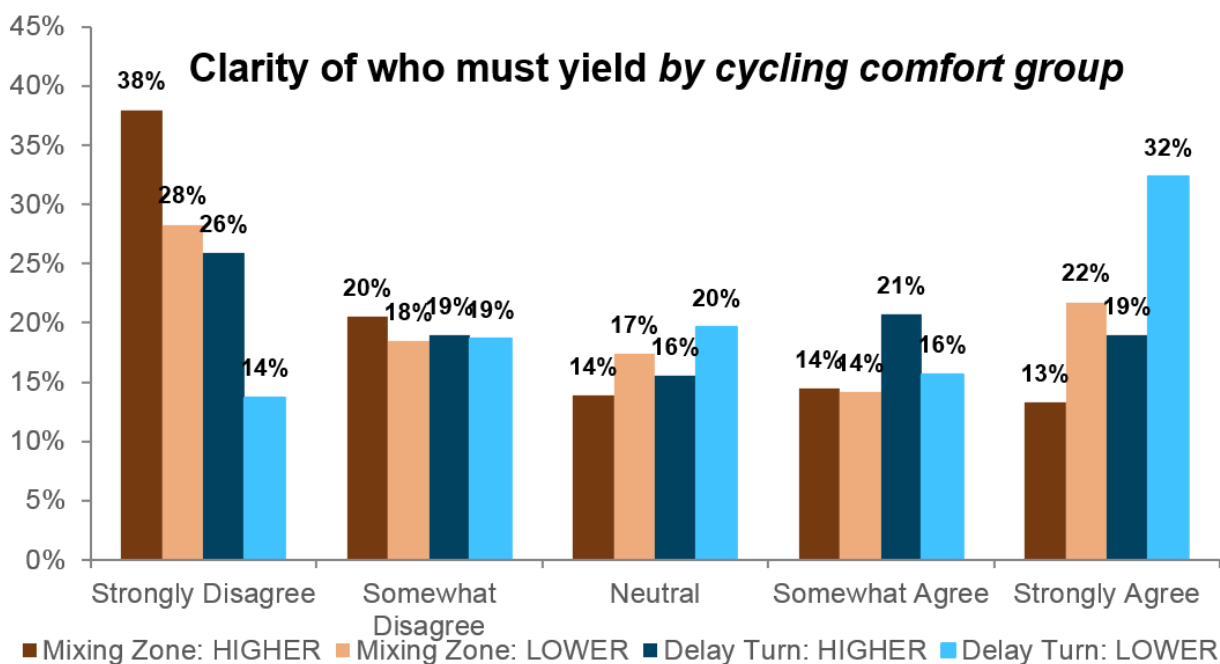
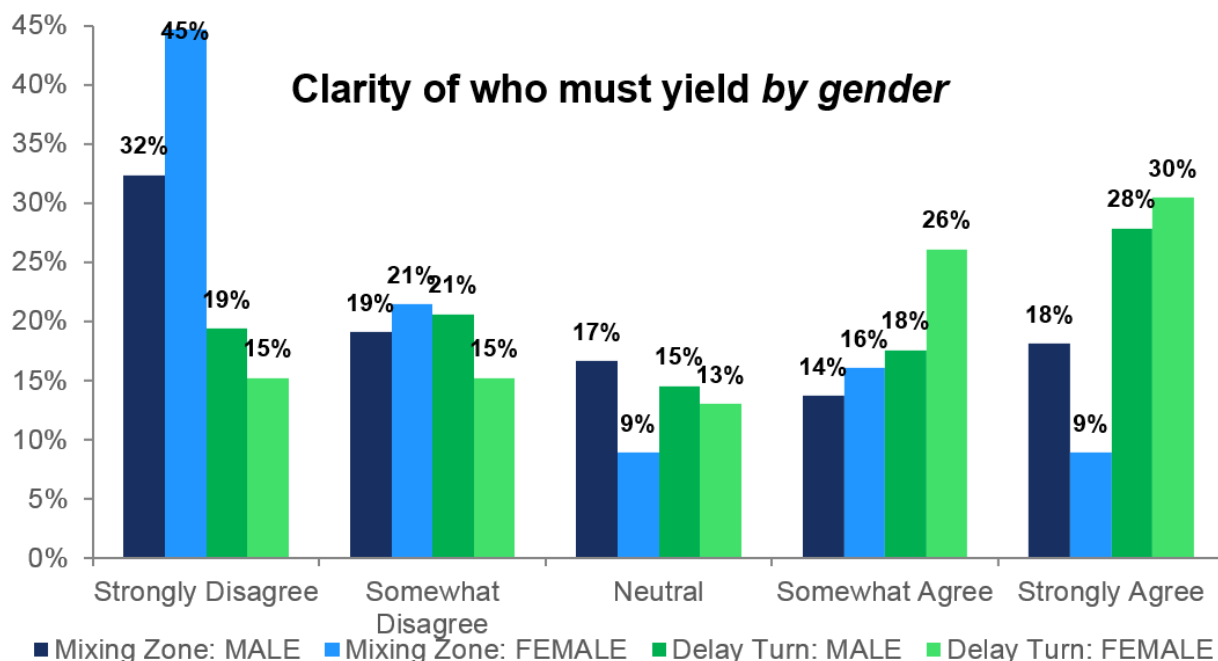


Survey Question: This design makes it clear who must yield (the driver or cyclist) at the intersection

The next intersection design question asks whether it's clear who must yield at the intersection. The results of this survey are the most ambiguous with the majority or near majority stating that it is unclear who must yield at the intersection. This is most stark for the Mixing Zone design where over 1/3 of the respondents strongly disagree with the question.

When comparing the responses by gender, female cyclists overwhelmingly responded (66%) that yielding is unclear at Mixing Zones. Another interesting result is that the higher comfort cycling group responded strongly against Mixing Zones and were less likely to agree that the Delay Turn made yielding clear.



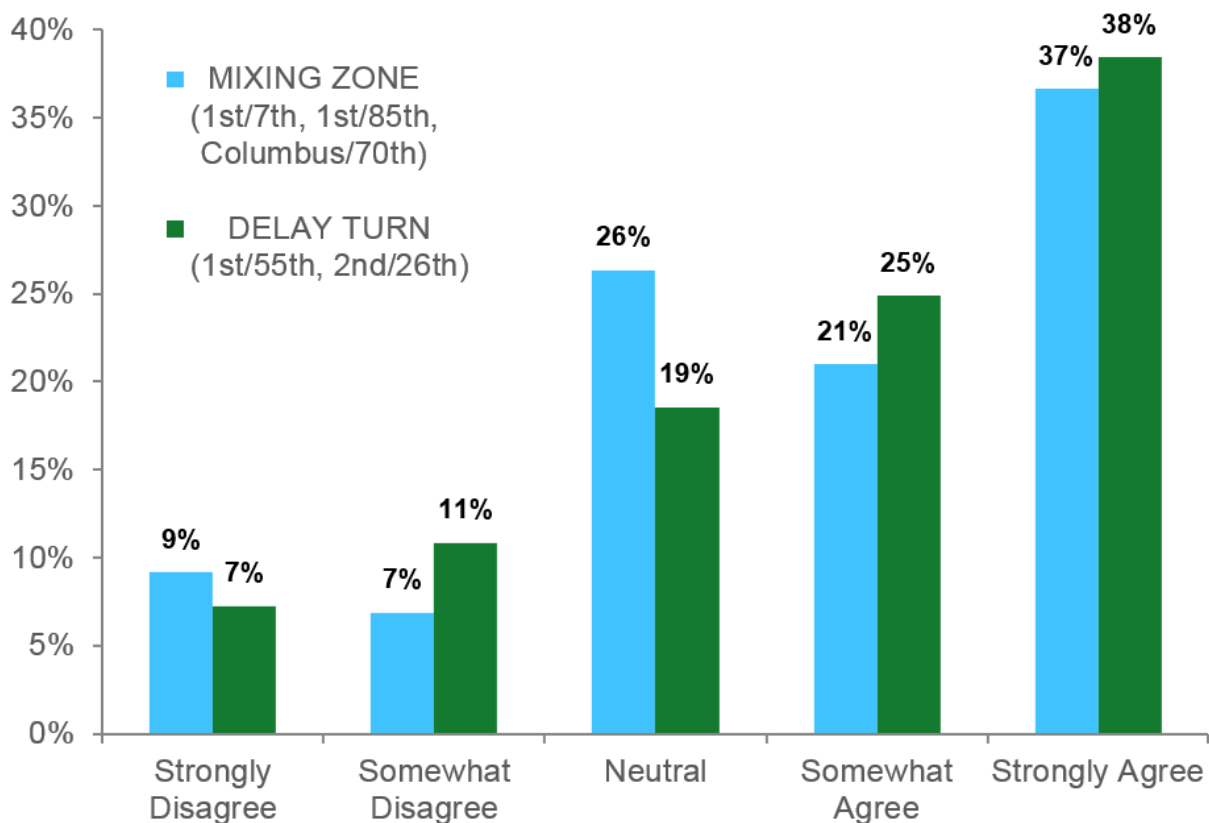


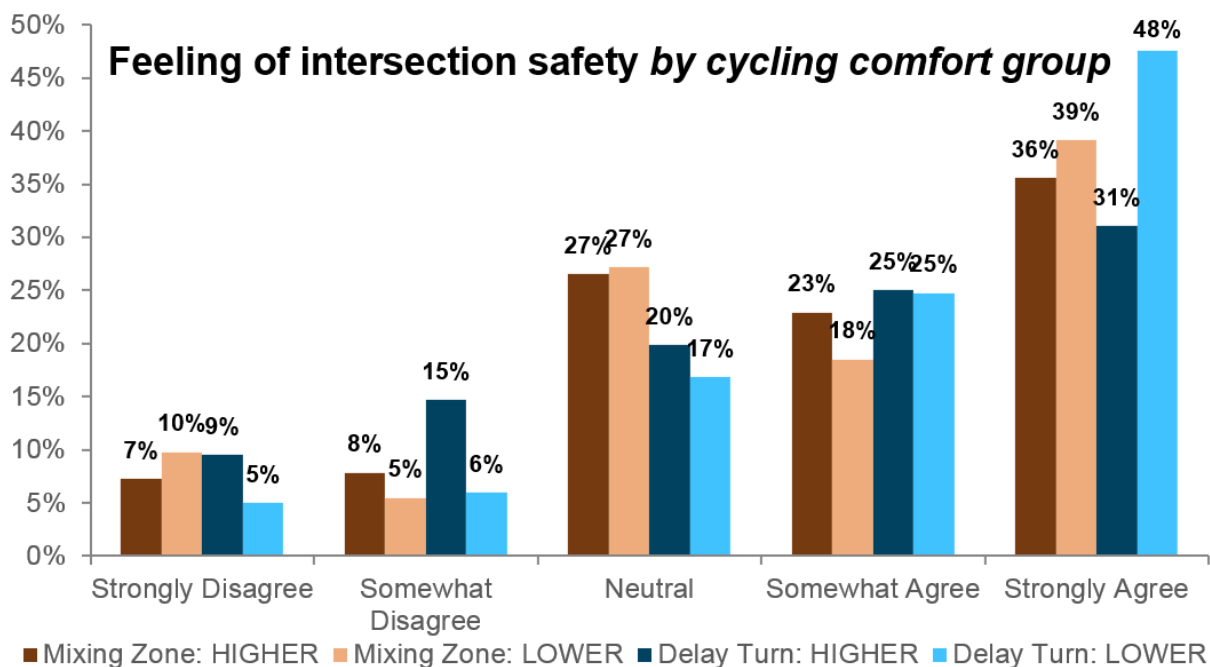
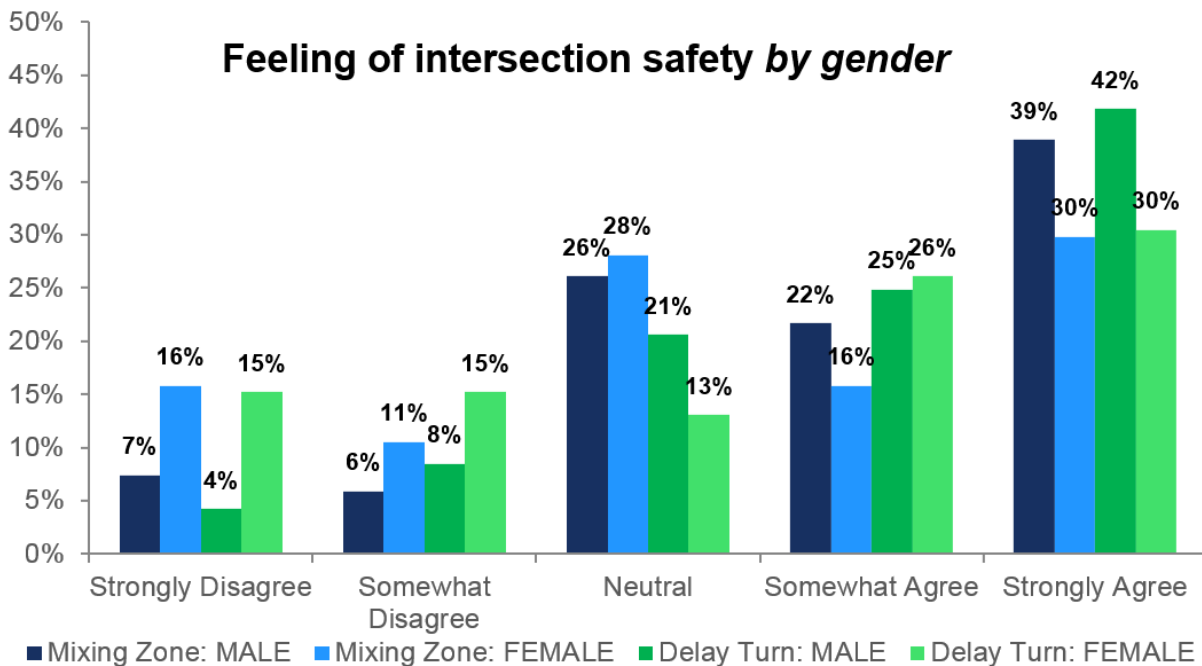
Survey Question: I feel safe cycling through this intersection

The final intersection design question asks whether they feel safe riding through the intersection. Approximately 60% of respondents at both the Mixing Zone and Delay Turn locations responded that they do feel safe. The percent of neutral responses are the highest of all the design questions.

The comparison of responses between gender is most stark in the 'strong' categories where female respondents are less likely to feel safe in either intersection type. The difference between responses is also great in the cycling comfort group where the cyclists with a lower level of comfort riding in NYC have a higher level of comfort at Delay Turn intersections.

I feel safe cycling through this intersection





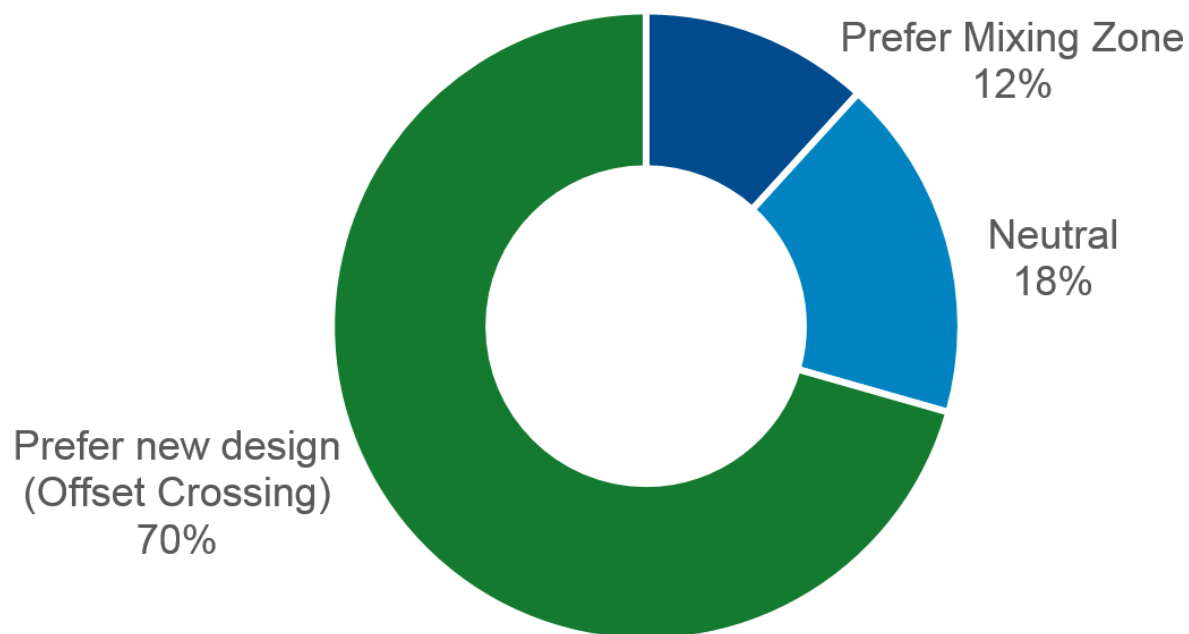
Offset Crossing Pilot

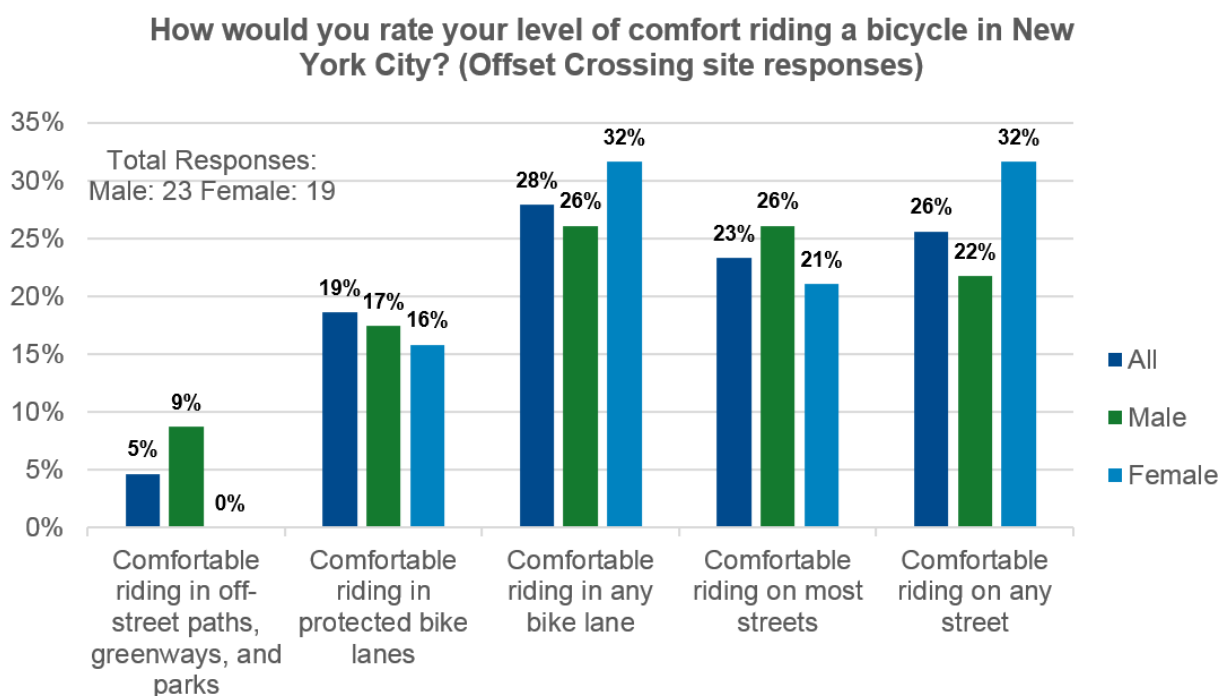
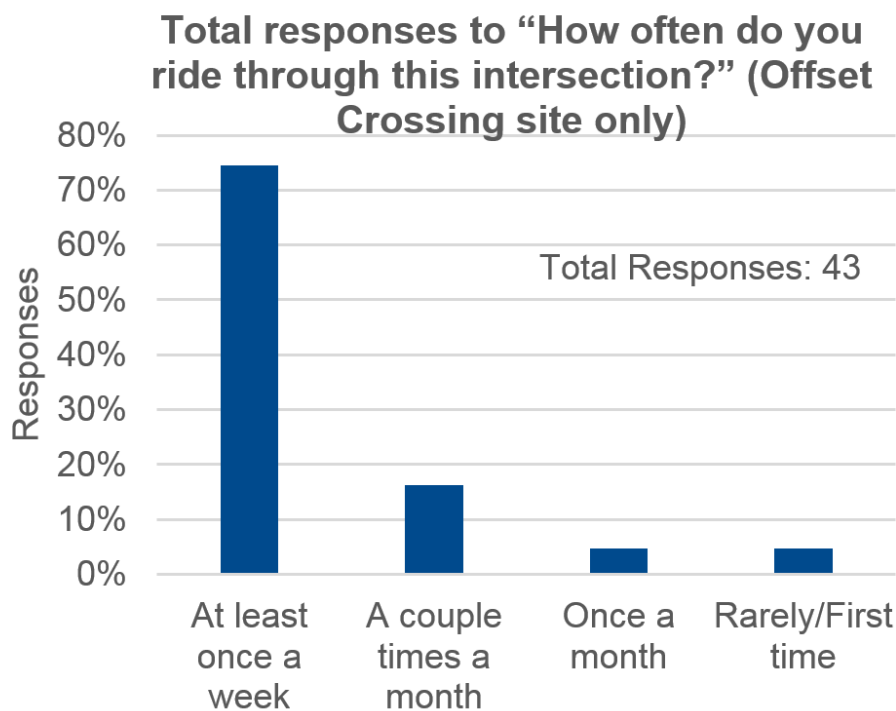
At Columbus Ave & W 70th St, the Mixing Zone was converted into a pilot Offset Crossing location. This afforded the opportunity of conducting an intercept survey for both treatments at the same location. The response rate was lower due to the cooler, late fall weather of when the pilot treatment was installed but 43 surveys were still recorded.

When asked whether the cyclists preferred the old or new design, 71% stated that they preferred the new (Offset Crossing) design and 18% were neutral.

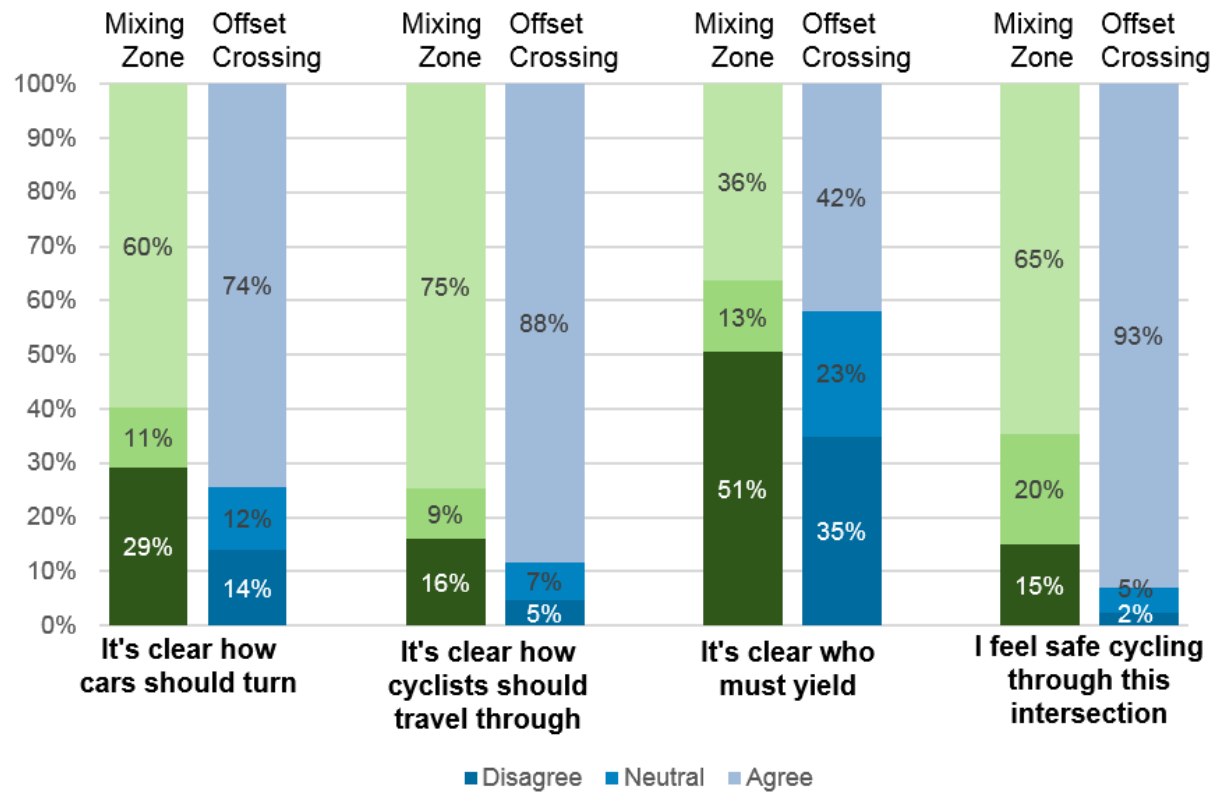
The results of the four design questions asked at Columbus Ave & W 70th St before (Mixing Zone) and after (Offset Crossing pilot) are presented for a direct comparison. Consistent with the stated preference for the Offset Crossing, the feeling of safety is much greater when compared to the Mixing Zone. The clarity of vehicle turns is also greatly increased but the confidence in knowing who should yield remains low.

The NYC DOT recently changed the design of this intersection, if you noticed a difference, which intersection design do you prefer? (43 responses)





Comparison of before (Mixing Zone) and after (Offset Crossing pilot) cyclist intercept survey responses at Columbus Ave & W 70th Street



Survey Key Findings

The intercept surveys of **530 cyclists** at riding in PBLs revealed that:

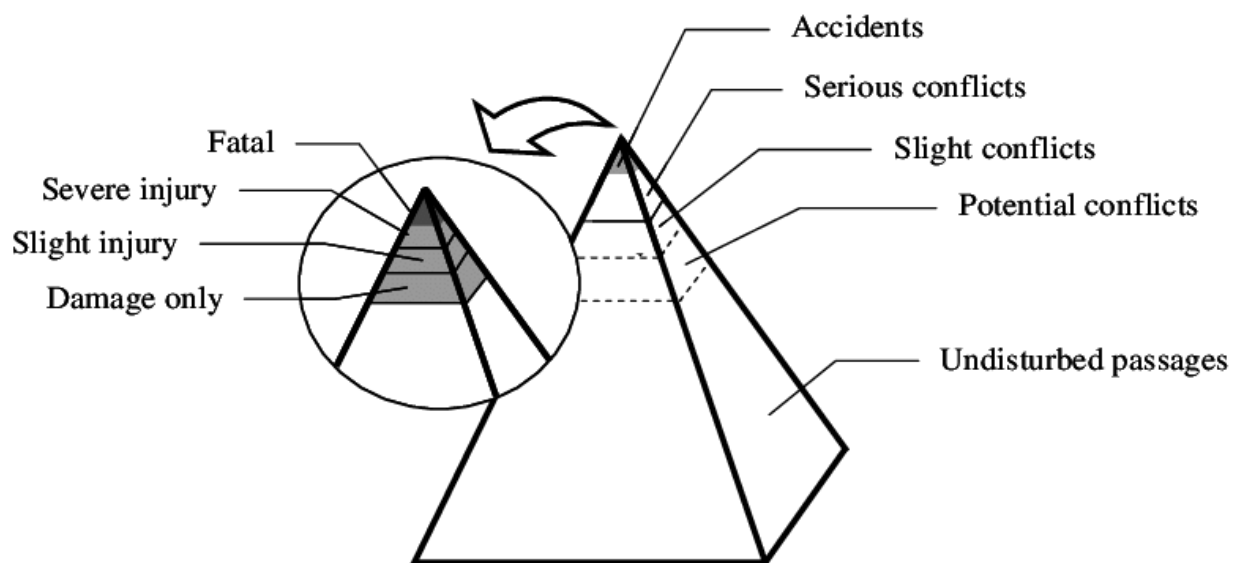
- 42% of the respondents only feel comfortable riding on streets with bike lanes or paths. For female respondents, this rate is 50%.
- When asked whether the intersection designs made it clear who must yield, 55% of cyclists at Mixing Zones said that it did not. Female cyclists overwhelmingly responded (66%) that yielding is unclear at Mixing Zones. At the Delay Turn treatment, 40% of the respondents state that it is unclear who should yield.
- In terms of comfort, approximately 60% of respondents at both the Mixing Zone and Delay Turn locations report that they feel safe riding through them. Additionally, the percent of neutral responses are the highest of all the design questions. However, approximately 30% of female cyclists at both of the intersection types stated that they do not feel safe.
- Where the pilot Offset Crossing replaced a Mixing Zone, 71% of the cyclists stated that they preferred the new (Offset Crossing) design and 18% were neutral.
- The Offset Crossing also appears to be clearer about how cars should turn but there is still ambiguity about who must yield.
- When asked about safety, 93% of the respondents stated that they feel safe riding through the intersection.

Observational Study

Method

As a complementary approach to the crash analysis study, an observational study provides a method to evaluate more recent intersection designs that do not have sufficient crash data. This technique analyzes conflicts and interactions between turning vehicles and bicyclists to identify whether the designs are functioning safely and as intended. An additional benefit to using video is that observations can be made on other interactions and road user behaviors. This can help inform design modifications that incorporate bicyclist comfort and better guide people into safer behaviors.

Evaluating conflicts between road users to identify the potential for crash risk, often referred to as a surrogate safety analysis, has a long history in the traffic safety profession beginning in the 1970-1980s with the Swedish Traffic Conflict Technique (Swedish TCT) and the Dutch Objective Conflict Technique for Operation and Research (DOCTOR) method. These methods rely on the theory that there is a continuum of traffic interactions with the most severe being related to actual crashes, as demonstrated in the below figure. While traffic crashes occur too infrequently to conduct a safety analysis without often waiting years for sufficient data, the related traffic conflicts occur frequently enough to more quickly provide some insight into the safety of the study area or treatment.



Conceptual Safety Pyramid (C. Hyden, 1987)

This study recorded video at nine intersections. This video was reduced following the guidelines provided at the end of the Appendix to classify behaviors and identify conflicts. To classify the conflicts between bicyclists and turning vehicles, reviewers were asked to flag any maneuver that appeared to be greater than a normal traffic interaction. All conflicts were then scored by a single reviewer to remove any potential bias and differences in interpretation that can occur when using several observers. The conflict scoring was based on an adaptation of the DOCTOR method (see the following table) and considered both the probability of a collision and the potential severity of the consequences if a collision would have occurred.

Classification of conflicts by severity (Source: Manual conflict observation technique DOCTOR, Foundation Road Safety for All, 2013.)

| Conflict severity | Class | Definition |
|-------------------|-------|---|
| Slight | 1 | Precautionary braking or changing lanes or other anticipatory braking or changing lanes with a low probability of a collision |
| | 2 | Controlled braking or changing lanes to avoid a collision with little manoeuvring time |
| Serious | 3 | Strong braking, rapid changing lanes or stopping to avoid a collision, resulting in a near-crash (No time left for a controlled manoeuvre) |
| | 4 | Emergency braking or strong swerving resulting in a near-crash or slight collision |
| | 5 | Emergency action followed by a collision |

Locations

The locations for the observational study were selected to provide a sample of the different street characteristics where each of the PBL intersection treatments is typically applied (i.e. and turning movement volumes and cross-street lanes).

Four intersection types, Mixing Zones, Fully Split Phase, Delayed Turn, and two pilot Offset Crossing sites are evaluated. Video was recorded during weekdays in dry weather with the morning and evening peak hours analyzed.

Due to time limitations and the complexity of the video, only cyclist interactions with motor vehicles are analyzed. Cyclists riding the wrong-way, out of the bike facility, or other users of the bike lanes such as skateboards and scooters are also not included in this evaluation.

| Location | Treatment | Cross-Street Characteristics | Total study hours | Observed Avg Hourly Bike Volume | | Observed Avg Hourly Turning Vehicle Volume | |
|---|-------------------|------------------------------|-------------------|---------------------------------|-----|--|-----|
| | | | | AM | PM | AM | PM |
| 1 st Ave & E 55 th St | Delayed Turn | One lane, one-way | 12 | 86 | 366 | 260 | 147 |
| 2 nd Ave & E 26 th St | Delayed Turn | Two lanes, two-way | 12 | 138 | 382 | 137 | 91 |
| 2 nd Ave & E 74 th St | Mixing Zone | One lane, one-way | 8 | 180 | 134 | 124 | 116 |
| 6 th Ave & W 23 rd St | Delayed Turn | Two lanes, two-way | 9 | 210 | 183 | 90 | 103 |
| 8 th Ave & W 31 st St | Mixing Zone | One lane, one-way | 12 | 135 | 309 | 148 | 186 |
| Amsterdam Ave & W 85 th | Offset Crossing | One lane, one-way | 12 | 28 | 114 | 47 | 47 |
| Columbus Ave & W 70 th | Mixing Zone | One lane, one-way | 12 | 114 | 92 | 56 | 88 |
| Columbus Ave & W 70 th | Offset Crossing | One lane, one-way | 12 | 135 | 112 | 63 | 66 |
| Columbus Ave & W 72 nd | Fully Split Phase | Four lanes, two-way | 12 | 109 | 95 | 116 | 74 |

Cyclist Behaviors

At each of the nine study intersections, the video was coded to categorize bicycle and turning vehicle behaviors. For cyclists this behavior includes how they navigated an intersection when a turning vehicle was present and, if they arrived on a red signal, whether they waited until the green to go (did not run the red light).

Each of the designs have different intentions for how cyclists should negotiate the space with a turning vehicle. For example, Mixing Zones provide more space to maneuver out of the turn path of a vehicle through providing a longer conflict zone.

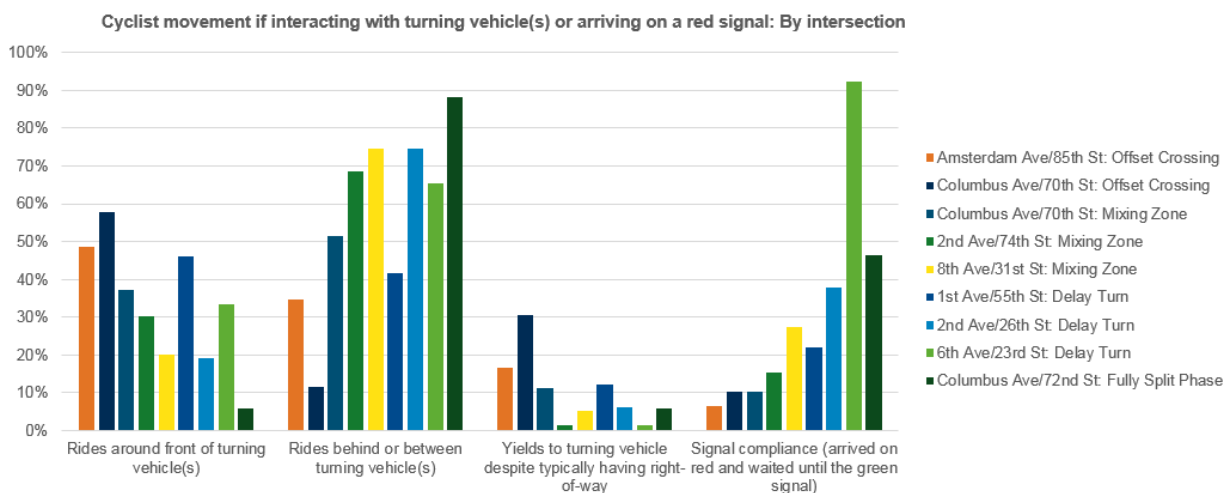
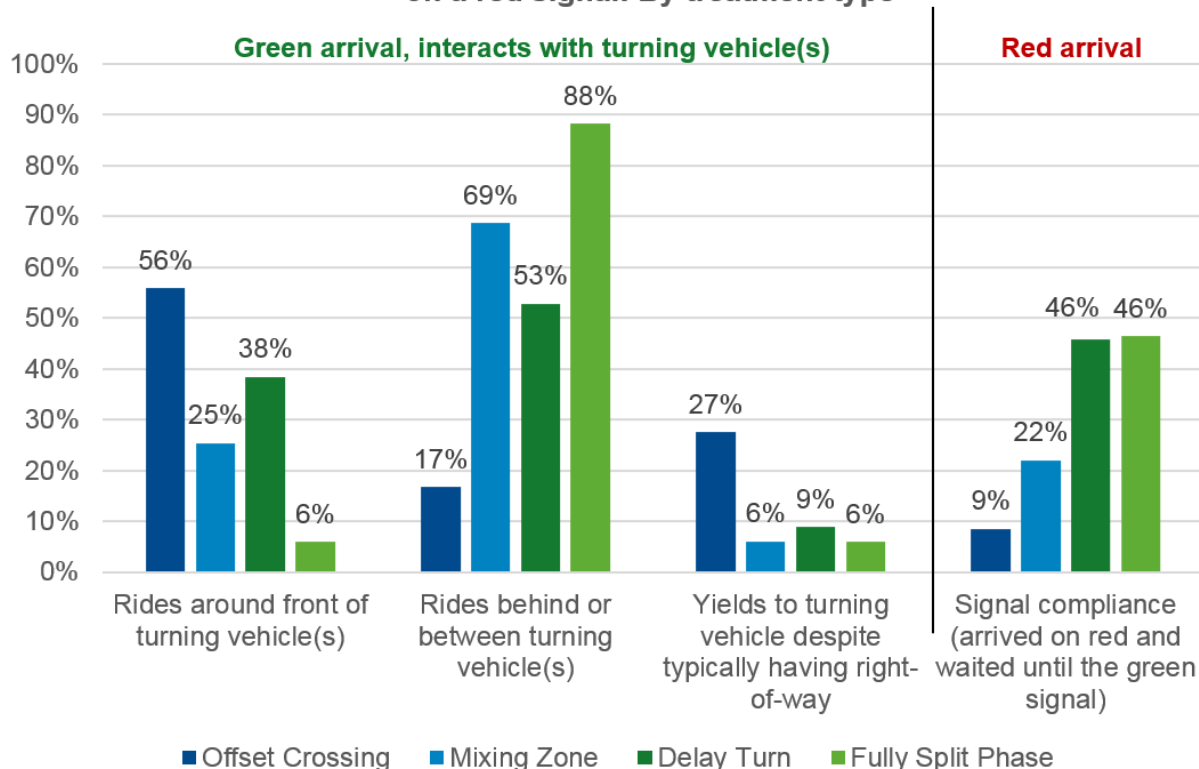
These design differences largely bear themselves out in the observed behaviors such as the Offset Crossing having the highest number cyclists riding around the front of turning vehicles. However, there are some interesting observations:

- The number of cyclists yielding to turning vehicles is the highest at Offset Crossing
- Signal compliance is quite low. The highest compliance rate occurs at wide 4-lane, 2-way streets
- The Mixing Zone & Delay Turn locations exhibit somewhat similar characteristics where cyclists at the Delay Turn location often (53%) leave the bike lane to go around the back of turning vehicles similar to how many navigate Mixing Zones

Cyclist observation summary

| Treatment | Sites | Total cyclists | Green arrival, no interaction with turning vehicles | Hours of observation |
|----------------------|-------|----------------|--|-------------------------|
| Offset Crossing | 2 | 2,068 | 1,181 | 24 |
| Mixing Zone | 3 | 5,242 | 1,984 | 32 |
| Delayed Turn | 3 | 7,227 | 3,319 | 33 |
| Fully Split Phase | 1 | 1,222 | 483 | 12 |

Cyclist movement if interacting with turning vehicle(s) or arriving on a red signal: By treatment type



Driver Behaviors

In addition to coding cyclist behaviors, driver behaviors when turning are also categorized. The percent of turns where a cyclist is present group gives a sense for the potential opportunities for a conflict between a turning vehicle and bicycle however the pedestrian volume is high at many of the study locations meaning that drivers are often already yielding to pedestrians in the crosswalk.

When drivers do yield to pedestrians or bicyclists or are forced to stop due to traffic two behaviors are measured. The first is whether the driver blocks the dashed bike lane extension through the intersection or if they keep it clear. The Offset Crossing has the highest rate of keeping the bike lane clear with the Mixing Zone being the lowest.

Another measure that is of interest in the design of intersections is their capacity handle vehicle turns without blocking the through travel lane. This is measured by the number of events where a turning vehicle or the back of the queue of turning vehicles blocks the travel lane. As expected due to the smaller size, Offset Crossings have the least capacity for handling turning vehicles. However, the Delayed Turn also saw frequent queue back-ups into the travel lane. The number of pedestrians and bicyclists crossing is certainly a large site-specific factor since it will generally take longer for each vehicle to make a turn if they are yielding to more people.

Turning vehicle observation summary

| Treatment | Sites | Total turning vehicles | % of turns with cyclist(s) present | % of yielding turning vehicle that keep the bike lane clear* | Number of events where turning vehicles block the through-travel lane^ | |
|-------------------|-------|------------------------|------------------------------------|--|--|-----------------|
| | | | | | Blocks per turning vehicle | Blocks per hour |
| Offset Crossing | 2 | 1,417 | 23% | 77% | 20 | 2.9 |
| Mixing Zone | 3 | 3,754 | 37% | 17% | 99 | 1.2 |
| Delayed Turn | 3 | 4,561 | 35% | 37% | 25 | 5.5 |
| Fully Split Phase | 1 | 1,169 | 9% | N/A | 167 | 0.6 |

*Defined as a turning vehicle that stops or slows to yield to bicyclists or pedestrians or due to traffic and keeps the bike lane extension through the intersection clear

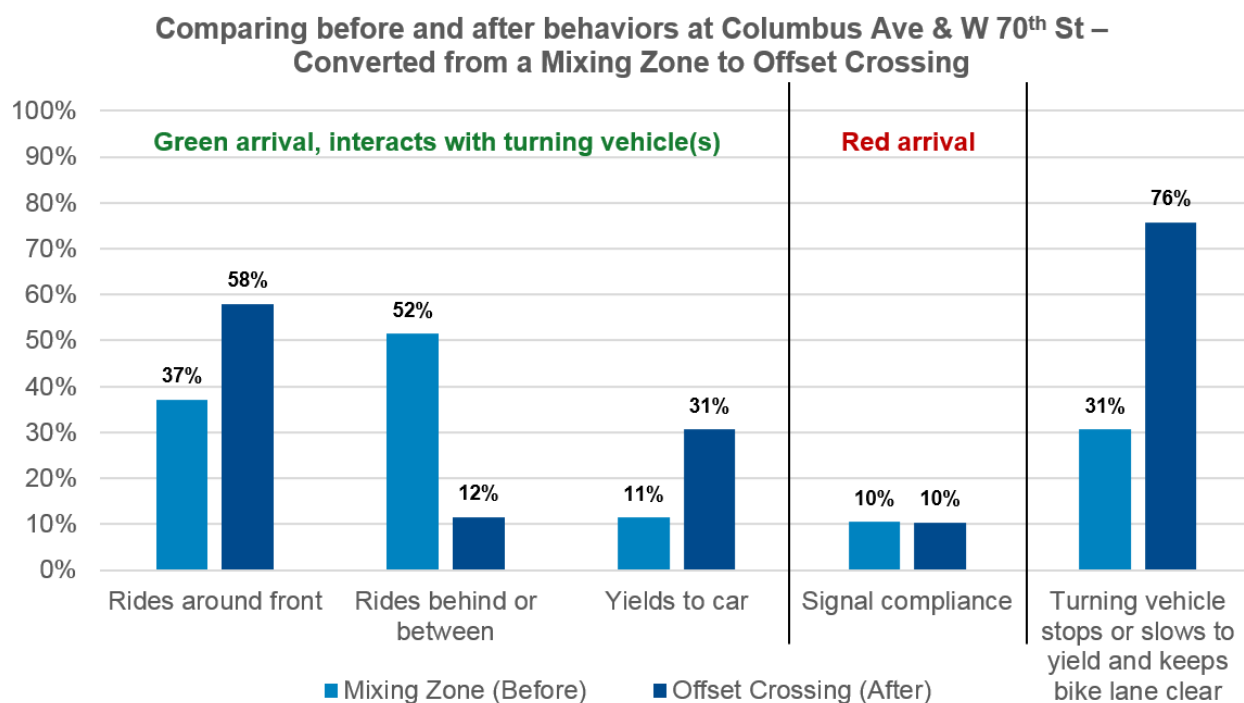
^Defined as a turning vehicle that stops to yield or due to traffic and blocks (or the back of the queue of turning vehicles blocks) the through-travel lane

Mixing Zone to Offset Crossing Conversion

At Columbus Ave and W 70th St, the Mixing Zone was converted into one of the pilot Offset Crossing locations providing a great opportunity for a direct comparison between these two designs. Several interesting observations include:

- Few cyclists leave the offset crossing markings to ride around the back of turning vehicles
- Many more cyclists yield to turning vehicles even though they have the right-of-way
- The cyclist signal compliance rate remained low
- Drivers kept the bike lane clear at a much higher rate with the Offset Crossing design

Note that before and after bicycle intercept surveys at this location were also conducted.



Conflict Analysis

The following tables provide the number of conflicts observed at each site. These are raw observations but are used to demonstrate the rarity of the more serious types of conflicts. The majority of conflicts are coded as level 1 meaning that a crash was unlikely but some precautionary measures were still taken. No serious crashes were observed.

Summary of conflicts by treatment type (note: these are total observations for each treatment - sample sizes vary)

| Treatment | Sites | Conflict 1: Slight | Conflict 2: Slight | Conflict 3: Serious | Conflict 4: Serious | Conflict 5: Crash |
|-------------------|-------|-----------------------|-----------------------|------------------------|------------------------|----------------------|
| Offset Crossing | 2 | 25 | 8 | 2 | 0 | 0 |
| Mixing Zone | 3 | 123 | 64 | 8 | 1 | 0 |
| Delayed Turn | 3 | 93 | 30 | 2 | 1 | 0 |
| Fully Split Phase | 1 | 16 | 1 | 0 | 0 | 0 |

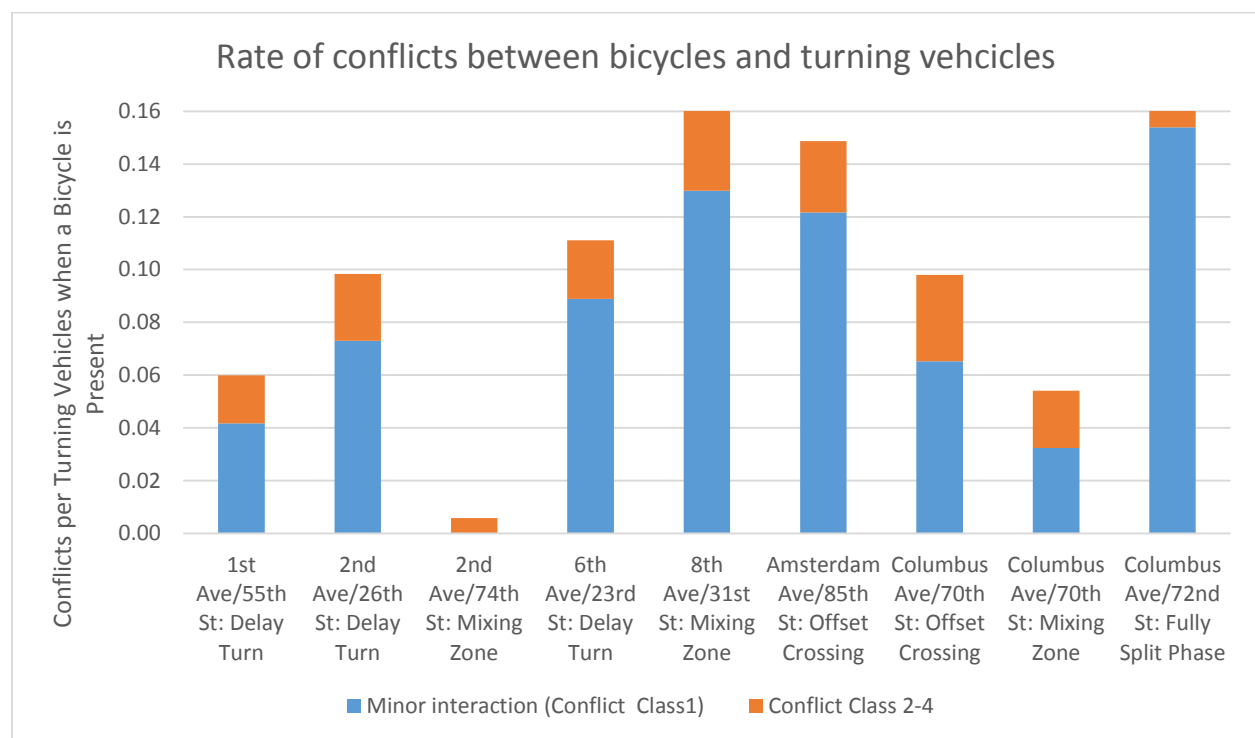
Summary of conflicts by location (note: these are total observations for each location - sample sizes vary)

| Treatment | Hours | Conflict 1: Slight | Conflict 2: Slight | Conflict 3: Serious | Conflict 4: Serious | Conflict 5: Crash |
|---|-------|-----------------------|-----------------------|------------------------|------------------------|----------------------|
| 1st Ave/55th St: Delay Turn | 12 | 39 | 15 | 1 | 1 | 0 |
| 2nd Ave/26th St: Delay Turn | 12 | 26 | 8 | 1 | 0 | 0 |
| 2nd Ave/74th St: Mixing Zone | 8 | 0 | 0 | 0 | 1 | 0 |
| 6th Ave/23rd St: Delay Turn | 9 | 28 | 7 | 0 | 0 | 0 |
| 8th Ave/31st St: Mixing Zone | 12 | 111 | 56 | 8 | 0 | 0 |
| Amsterdam Ave/85th St: Offset Crossing | 12 | 9 | 2 | 0 | 0 | 0 |
| Columbus Ave/70th St: Offset Crossing | 12 | 16 | 6 | 2 | 0 | 0 |
| Columbus Ave/70th St: Mixing Zone | 12 | 12 | 8 | 0 | 0 | 0 |
| Columbus Ave/70th St: Fully Split Phase | 12 | 16 | 1 | 0 | 0 | 0 |

Conflicts by Site

Examining each intersection individually provides a more nuanced understanding of the variations in behaviors, even between intersections of the same treatment type. Interesting findings include:

- At Columbus Ave & W 70th St where an Offset Crossing replaced a Mixing Zone there was a slight increase in the total interaction rate and two Level 3 (more serious) conflicts were observed where none were observed in the before period.
- There is a large difference in conflict rates between the different Mixing Zone intersections; the 2nd Ave & E 74th St location has the lowest conflict rate of all the study intersections while the 8th Ave & W 31st St intersection has the highest. These rates account for both cyclist and turning vehicle volumes.



Additional observations

While reviewing the video for conflicts, several additional observations have been made that do not fit into the study's categorization but are summarized here:

Offset Crossing

- Due to speed of turns, there is little reaction time for cyclists to determine whether a driver will yield. Drivers often brake rapidly further reducing the reaction time.
- When multiple vehicles are turning it appears to be particularly difficult to determine whether the car(s) in queue will yield

Delay Turn

- Several instances were observed where the Leading Interval phase ends and the Flashing Yellow Arrow turns on just as a cyclist is approaching the intersection and the driver does not yield to cyclists.

Mixing Zone

- There is a mix in how cyclists navigate Mixing Zones with turning vehicles present; some go behind, others in front, even when arriving as a group
- Parking in Mixing Zone and taper leads to blind spots and more aggressive turning behavior

Fully Split Phase

- Cyclists often violate the signal during the protected left-turn phase. There is a mix between cyclists continuing in the bike lane and those merging into the turn lane to continue straight.

Other observations

- Cyclists going around front of turning vehicles can be forced to swerve into the crosswalk by the turning vehicle
- Queue spillbacks into the travel lane leads to double turns when drivers attempt to skip the queue, these double turns may to be more dangerous due to their unexpected nature and blocked view of the bike lane
- Double parking in the through lane adjacent to the left turn leads to wider and more dangerous turns
- EXAMPLES OF OBSERVED BEHAVIORS FROM VIDEO SCREENSHOTS:



Example of a driver bypassing the turning queue and making a double turn at a Mixing Zone location



Example of a driver bypassing the turning queue and making a double turn at a Mixing Zone location



Example of a wider turn due to a truck parked in the mixing zone taper



Cyclists at Delayed Turn locations exhibit similar behaviors for going around the front or rear of turning vehicles



Example of cyclists in a Mixing Zone weaving through or behind turning vehicles

Observational Study: Key Findings

- Likely due to the turn speeds and reaction time, Offset Crossings were observed to have the highest proportion of cyclists yielding to turning vehicles and a slightly higher bicycle-vehicle interaction rate when compared to the Mixing Zone
- Compared to the Mixing Zone, drivers kept the bike lane clear at a much higher rate with the Offset Crossing design
- Signal compliance at all sites is low. The highest compliance rate is at the Fully Split Phased location and a Delay Turn location, both of which cross a wide 4-lane, 2-way street with heavy pedestrian volumes
- The Mixing Zone & Delay Turn locations exhibit similar characteristics where cyclists at the Delay Turn location often leave the bike lane to go around the back of turning vehicles similar to how many navigate Mixing Zones
- When the Flashing Yellow Arrow first turns on (from red) at a Delay Turn location, there is a frequent conflict with cyclists as turning vehicles start without checking the bike lane
- Offset Crossings have the least capacity for handling turning vehicles.
- At Columbus Ave & W 70th St where an Offset Crossing replaced a Mixing Zone there was a slight increase in the total interaction rate and two “more serious” conflicts were observed where none were observed in the before period.
- Conflict rates vary considerable between intersections, even when accounting for cyclist and turning vehicle volumes.
- Double parking and parking in Mixing Zones and their taper leads to blind spots and more aggressive turns

Bicycle Intersection Interaction Video Data Reduction Guide

General notes

- Only count cyclists in the bike lane – DO NOT count skateboards, hoverboards, scooters, delivery hand trucks, etc.
- DO NOT count cyclists riding the wrong-way
- DO NOT count cyclist riding on the far side of the street from the bike facility, only count those who approach the intersection in, or adjacent to, the upstream bike facility
- Only count cyclists who cross to the far side of the intersection, if they turn but do so on the far side they should be counted, if they turn on the near side or get off their bike and walk, do not code

Cyclist Fields

This group of fields should be coded for all cyclists that travel through the intersection in, or adjacent to, the left side bike facility. Code each bike only once so that the sum is the total number of cyclists passing through with no double counting.

GREEN/YELLOW SIGNAL ARRIVAL

Whether the bicyclist arrived at the intersection on the green or yellow signal indication (legal crossing). At many sites this may be observed by viewing the pedestrian signal indication which should be in WALK or FLASHING DON'T WALK.

No interaction

Cyclist rode through the intersection in the mixing zone or through bike lane and passed through with no interaction or interference with any motor vehicle (no vehicle is present).

Cyclist rides around front of yielding vehicle

The motor vehicle yields to the cyclist or pedestrians and the cyclist rides around the front of the car.

Cyclist rides behind or between yielding vehicles

Motor vehicles are either yielding to pedestrians or slowly moving in the queue to turn and the cyclist rides between vehicles or behind the last vehicle in the queue.

Cyclist yields to turning vehicle

Code if they stop or significantly slow to intentionally allow the vehicle to pass before them, but it is a civil exchange with no obvious conflict, braking, or swerving.

RED SIGNAL ARRIVAL

Whether the bicyclist arrived at the intersection on the red signal indication. At many sites this may be observed by viewing the pedestrian signal indication which should be in DON'T WALK.

Cyclist runs red light (either stops or continues without stopping)

If a cyclist was required to stop for a signal, whether he or she stopped and remained stopped until the signal turned green.

Cyclist complies with signal (complies with signal then only flag if a conflict occurs (driver cuts off))

Code if the cyclist complies with red signal. If a potential conflict occurs as the cyclist traverses the intersection area then it could *additionally* be flagged as a potential conflict. To avoid double counting, do not use any of the green/yellow signal arrival codes.

Turning vehicles

This group of fields should be coded for all drivers that make a left turn across/through the bike facility at the intersection.

BICYCLE(S) IS PRESENT IN THE INTERSECTION AREA – YES/NO

Whether a cyclist (an individual or multiple cyclists) is present in approach or turn space of an intersection [see figure] at the time that a vehicle is beginning their turn.

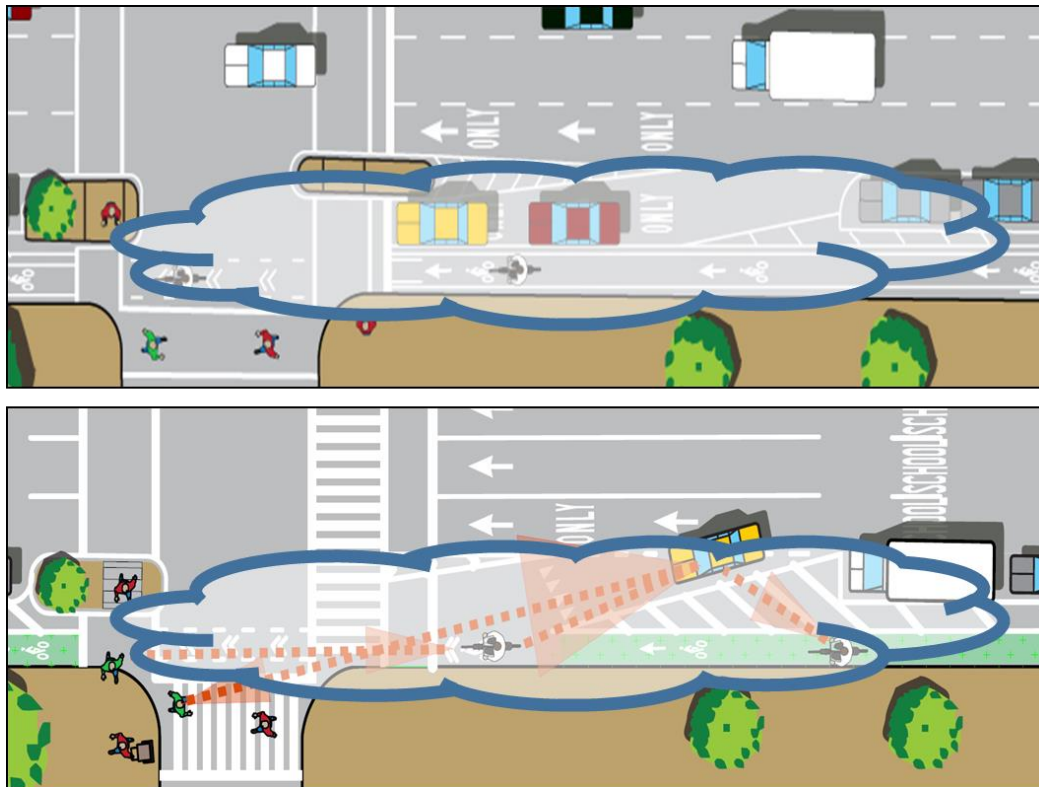


Figure 1: Examples of approximate approach and turn space at an intersection

Code each turning vehicle individually even if in a queue. If the a cyclist arrives while the vehicle is in queue those vehicles should be recorded as 'YES' a bicycle is present even if the cyclist rides around the back of the queue.

If there is a queue of vehicles on red and bicycles waiting on red than the first vehicle should be recorded as 'YES' and the subsequent vehicles should be based on whether additional cyclists arrive or that the waiting cyclists are blocked by the first vehicle who does not yield to them.

Each turning vehicle should be recorded once so that the sum of the YES and NO codes totals ALL of the turning vehicles observed.

TURNING VEHICLE STOPS

Code if the turning vehicle stops *or slows to a crawl* to yield to cyclists or pedestrians or the side street is otherwise blocked. *The crosswalk is not always visible in the video so some assumption is required.* If so, then code as EITHER:

Vehicle keeps the bike lane (or bike lane extension) clear

The vehicle stops short of the extension of the bike lane through the intersection to allow for a clear path of travel for cyclists.

Vehicle blocks the bike lane (or bike lane extension)

The vehicle stops IN the extension of the bike lane through the intersection. This should be a clear infringement where the vehicle blocks the majority of the bike lane or otherwise blocks the path of cyclists so that they must either stop or significantly divert. TEMPORARY INFRINGEMENTS THAT ARE PART OF THE TURNING PROCESS SHOULD NOT BE COUNTED. *For example, if a driver yields to a pedestrian and slowly rolls through/blocks the bike lane extension but there is no bike present on that block then do not consider this an infringement.*

VEHICLE BLOCKS THROUGH LANE WHILE QUEUING TO TURN

The turning vehicle or the back of the queue of turning vehicles blocks the through or shared through/left travel lane.

Code each instance once. If multiple vehicles in a queue are blocking the lane, this is one instance.

If a vehicle (likely a truck) is blocking approximately more than 1/3 of the lane then this should be coded as a blocked lane.

Possible conflict (mm:ss)

Flag all potential conflicts between motorists and cyclists with a timestamp for further review. POSSIBLE conflicts should be liberally defined to include any interaction between motorists and cyclists where one or both of parties slowed or changed trajectory in a fashion that was slightly (or greatly) less typical than a normal interaction. Examples include:

- A car passing closely behind or in front of a bicyclist at a non-cautious speed
- A cyclist cutting off a moving vehicle that may have had the right-of-way
- Rapid braking
- Swerving
- Hand gestures indicating that someone feels like the other did not behave appropriately
- An actual collision

Err on the liberal side with flagging these conflict events. All events will be reviewed and coded by NYC DOT.

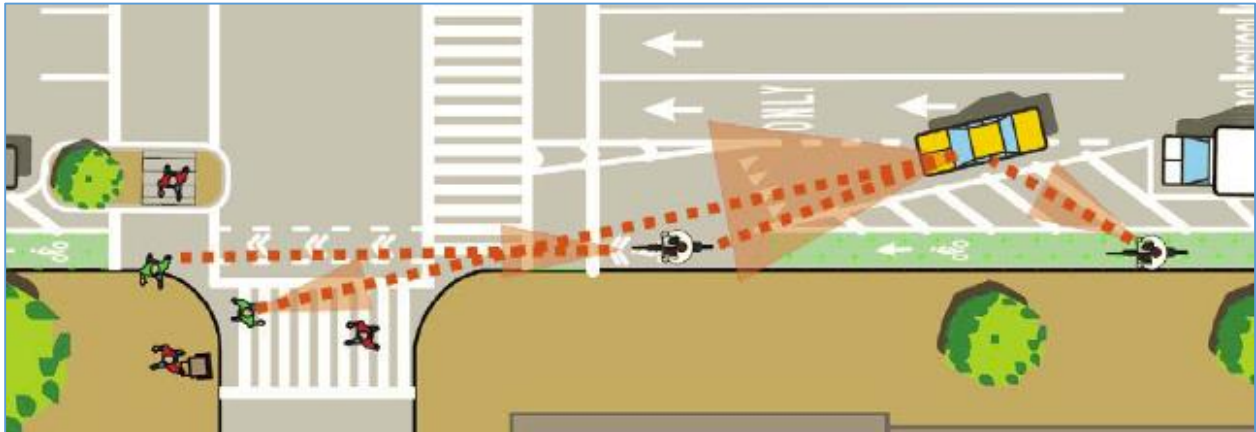
Additional Notes

Use this optional space for additional observations or notes of anything unusual (i.e. construction or other blockage or closures, drivers frequently running lights, driving over islands, cyclists leaving the lane, a noticeable amount of bicycle/pedestrian conflicts). This space can also be used to make notes on questionable types of interactions that were not coded.

Intersection Specific Comments

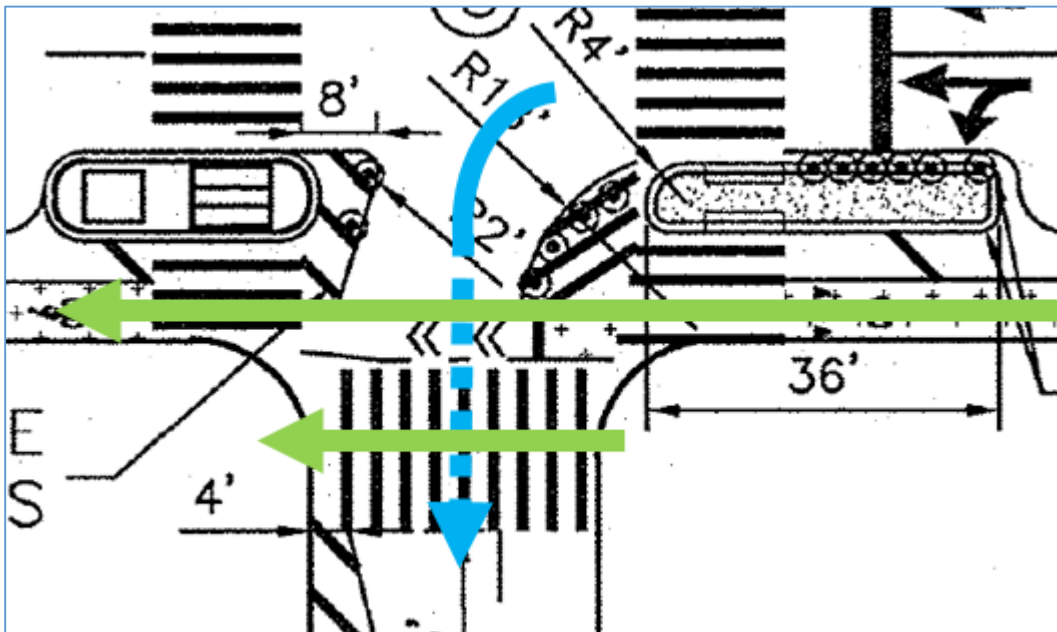
Amsterdam/85th before

Standard mixing zone, bicycles and turning vehicles are intended to merge prior to the intersection.



Amsterdam/85th after

New “offset crossing” design, the bike lane is set back from the intersection, turning vehicles are to yield to cyclists and pedestrians crossing the street.



Columbus/70th before

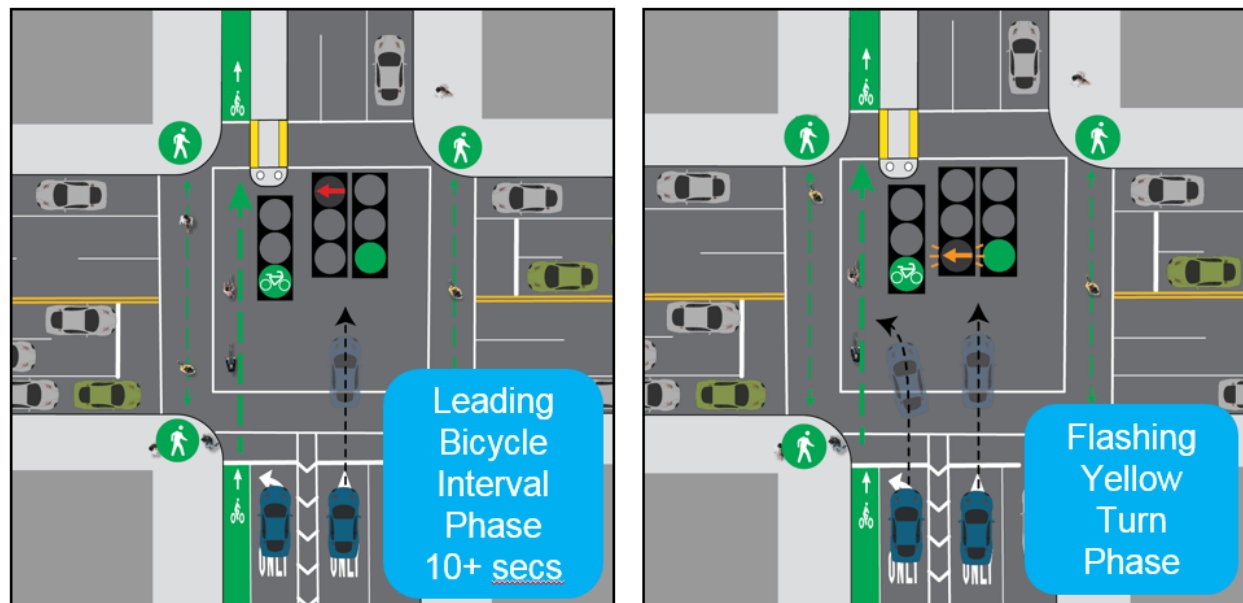
Standard mixing zone, bicycles and turning vehicles are intended to merge prior to the intersection.

Columbus/70th after

New “offset crossing” design, the bike lane is set back from the intersection, turning vehicles are to yield to cyclists and pedestrians crossing the street.

1st/55th

Split Leading Bicycle Interval (Delayed Turn) treatment. Cyclists and pedestrians are given a 7 sec leading interval along with northbound vehicles. Left turns are held for those 7 seconds and are then giving a Flashing Yellow Arrow signal indication to allow left turns after yielding to bicycle and pedestrian traffic.



6th/23rd

Split Leading Bicycle Interval (Delayed Turn) treatment

8th/31st

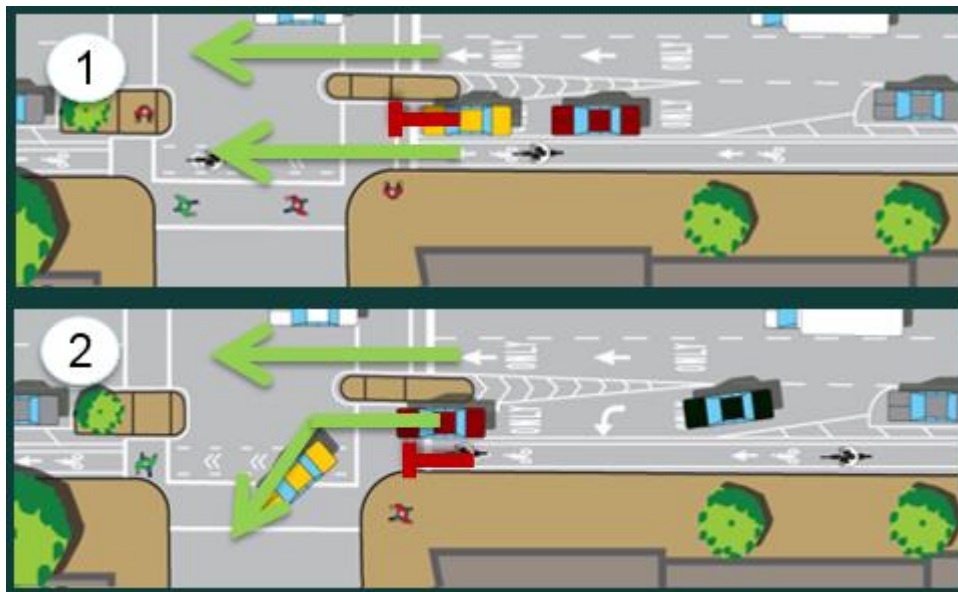
Standard mixing zone

1st/85th

Standard mixing zone

8th/19th

Full split phase treatment where the bicycles and pedestrian through movement has a protected phase followed by a signal phase for the turning movement. IN THE VIDEO, BICYCLES HAVE A GREEN INDICATION DURING THE PEDESTRIAN WALK/FLASHING DON'T WALK PHASE. During DON'T WALK, vehicles have an exclusive phase, any bicycles would be considered running the red light here even if they merge into the turn lane. In this scenarios there *should be* no conflicts since cyclists and turn movements are separated in time but in reality cyclists (and likely some drivers) will proceed when they have the red – record these violations (cyclist red light running) and any conflicts that occur.



2nd/26th

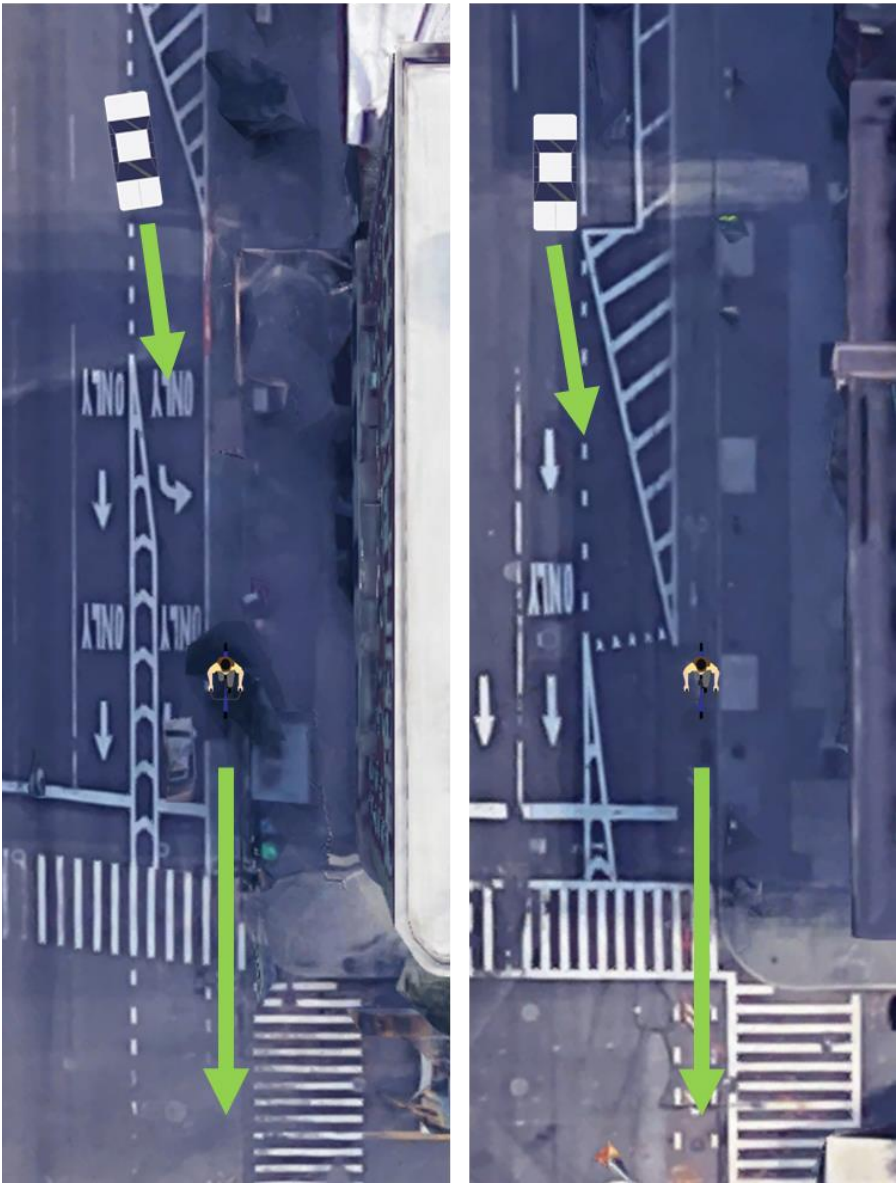
Split Leading Bicycle Interval (Delayed Turn) treatment

Columbus/72nd

Full split phase treatment where the bicycles and pedestrian through movement has a protected phase followed by a signal phase for the turning movement. IN THE VIDEO, BICYCLES HAVE A GREEN INDICATION DURING THE PEDESTRIAN WALK/FLASHING DON'T WALK PHASE. During DON'T WALK, vehicles have an exclusive phase, any bicycles would be considered running the red light here even if they merge into the turn lane. In this scenarios there *should be* no conflicts since cyclists and turn movements are separated in time but in reality cyclists (and likely some drivers) will proceed when they have the red – record these violations (cyclist red light running) and any conflicts that occur.

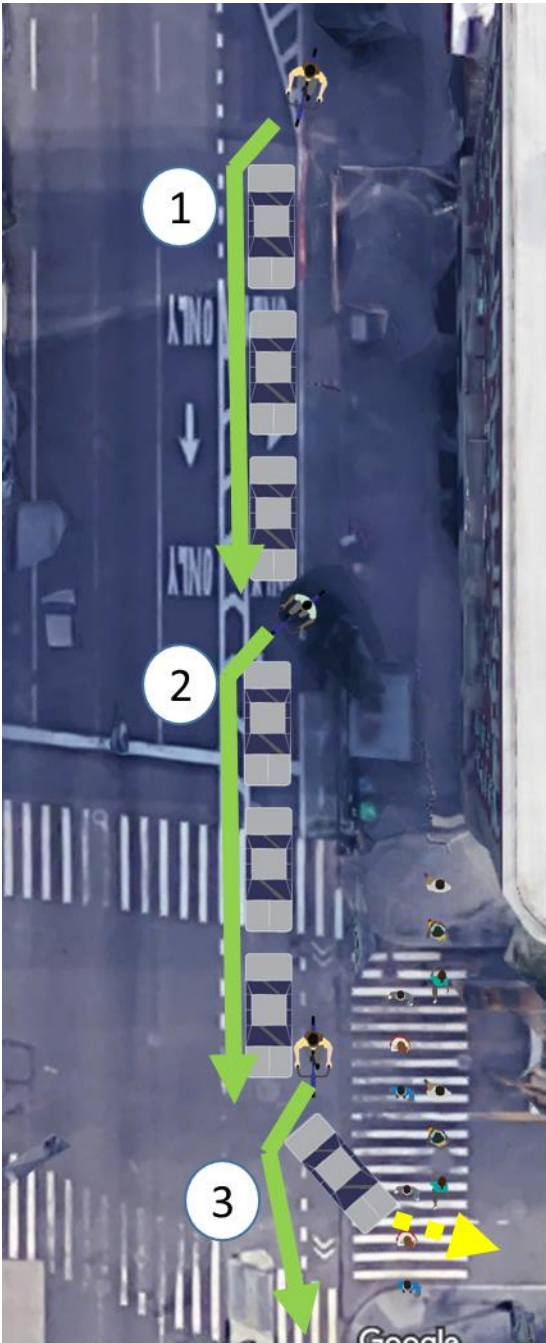
Example Interaction Diagrams

Example Scenarios:
No interaction

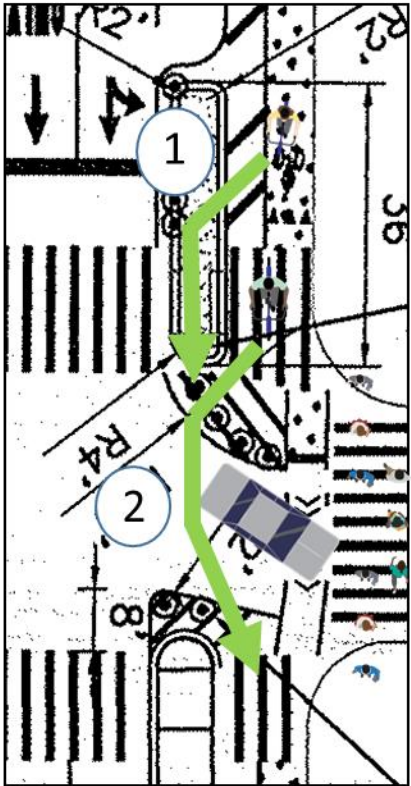


Example Scenarios:
Rides around front





Example Scenarios:
Rides behind or between

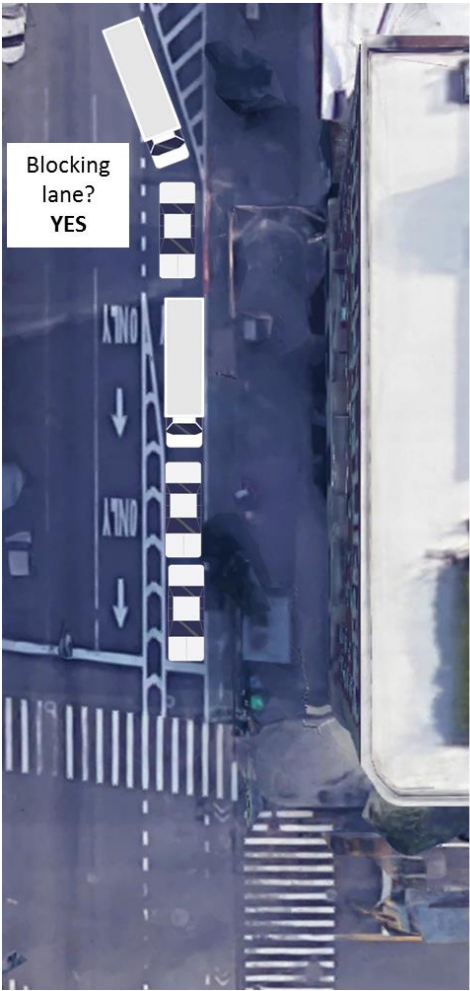


Example Scenario:
Yields to car



Example Scenarios:
Blocks bike lane? Y/N





Example Scenarios:
Queue blocks travel lane

