Understanding Pedestrian Behaviors and Traffic Controls at Signalized Crosswalks for Safety Improvements in Japan and USA

Presented by

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Moderator: Lee Kim

Purpose:

Examine how crosswalk geometry and signal timing/indication impact pedestrian speed and decision making process.

Review current traffic control policies and discuss ways improve safety at signalized crosswalks.

This webinar will:

Provide general introduction about existing design and operational policies for pedestrians at intersections in different countries.

Examine pedestrian behavior and traffic controls at crosswalks in US.

Examine **p**edestrian behavior at crosswalks in Japan considering the effect of signal timing.

Concepts of Traffic Signal Control for Pedestrians in Different Countries

Miho IRYO-ASANO, Associate Professor

Institute of Industrial Science

The University of Tokyo, JAPAN

Problem Statement

Pedestrian-vehicle conflicts are common safety problems.

- More than one-third of the total number of fatalities in traffic accidents were pedestrians
- 29% of pedestrian fatalities (42% of elderly fatalities) can be attributed to illegal crossing behavior

(National Police Agency in Japan, Accident statistics in 2011)

5th Ave and 42nd St in New York, USA

Hachiko intersection in Shibuya, Tokyo, Japan

Problem Statement ……cont.

Intersections at the common locations for ped-veh conflicts

- At signalized intersections pedestrian streams are controlled through three intervals:

Walk (Green)

Clearance (Flash green, red or yellow)

Don’t Walk (Red)

The time required by pedestrians who enter the crosswalk at the end of the green indication to complete crossing before conflicting vehicular traffic movements are released

Problem Statement ……cont.

Walk (Green)

Clearance (Flash green, red or yellow)

Don’t Walk (Red)

- Different practices i… defining …
- Diffe… …ime

These different practices affects pedestrian behavior and leads to different patterns

⇓

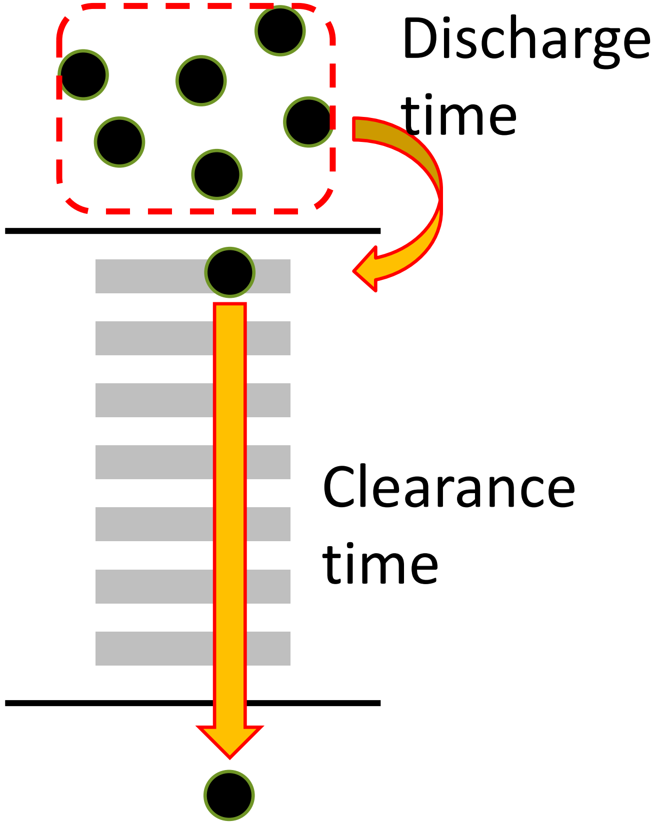
What is the most efficient signal design in terms of pedestrian compliance


Germany


…pan

Functions of pedestrian green phase

Theoretically, the pedestrian phase consists of:



Discharge time: Time required for pedestrians to leave curbs or shoulders

→ Dependent on the reaction time, pedestrian demand and crosswalk width

Clearance time: Time required for crossing pedestrians to complete crossing

→ Dependent on walking speed and crosswalk length

Definitions of pedestrian signal indications in US

Walk → Pedestrians are able to proceed → Time for all waiting pedestrians to start crossing (7 s reaction time + queue discharge time)

Discharge time

Flashing don't walk → Pedestrians should not start crossing →

$$\frac{\text{Crosswalk length}}{\text{Walking speed}}$$

Walking speed: 3 ~ 3.5ft/s (0.9 ~ 1.1m/s)

Clearance time

Don't walk → Pedestrians should not start crossing

Definitions of pedestrian signal indications in Japan

Green

Flashing Green

Red

By: Order of Enforcement of Road Traffic Act in Japan

Definitions of pedestrian signal indications in Japan

Green → Pedestrians are able to proceed

Flashing Green → Pedestrians should not start crossing. Pedestrians who are on the crosswalks have to complete crossing or **<u>give up crossing and return</u>** to the origin side **<u>immediately</u>**.

Red → Pedestrians should not cross roads

By: Order of Enforcement of Road Traffic Act in Japan

How to set minimum green/flashing green time in Japan

Green → Pedestrians are able to proceed → Crosswalk length / Walking speed 1.0m/s (3.3ft/s)

Flashing Green → Pedestrians should not start crossing. Pedestrians who are on the crosswalks have to complete crossing or **<u>give up crossing and return</u>** to the origin side **<u>immediately</u>**.

→ Crosswalk length/2 / Walking speed

1~1.5 m/s (3.3~4.9 ft/s)

Those who are on the first half should return

Immediately

Red → Pedestrians should not cross roads

Pedestrian signal indications in Germany

Green → Pedestrians can proceed →

$$\frac{\text{Crosswalk length /2}}{\text{Walking speed}}$$

1~1.5 m/s (3.3~4.9 ft/s)

Red → Pedestrians should not start crossing → Provide following time before the start of green on the crossing road

$$\frac{\text{Crosswalk length}}{\text{Walking speed}}$$

1~1.5 m/s (3.3~4.9 ft/s)

Pedestrian signal indications in UK (Puffin control, midblock crosswalks)

Green → Pedestrians can proceed → $\frac{\text{Crosswalk length /2}}{\text{Walking speed}}$

1.2 m/s (3.9 ft/s)

Blackout → Pedestrians should not start crossing → Fixed time + extension time considering the existence of crossing pedestrians

With pedestrian detection system

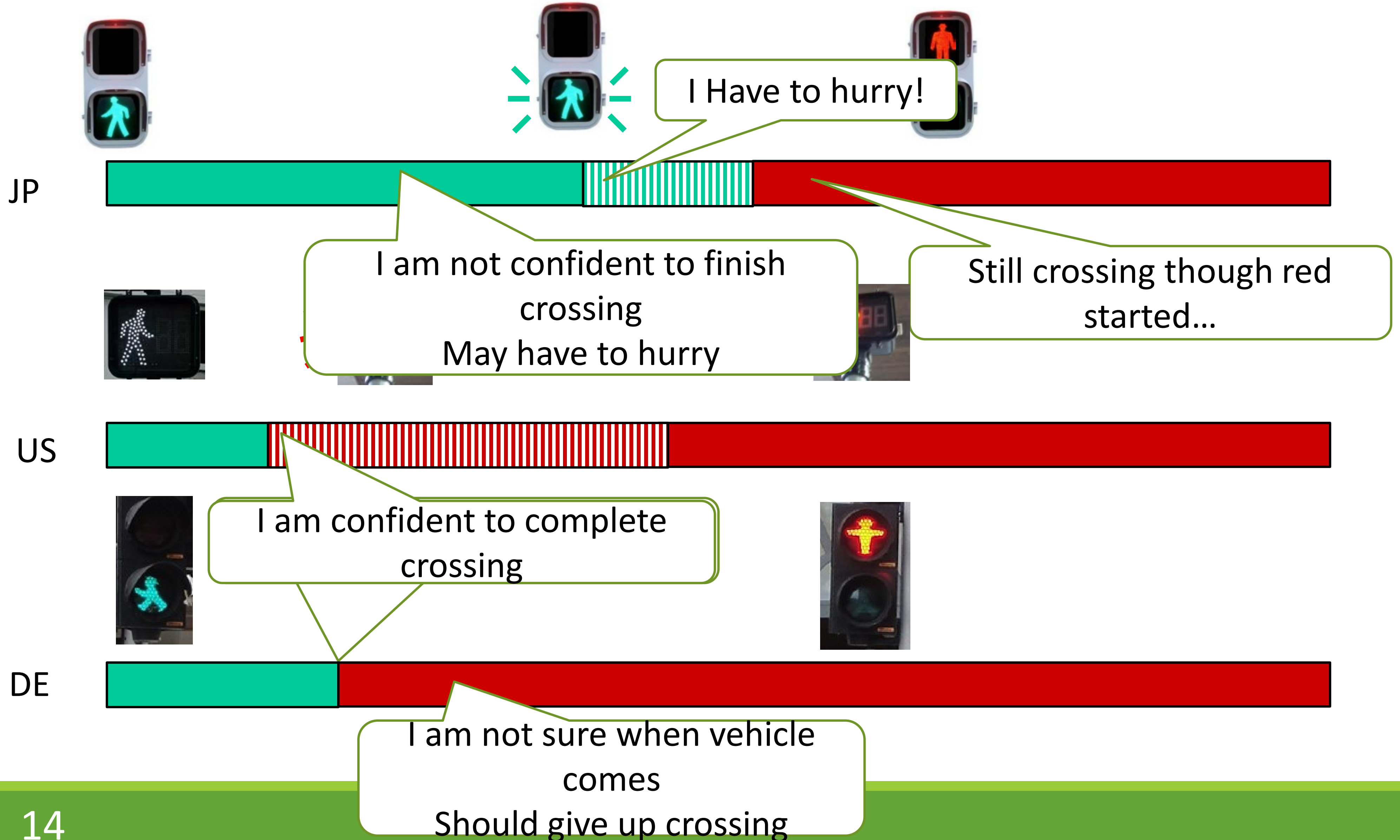
Red → Pedestrians should not start crossing

Locations of signal indicator: Puffin control in UK

Located only at Nearside
"Green" → "Blackout" → "Red"
Clearance time is adjusted by detecting existence of pedestrians on crosswalks

Pedestrian compliance becomes better than indicators located at farside

Difference of definition causes different user behavior

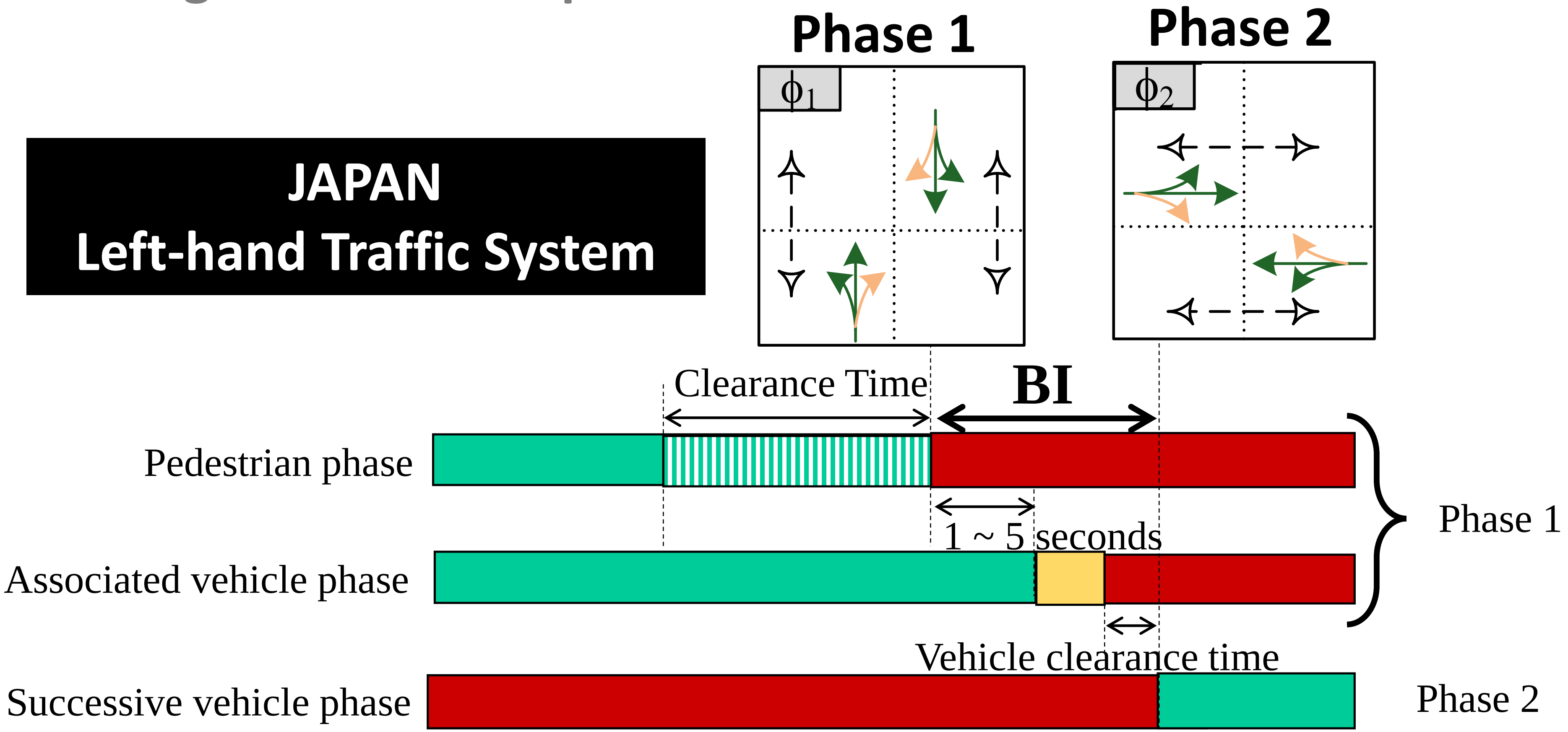


Buffer Intervals BIs in Japan

BIs are the time between the end of the PFG and the succeeding vehicle green indication.

- Ideally provided to increase the capacity of left-turners by avoiding conflicts with pedestrians

JAPAN
Left-hand Traffic System



Summary of Pedestrian Clearance Time

Japan

- Short PFG (**pedestrian have to return if the did not finish crossing half of the crosswalk**)
- Long Buffer Intervals BI (**5 -10 sec**)

US

- Long Flashing Don't Walk
- Medium BIs (**3 -5 sec**)

Germany

- Clearance interval is indicated by red
- Clearance and BIs can not be distinguished
- Low capacity

Pros and cons will be discussed in the following presentations

Qatar Road Safety Studies Center

Qatar University

Pedestrian Behavior at Signalized Intersections in Japan

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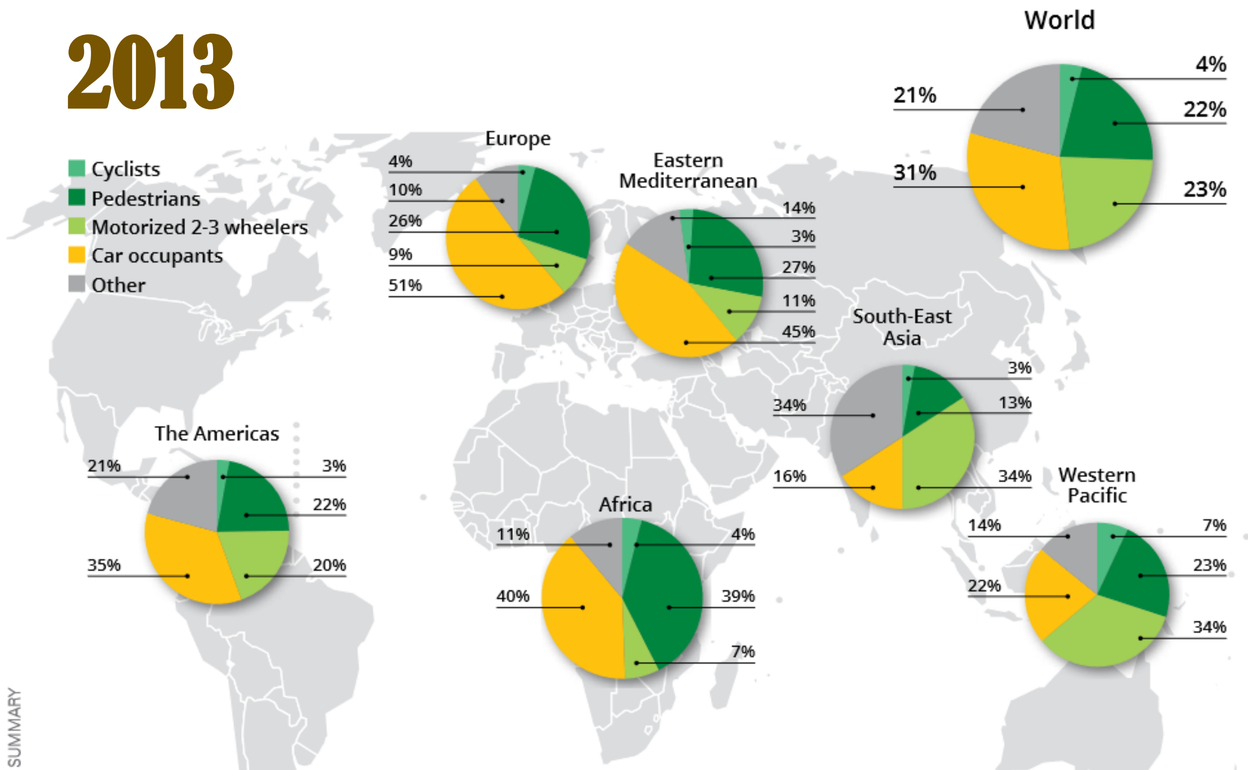
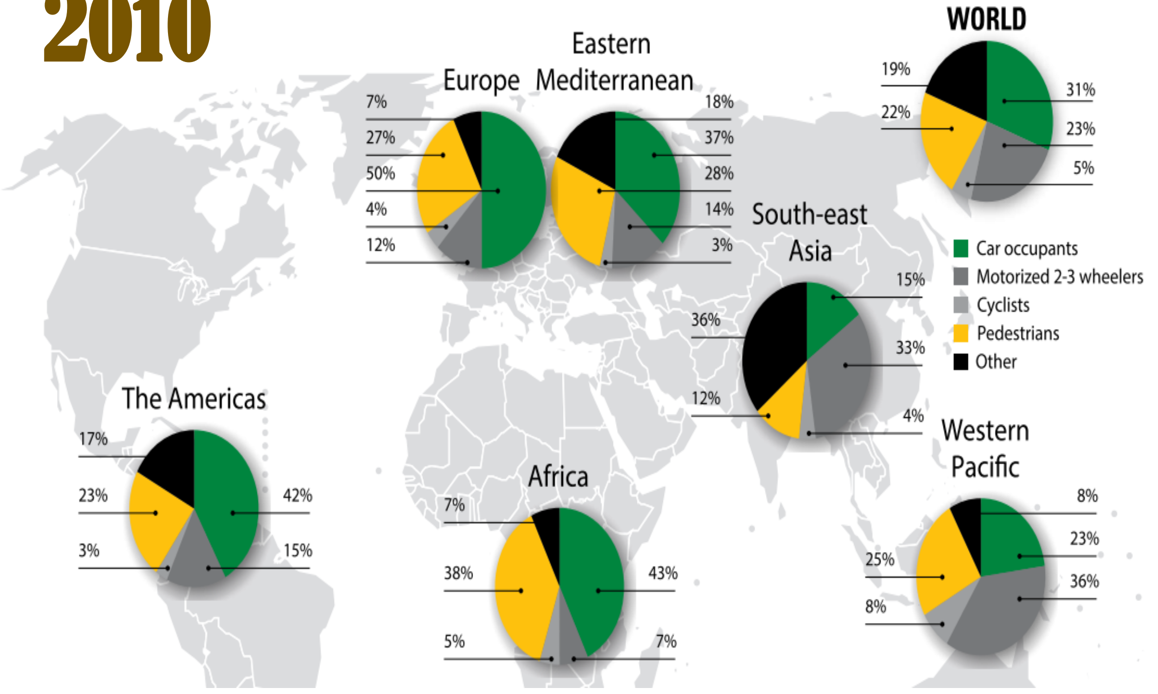
Pedestrian Fatalities: Trends

2013



22 % of total fatalities are pedestrians

2010



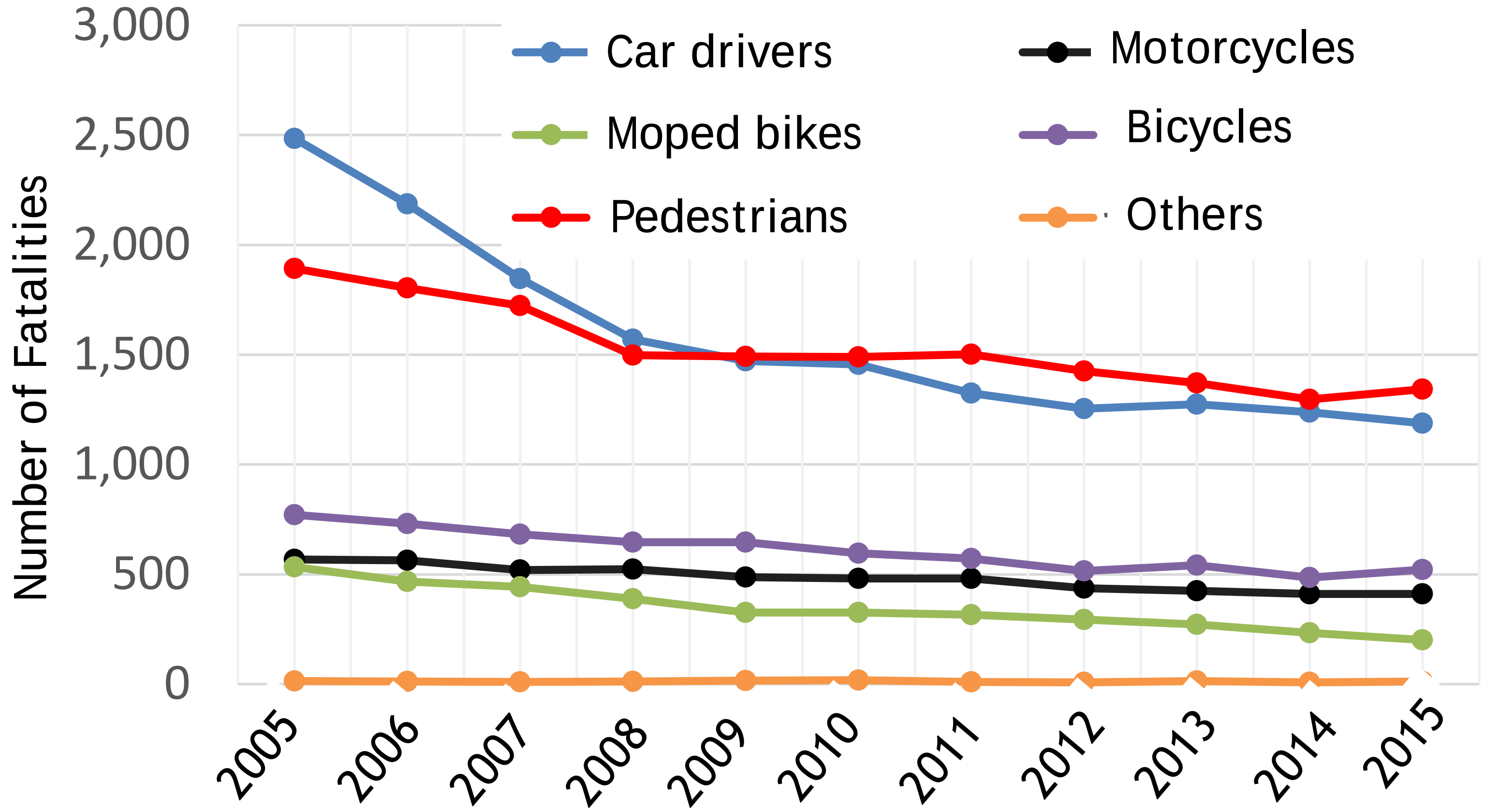
22 % of total fatalities are pedestrians

Ref.: Global Status Report on Road Safety 2015 & 2013, World Health Organization

Pedestrian Fatalities: Japan

- JAPAN: More than third of the crash fatalities are pedestrians

National records = 35%, Police Department of Tokyo= 48%



Signalized Intersections in Japan

- Severe traffic crashes at intersections
- Too large intersections with long delay

Layouts

Large corner radii

Enlarge speed of turning vehicles, which induce pedestrian accidents. Illegal parking at corners.

Large setback distance

Enlarge clearance distance and all red time

Channelization by zebra marking

Left-turning vehicle can run on the marking
Encourage high-speed turn

Wide crosswalk and long setback distance

Turning vehicle can enter the crosswalk with high speed

Signal control

- **Too long cycle time**
- **Long intergreen time (Yellow + all red)**
- **"Arrow" is used only for green phase**
- **4-phase control is dominant**
- **Traffic lights are placed at near-side**
- **No 2-stage crossing for pedestrians**

Problem Statement

- **Intersection layout (crosswalk length and position)**
  - ✓Vehicles enter in high speed
  - ✓High degree of freedom gives variety of movements
- Common Objective of Traffic signal control

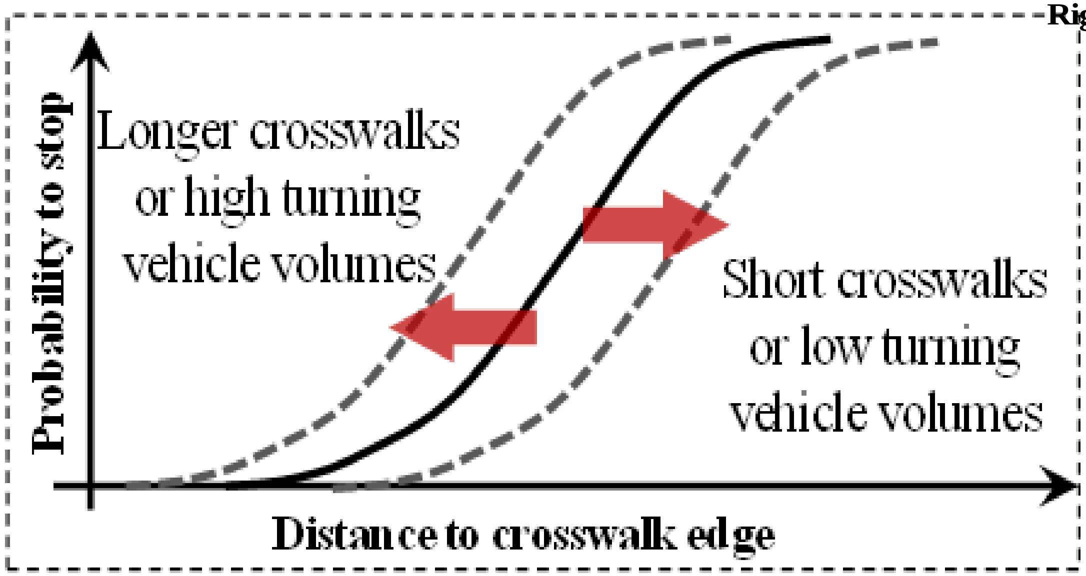
  { Provide sufficient capacity for motorized traffic
  Minimize vehicle delay

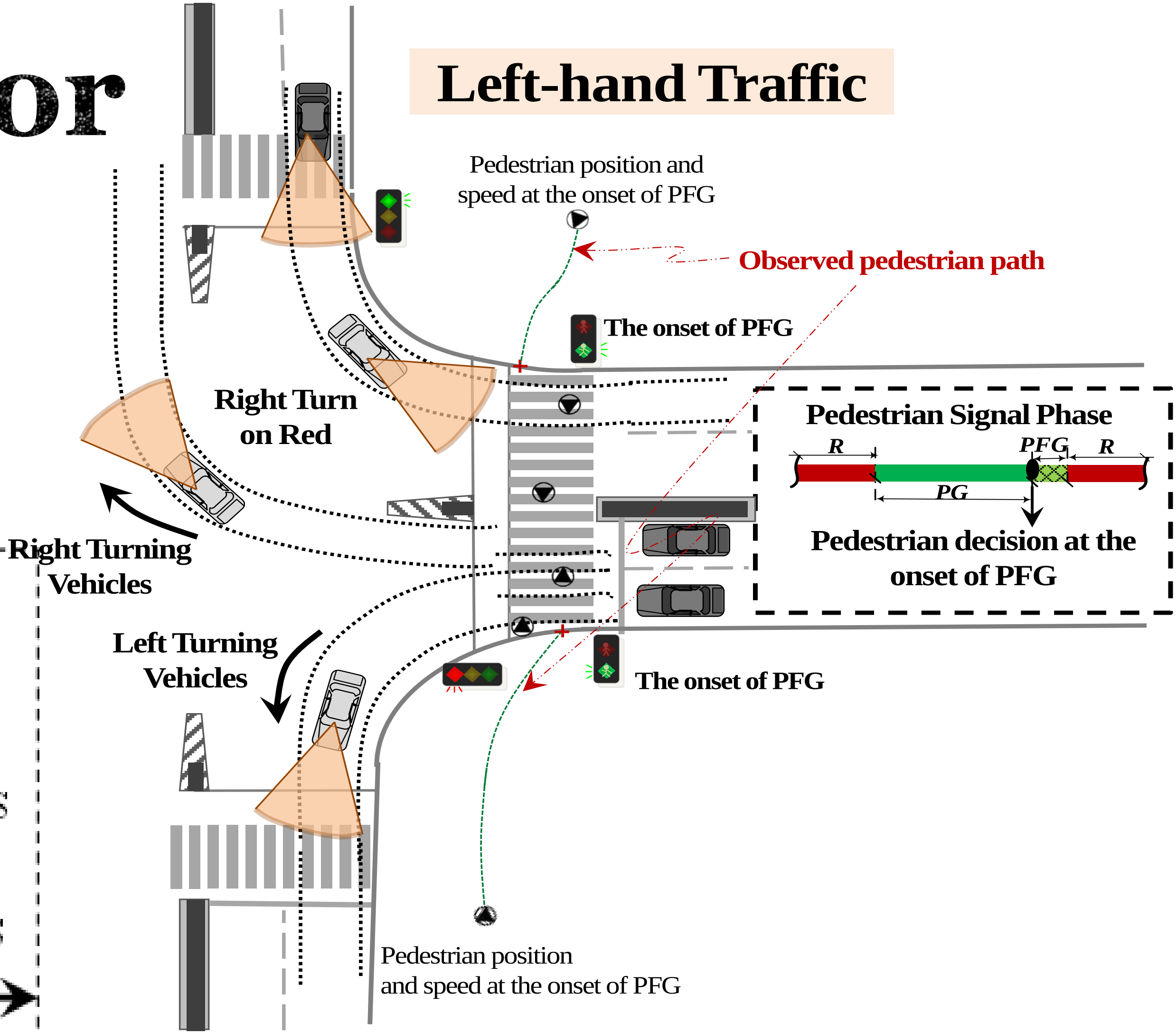
- **Inappropriate signal setting → too long cycle lengths → Long delays**
  - ✓Induces hazardous maneuver, such as red light running and early starts at onset of green

Compared to vehicles, pedestrians violate traffic regulations more frequently

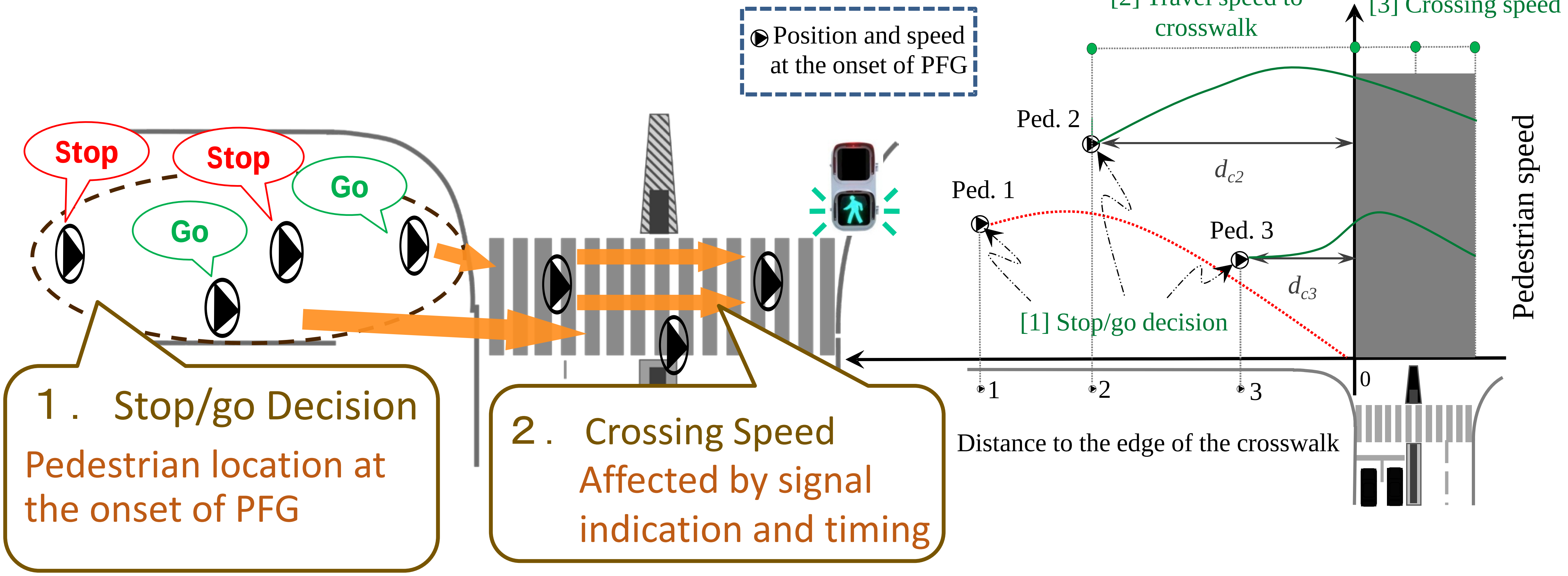
Pedestrian Behavior

- Dynamic interaction with
  - Signal indication and timing
  - Traffic conditions
  - Intersection layout
    - Crosswalk length & width
    - Channelization

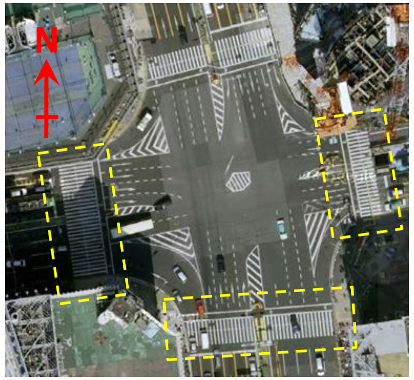
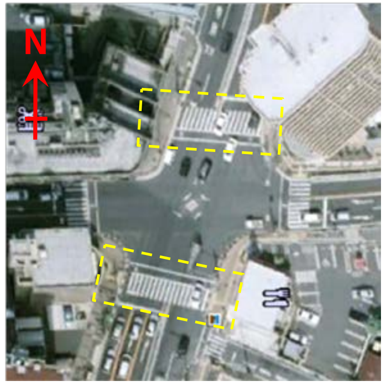




Pedestrian Behavior

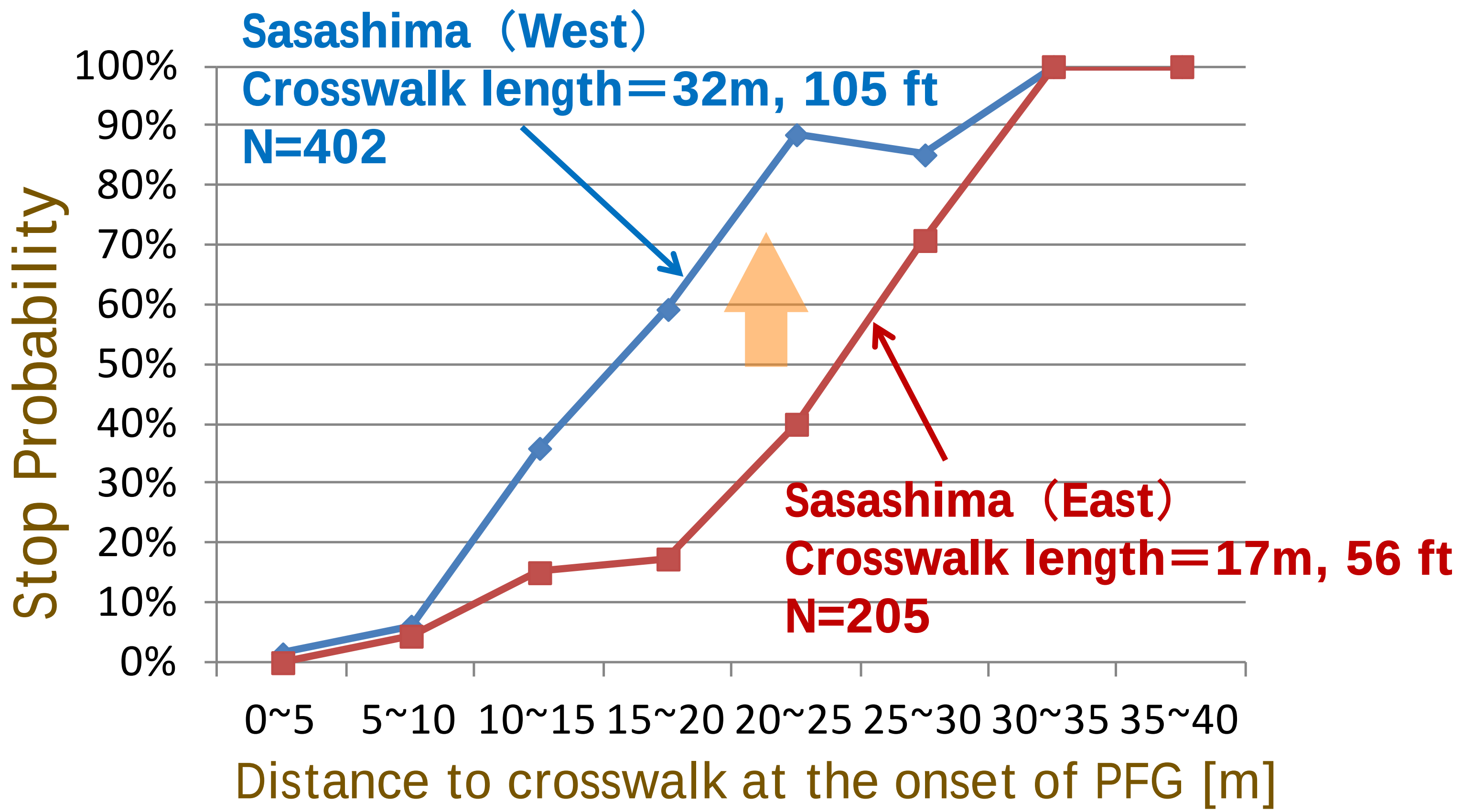


Observation Sites

Intersection	Sasashima			Imaike			Yagoto Nisseki	
Intersection Layout								
Approach	West	East	South	West	East	North	South	North
Crosswalk Length (m, ft)	32, 105	17, 56	36, 118	21, 69	21, 69	22.5, 74	17, 56	18, 59
PFG (Sec)	6	6	7	8	8	8	7	7
Pedestrian volume (ped/hr)	2025	1238	1103	360	327	147	734	250
Sample Size: Go	249	154	32	28	45	11	122	32
Sample Size: Stop	153	51	16	24	32	3	4	8
Sample Size: Total	402	205	48	52	77	14	126	40

Stop/Go Decision

- Impact of Crosswalk Length



At long crosswalks, Stopping probability is significantly higher

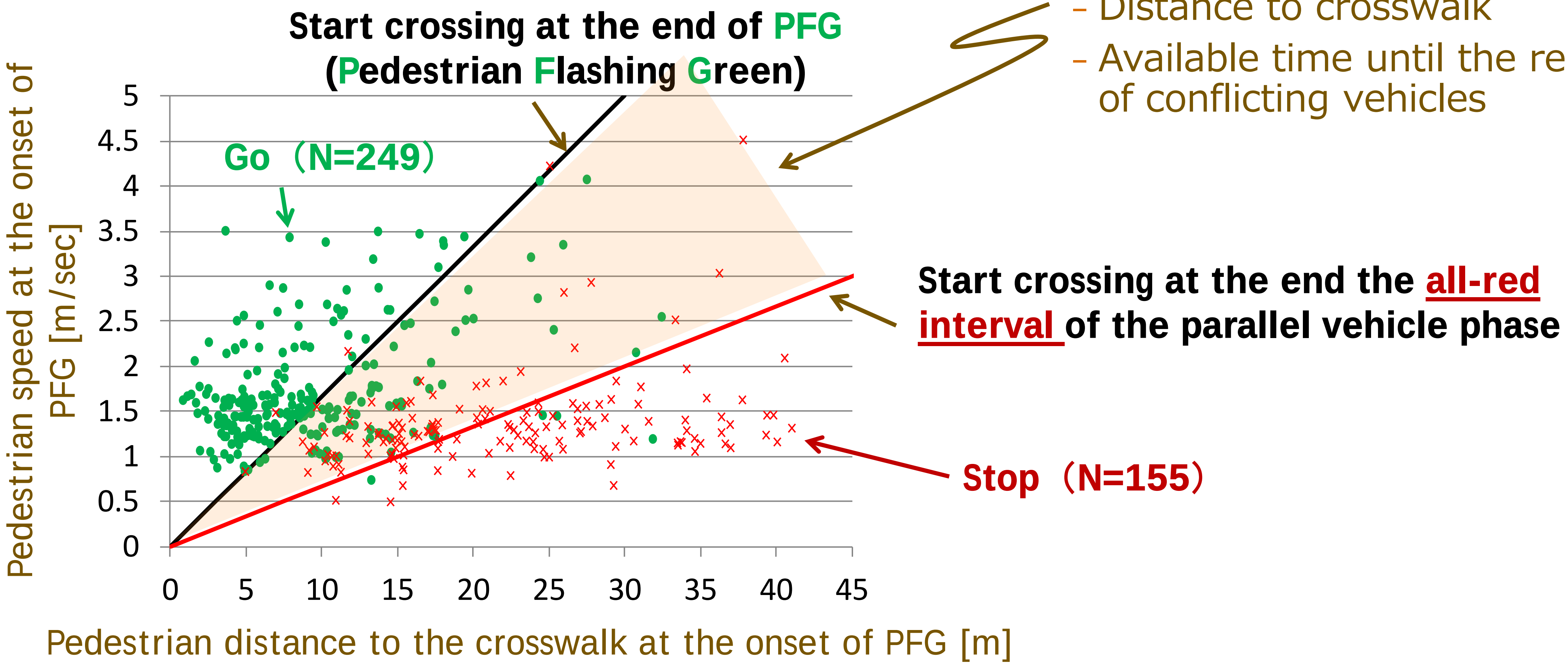
→The crossing decision is made based on pedestrians judgment whether they can complete crossing during the available time

Stop/Go Decision

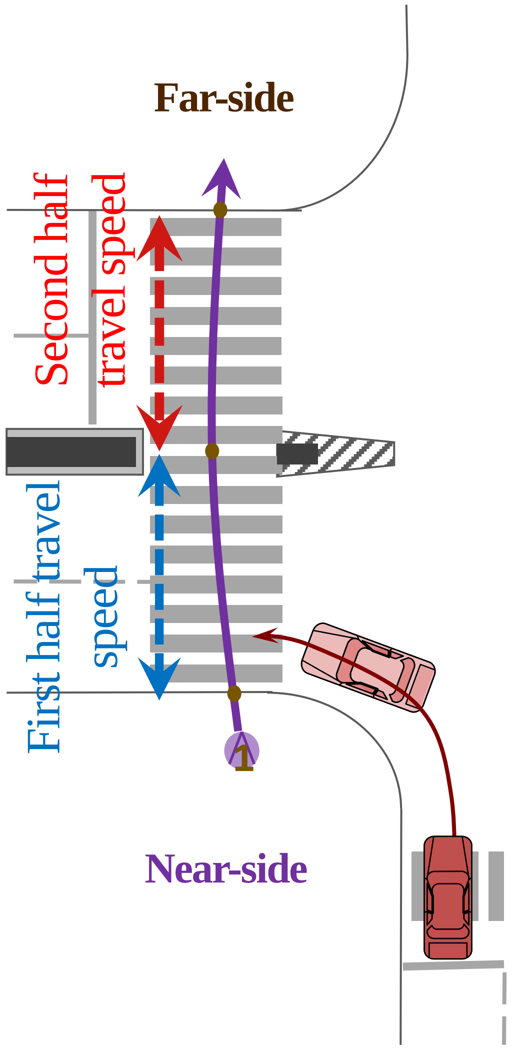
- Walking speed and position at the onset of PFG

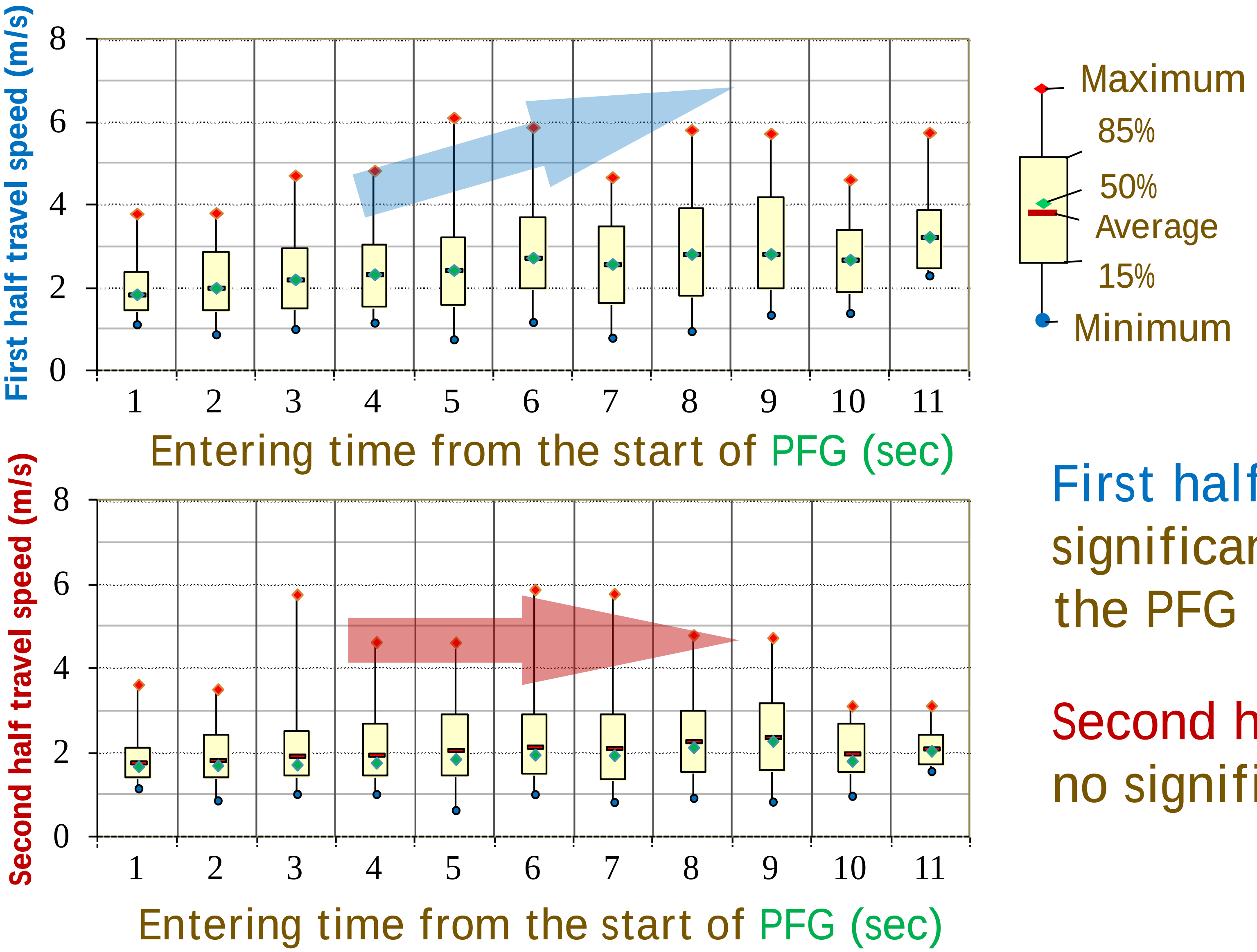
Sasashima West（32m [105 ft], PFG 6 sec）

Pedestrian judgment whether to stop or go is influenced by:
- Their speed
- Distance to crosswalk
- Available time until the release of conflicting vehicles



Crossing Speed with Distance and Timing

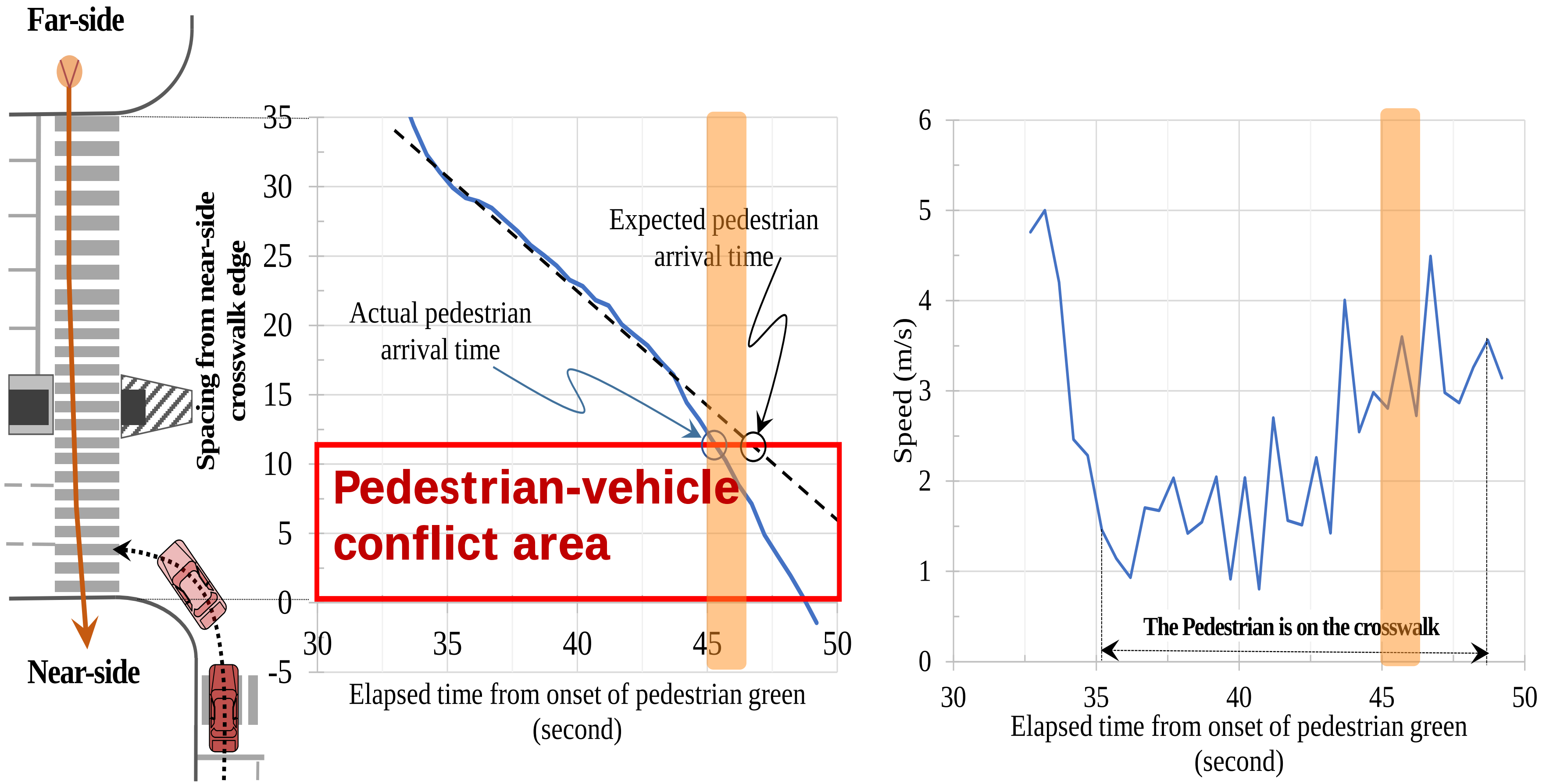




First half travel speed significantly increase as the PFG interval proceeds

Second half travel speed no significant change

Speed Change Events

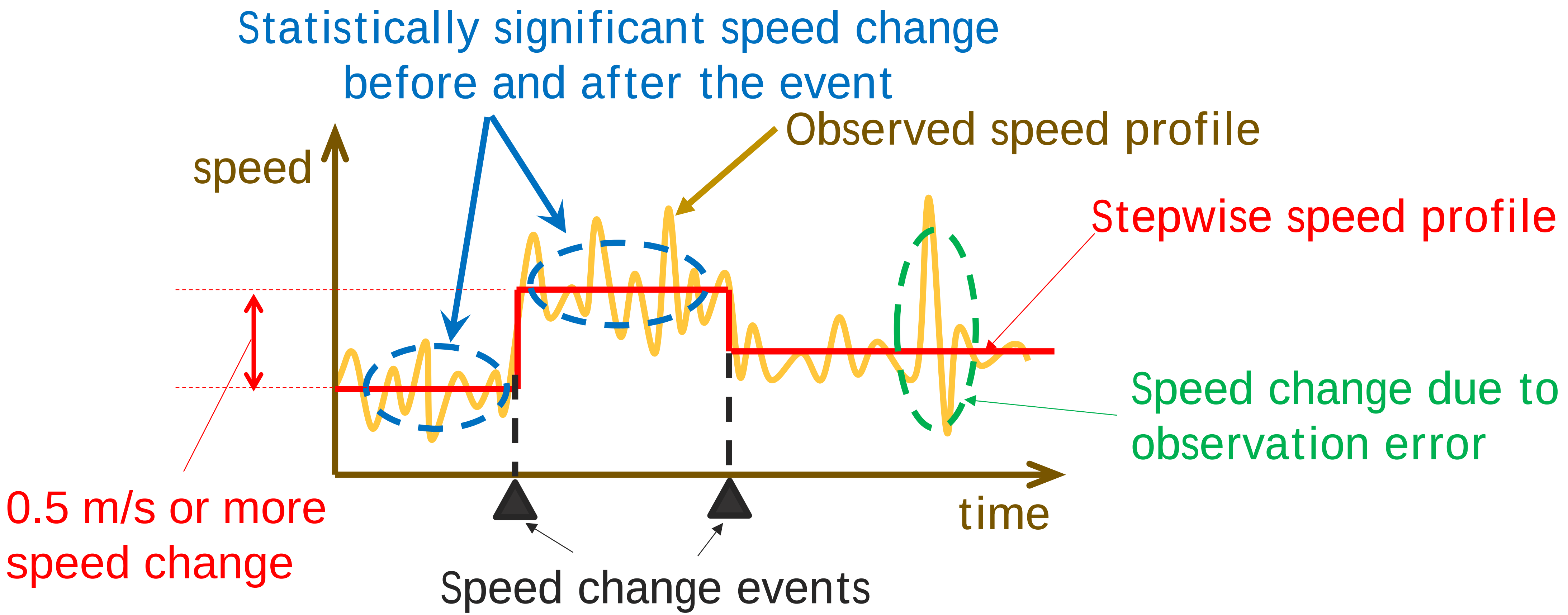


Sudden Pedestrian Speed Changes

Unpredicted by drivers

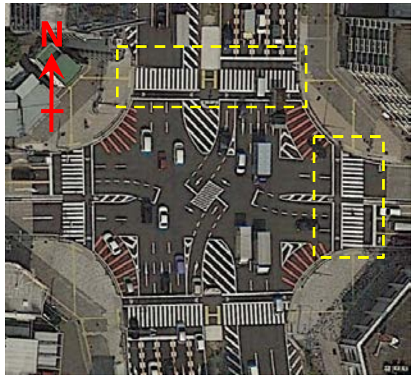
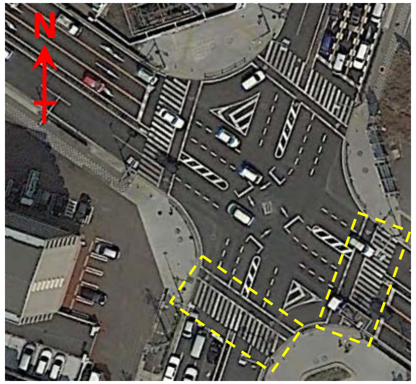
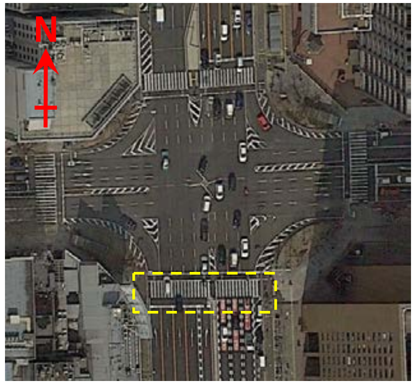
Safety Hazard

Extraction of Speed Change Events



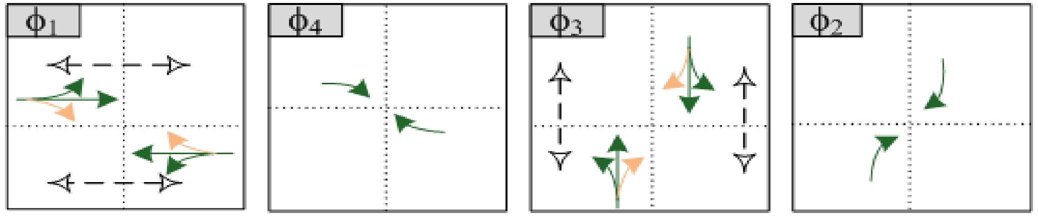
Conceptual figure of Stepwise Speed Profile and speed change event

Observation Sites

Intersection	Kanayama		Ueda		Fushimi
Intersection Layout					
Approach	East	North	East	South	South
Crosswalk Length (m, ft)	16, 52	36, 118	28, 92	21, 69	30, 98
PFG (Sec)	6	9	10	8	10
Pedestrian volume (ped/hr)	179	338	90	114	322
Sample Size — Total	263	373	71	135	128

Observation Sites

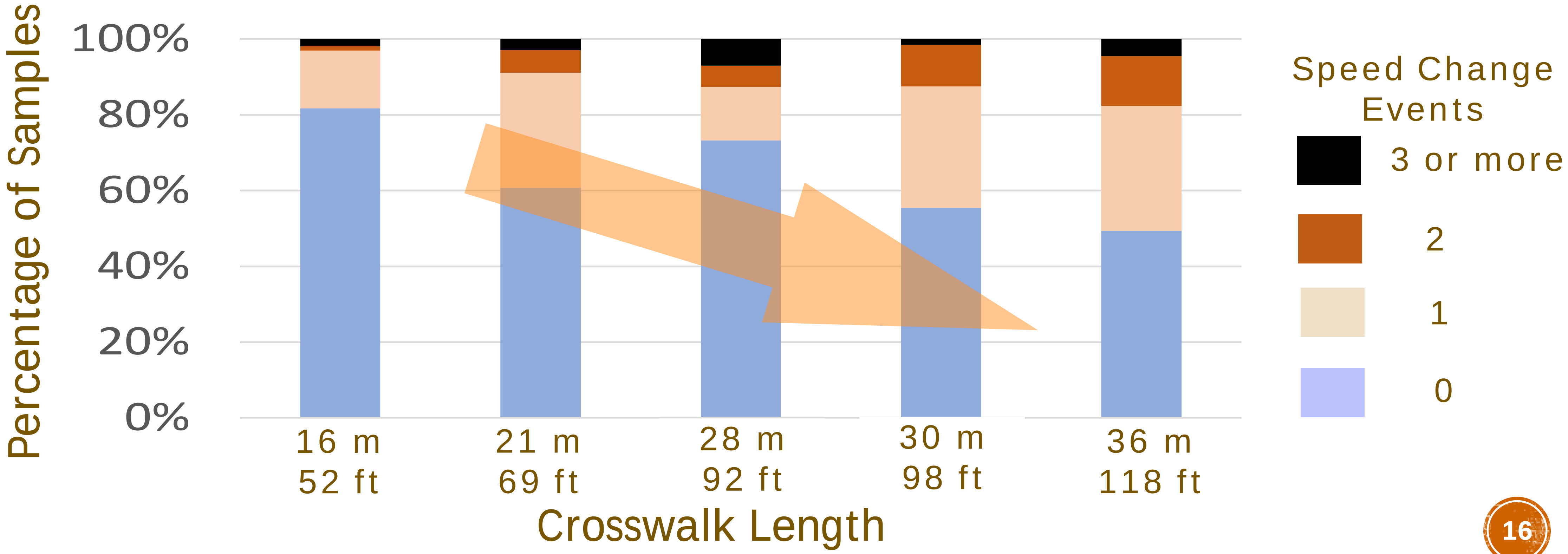
Mode		Signal phasing length (sec)														Cycle length (sec)
		φ1				φ2			φ3				φ4			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
E-W	Vehicle															
	Pedestrian (location S and N)															
	Right-turning vehicle		Shared													
S-N	Vehicle															
	Pedestrian (location E and W)															
	Right-turning vehicle									Shared						
Intersection name	Kanayama	39	9	3	3	7	2	5	54	6	5	3	17	2	5	160
	Ueda	54	8	2	3	9	2	5	45	10	4	4	7	2	5	160
	Fushimi	40	10	2	4	7	2	5	62	7	3	4	8	1	5	160
Signal phase plan																



Green, Right-turning arrow, Pedestrian flashing green, Amber, Red

Number of speed change events at each site

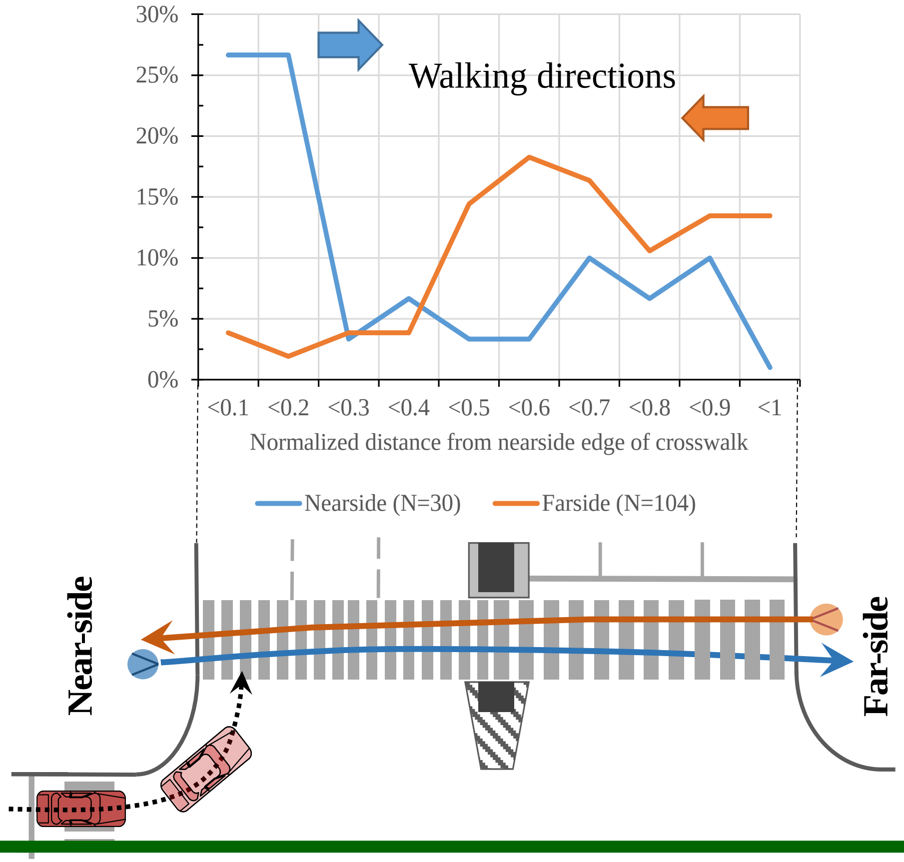
- **20-50%** pedestrians change their speeds at least once during crossing
- Long crosswalks have more frequent speed change events (Kanayama North, Fushimi South)



Location & Distribution of Speed Change Events

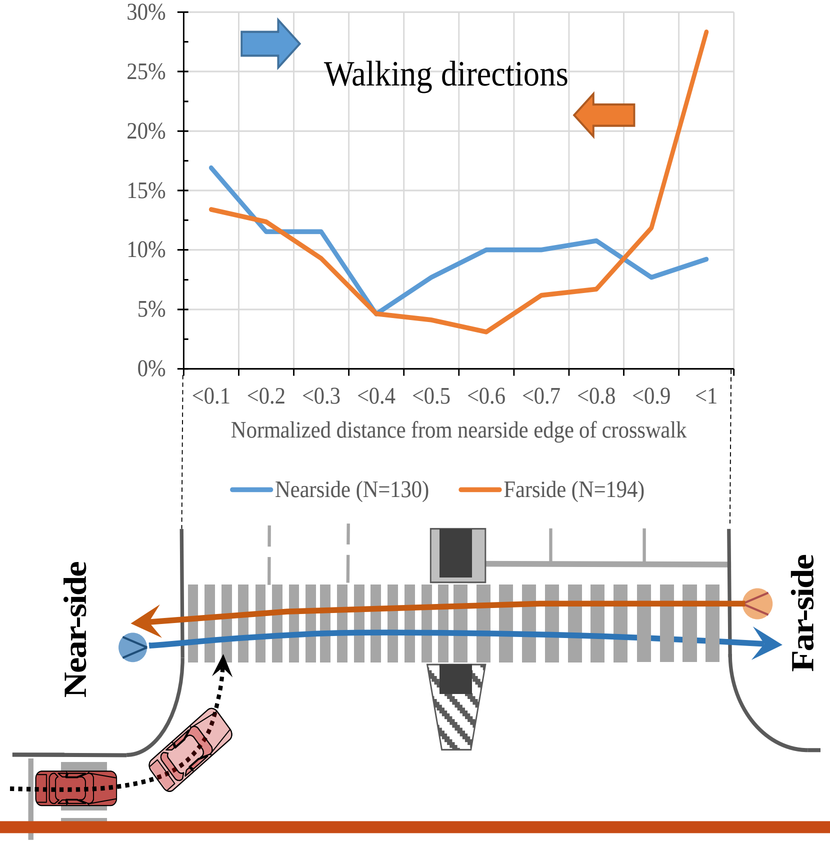
Acceleration events:

- Occur frequently at the entrance of conflict area



Decelerations events:

- Occur at either edge of crosswalks



Summary

- ## Crosswalk Geometry

  Crosswalk geometry and layout affects pedestrian behavior

  - As crosswalk length increase:
    - Pedestrian stopping probability at the onset of PFG increases
    - Pedestrians tend to cross with higher speeds
    - More sudden speed changes → **more severe conflicts** → **safety hazards**
      - Mostly occur around the conflict area with exiting vehicles

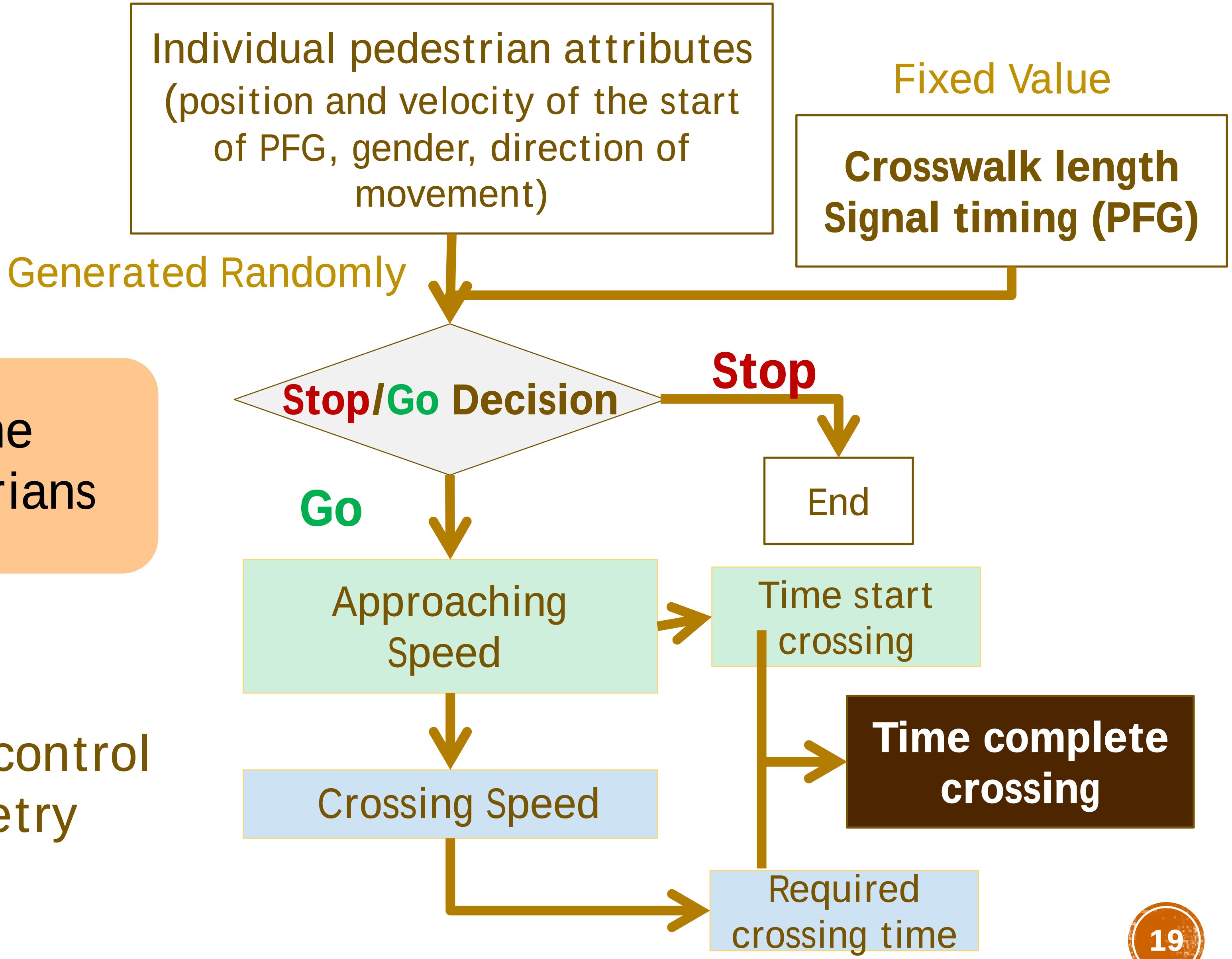
- ## Signal Timing
  - Significant noncompliance with signal indication
    - **Even after the onset of pedestrian red, pedestrian continue crossing until the onset of conflicting vehicles green**
  - Pedestrian crossing speed increases as PG and PFG intervals proceeds.
    - **Increasing tendency with time**
  - Frequent sudden velocity changes during PFG interval

Quantification of Pedestrian Behavior

- Stop/Go decision
- Speed adjustment

Quantified considering the stochastic nature of pedestrians

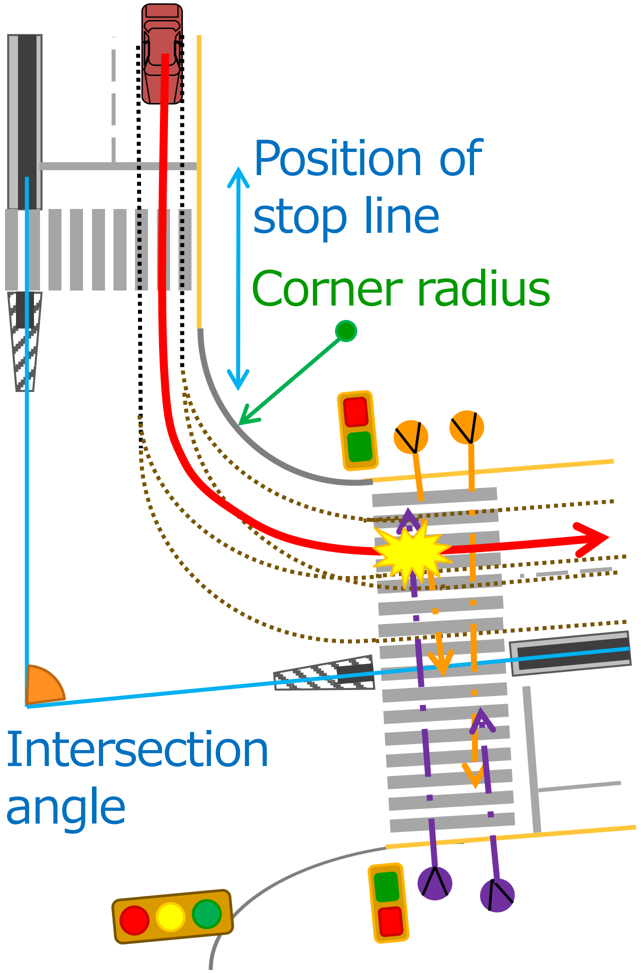
Taking in account: **(1)** traffic control and **(2)** intersection geometry



Applications

1) Proactive Safety Assessment using microsimulation

- Realistic representation of pedestrian-vehicle



Scenarios with different layouts

Input data
- Intersection geometries
- Signal control parameters
- Vehicle and pedestrian demand (assuming random arrival)

Pedestrian maneuver
- Velocity distribution

(depend on layouts and starting time to cross)

Vehicle maneuver
- Path distribution
- Speed profile
- Lag/gap choice

Output: Conflict characteristics

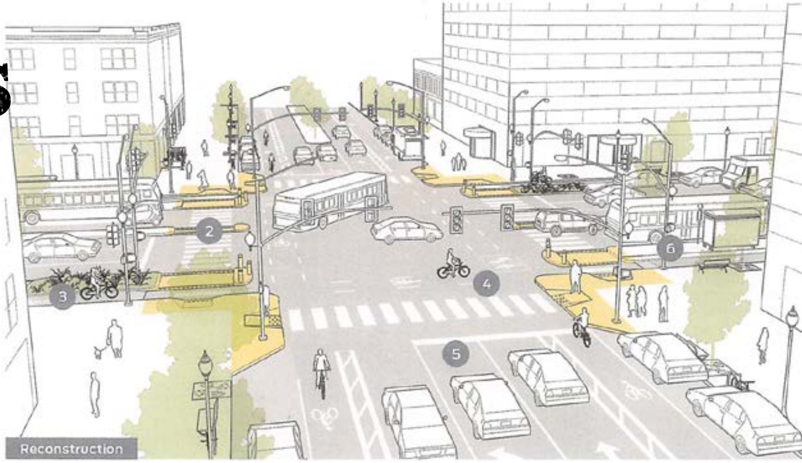
Safely indices

Comparison between different scenarios

Applications: Improvements on the Design and Control

2) Road Structure

- Two-stage crossing
- Road narrowing
- Raised crosswalks
- Overpasses / underpasses



NACTO : Urban Street Design Guide

Applications: Improvements on the Design and Control

3) Signal Control

- Pedestrian Signal Setting
  - PFG length
  - Buffer time
- Countdown signals
- Position of the signal lights
- Dilemma zone for pedestrians

More efficient setting of pedestrian signal timing to improve compliance

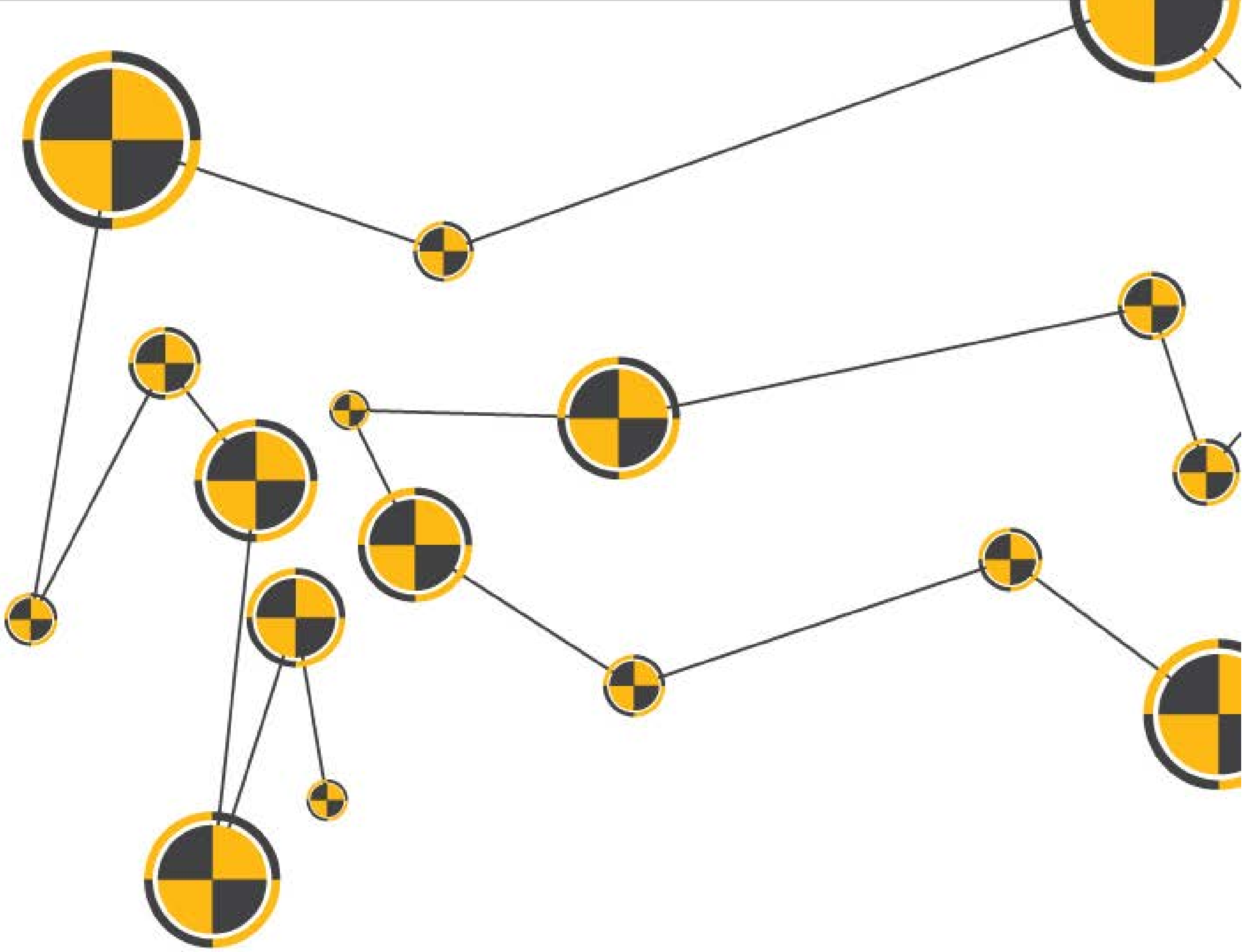
Germany

USA

UK

Japan

Thank You



Pedestrian Behavior and Traffic Controls at Crosswalks in New York City (US)

Mar 2016

H. Joon Park, Ph. D., AICP, New York City Department of Transportation

"Understanding Pedestrian Behaviors and Traffic Controls at Signalized Crosswalks"

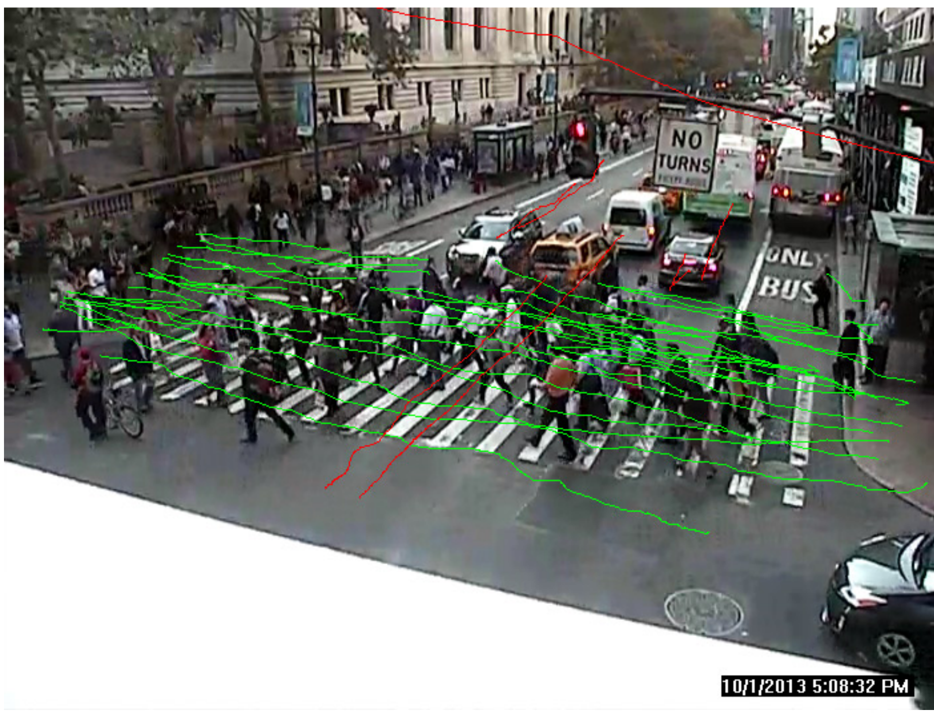
Pedestrian Behaviors

- **Macroscopic approach**
  - **Pedestrian flow fundamental diagram**
  - **Average travel time and speed**

- **Microscopic approach**
  - **Profile on trajectories and speed of pedestrian and conflicting turning vehicles**
  - **Pedestrian compliance on control policy**

Data Collection and Reduction

- **Video Data Collection: pedestrian and traffic**
- **A combination of manual data reduction and video tracking analysis because of heavy pedestrians and video data quality (i.e., camera angle, object overlapping, and homography issues)**



Video Data Examples

- **Perpendicular view (Park Ave and 29th St)**

- **Multiple camera views (89 Ave and Merrick Blvd)**

Pedestrian Speeds

- **Pedestrian speed is an important factor to influence level of service for pedestrian facility and to determine flashing DON'T Walk time at crosswalks.**

- Constant pedestrian crossing speed to determine pedestrian clearance time

- Many crosswalks in NYC with hourly pedestrian volume over 2,000

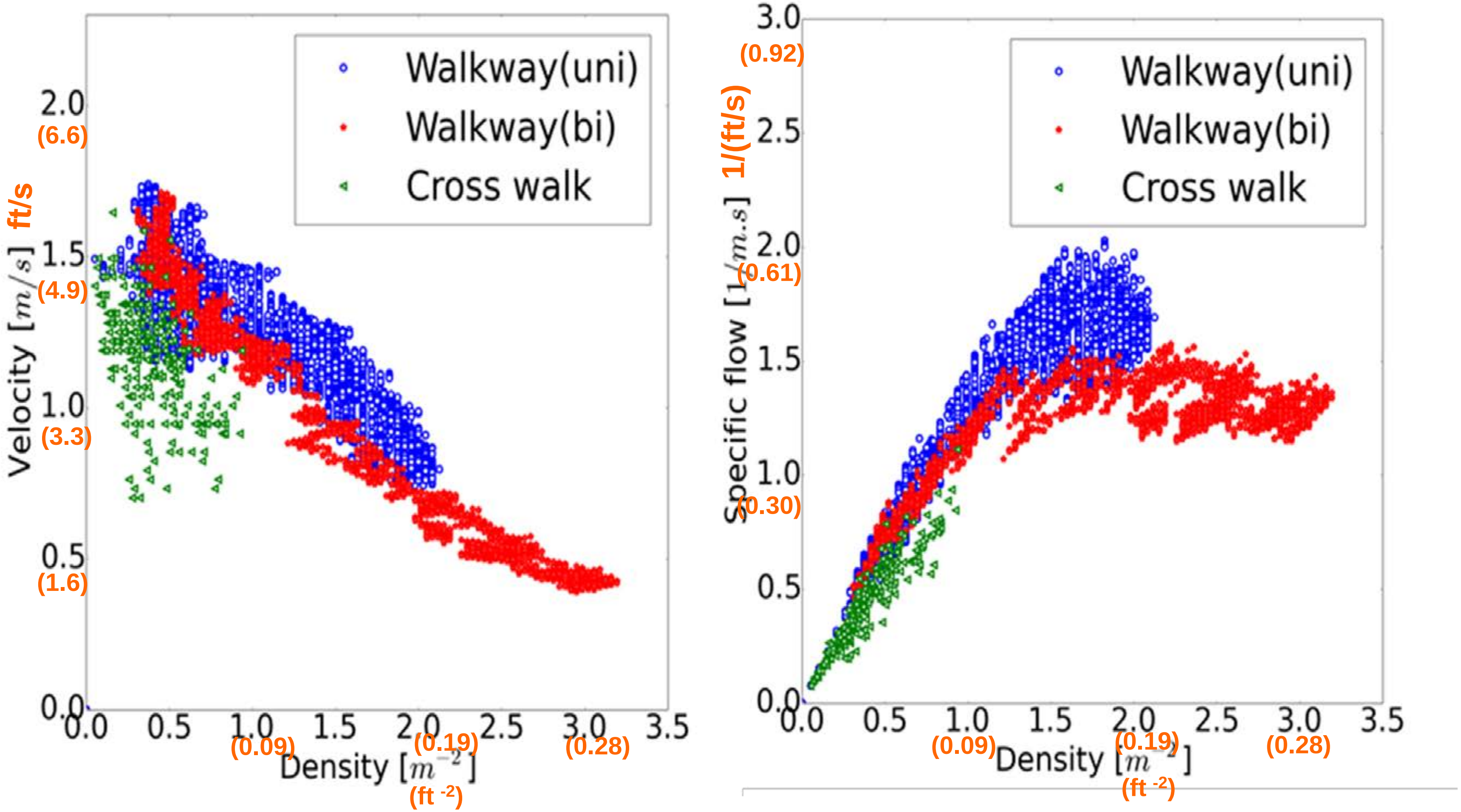
- 2009 MUTCD: 3.5 ft/s (1.1m/s)

- HCM 2010:
4.0 ft/s (1.2 m/s), or 3.3 (1.0) if >20% elderly population, and reduction of .3 ft/s (0.1 m/s) with >10% upgrade

- NYC standard:
3.5 ft/s(1.1 m/s), 3.0(0.9) in senior areas & school zones

Note) 1 ft/s is equal to approximately 0.3 meter/s.

Pedestrian Fundamental Diagram
Based on Recent Studies

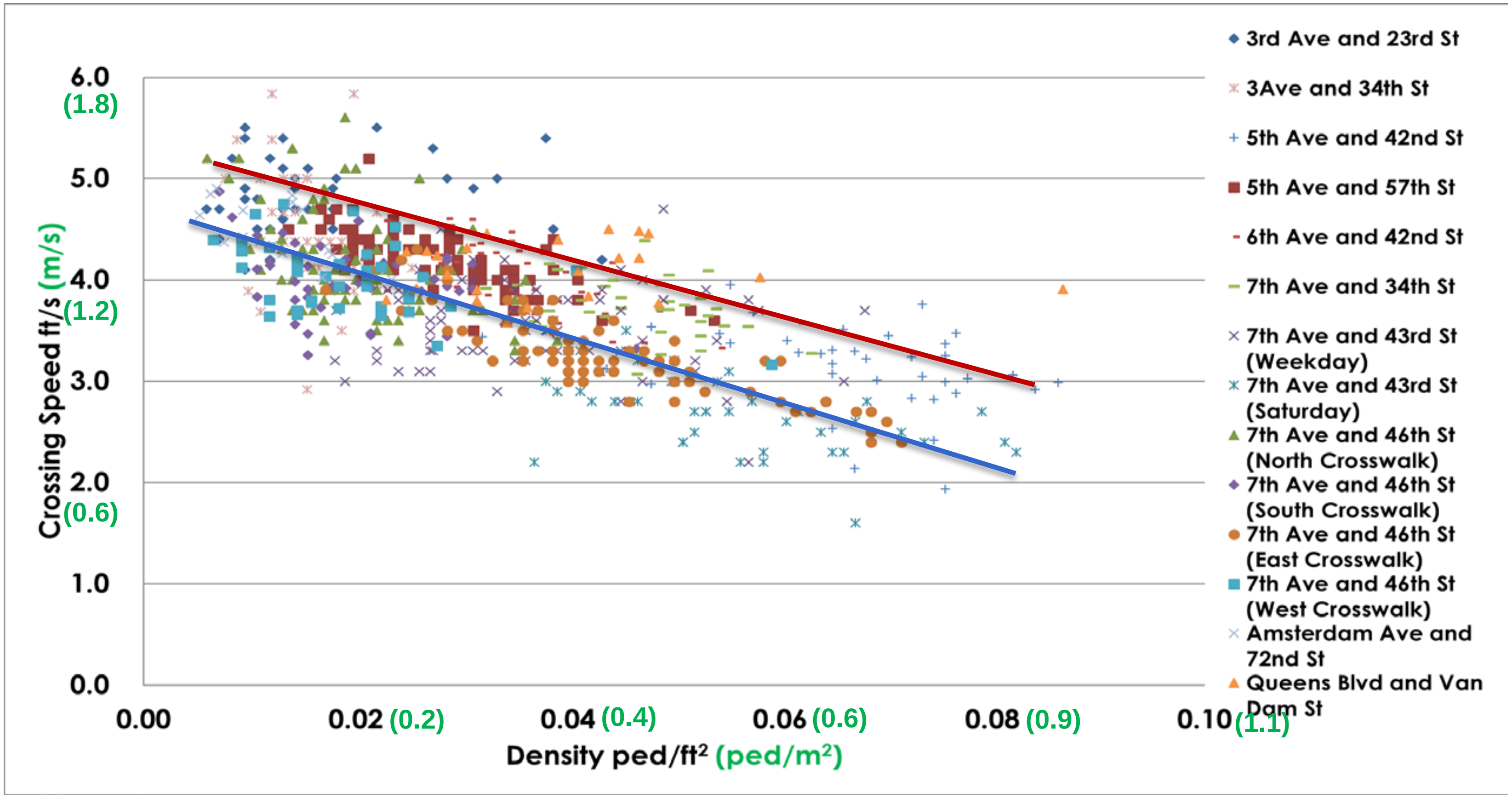


Source) 1. Jun Zhang, et al, "Ordering in bidirectional pedestrian flows and its influence on the fundamental diagram." *Journal of Statistical Mechanics: Theory and Experiment 2012*, no. 02

2. H. Joon Park, et al, An Investigation of Pedestrian Crossing Speeds at Signalized Intersections with Heavy Pedestrian Volumes. TRR Vol. 2463, 2015

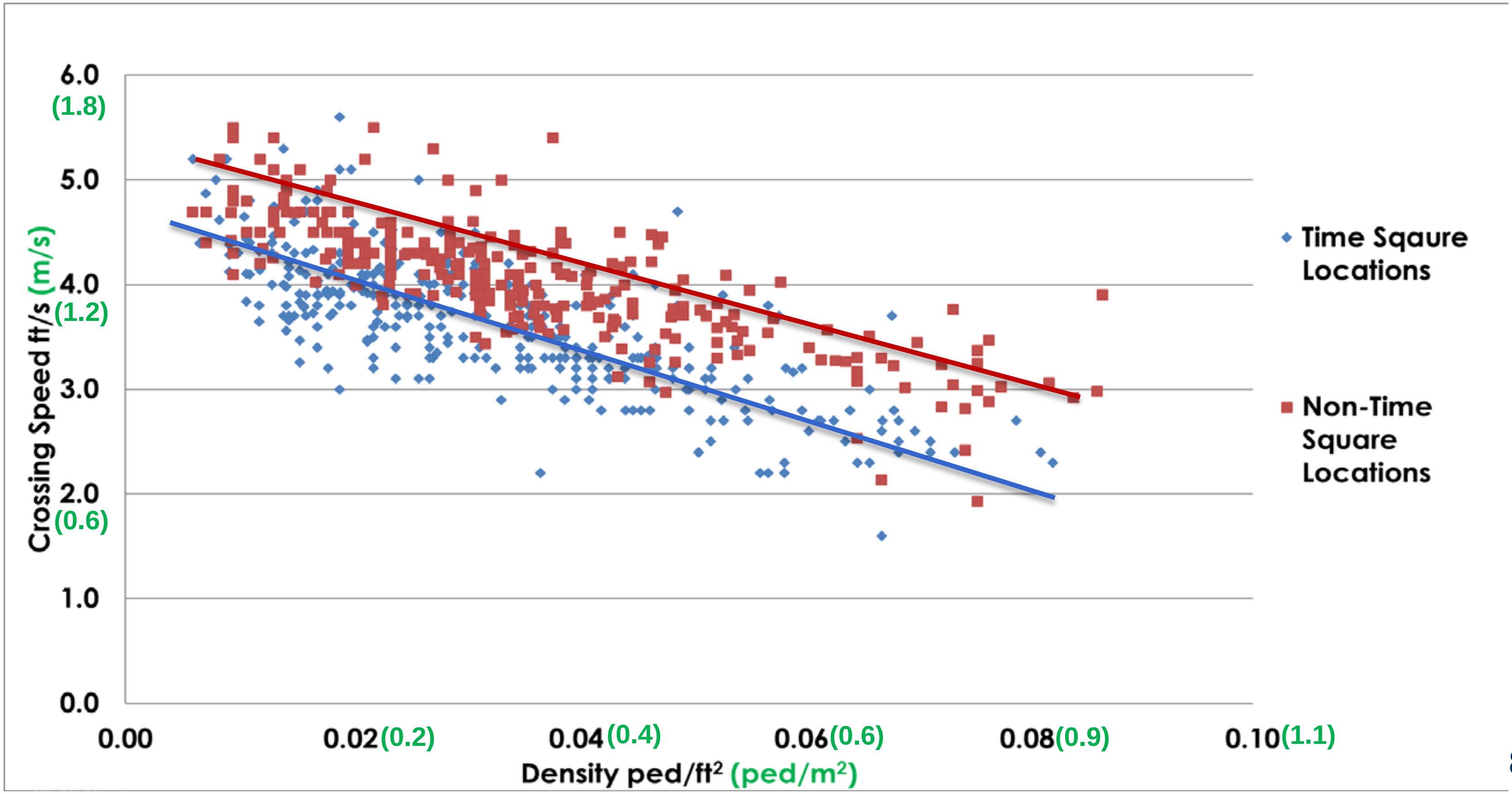
Pedestrian Fundamental Diagram at NYC Crosswalks

- Hourly pedestrian volumes at 14 locations were observed from 655 with low density of 0.020 ped/ft² at the west crosswalk of 3rd Ave and 23rd St to 7,655 with high density of 0.082 ped/ft² at west crosswalk of 7th Ave and 43rd St (Saturday). As the crosswalk densities increased, pedestrian speeds gradually decreased.



Pedestrian Fundamental Diagram at NYC Crosswalks by Land Use Patterns

- **According to land use characteristics or trip purpose (i.e., tourist/shopper vs. commuter), pedestrians tend to show different crossing speeds. However, these speeds generally do not drop to below 2 ft/s (0.6m/s).**

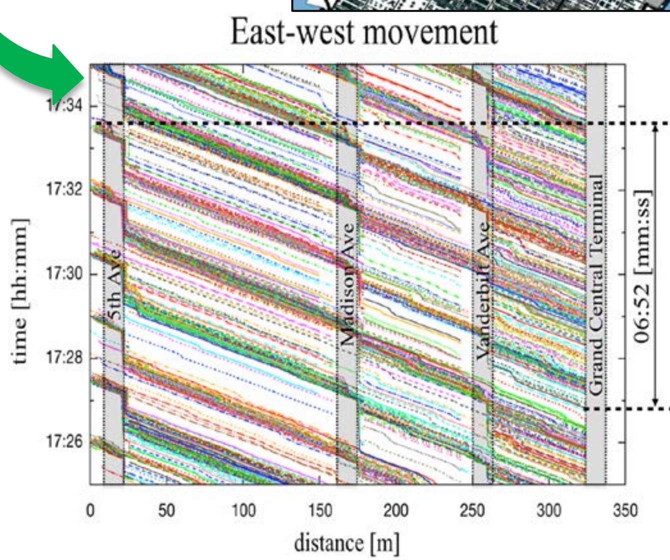


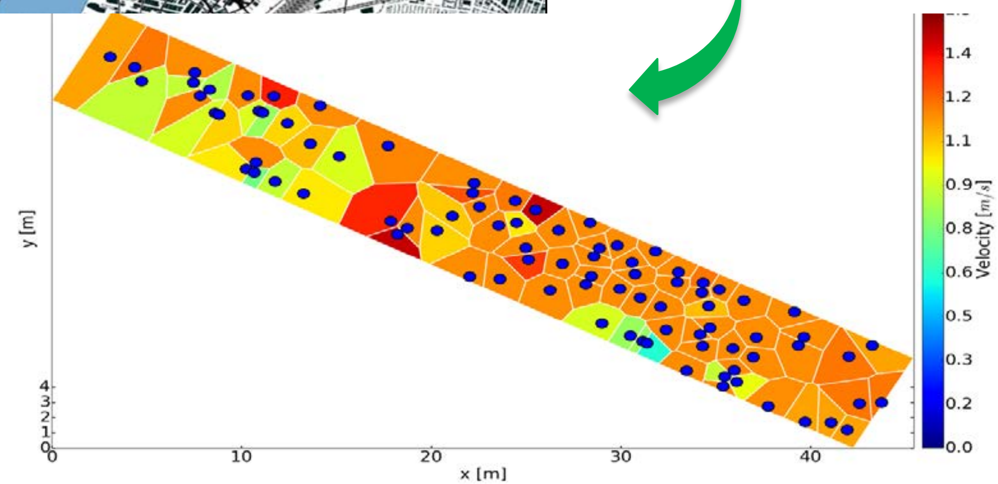
Examples of Various Pedestrian Density Levels

Location	3rd Avenue and 23rd Street	5th Avenue and 57th Street
Captured Image		
Density	0.019 ped/ft^2	0.031 ped/ft^2
Speed	5.0 ft/sec	4.0 ft/sec
Location	7th Ave and 46th Street (North)	7th Ave and 46th Street (East)
Captured Image		
Density	0.039 ped/ft^2	0.050 ped/ ft^2
Speed	3.4 ft/sec	3.2 ft/sec
Location	7th Avenue and 46th Street (East)	7th Avenue and 43th Street
Captured Image		
Density	0.071 ped/ft^2	0.082 ped/ft^2
Speed	2.4 ft/sec	2.3 ft/sec

Travel Time and Speed of Pedestrian At Urban Street Facility –Simulation

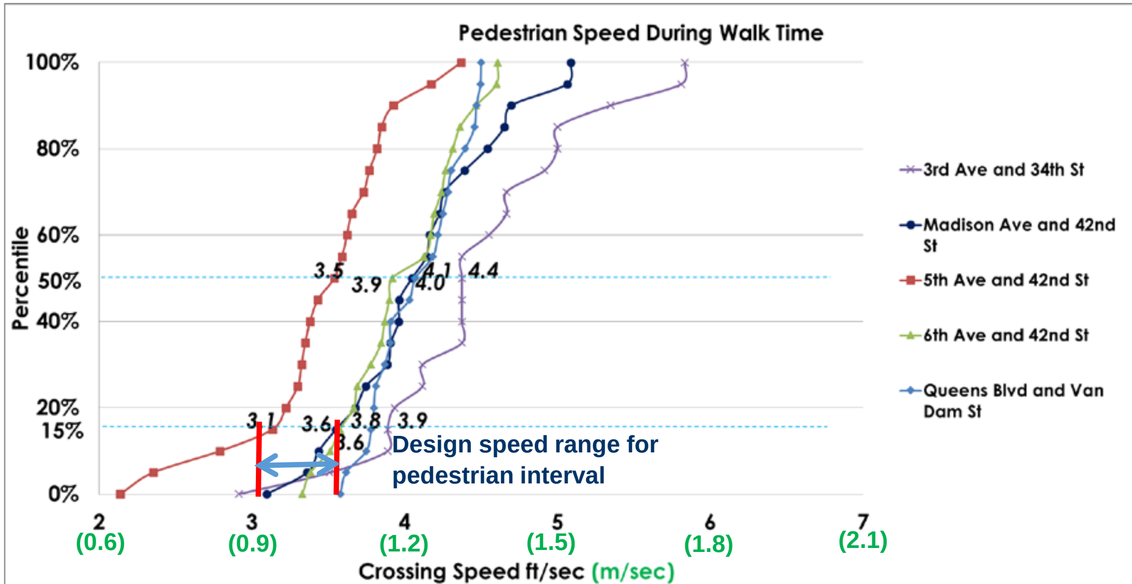
- **Pedestrian simulation model application for urban street facility in vicinity of Grand Central Terminal**

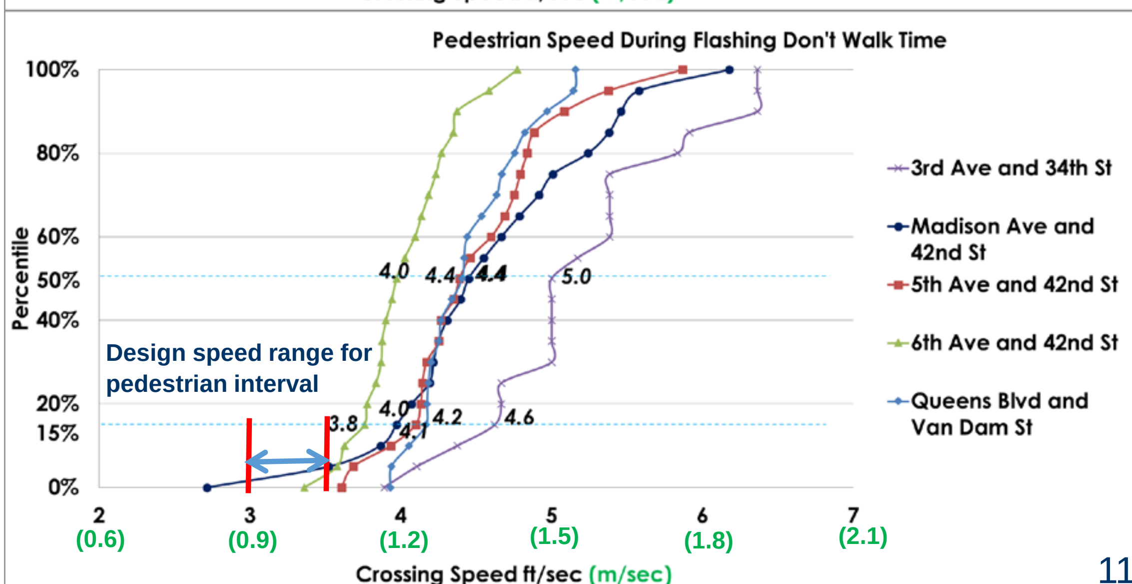




Crossing Speed by Pedestrian Intervals

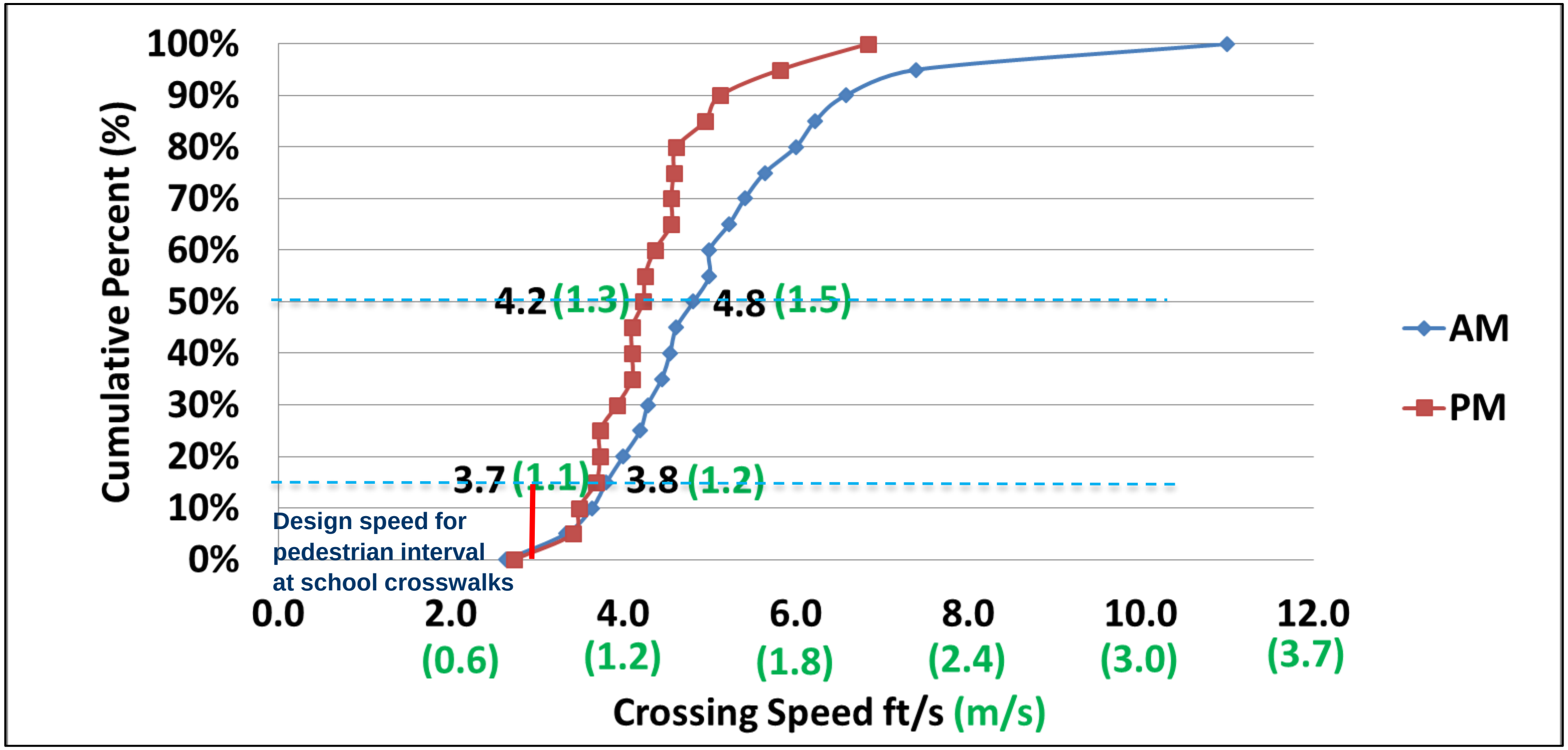
- **Pedestrians walk faster during flashing DW time than during Walk time.**





Crossing Speed - School Children (1)

- Video surveys at 17 intersections in the vicinities of seven primary schools in NYC.
- The comparison between morning school hour and after school hour showed children walked faster during the morning.



Crossing Speed - School Children (2)

- **The tables below demonstrate the difference in speed between children alone and children with guardians (i.e., father, mother, parents or grand parents) during school peak periods.**

	Childeren Alone	Childeren with Guardians	% Difference
Average Speed	5.6 (1.7)	4.7 (1.4)	19.1%
15th Percentile Speed	4.0 (1.2)	3.7 (1.1)	8.1%
Median Speed	5.0 (1.5)	4.5 (1.4)	11.1%
85th Percentile Speed	6.8 (2.1)	5.6 (1.7)	21.4%

Unit: ft/sec (m/sec)

Groups	Count	Average Speed	Variance	p-value	Significant (p-value<=0.15)
Children Alone	458	5.6 (1.7)	5.26 (1.60)	6.67029E-14	Yes
Children with Guardians	501	4.7 (1.4)	1.42 (0.43)		

Unit: ft/sec (m/sec)

Pedestrian–Vehicle Crashes

- Based on 5-year crash data (2009-2013), 31 % and 10 % pedestrian crashes involved with left turn and right turn vehicles, respectively, in New York City.

Vehicle Direction	Left Turn	Right Turn	Thru/Other	Overall
Pedestrian Crashes	14,474	4,517	27,874	46,865
Percentage (%)	31	10	59	100

Source: NYSDOT/NYSDMV Accident Database

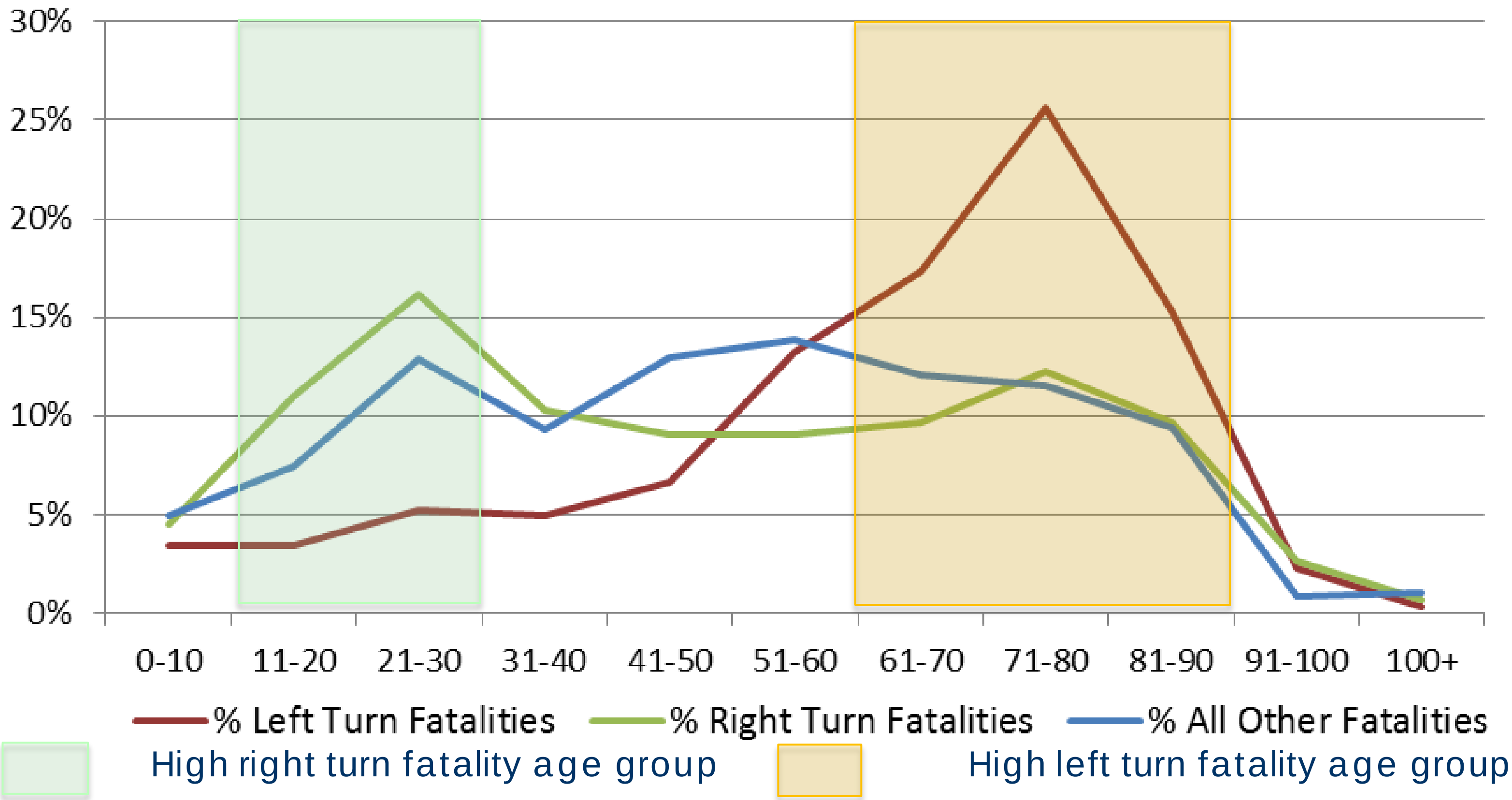
Intersection Conflicts

- **Driver Perspective**
  - **Conflicts with Opposing Traffic**
  - **Turning (left and right turn) conflicts with Pedestrians**

- **Pedestrian Perspective**
  - **Left or Right Turn Conflicts with Pedestrians**
  - **Pedestrian interactions with opposing flow**

Pedestrian Crashes by Age

- **Elderly citizens were more vulnerable to fatality crashes with turning vehicles, especially with left turn vehicles, while young age (11-30) groups showed higher fatality crashes with right turn vehicles.**



Source: Left-turn study, NYCDOT (2015)

Video Tracking of Near-side Turning Vehicle Movements

Location 1

Flatbush Ave./Fulton St. (North)

Location 3

46th St./7th Ave. (South)

Location 2

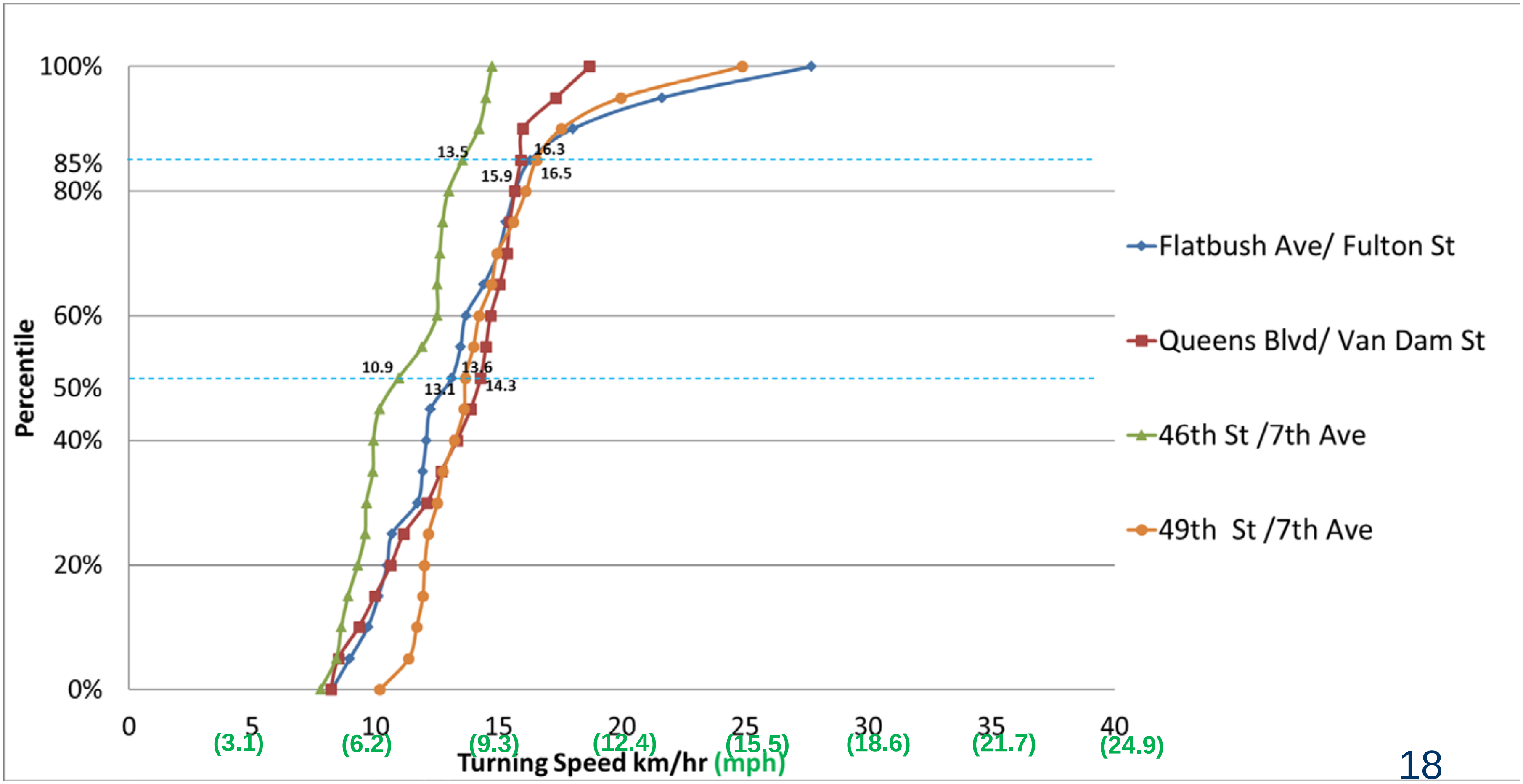
Queens Blvd./Van Dam St. (South)

Location 4

49th St./7th Ave. (West)

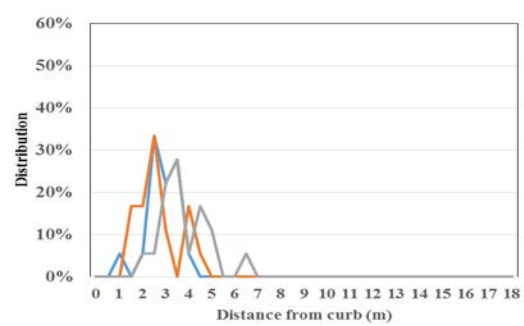
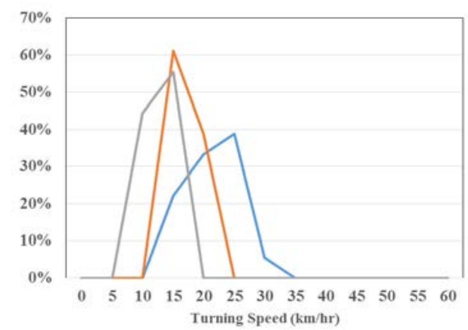
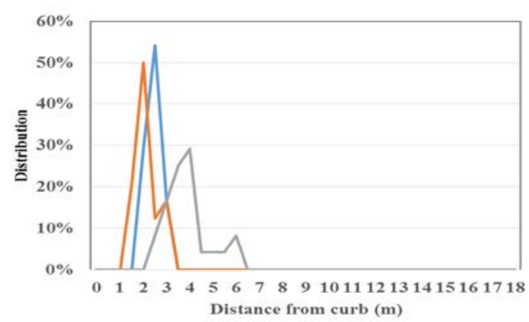
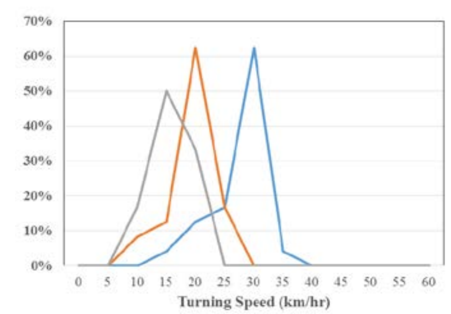
Turning Vehicle Speed

- **The average exit speeds at study locations ranged from 11.2 (7 mph) to 14.4 km/hr (9 mph).**



Detailed information of Near-side Turning Vehicles

➢ **The conflicts between illegal pedestrian crossings and high-speed vehicles are most likely to occur in a narrower zone at the upstream stop line, but a wider conflict zone at the exit crosswalks.**

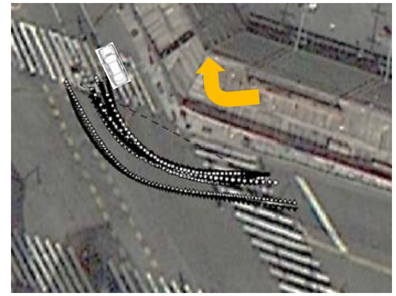
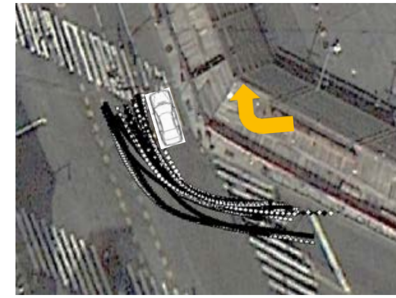
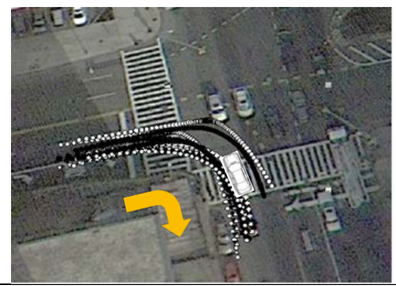
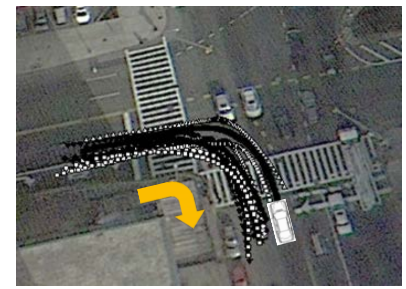
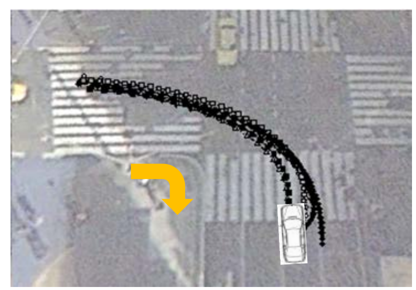
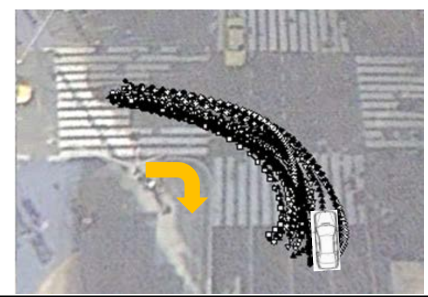
	Turning Vehicle Distance from Curb	Turning Vehicle Speeds
46th St./7th Ave.		
Queens Blvd./ Van Dam St.		

Initial Stop Bar — Middle of the corner — Crosswalk Edge

CS-1 CS-2 CS-3

Trajectories of Turning Vehicles

- **Trajectories of observed turning vehicles showed substantial variations in the pre-peak hour and peak period as well as downstream congestion of turning vehicles.**

	7-8 AM	7-9 AM
Location 1: Flatbush Ave./Fulton St.		
Location 2: Queens Blvd./Van Dam St.		
Location 3: 46th St./7th Ave.		
Location 4: 49th St./7th Ave.		

One-Way ANOVA & Post Hoc Test Summary

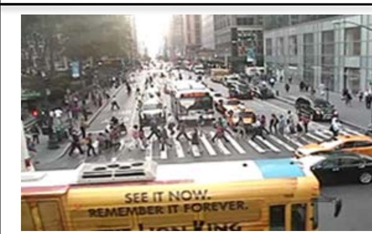
Location	Average Speed (km/hr)	Standard Deviation	15^{th} Percentile (km/hr)	85^{th} Percentile (km/hr)	F-Statistic	F-Critical	p-value
Flatbush Ave./ Fulton St.	13.7	4.2	9.7	16.3	7.70	2.64	< 0.00
Queens Blvd./ Van Dam St.	13.5	2.8	10.1	15.9			
49^{th} St./ 7^{th} Ave.	14.4	3.7	11.9	16.5			
46^{th} St./ 7^{th} Ave.	11.2	2.2	8.9	13.5			
3 Locations except 46^{th} St./ 7^{th} Ave.	-				1.19	3.04	0.31

Location	t value	t Critical two-tail	P(T<=t) two-tail	Bonferroni Correction Significance level	Post Hoc Test Result
Flatbush Ave./ Fulton St. vs. Queens Blvd./ Van Dam St.	0.3450	1.9803	0.7307	0.0125	False
Flatbush Ave./ Fulton St. vs. 49^{th} St./ 7^{th} Ave.	-1.1117	1.9766	0.2681		False
Flatbush Ave./ Fulton St. vs. 46th St./ 7th Ave.	3.3728	1.9826	0.0010		True
Queens Blvd./ Van Dam St. vs. 49^{th} St./ 7^{th} Ave.	-1.6611	1.9799	0.0993		False
Queens Blvd./ Van Dam St. vs. 46th St./ 7th Ave.	4.0180	1.9893	0.0001		True
49th St./ 7th Ave. vs. 46th St./ 7th Ave.	5.6125	1.9822	0.0000		True

Pedestrian Compliance

- Pedestrians often understood FDW time as an extension of pedestrian Walk time and non-compliance rates on FDW ranged from 14.3% to 26.9 % during the PM peak hour.

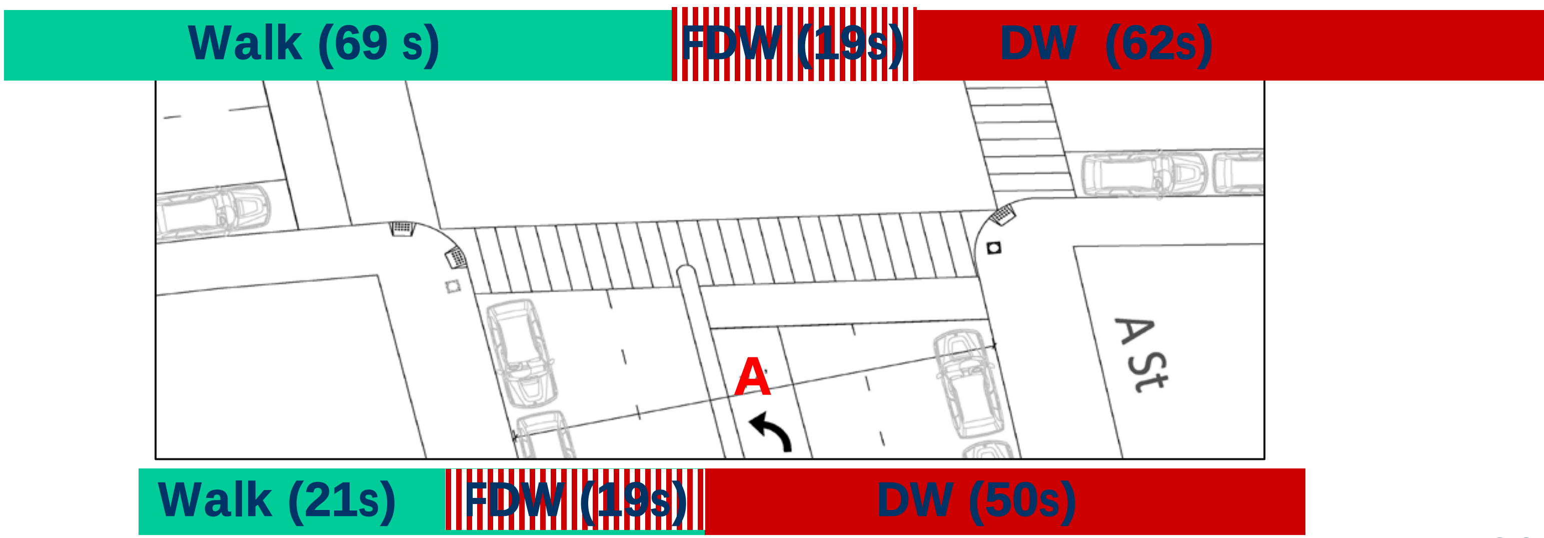
- Noncompliance rates on crosswalk and corner area were from 3.2% to 21.9 % and from 5.0% to 46.0%, respectively. Approximately 46.0 % stood in the parking lane at northwest corner, Madison Avenue and 42nd Street.

	Corner Waiting Area	Crosswalk Area
3rd Ave. and 34th St. (South Crosswalk)		
Madison Ave. and 42nd St. (North Crosswalk)		
5th Ave. and 42nd St. (West Crosswalk)		
6th Ave. and 42nd St. (South Crosswalk)		
Queens Blvd. and Van Dam St. (South Crosswalk)		

Pedestrian Compliance (2)

- **Among the study locations, the lowest pedestrian noncompliance percentages on crosswalk area & FDW and steady DW intervals occurred at longer crosswalk with crossing distance of approximately 70-foot and very long Walk time (Ped Timing 1) of 69 seconds.**
- **Third Avenue and 34th Street with same crosswalk length was identified with high noncompliance rates in those categories because there were vehicles occupying the crosswalk and relatively shorter Walk time (Ped. Timng 2).**

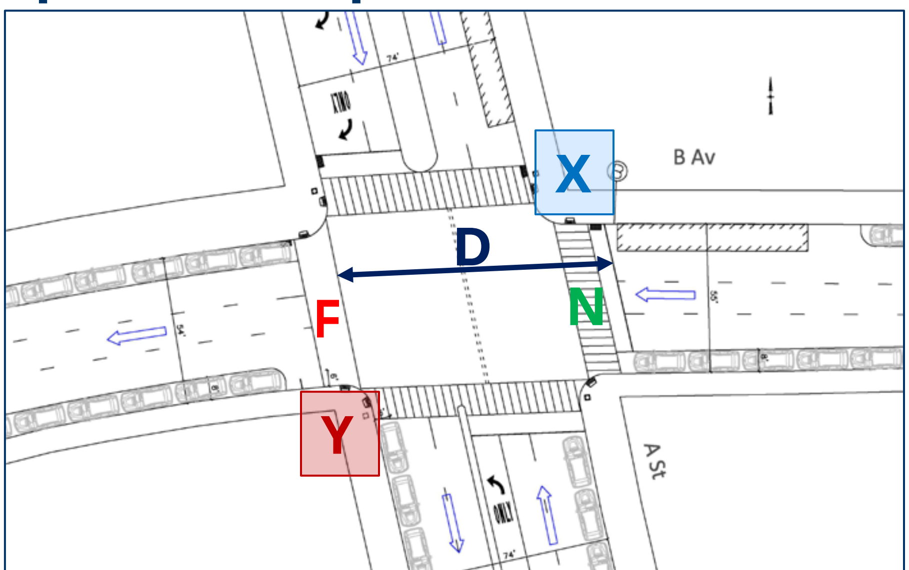
Pedestrian Timing 1

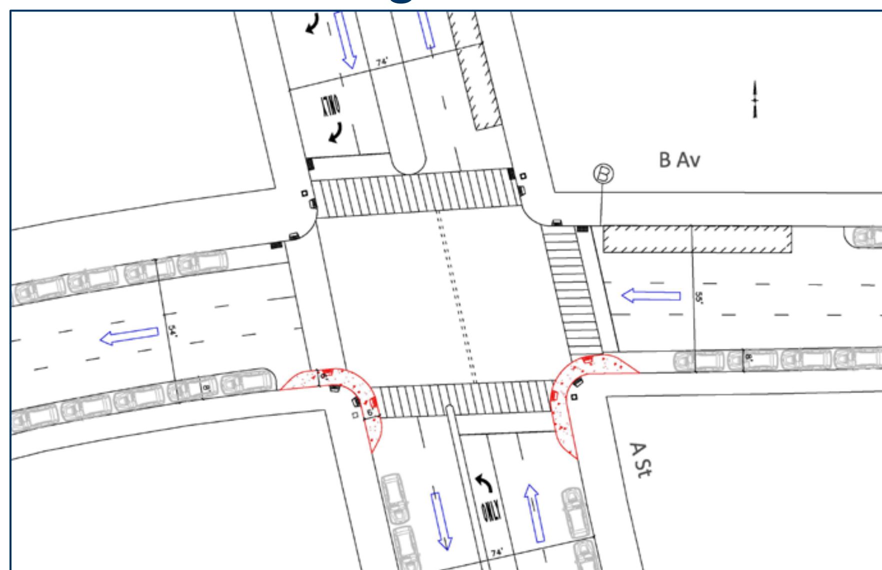


Pedestrian Timing 2

Pedestrian Compliance (3)

- Pedestrian noncompliance rates at corner waiting areas were highest far-side crosswalk (“F”) in a one-way street approach, when the distance (“D”) between the approach stop bar and the opposing crosswalk is longer.
- A near-side crosswalk from approaching traffic without a parking lane caused pedestrians to remain in the corner waiting area (“X”) but induced higher noncompliance on pedestrian Walk time when pedestrians perceived that Walk time is not enough.





Control Policy Score for Pedestrian Safety and Mobility

- **Protecting Signal Timing for Pedestrians**
  - **Leading Pedestrian Interval (LPI)**
  - **Split Phase**
  - **Split LPI**
  - **Barnes Dance**
- **Turn Prohibitions**
- **Curb Extension and Safety Island**
- **Signal Timing Modification (Walk & Flashing DW)**
- **Exclusive Turn Lanes**
- **Others**

Effectiveness

Control Scale?

Cost & Easy Implementation

Case Study: Downtown Flushing

Downtown Flushing

Downtown Flushing is a thriving community with a dense concentration of businesses and residents. The area serves as one of the largest intermodal transportation hubs in New York City with the 7 train, the Long Island Rail Road, 20 bus routes, and commuter vans all converging in the downtown. Sidewalks and roadways are congested. Pedestrian traffic regularly spills into the street in many areas, disrupting traffic and posing safety risks. Of particular concern was the intersection of Union Street and Northern Boulevard, which had the greatest number of crashes with pedestrian injuries in the entire borough.

To ease congestion and improve safety in Downtown Flushing, DOT worked with Community Board 7, local business owners and elected officials to analyze and discuss several options to improve pedestrian and traffic safety and reduce congestion. The MTA and NYCEDC were also important partners in the study.

- Total crashes with injuries down **10%**
- Crashes with injuries to vehicle occupants down **26%**
- Crashes with injuries to bicyclists down **31%**
- Travel times along the eastbound and westbound Northern Boulevard decreased by **16%** and **15%** in the PM peak hour, respectively, and **34%** and **37%** in the Saturday Midday peak hour

Facing north on Main Street at Roosevelt Avenue

Change in Travel Time
Northern Boulevard (Eastbound)

Time Period	Overall Travel Time Reduction
Weekday Morning Peak Hour	7%
Weekday Midday Peak Hour	5%
Weekday Evening Peak Hour	16%
Saturday Midday Peak Hour	34%

Crashes with Injuries
Northern Boulevard from Prince Street to Bowne Street, Main Street from Northern Boulevard to 41st Avenue, Union Street at 35th Avenue, Union Street at Roosevelt Avenue

	Before* (three previous years)			After
Total Crashes with Injuries	58	74	84	64.9
Number of Crashes with Injuries to:				
Motor Vehicle Occupants	20	25	31	18.7
Pedestrians	35	43	45	42.4
Bicyclists	3	6	8	3.9

*Before columns show the crash history for each of the three years immediately prior to project implementation. After column shows number of crashes since implementation (through May 2013) at annual rate. See page 46 for further information on crash data source and analysis methodology. The sum of the three specific categories may not equal "Total Crashes with Injuries" because some crashes involved injuries in multiple categories.

Source: Sustainable Streets Index 2012, NYCDOT