Video Analytics towards Vision Zero

PacTrans Regional Transportation Conference

October 14, 2016

Franz Loewenherz
Senior Transportation Planner
City of Bellevue, WA

Safer People, Safer Streets

U.S. Department of Transportation

MAYORS' CHALLENGE

GATHER DATA

Winner!
Bellevue, Washington

Bellevue, WA, pursued a range of data collection activities during the Mayors' Challenge to identify barriers to bicycling and walking, prioritize improvements, and guide investments. In February 2015, the Bellevue City Council introduced the Pedestrian and Bicycle Implementation Initiative (PBII) to improve safety for people of all ages and abilities who walk and bike in Bellevue. Using data collected from online sources, key-pad polling at public meetings, automated bicycle and pedestrian counters, and traffic camera videos, the PBII team identified barriers to walking and bicycling and developed a $6.8M Bicycle Rapid Implementation Program (BRIP) budget proposal to guide citywide investments through 2019. The BRIP aims to expand the city's bicycle network from 42 miles to more than 70 miles of conventional bike lanes, separated lanes or off-street paths, and to complete four continuous, cross-city bicycle corridors.

Demonstrated Successes

Innovative Data Collection Techniques Gather Real-Time and Long-Term Data with Public Input

Throughout the PBII process, Bellevue has emphasized understanding long-term trends and gathering feedback from people who walk and bike. Bellevue's PBII team:

- Conducted a longitudinal assessment from 2006–2015 of non-motorized collisions using the USDOT's Pedestrian and Bicycle Crash Analysis Tool (PBCAT) system;
- Gathered input using key-pad polling and comment cards at 20 public meetings and an open house that attracted 140 attendees; and
- Used online surveys to solicit public input at two stages in the BRIP development process;
  - Over 700 people placed more than 1,600 points in the first online map to identify locations that they felt were unsafe for walking and bicycling;
  - Over 120 people submitted more than 400 comments on conceptual designs for 52 proposed projects to make the pedestrian and bicycle systems safer.

Pedestrian and Bicycle project manager Franz Loewenherz (foreground) and Councilmember Lynne Robinson (center) lead a policy ride with local bicycle advocates in Downtown Bellevue.

Bellevue's Vision Zero Initiative: Why?

Hit-and-run driver nearly kills woman on bike in Bellevue

BY KOMO NEWS | WEDNESDAY, MARCH 23RD 2016

ADVERTISEMENT

Car strikes, kills toddler in stroller in Bellevue

Originally published September 29, 2015 at 11:03 am | *Updated September 30, 2015 at 10:27 am*

77-year-old pedestrian killed by teen driver in Bellevue

BY TIM HAECK, KIRO Radio Reporter | December 1, 2014 @ 10:17 am

Bellevue's Vision Zero Initiative: Dialogue with the Public

Amy Carlson, Vice President and Area Office Manager, CH2M HILL

Making Vision Zero a reality entails more than just engineering, education, and enforcement.

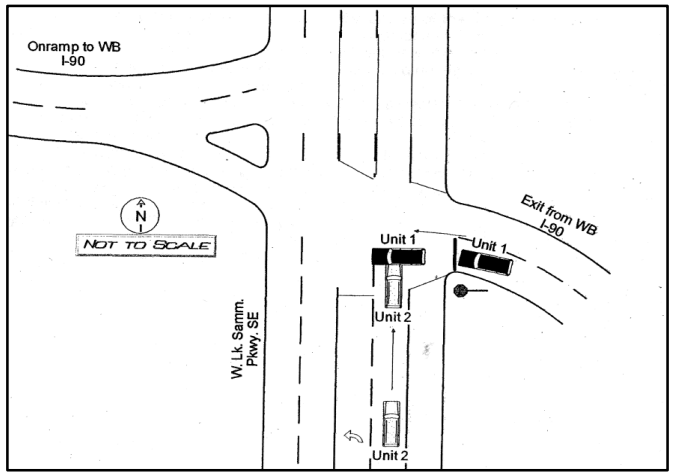
It's a collaborative effort involving Bellevue residents and businesses.

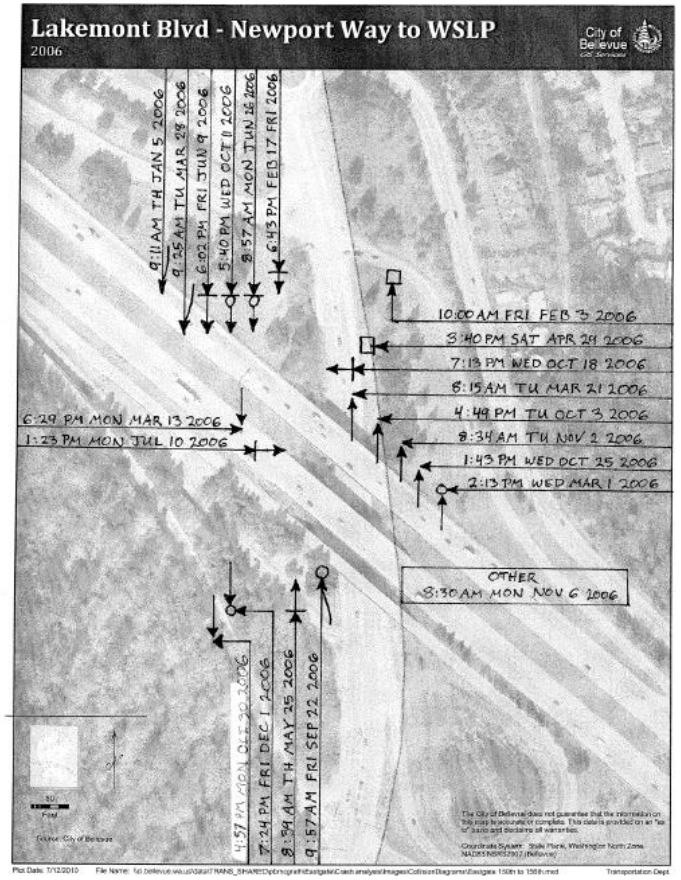
Vision Zero: Reframing Traffic Deaths & Injuries as Preventable

Reactive: Reacting to a problem after it arises.

Proactive: Preventing problems before they arise.

Crash-Based Approach: Lakemont Interchange Case Study





From 2005 through 2010 there were 60 collisions recorded by the Bellevue Police Department and the WSP at this location.

In 2013, WSDOT built a new roundabout at the intersection of the WB I-90 on- and off-ramps and WLSP SE/180 Ave SE.

Crash-Based Approach: Short-Comings

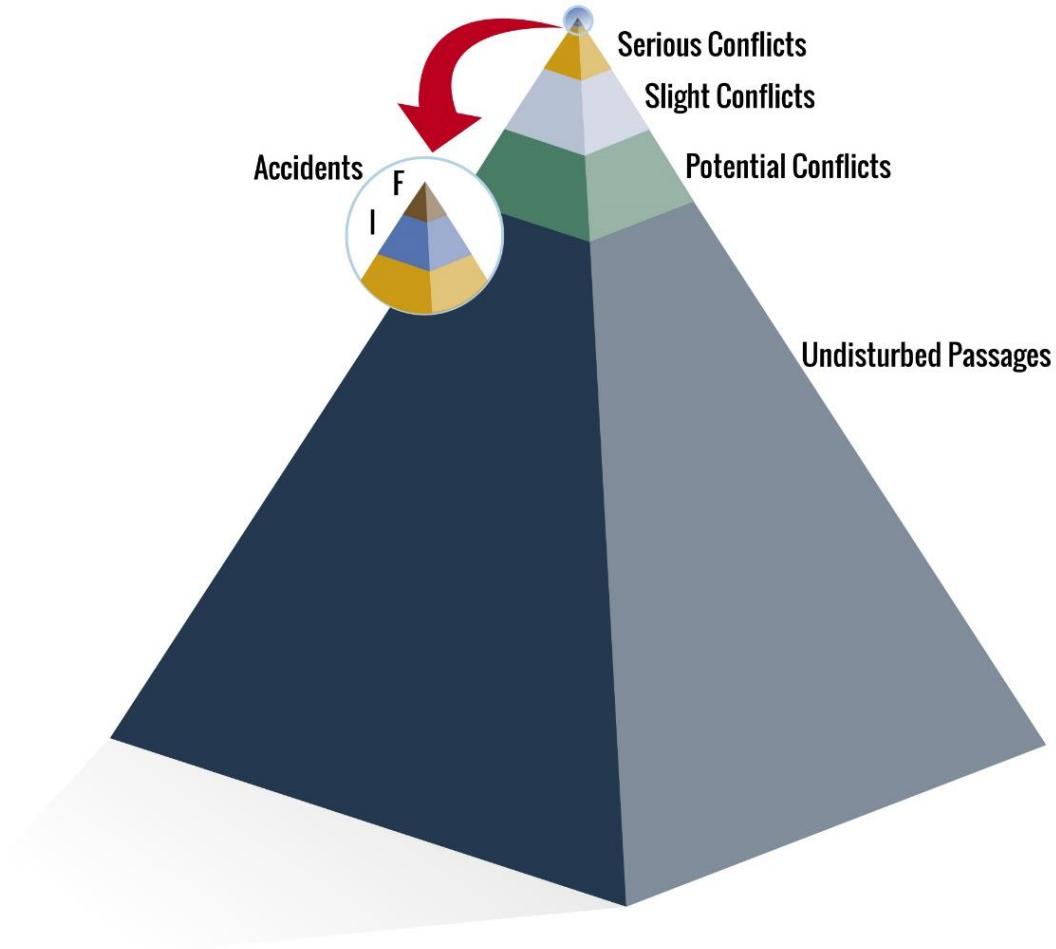
1. **Crashes are rare events and are therefore associated with the random variation inherent in small numbers.**

2. **Not all crashes are reported and the level of reporting is unevenly distributed with regard to the type of road users involved, location, severity of injuries, etc.**

3. **The behavioral or situational aspects of the events are not covered by police crash data.**

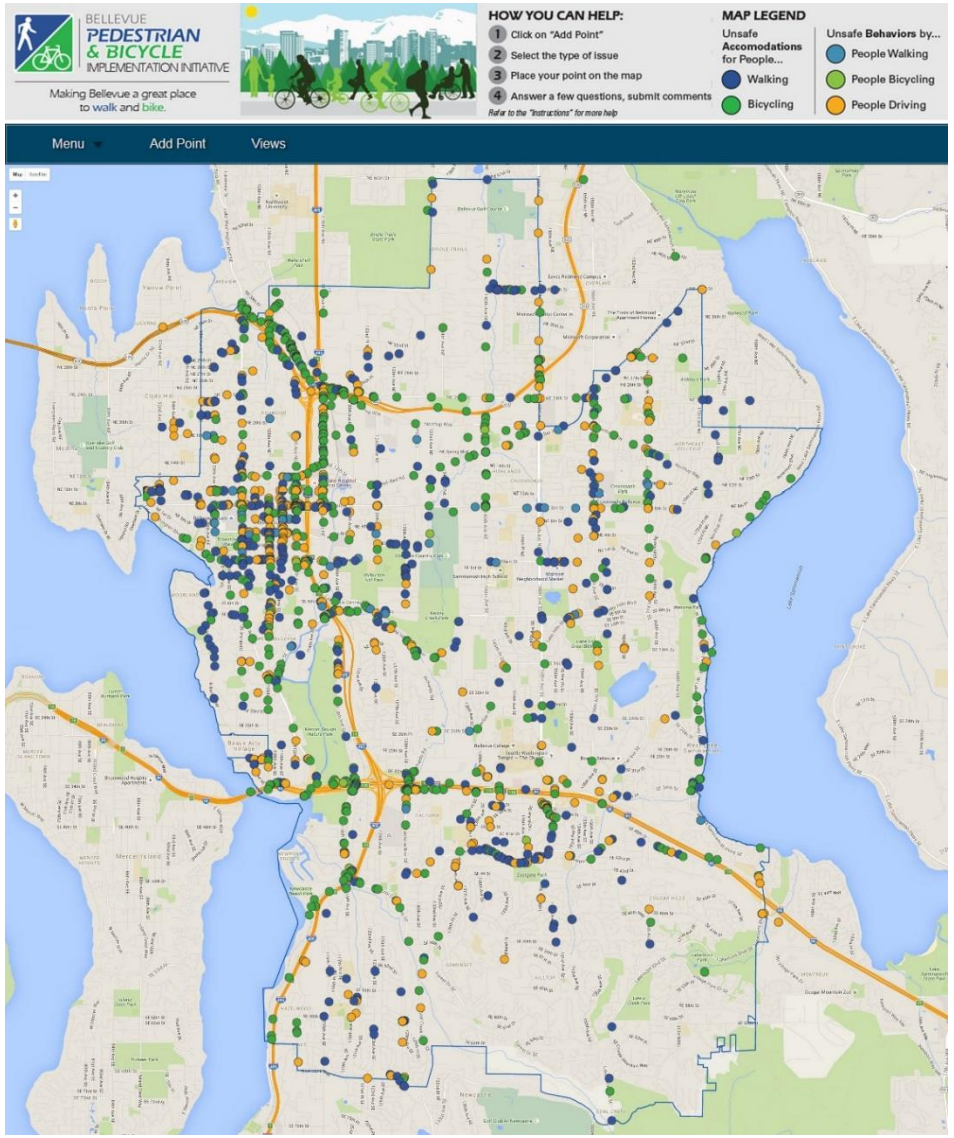
4. **Many years of crash data is typically required to develop an understanding of the situation.**

Conflict-Based Approach: Don’t Wait For Crashes to Happen



Hyden’s Safety Pyramid (adapted from Hyden, 1987)

Conflict-Based Approach: Public Involvement Strategy

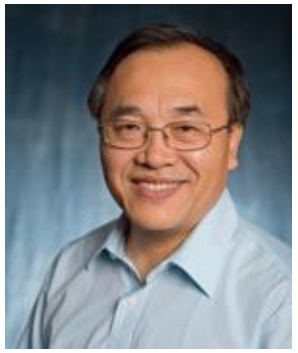


	Total Points Placed	
Ped Facilities	514	32%
Bike Facilities	573	35%
Ped Behaviors	57	4%
Bike Behaviors	22	1%
Car Behaviors	452	28%
Total	1618	

Technology Development Partnership

Microsoft

Dr. Victor Bahl
Director Mobility & Networking Research



Dr. Yinhai Wang
Director PacTrans and STAR Lab

Franz Loewenherz
Senior Transportation Planner

Exploring potential to leverage a city's existing traffic camera system to simultaneously:

- **monitor counts and travel speed of all road user groups (vehicle, pedestrian, and bicycle);**
- **document the directional volume of all road user groups as they move through an intersection; and,**
- **assess unsafe "near-miss" trajectories and interactions between all road user groups.**

Partnership Approach

Milestone 1: Demonstrate the capability of vision technologies by detecting relevant events in the sample traffic videos (e.g., detecting cars, pedestrians, and bikes and tracking their movements).

Milestone 2: Demonstrate an end-to-end system that will, continuously in real-time, detect and store the events, and present aggregated information.

Milestone 3: Pilot deployment of end-to-end system (running on servers provided by Microsoft) in the City of Bellevue traffic control center. The system will run off of a live feed.

Milestone 4: Support additional scenarios (e.g., near-collisions of cars with pedestrians and bikes or patterns of bikers crossing a busy intersection).

How Neural Networks Work

training

during the training phase, a neural network is fed thousands of labeled images of various objects, learning to classify them

input

new image is shown to the pretrained network

first layer

the neurons respond to simple shapes, like edges

higher layer

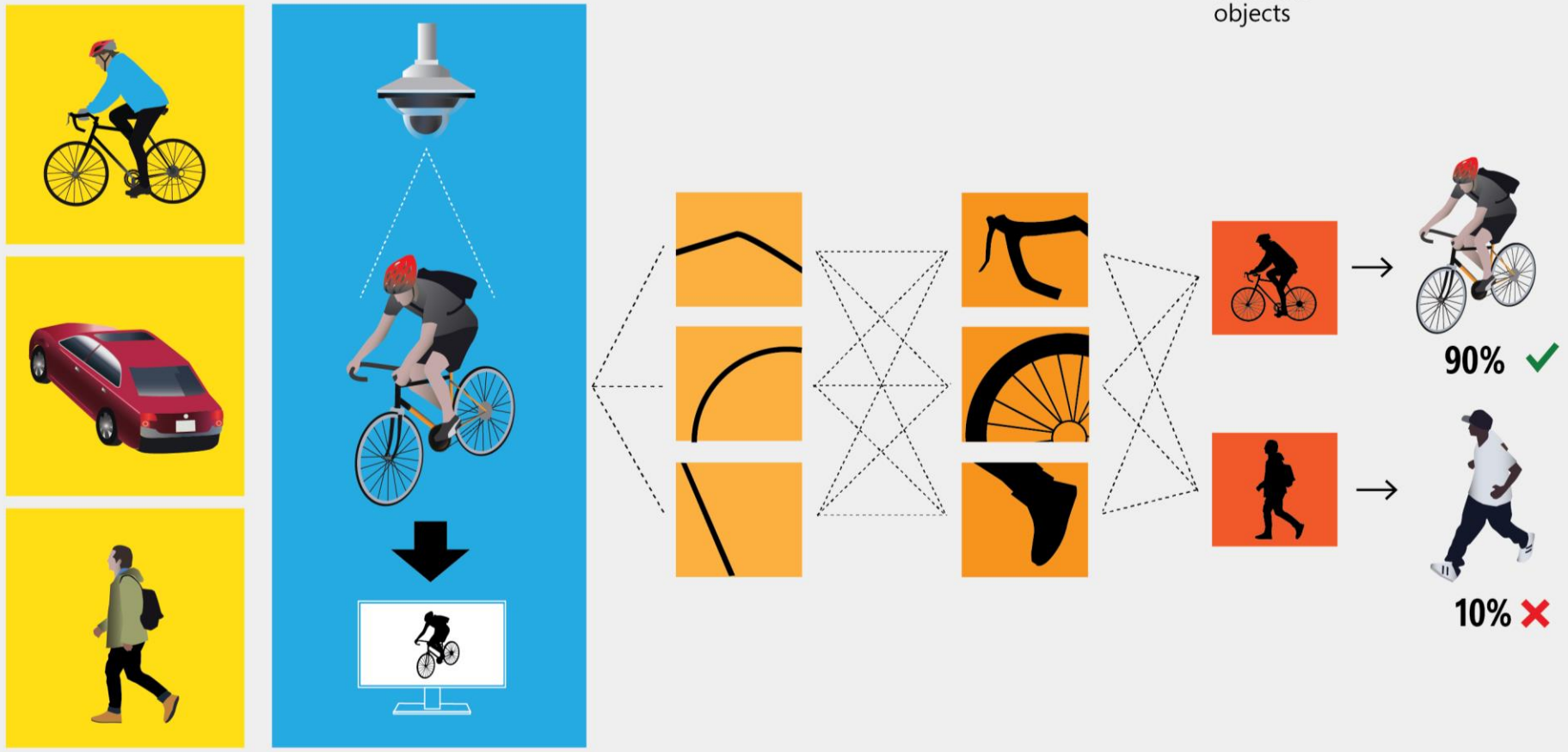
the neurons respond to complex shapes

top layer

neurons respond to highly complex abstract concepts that we would identify as different objects

output

the network predicts what the object most likely is based on its training.



Object Classification Accuracy

We recognized it as…

When it really is…

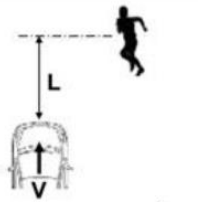
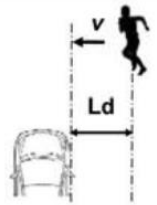
Classified-as → / Truth ↓	*Vehicles*	*Bikes*	*Peds*	*None*
Vehicles	**0.95**	0.01	0.02	0.02
Bikes	0.08	**0.66**	0.16	0.08
Peds	0.15	0.15	**0.65**	0.05
None	0.09	0.03	0.11	**0.75**

0.67

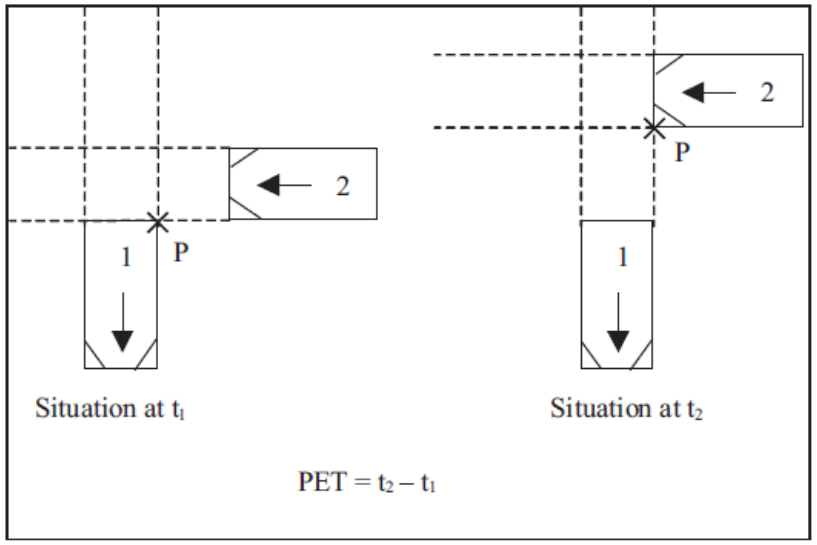
0.73

0.81

Literature Review: Classifying Near-Miss Events

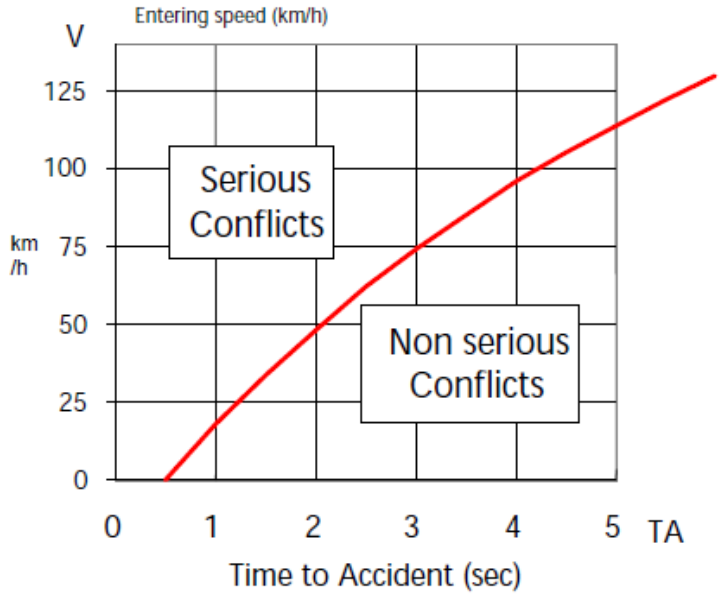
Focused object	Vehicle	Pedestrian
Time	Vehicle time to collision (Vehicle TTC)	Pedestrian time to vehicle (Pedestrian TTV)
Definition	 Vehicle TTC = $\frac{L}{V}$	 Pedestrian TTV = $\frac{Ld}{v}$
Study	Previous study (Matsui et al. 2011b)	Present study

Time to Collision (Matsui et al., 2013)



Post Encroachment Time (Van der Horst et. al., 2014)

The border between Serious and Non-serious Conflict



Definition of a Serious Conflict

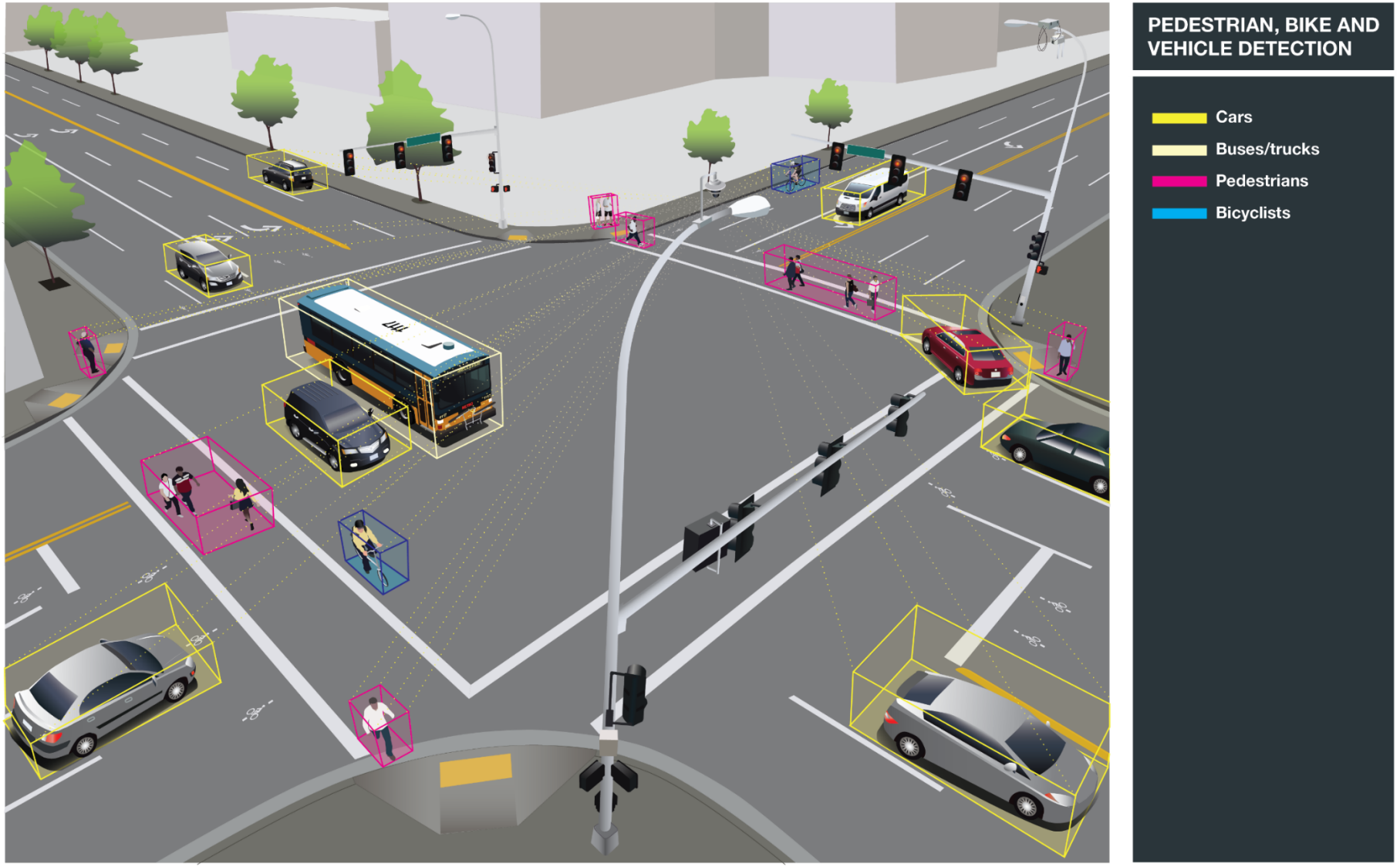
TA = Time to Accident
The time that is remaining from when the evasive action is taken until the collision would have occurred *if* the road users had continued with unchanged speeds and directions.
The TA value can be calculated based on the estimates of distances **d** and speed **v**.

d = Distance to the potential point of collision

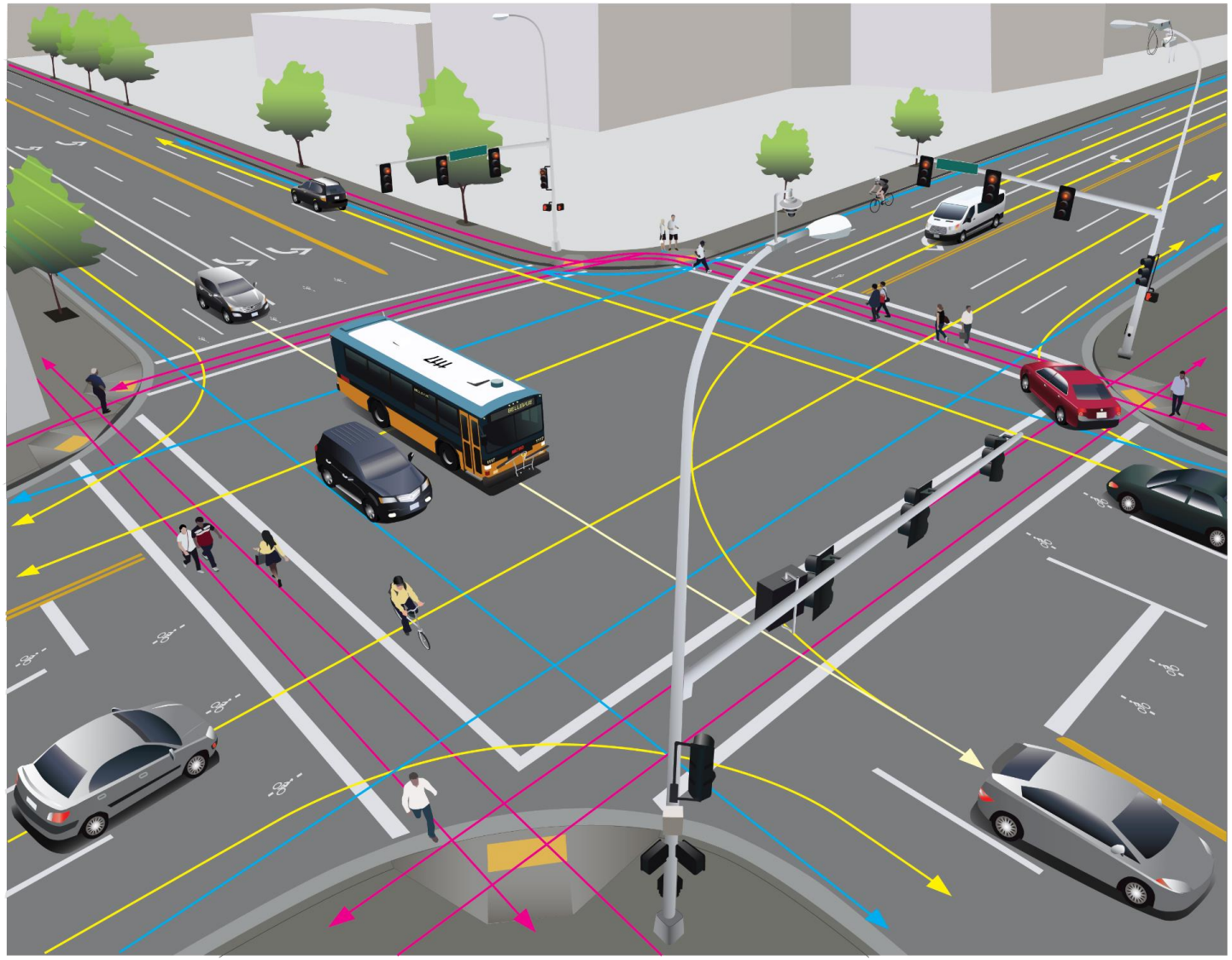
v = Speed when the evasive action is taken

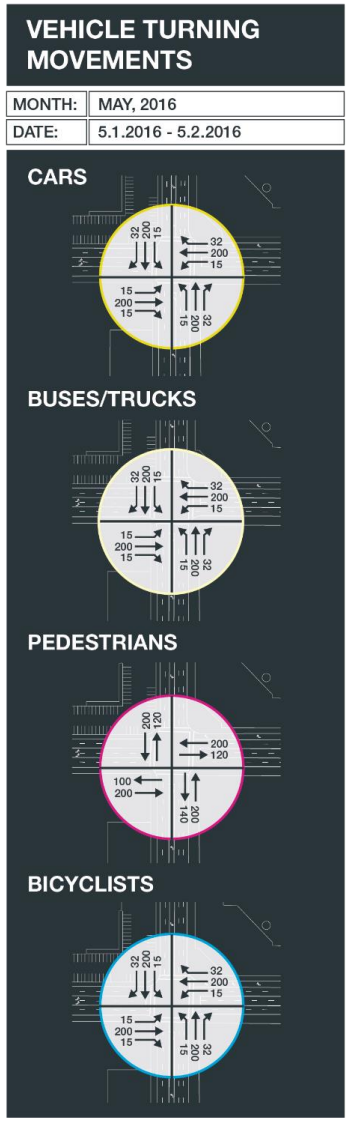
Swedish Conflict Technique (Hyden et. al., 1987)

Object Detection

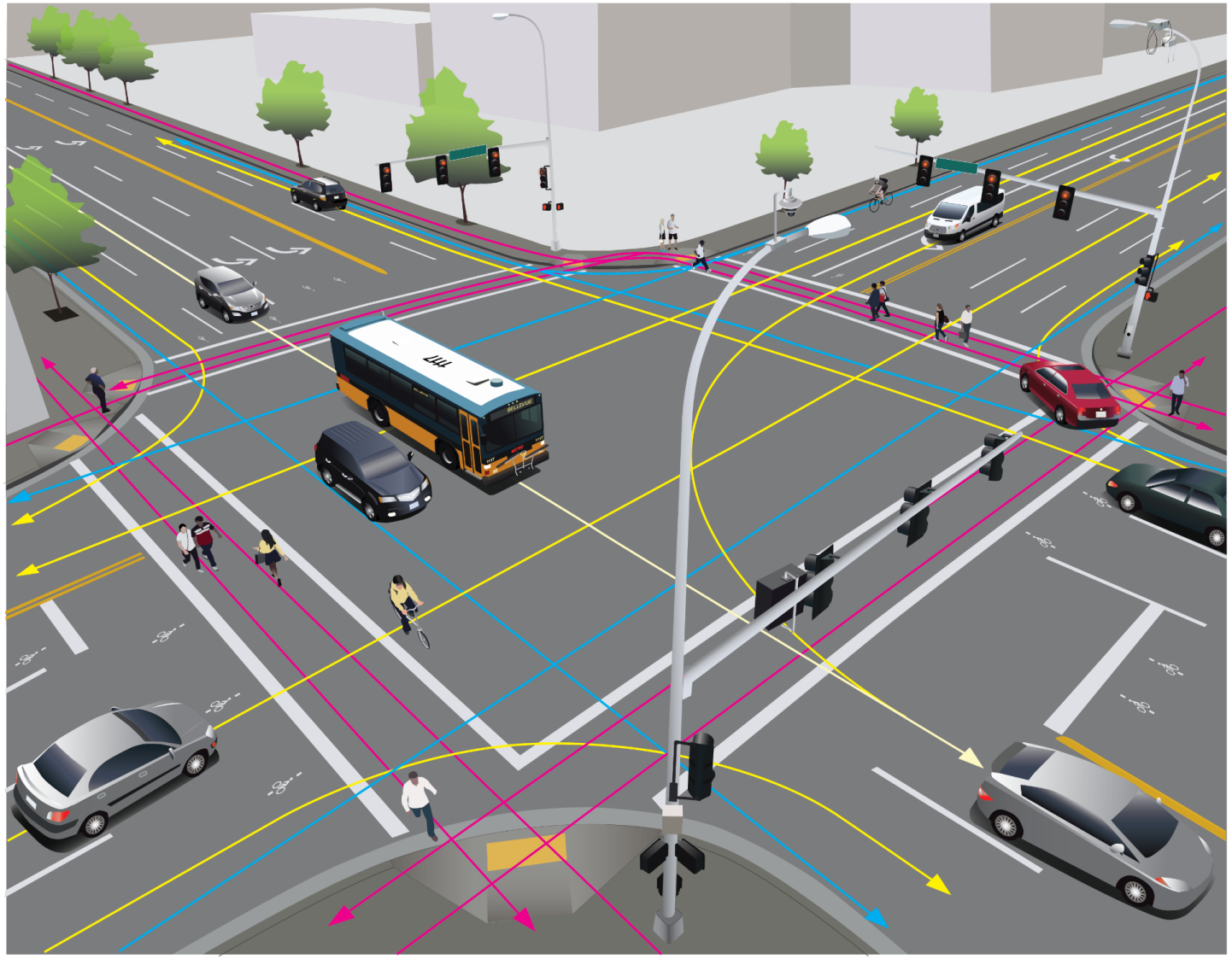


Trajectory Detection & Turning Movement Counts





Vehicle Distribution Charts



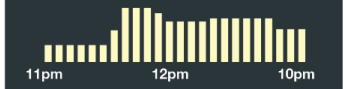
VEHICLE DISTRIBUTION CHARTS BY TIME OF DAY

MONTH:	MAY, 2016
DATE:	5.1.2016 - 5.1.2016

CARS

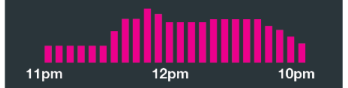
30,000 cars/day

BUSES/TRUCKS



400 buses & trucks/day

PEDESTRIANS

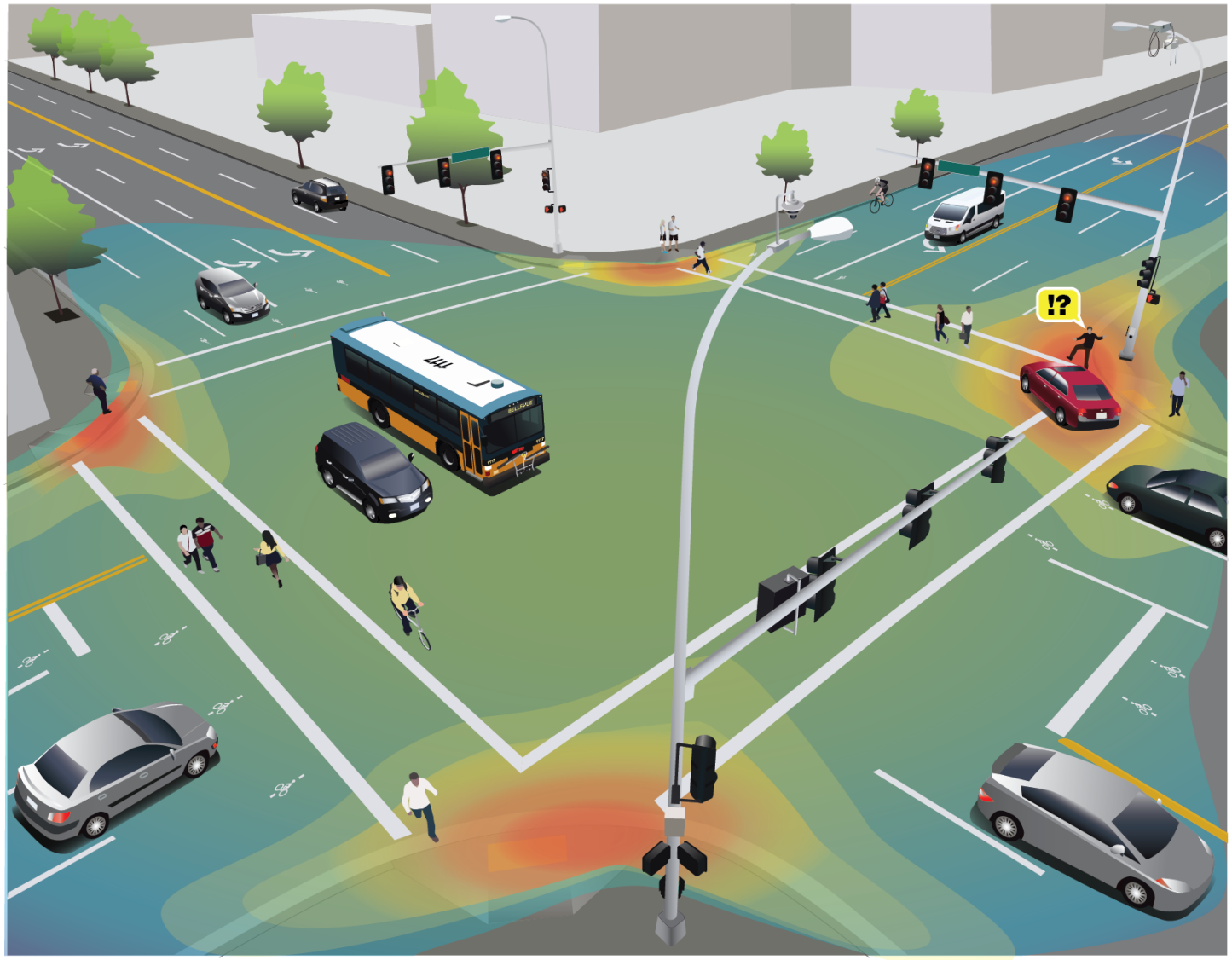


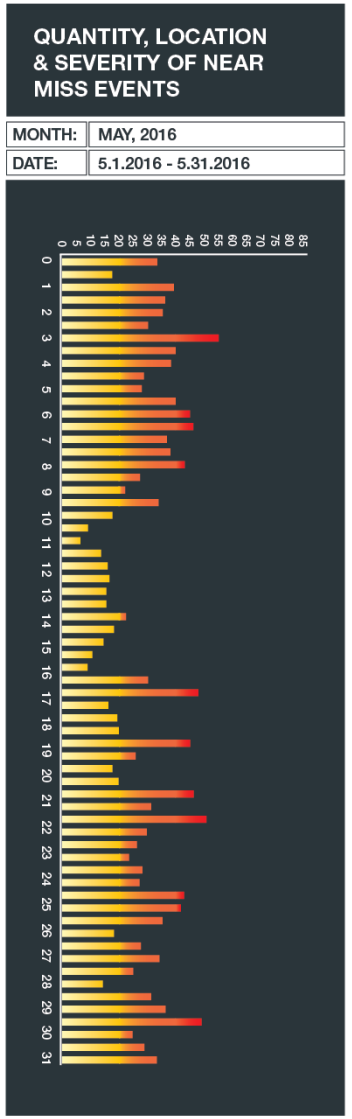
1,000 pedestrians/day

BICYCLISTS

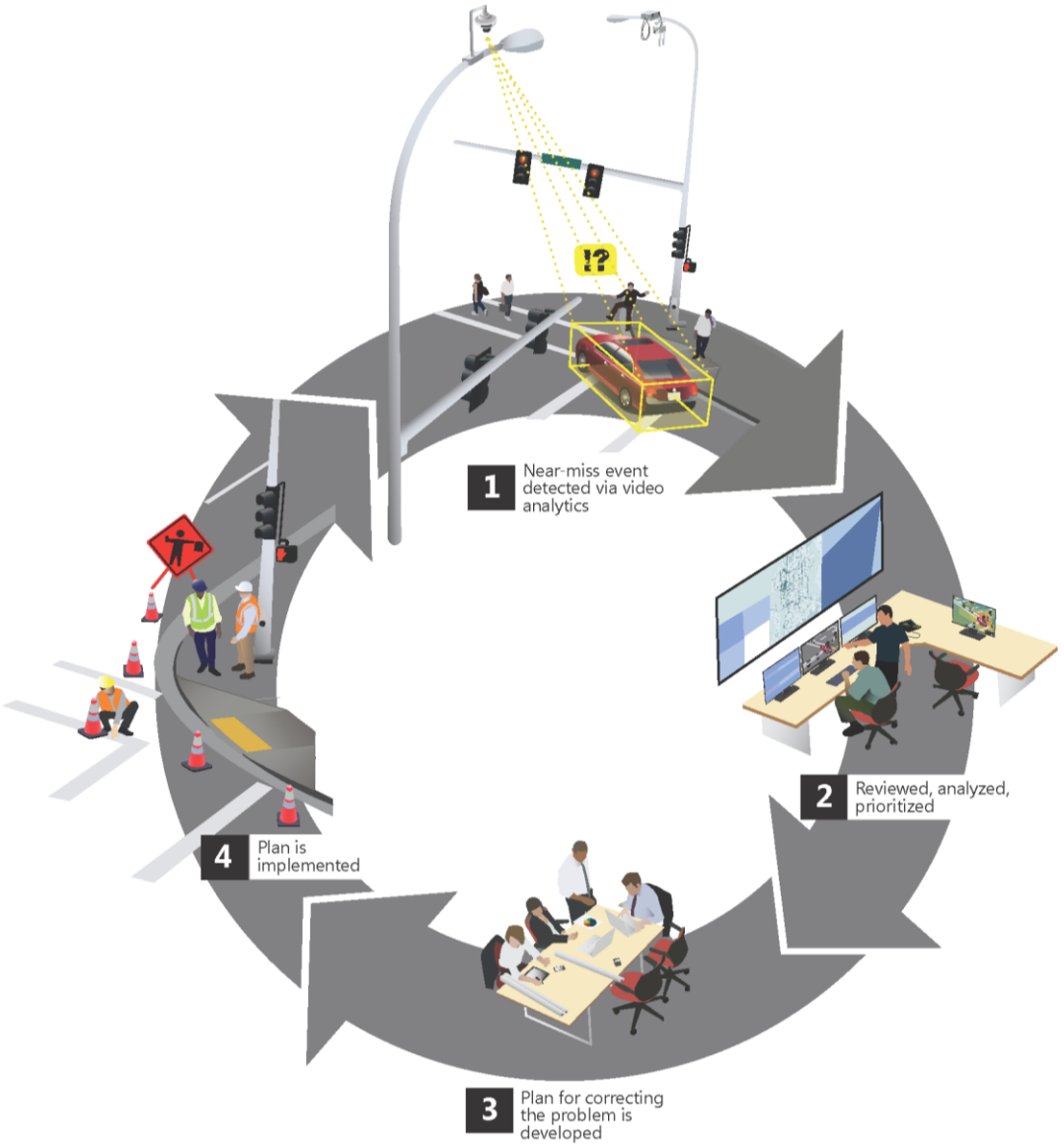
100 bikes/day

Near-Miss Detection





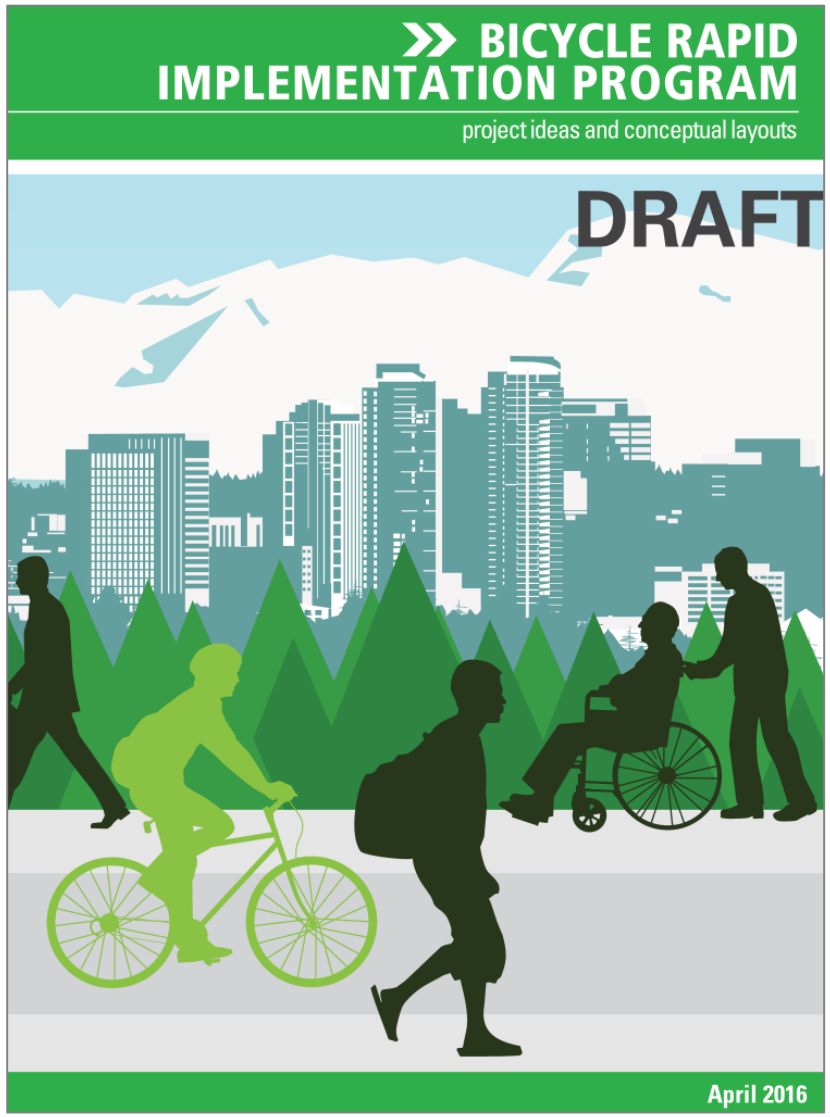
From Video Analytics to Corrective Measures

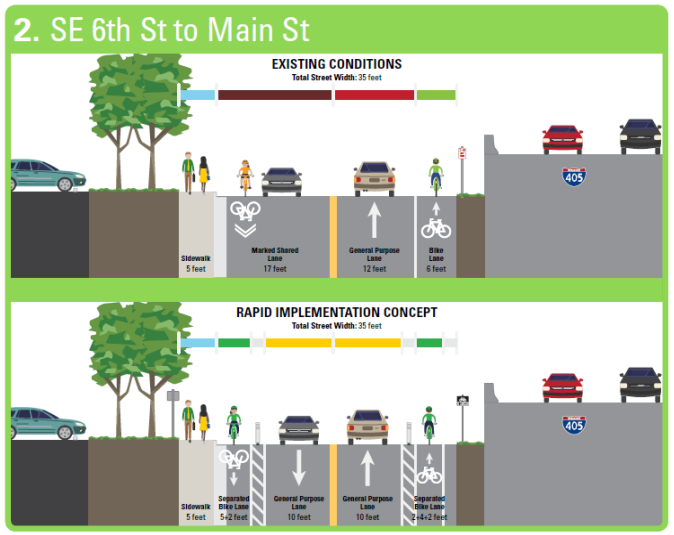


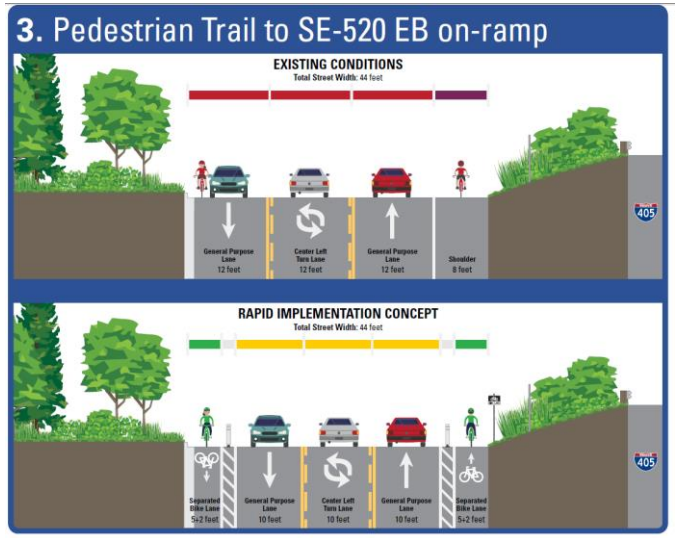
Potential Research Questions

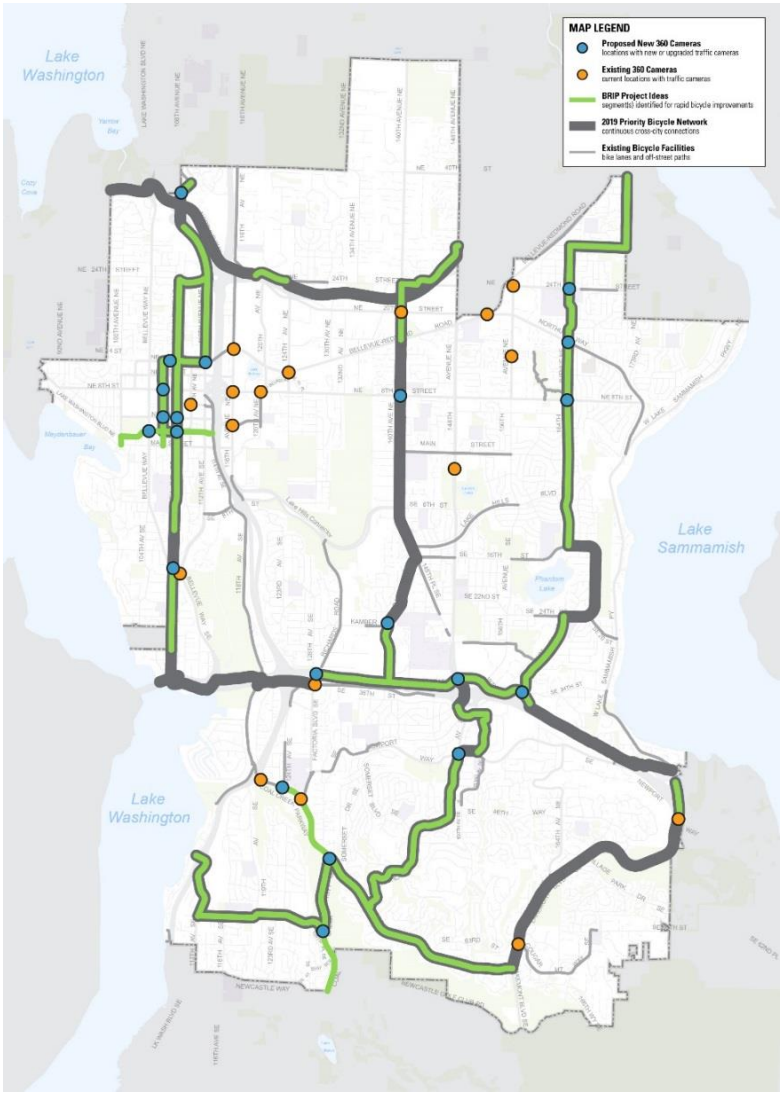
1. How often are vehicles speeding and failing to yield to pedestrians?
2. How often do pedestrians disregard traffic signals?
3. How often do bicyclists fail to stop at stop signs or run red lights?
4. Are there any identifiable trends that hint at the reasons why certain laws are broken in certain places?
5. Did a countermeasure have the desired effect?

Does Bicycle Usage Increase?









Does the Conflict Rate Decrease?

$$R = \frac{A \text{ X } 1{,}000{,}000}{V * 365}$$

Where:

A = Average number of conflicts at the study location per year

V = Intersection ADT (total daily approach volume)

For More Information

Franz Loewenherz
Transportation Department
floewenherz@bellevuewa.gov
425-452-4077