A PROACTIVE APPROACH TO ROAD SAFETY ANALYSIS

Charles Chung (Brisk Synergies)
Franz Loewenherz (City of Bellevue)
James Barr (Miovision)

LEARNING OBJECTIVES

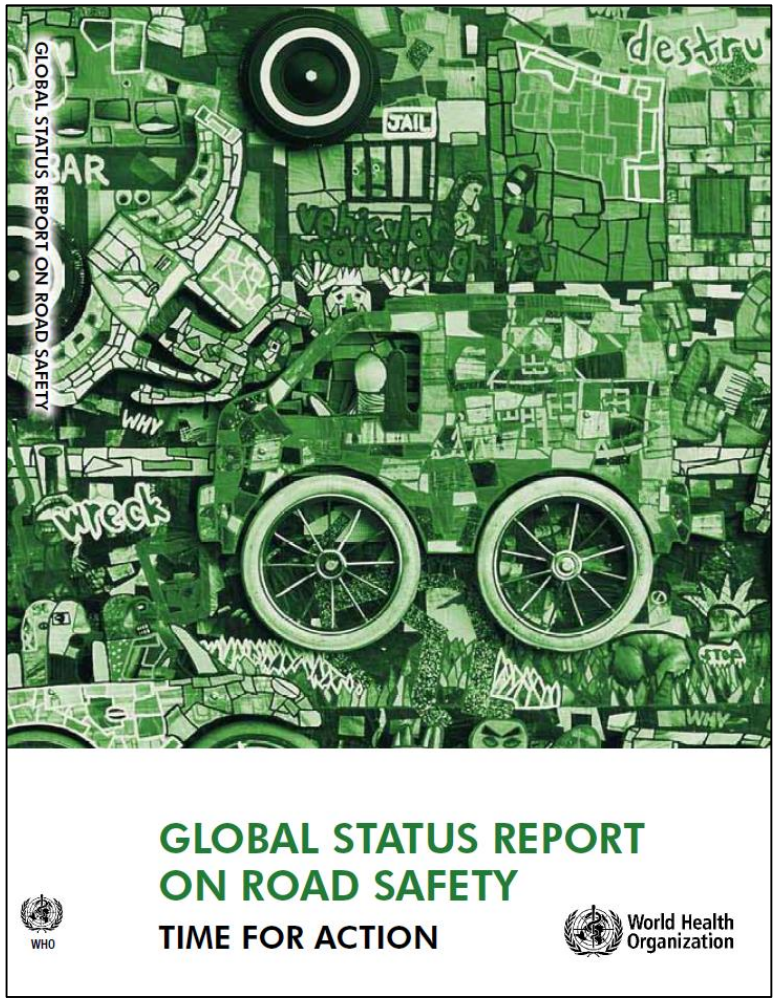
1. How can we use traffic conflict analytics to inform proactive actions for improved road safety?

2. How can we use video analytics and machine learning systems to detect conflicts?

3. How can we work together to move towards Vision Zero?

Franz Loewenherz
Principal Planner
City of Bellevue, WA

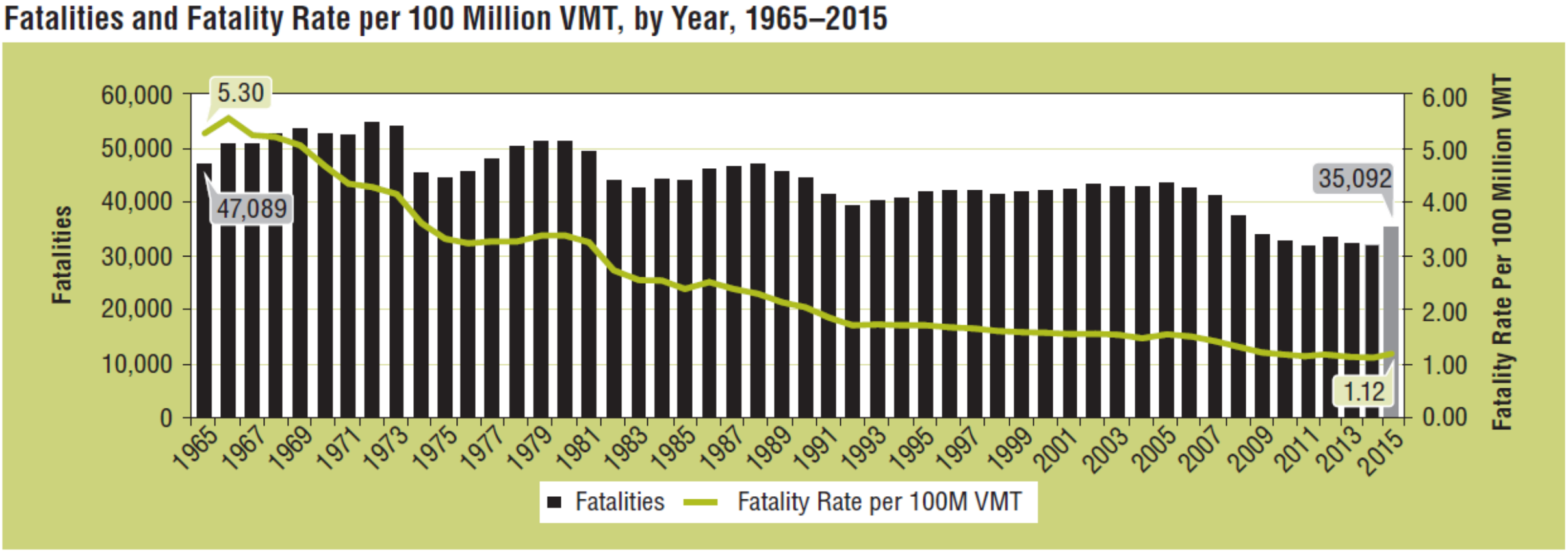
WORLDWIDE: TRAFFIC FATALITIES



Leading Causes of Death (2004)

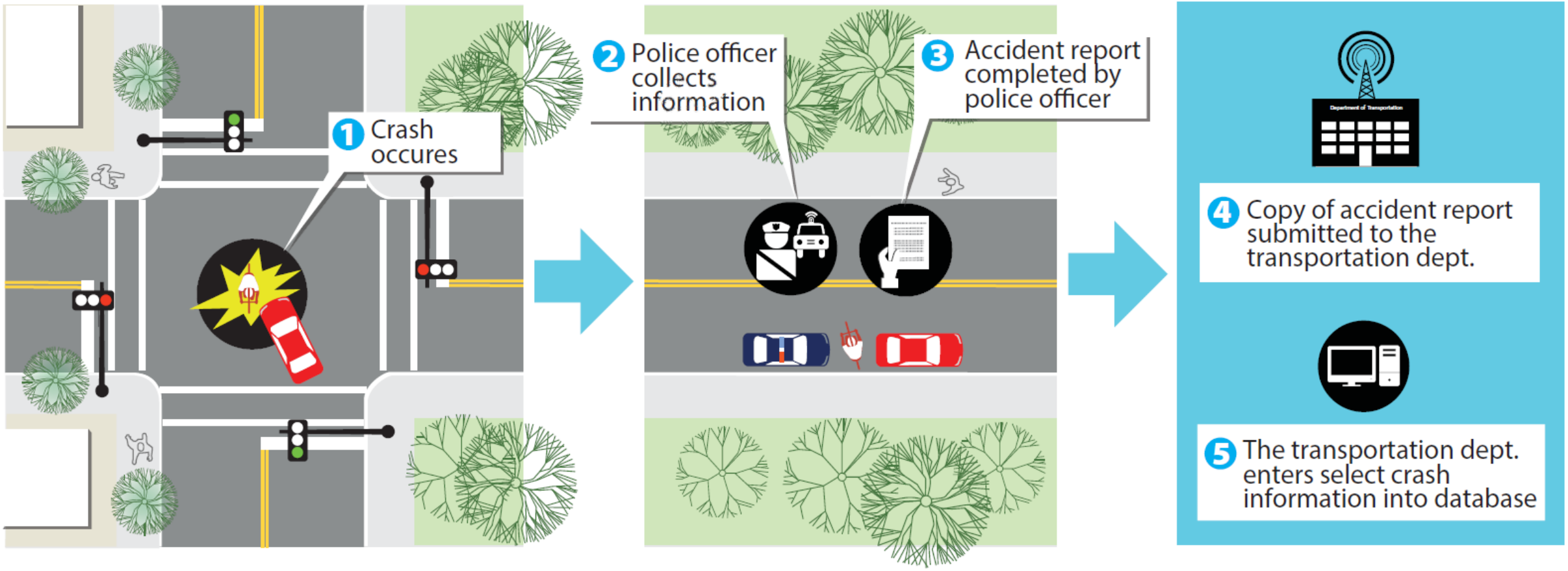
RANK	LEADING CAUSE	%
1	Ischaemic heart disease	12.2
2	Cerebrovascular disease	9.7
3	Lower respiratory infections	7.0
4	Chronic obstructive pulmonary disease	5.1
5	Diarrhoeal diseases	3.6
6	HIV/AIDS	3.5
7	Tuberculosis	2.5
8	Trachea, bronchus, lung cancers	2.3
9	Road traffic injuries	2.2
10	Prematurity and low birth weight	2.0
11	Neonatal infections and other	1.9
12	Diabetes mellitus	1.9
13	Malaria	1.7
14	Hypertensive heart disease	1.7
15	Birth asphyxia and birth trauma	1.5
16	Self-inflicted injuries	1.4
17	Stomach cancer	1.4
18	Cirrhosis of the liver	1.3
19	Nephritis and nephrosis	1.3
20	Colon and rectum cancers	1.1

USA: TRAFFIC FATALITIES



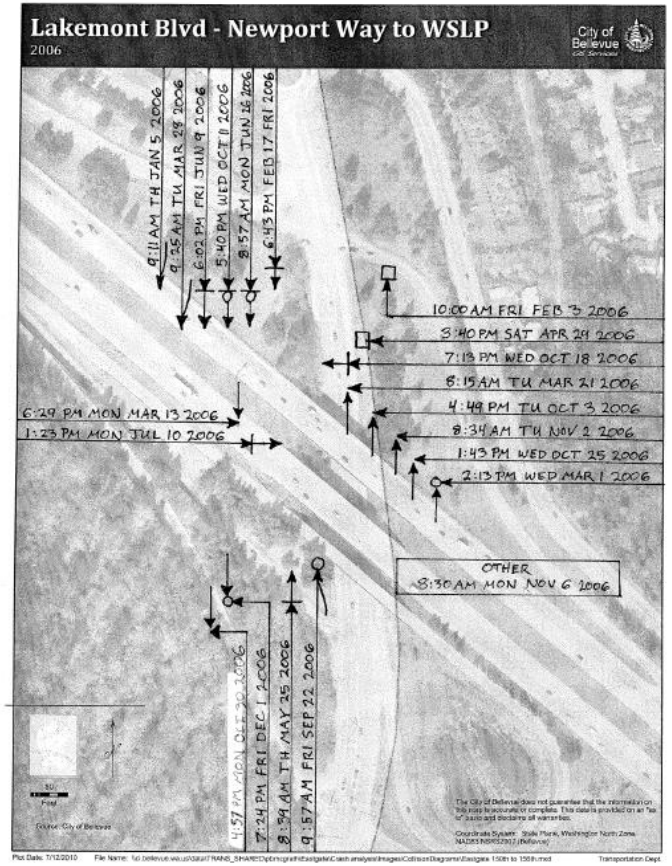
NHTSA, Impact of Crashes (2010): Economic Cost: $242B; Societal Harm: $836B

TRADITIONAL CRASH REPORTING PROCESS



CRASH BASED APPROACH: LAKEMONT INTERCHANGE CASE STUDY

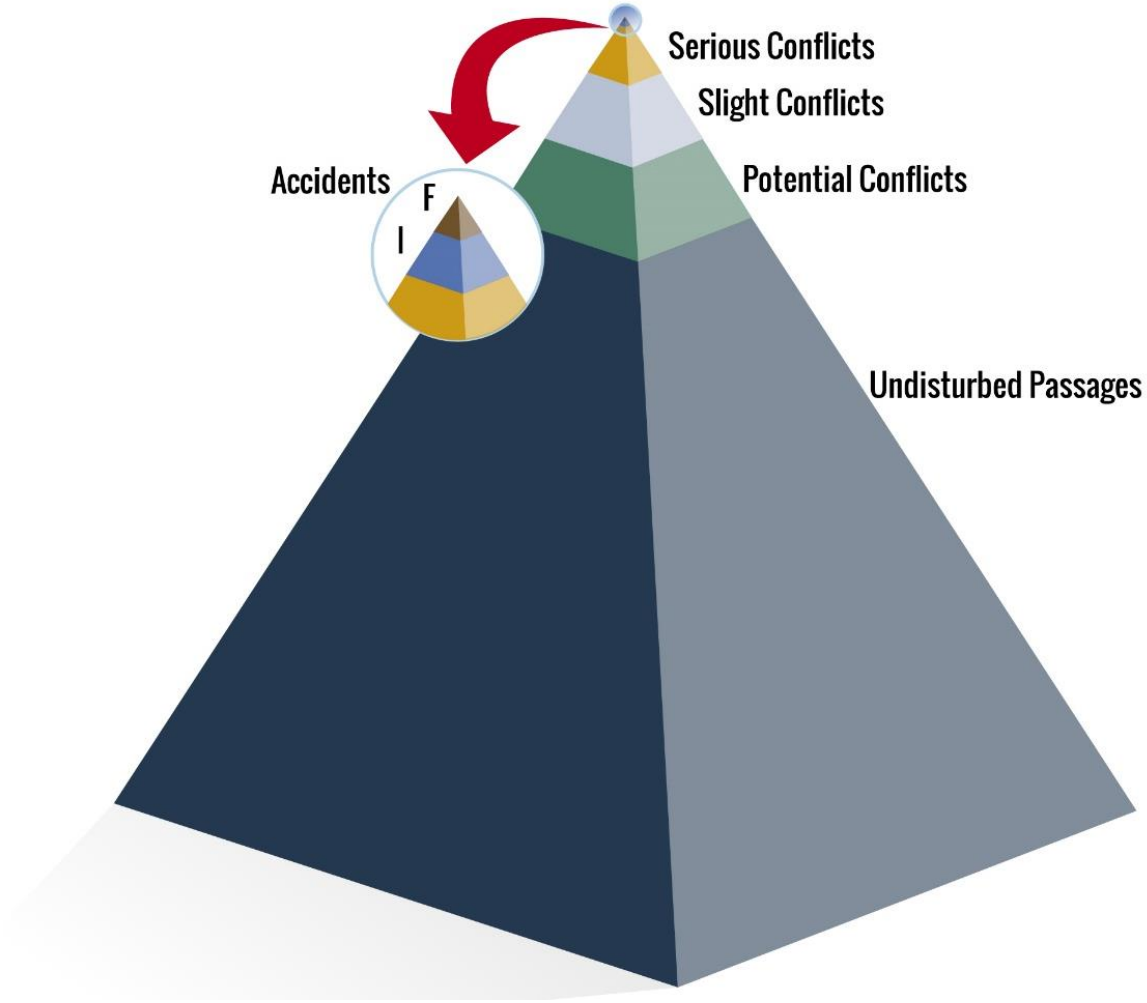
From 2005 through 2010 there were 60 collisions recorded by the Bellevue Police Department and the WSP at this location.



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.

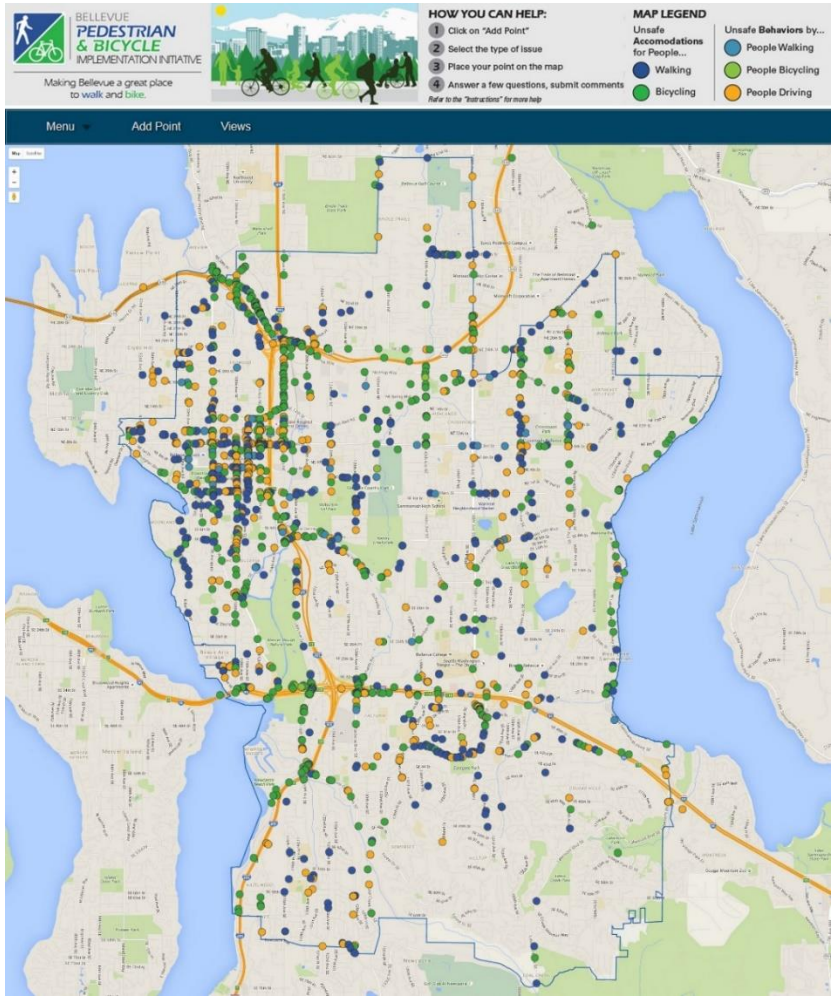
VISION ZERO: REFRAMING TRAFFIC DEATHS & INJURIES AS PREVENTABLE

CONFLICT-BASED APPROACH: DON'T WAIT FOR CRASHES TO HAPPEN



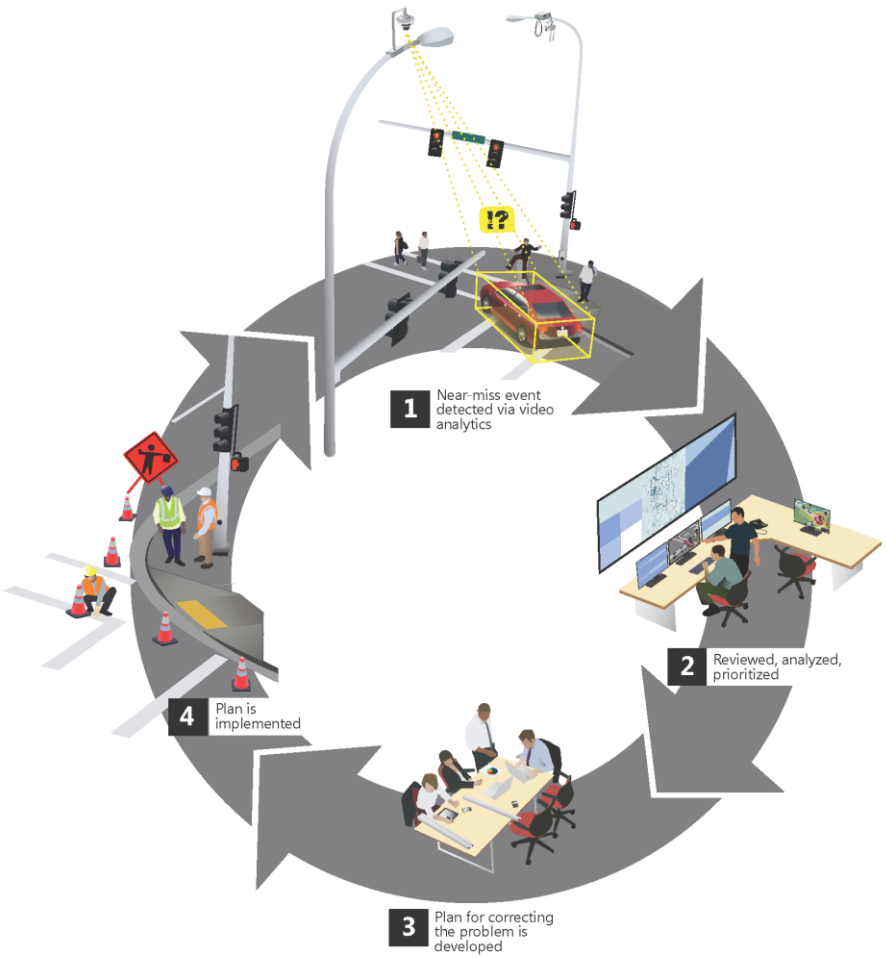
Hyden's Safety Pyramid (adapted from Hyden, 1987)

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	

CONFLICT-BASED APPROACH: VIDEO ANALYTICS STRATEGY



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 MOMENTUM

OVERSIGHT

Microsoft

City of Bellevue Washington

University of Washington

GOVERNMENT

WSDOT

SDOT Seattle Department of Transportation

New York City DOT

LADOT Moving Los Angeles Forward

City of Redmond Washington

Snohomish County Washington

RESEARCH

UBC The University of British Columbia

Lund University

McGill

Polytechnique Montréal

NON-PROFIT

ITS America

ite A Community of Transportation Professionals

Vision Zero Network

cascade BICYCLE CLUB

peopleforbikes

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).

TURNING MOVEMENT COUNTS SAMPLE: 116TH NE & NE 12TH

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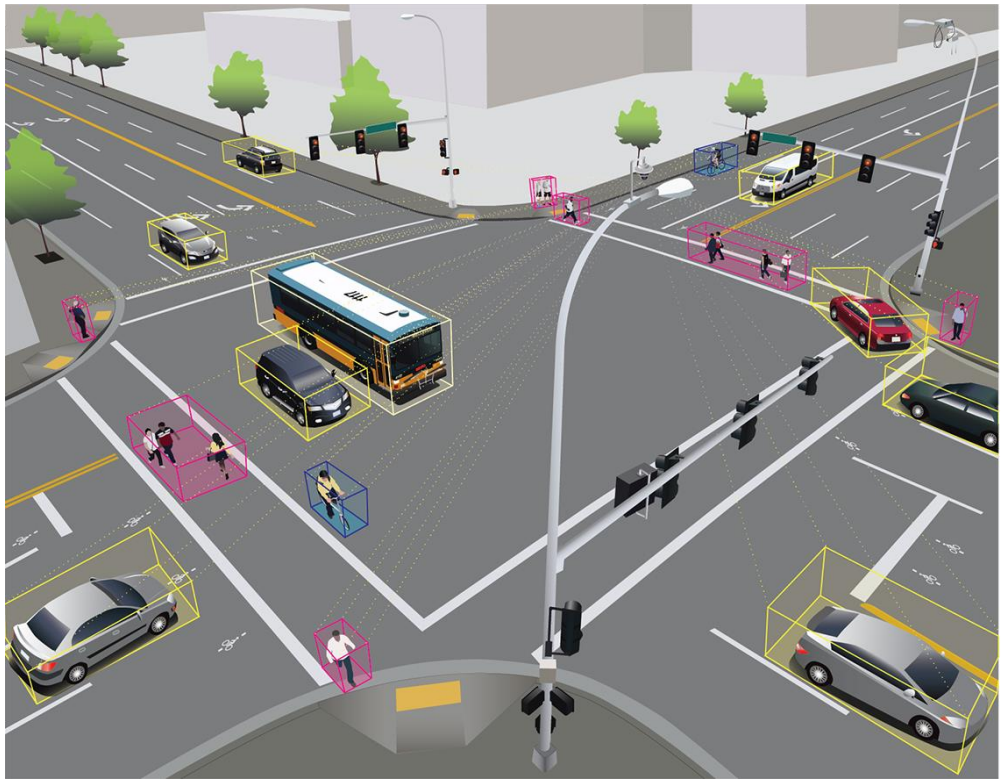
OBJECT CLASSIFICATION ACCURACY

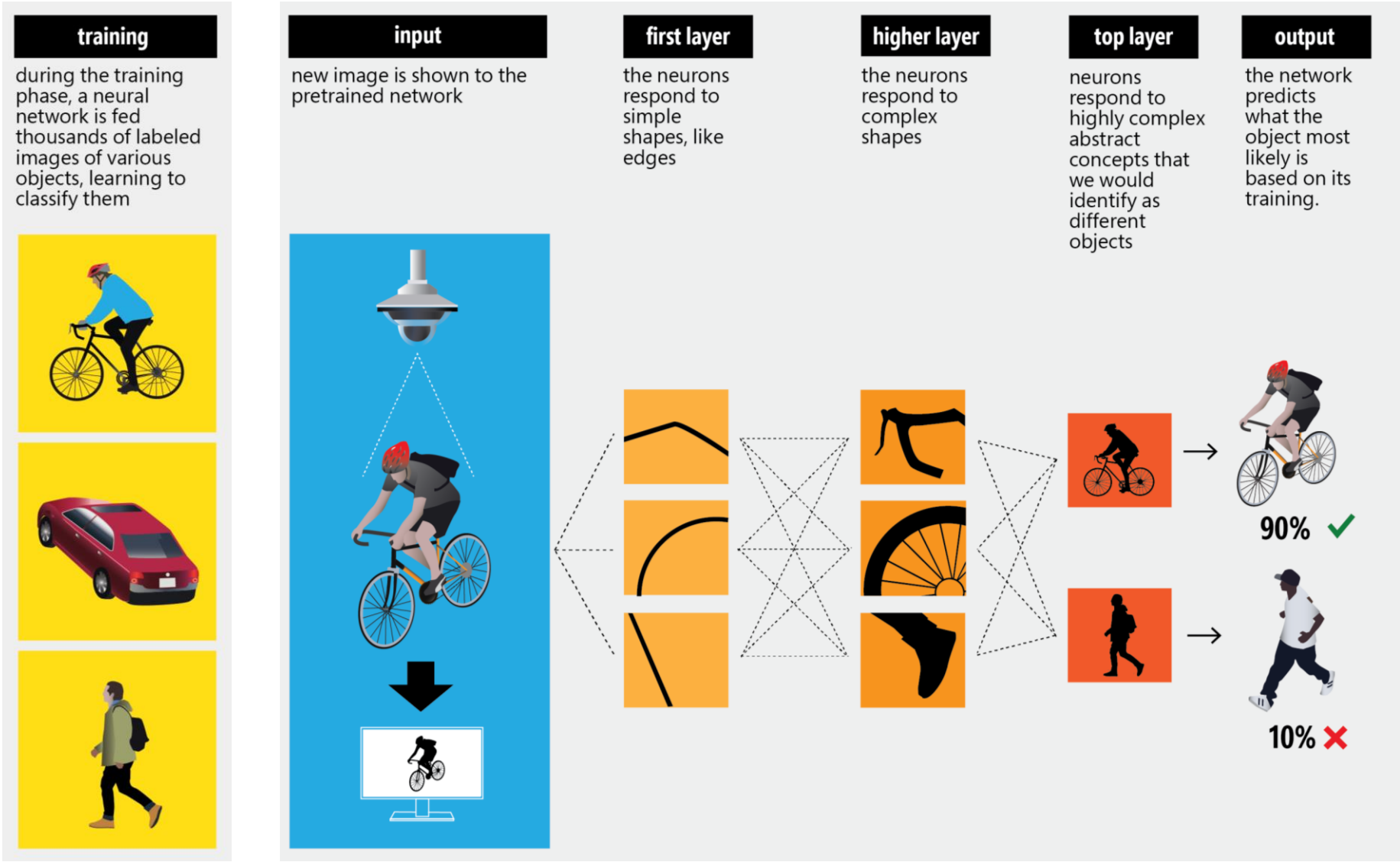


We recognized it as…

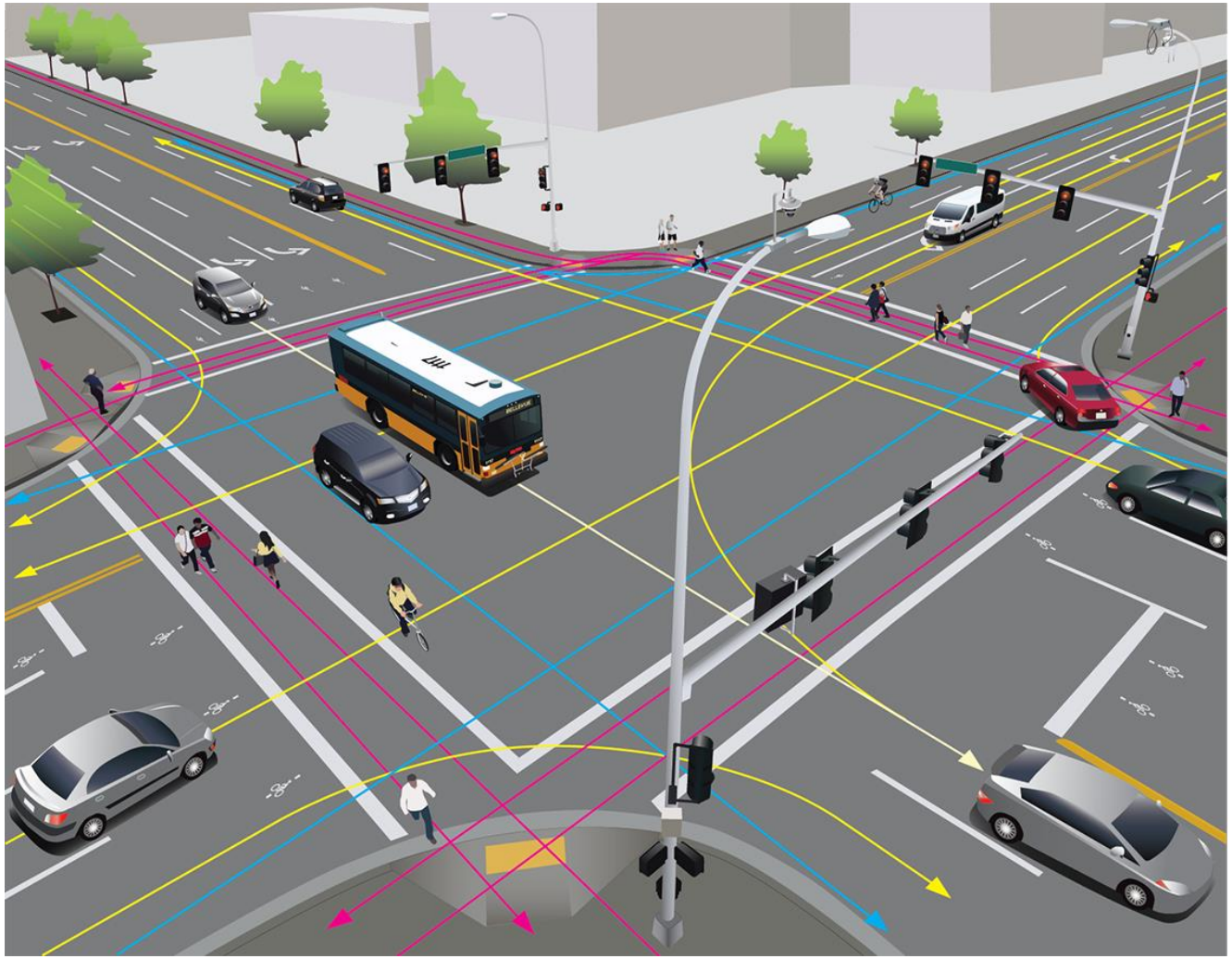
When it really is…

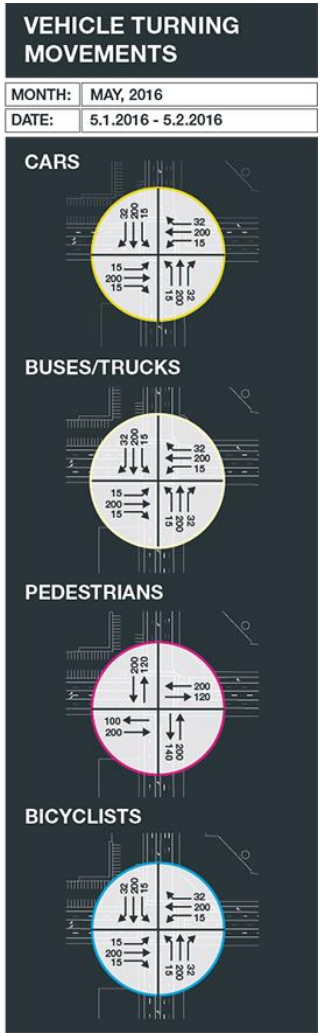
Classified-as → / Truth ↓	Vehicles	Bikes	Peds	None
Vehicles	0.95	0.01	0.02	0.02
Bikes	0.08	0.67	0.16	0.08
Peds	0.15	0.15	0.73	0.05
None	0.09	0.03	0.11	0.81

HOW NEURAL NETWORKS WORK

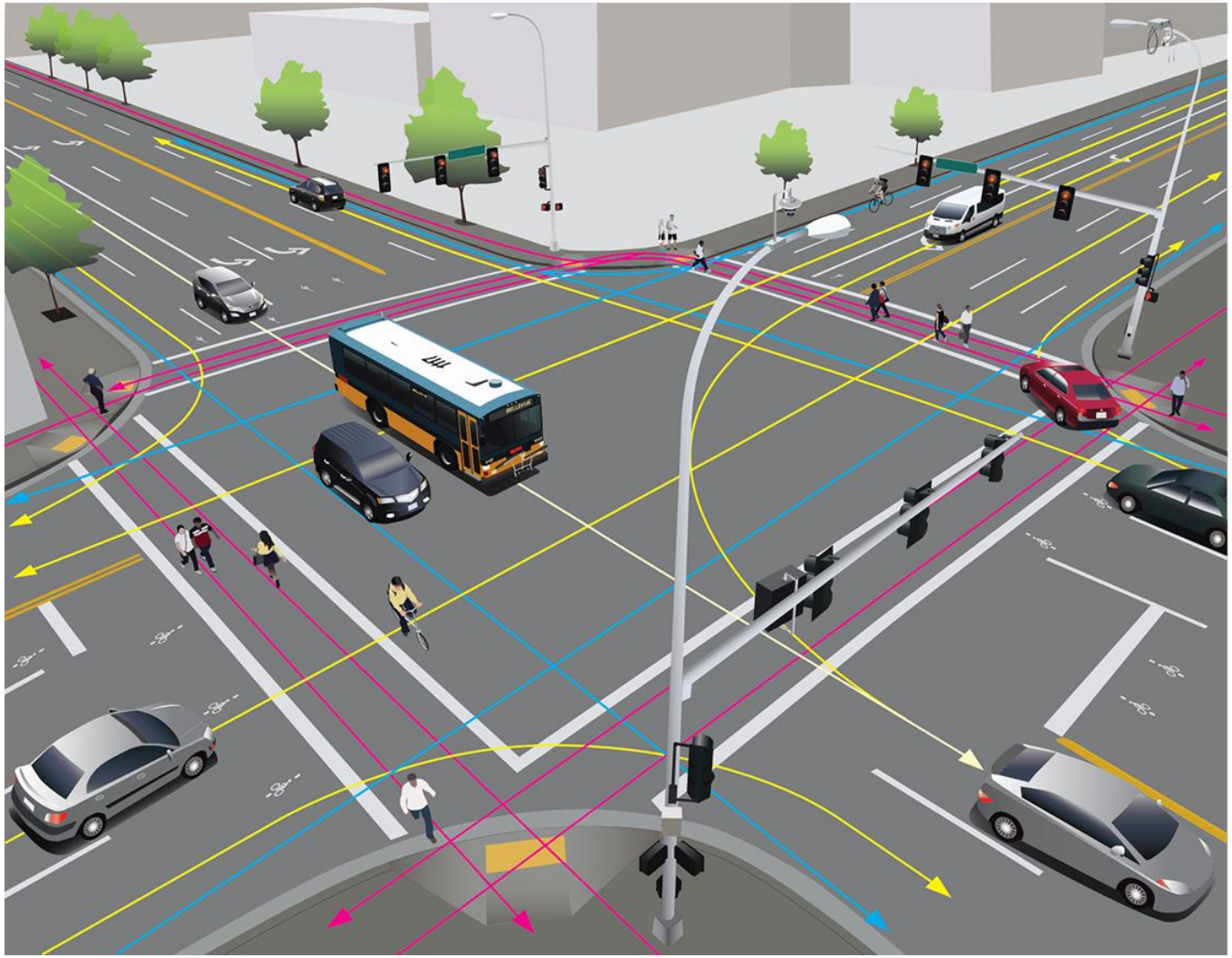


TRAJECTORY DETECTION & TURNING MOVEMENT COUNTS





VOLUME CHARTS



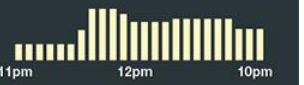
VEHICLE DISTRIBUTION CHARTS BY TIME OF DAY

MONTH:	MAY, 2016
DATE:	5.1.2016 - 5.1.2016

CARS

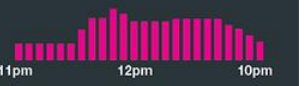
30,000 cars/day

BUSES/TRUCKS



400 buses & trucks/day

PEDESTRIANS

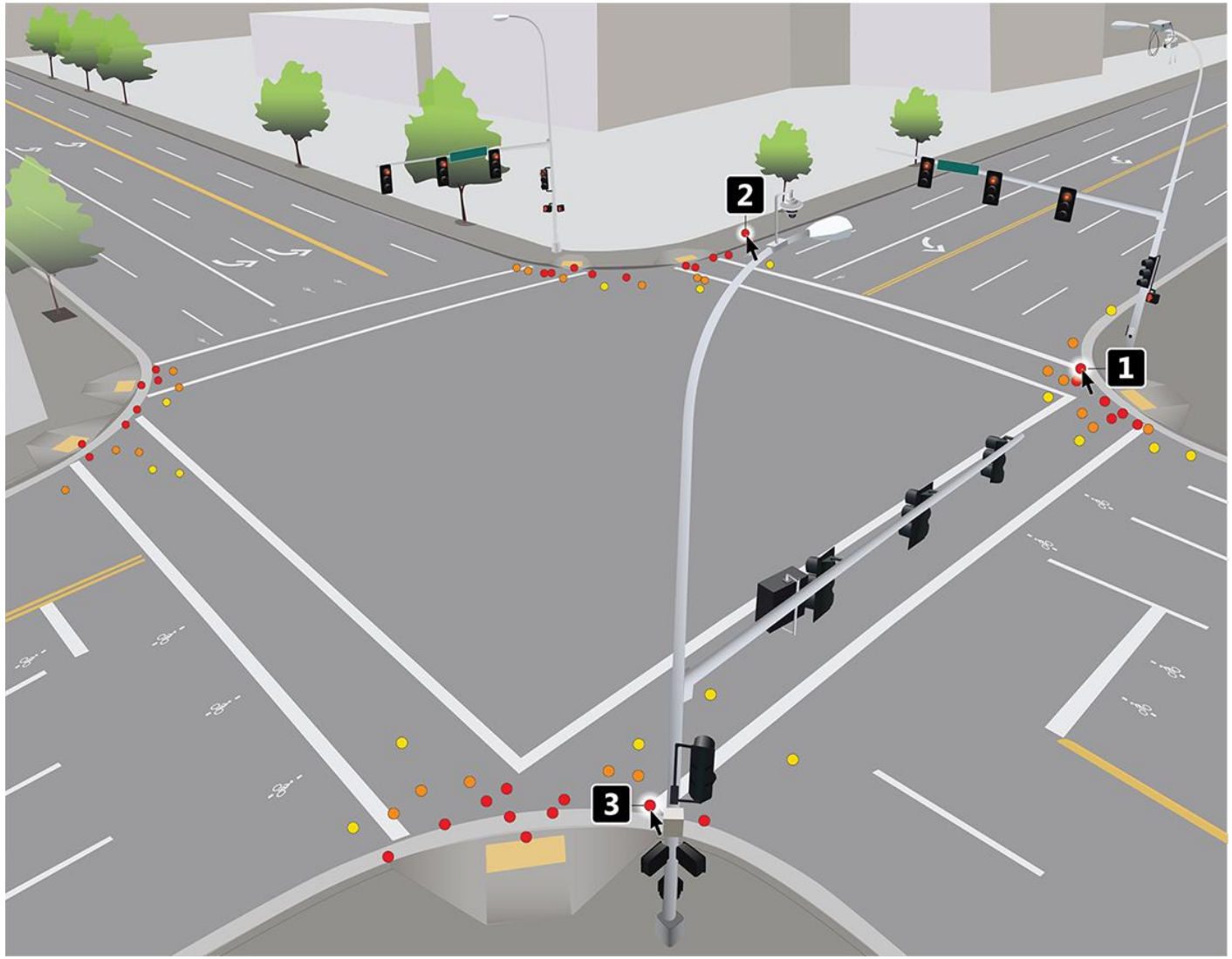


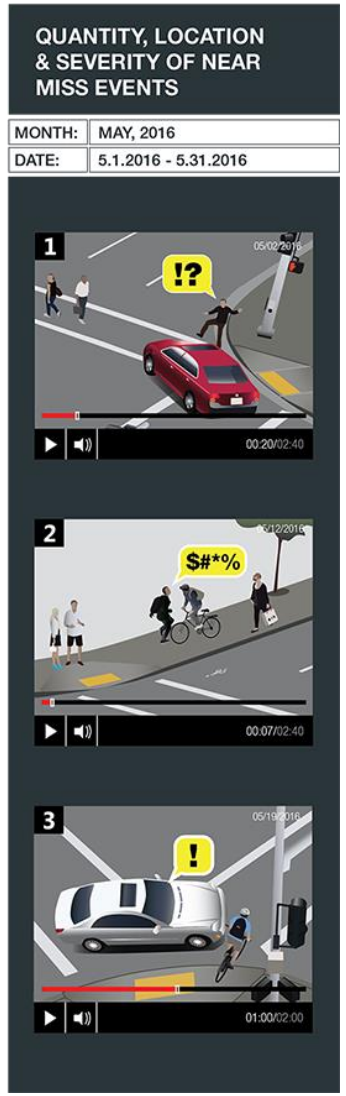
1,000 pedestrians/day

BICYCLISTS

100 bikes/day

NEAR-MISS DETECTION





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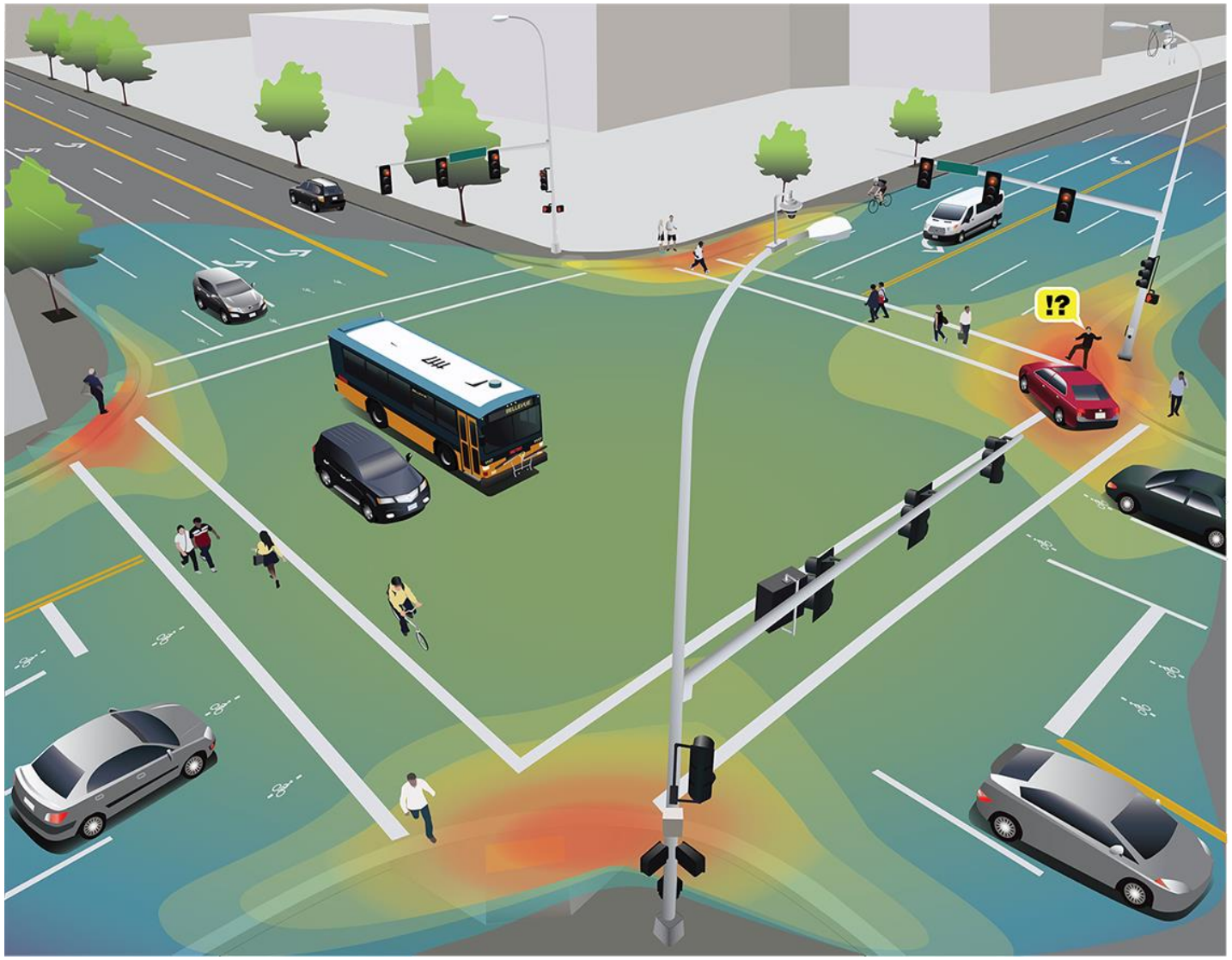
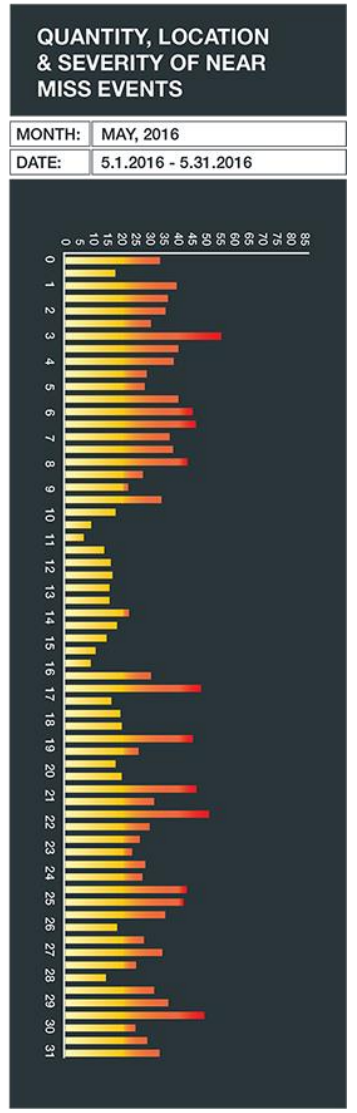
NEAR-MISS DETECTION





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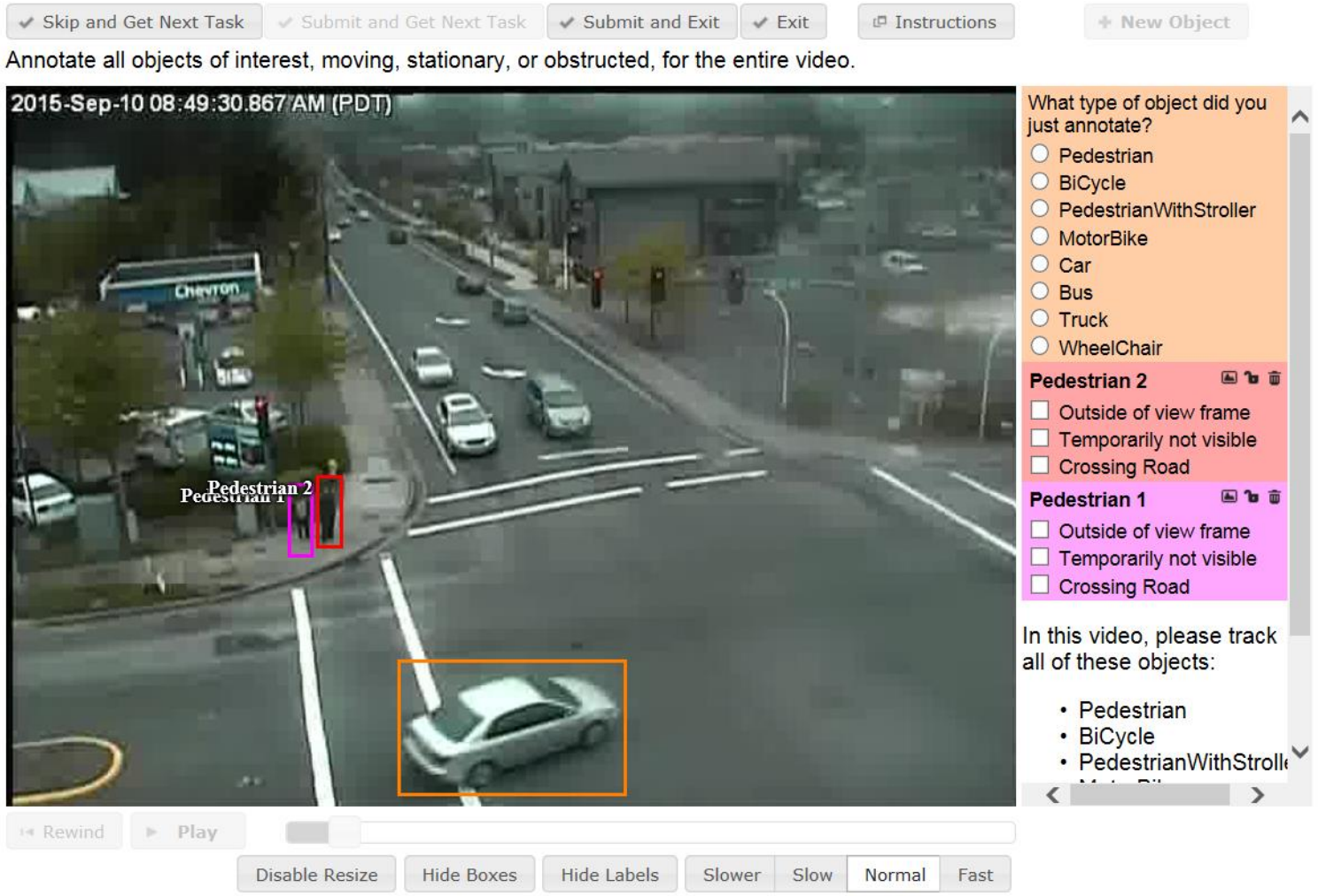
JANARY 2017: COLLECT PRE-RECORDED TRAFFIC CAMERA FOOTAGE

FEBRUARY-MARCH 2017: FINALIZE VIDEO ANNOTATION USER INTERFACE

Microsoft



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SPRING 2017: LAUNCH PUBLIC FACING WEBPAGE

ITE NEWS

ITE Joins Video Analytics towards Vision Zero Partnership

ITE is one of several organizations joining the City of Bellevue, WA, USA, Microsoft Corp., and the University of Washington in supporting their Video Analytics towards Vision Zero Partnership. Through this effort, the City of Bellevue, Microsoft, and the University of Washington will develop a video analytics platform that could fundamentally transform how jurisdictions approach traffic safety analysis.

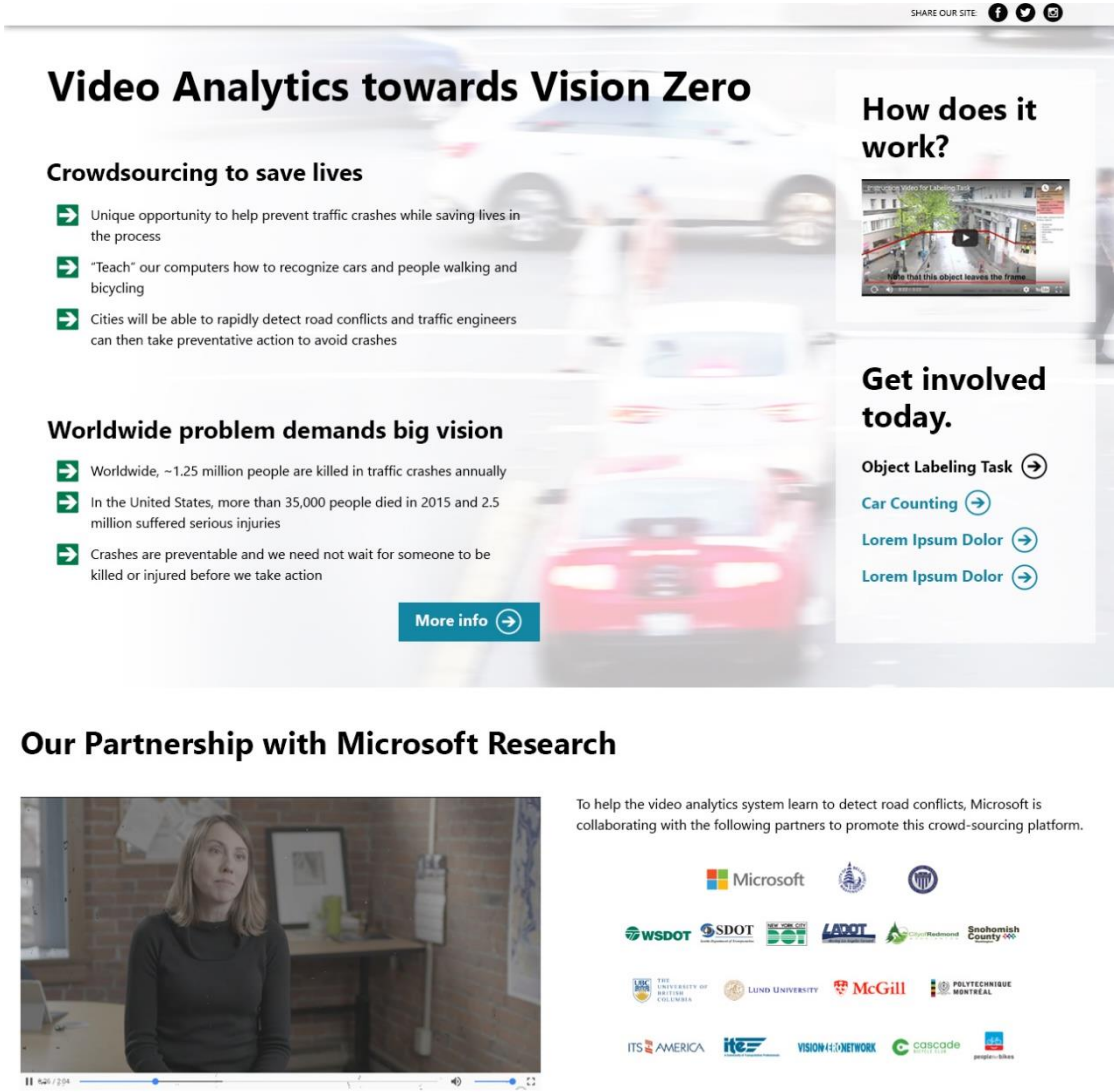
According to the partners, although traffic collisions can happen anywhere, there are often early warning signals in the form of near-miss events at specific locations. These signals could provide insight into when, where, and why crashes are most likely to occur, helping transportation professionals to better target safety improvement projects. The new technology in development offers unprecedented ways to map, manage, and analyze near-miss data in real time. This data will provide essential information so that governments can evaluate the effectiveness of current safety programs and pinpoint interventions.

The Video Analytics towards Vision Zero Partnership seeks to use available public agency traffic video and crowdsourcing from interested stakeholders who will annotate video clips to identify vehicle, pedestrian, and bicycle movements at intersections. This is expected to inform the Deep Neural Networks algorithms Microsoft is developing and the deployment of a predictive crash analysis software tool that could be used in other locations with traffic cameras to detect near-miss crashes. Safety countermeasures could then be proactively implemented.

ITE, along with ITS America and the Vision Zero Network, have agreed to host a public-facing webpage that links to the video annotation user interface. We encourage our members to participate in the crowdsourcing platform when it is launched in the coming months. Stay tuned for more details once the site is available through all of ITE's communication channels.

Please join ITE and ITS America at a discussion on the Video Analytics towards Vision Zero Partnership during the week of the Transportation Research Board Annual Meeting. ITS America is hosting a lunch meeting in their Washington, DC, USA office on Monday, January 9, from 12:15 p.m. to 2:00 p.m. Please RSVP by contacting Annie Chang at achang@itsa.org.

More information can be found at www.bellevuewa.gov/pdf/Transportation/Video_Analytics_towards_Vision_Zero.pdf. **Itej**



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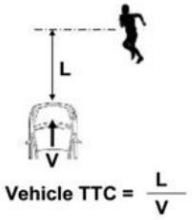
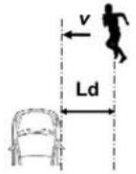
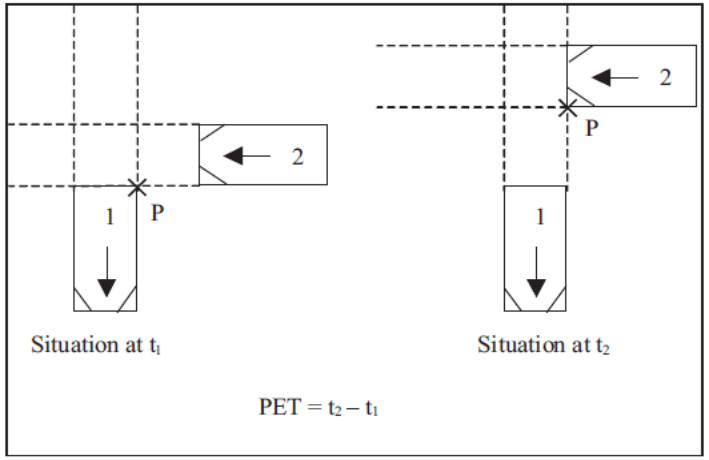
SPRING 2017: INVITE PUBLIC TO PARTICIPATE

SUMMER 2017: CLASSIFY NEAR-MISS EVENTS

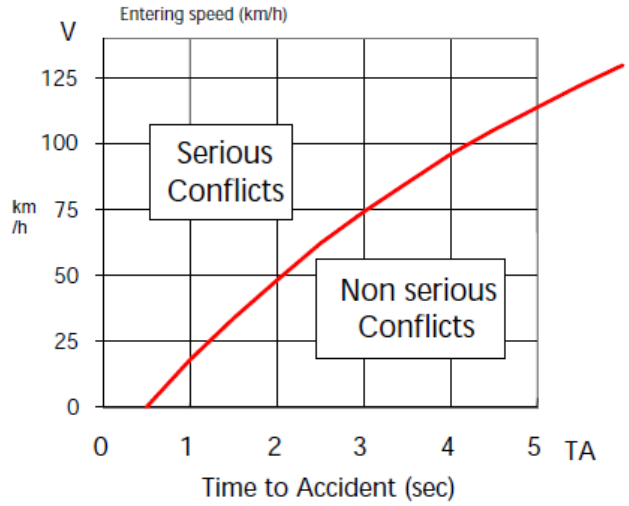
Focused object	Vehicle	Pedestrian
Time	Vehicle time to collision (Vehicle TTC)	Pedestrian time to vehicle (Pedestrian TTV)
Definition	 Vehicle TTC = $\frac{L}{V}$	 Pedestrian TTV = $\frac{Ld}{v}$
Study	Previous study (Matsui et al. 2011b)	Present study

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)

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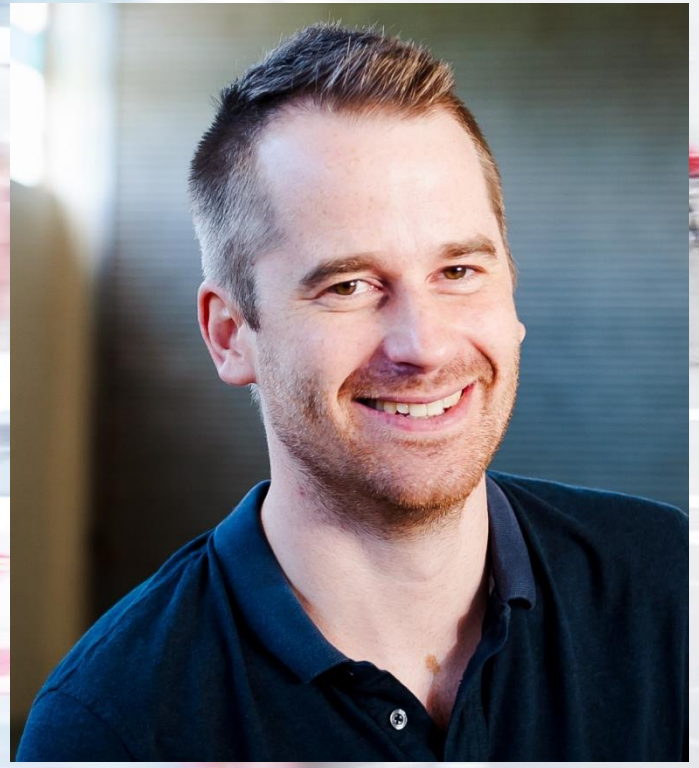
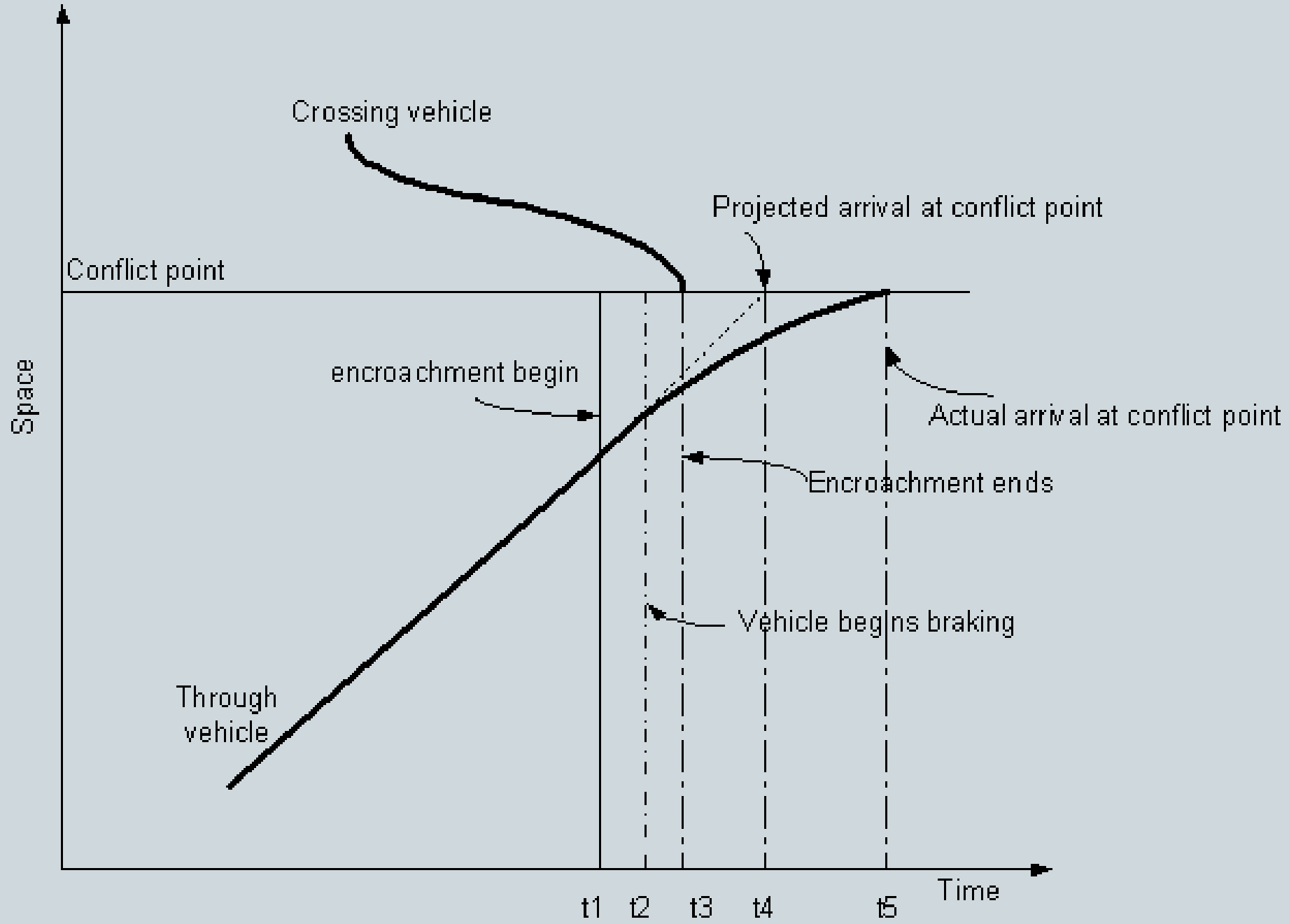
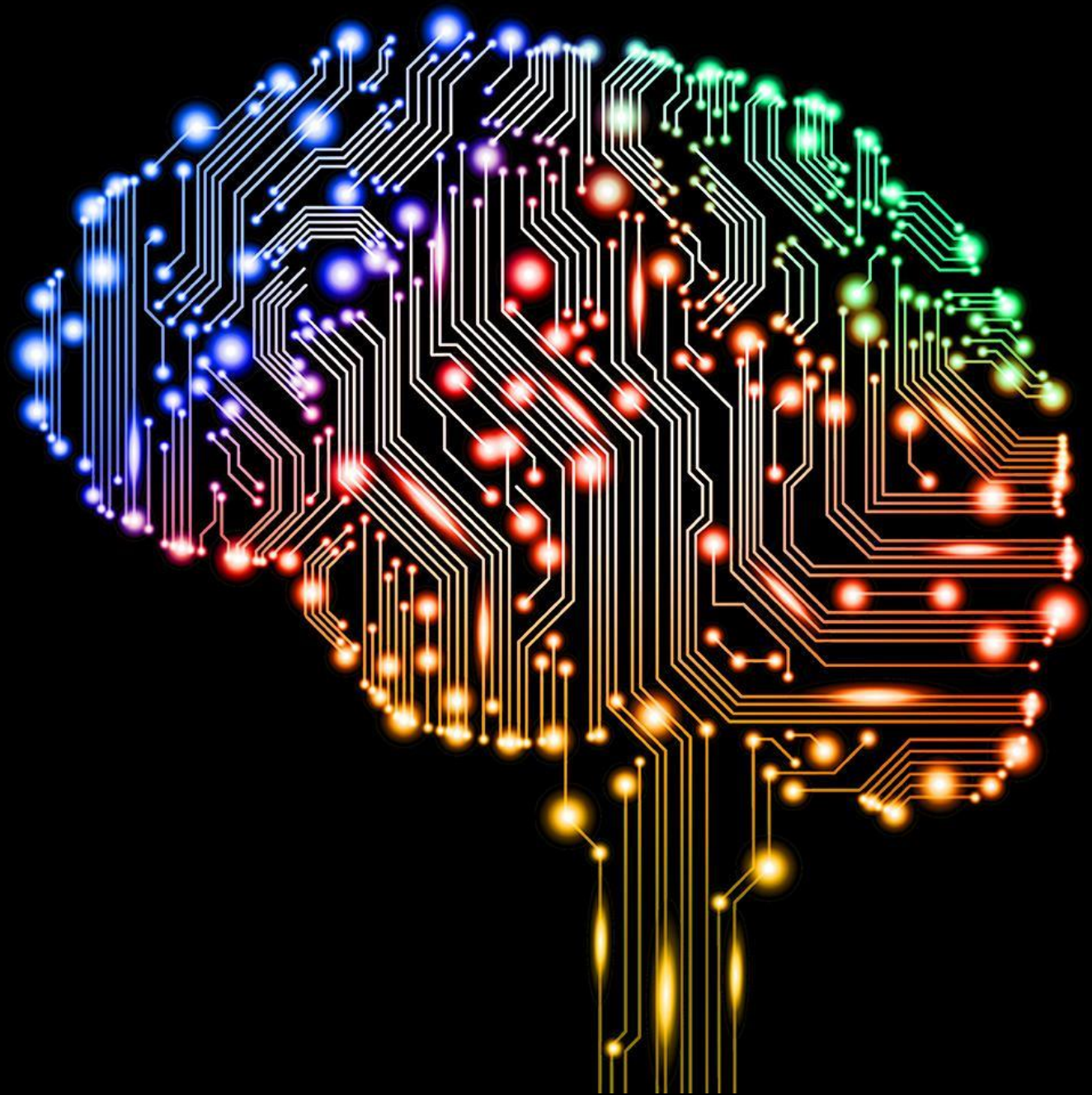
rethink traffic



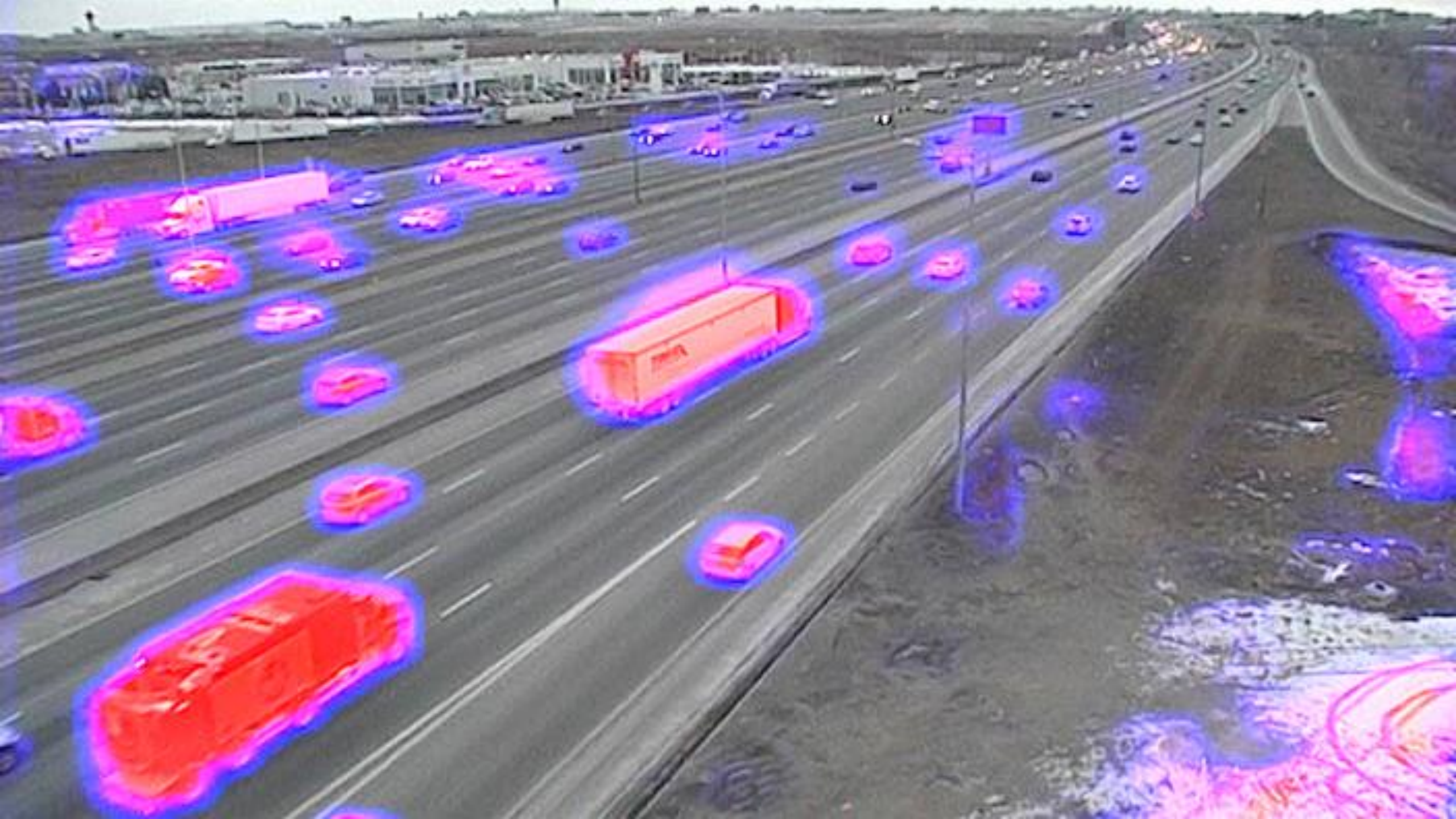
James Barr
Senior Product Manager
Miovision

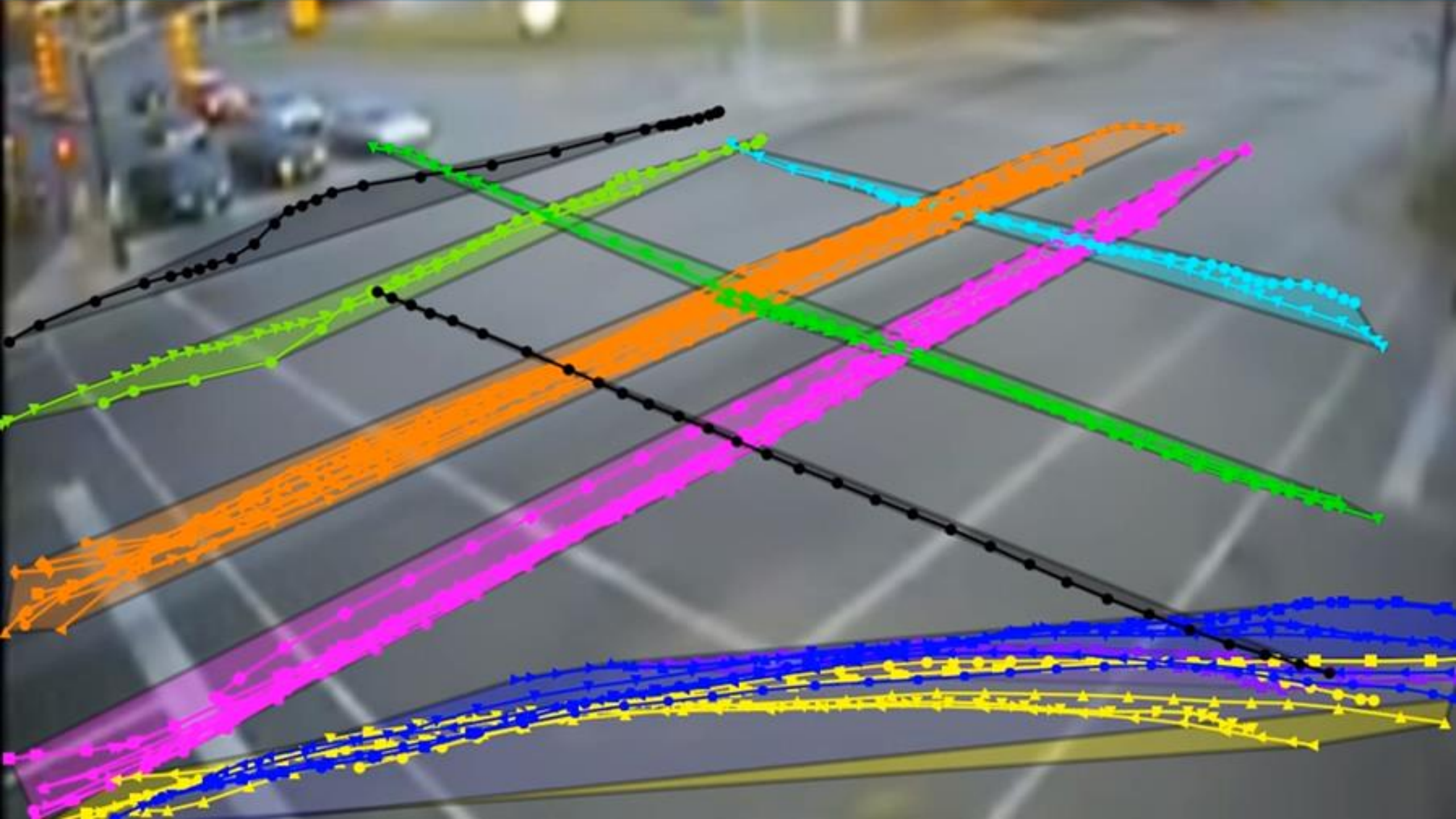
Credit: AP Photo/Seth Wenig

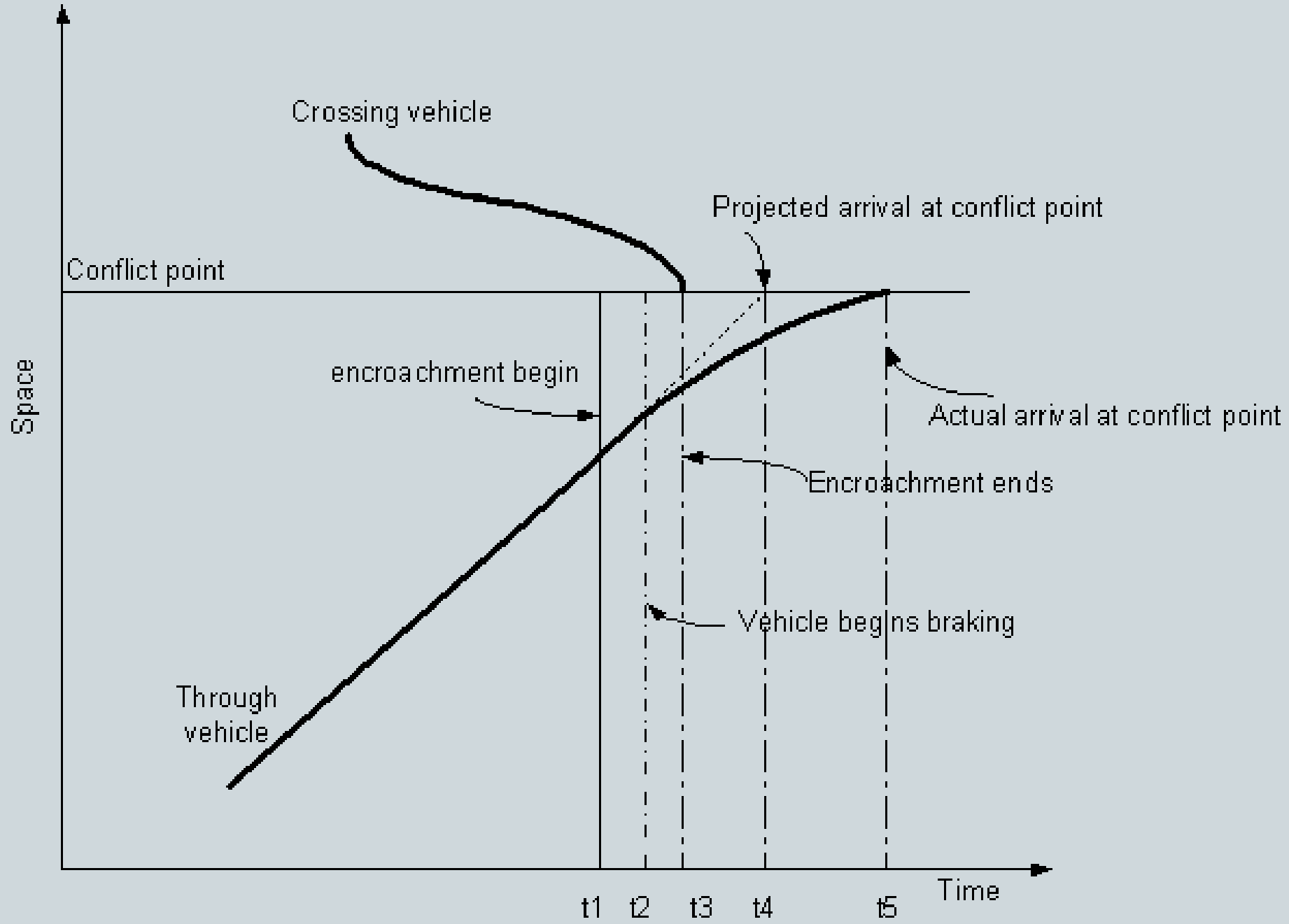

Crossing vehicle
Projected arrival at conflict point
Conflict point
encroachment begin
Actual arrival at conflict point
Encroachment ends
Vehicle begins braking
Through vehicle
Space
Time
t1
t2
t3
t4
t5



Credit: MIT Technology Review






Crossing vehicle
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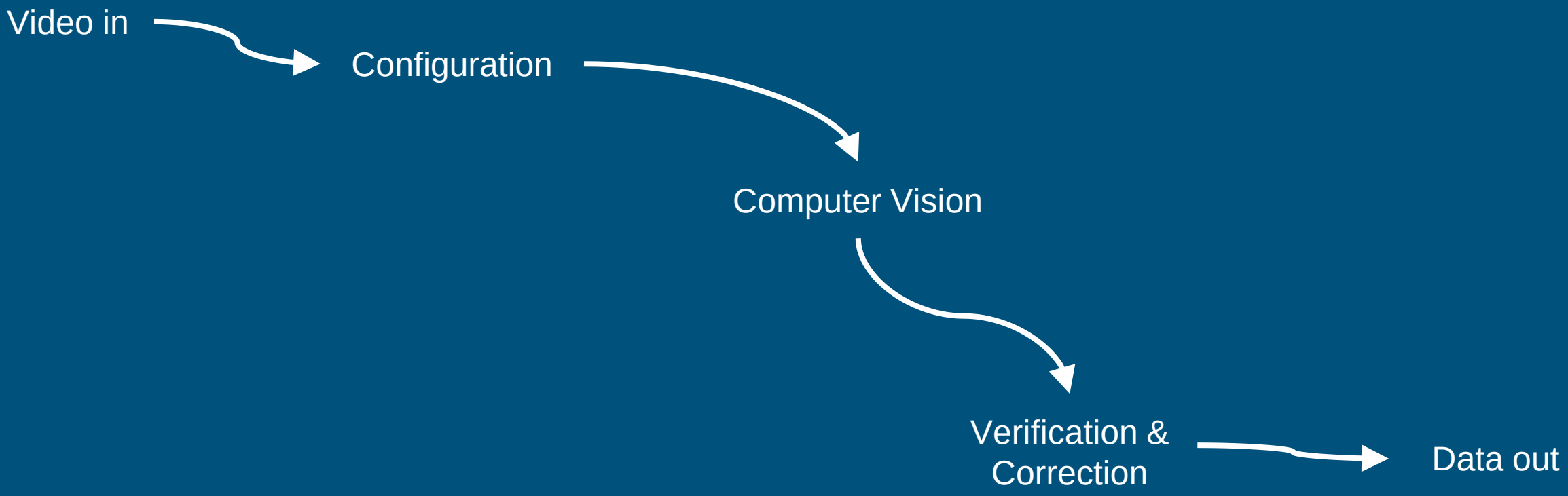
Space
Time
t1
t2
t3
t4
t5

Feeding A Neural Network


Video in
Configuration
Computer Vision
Verification &
Correction
Data out

Video in

Configuration

Computer Vision

Verification &
Correction

Data out

Video in

Configuration

Computer Vision

Verification &
Correction

Data out

Video in

Configuration

Computer Vision

Verification &
Correction

Training

Data out

Video in

Configuration

Computer Vision

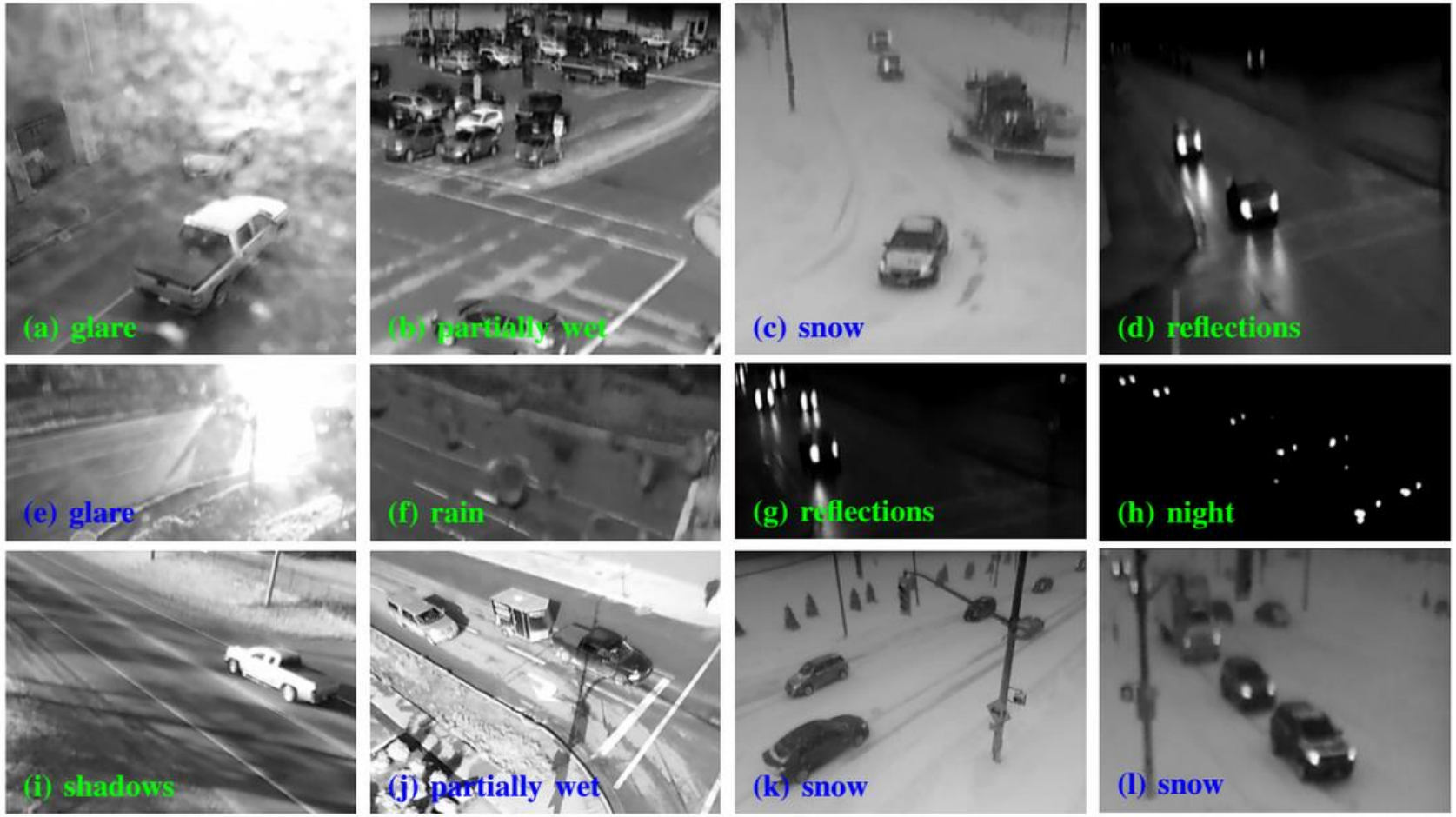
Verification &
Correction

Data out

Training

THE WORLD'S MOST TRUSTED TRAFFIC DATA PLATFORM
2.5B
VEHICLES COUNTED
2M
HOURS OF VIDEO DATA PROCESSED
650
CUSTOMERS IN 50 COUNTRIES

Real-world data



miovision
rethink traffic

Video in

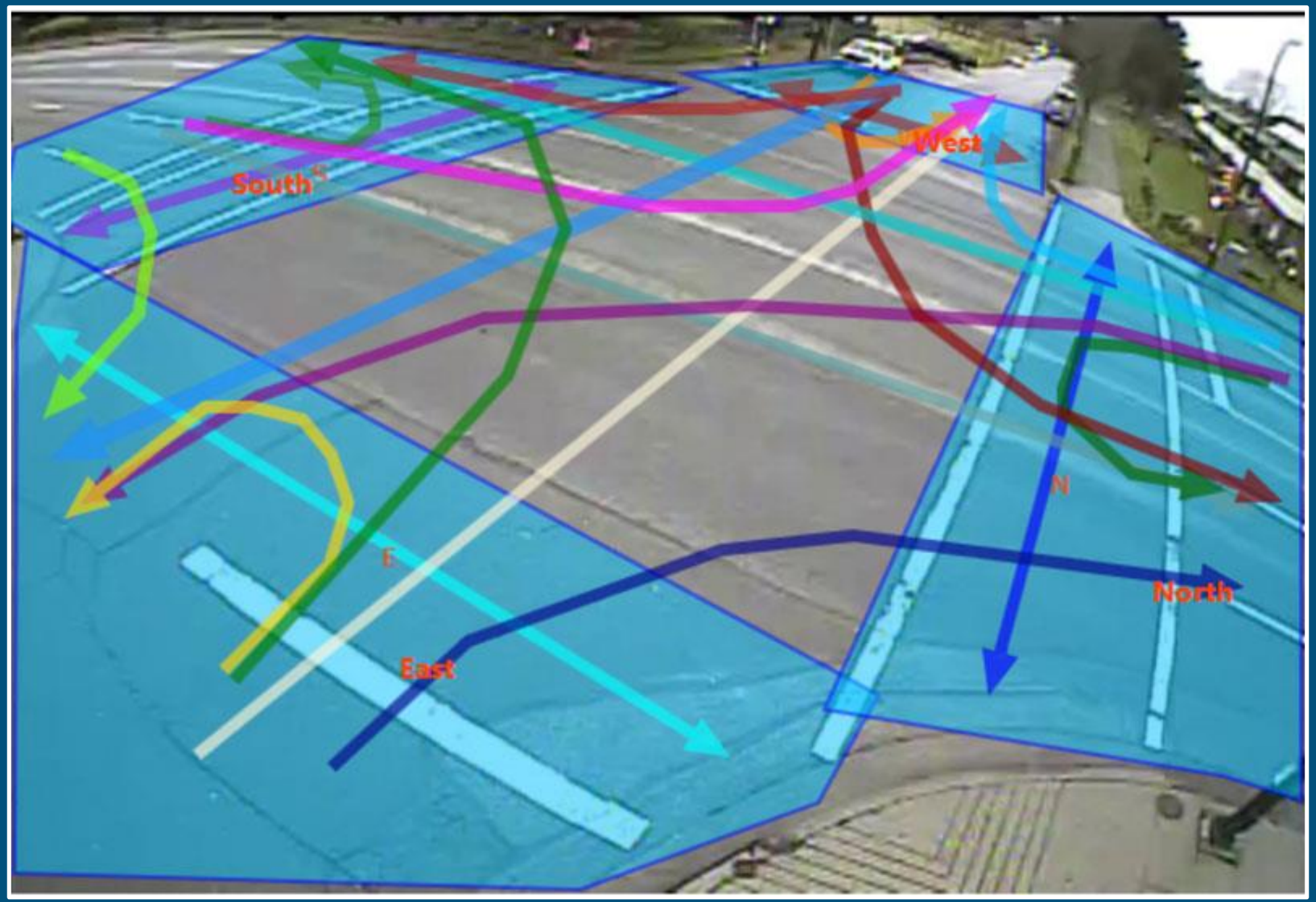
Configuration

Computer Vision

Verification &
Correction

Training

Data out


South
West
E
N
East
North

Video in

Configuration

Computer Vision

Training

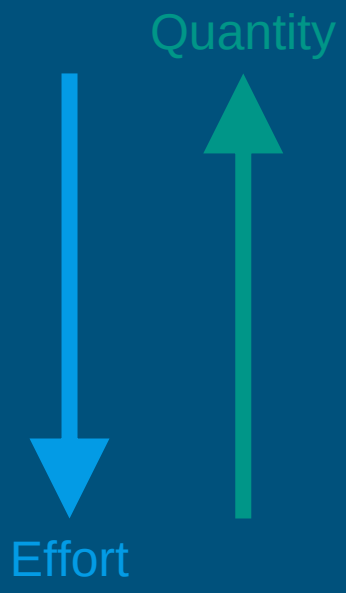
Verification &
Correction

Data out

Train

Evaluate

Data Sources



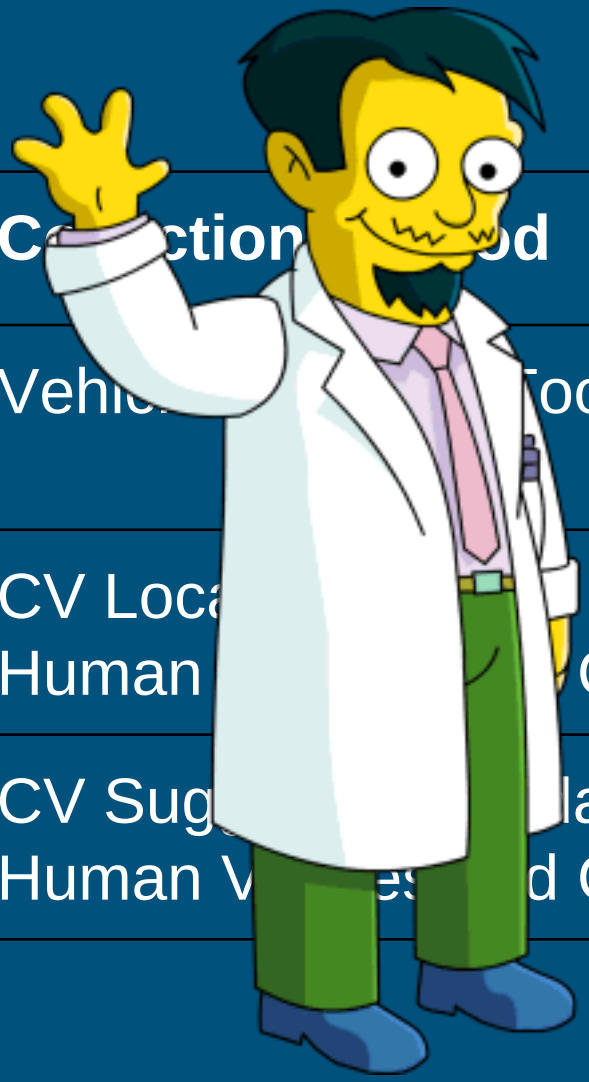
Usage	Collection Method	Fidelity
Evaluation	Vehicle Counting Tools	Approx. Location / Time
Evaluation / Training Source	CV Locates Vehicle Human Verifies and Corrects	Approx. Location / **Exact** Time
Training	CV Suggests Boundaries Human Verifies and Corrects	**Exact** Boundaries / **Exact** Time

Data Sources

Quantity

Effort

Usage	Collection Method	Fidelity
Evaluation	Vehicle Tools	Approx. Location / Time
Evaluation / Training Source	CV Loca Human Corrects	Approx. Location / **Exact** Time
Training	CV Sug laries Human V d Corrects	**Exact** Boundaries / **Exact** Time



Video in

Configuration

Computer Vision

Training

Verification &
Correction

Data out

Video in

Configuration

Computer Vision

Training

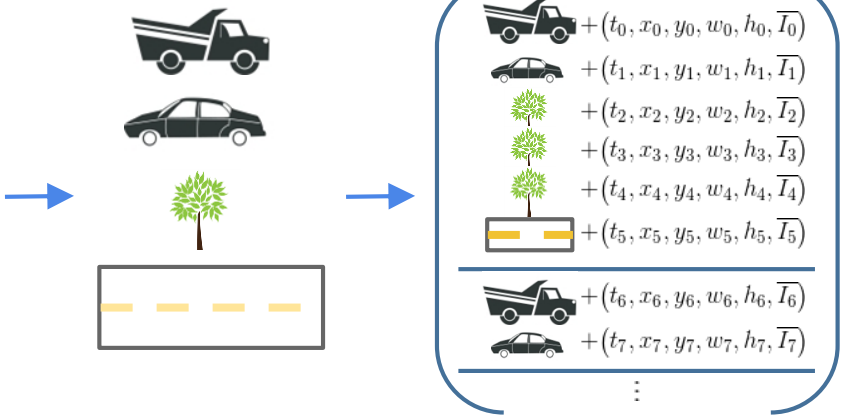
Verification &
Correction

Data out

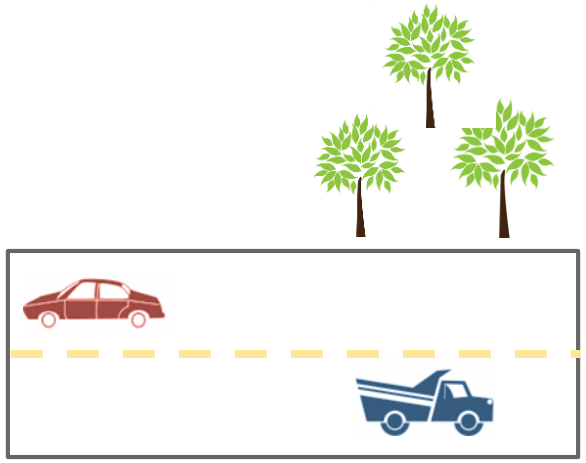
Strategy

Video

Decomposition

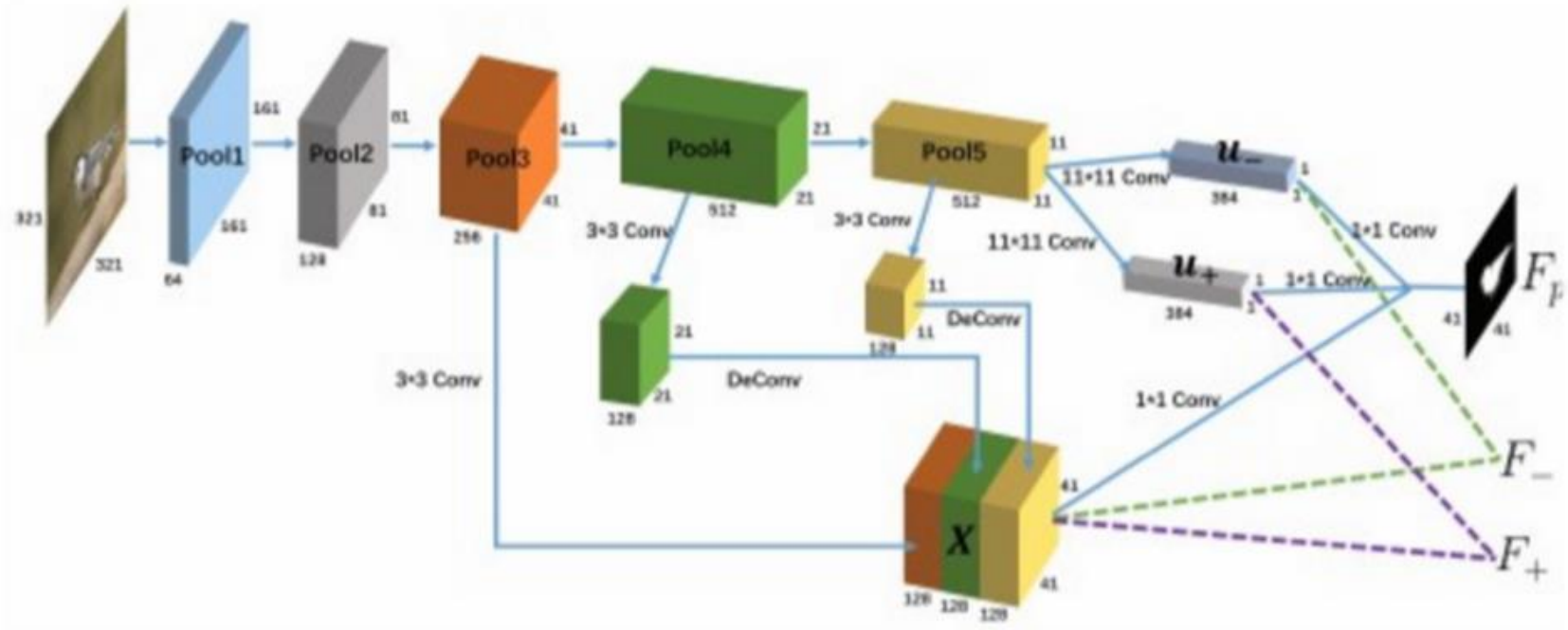


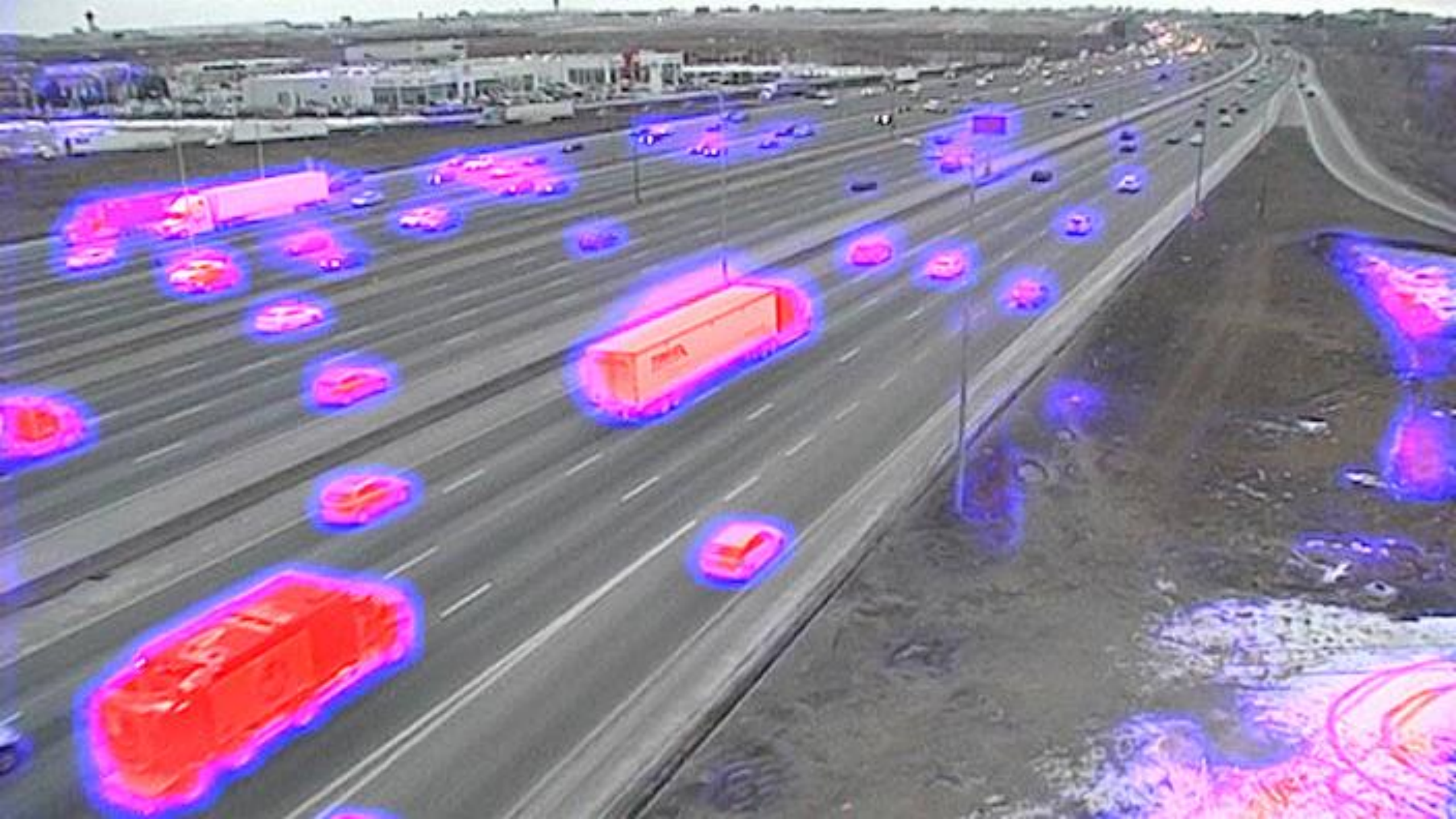
Representation



Formulation

$$F(I) = \underbrace{\lambda_- \sum_{i \in -} f_-(x_i, u_-)}_{F_-} + \underbrace{\lambda_+ \sum_{i \in +} f_+(x_i, u_+)}_{F_+} + \underbrace{\gamma \sum_i \sum_{c \in \{+,-\}} -p_i^c \cdot \log(\hat{p}_i^c)}_{\quad},$$





2016-06-14 1:00:30 PM
Full screen
0:02 / 5:48

Video in

Configuration

Computer Vision

Training

Verification &
Correction

Data out

Video in

Configuration

Computer Vision

Verification &
Correction

Training

Data out

Count Speed:
5.1
Complete End
Hide Lane Hotkeys
Adaptive playback speed
Fast E
Slow Q
26.53%
2016-04-17 10:35:26 AM
Upcoming CV Observation
THE PAST
THE FUTURE
Clear Remaining Backspace

ATR

2

Lanes

Lane	Key
1	NUM1
2	NUM2
1 (Delete)	NUM4
2 (Delete)	NUM5
Enhanced playback rate	☑

Clear Remaining

0:41 / 1:12

Video in

Configuration

Computer Vision

Training

Verification &
Correction

Data out

Video in

Configuration

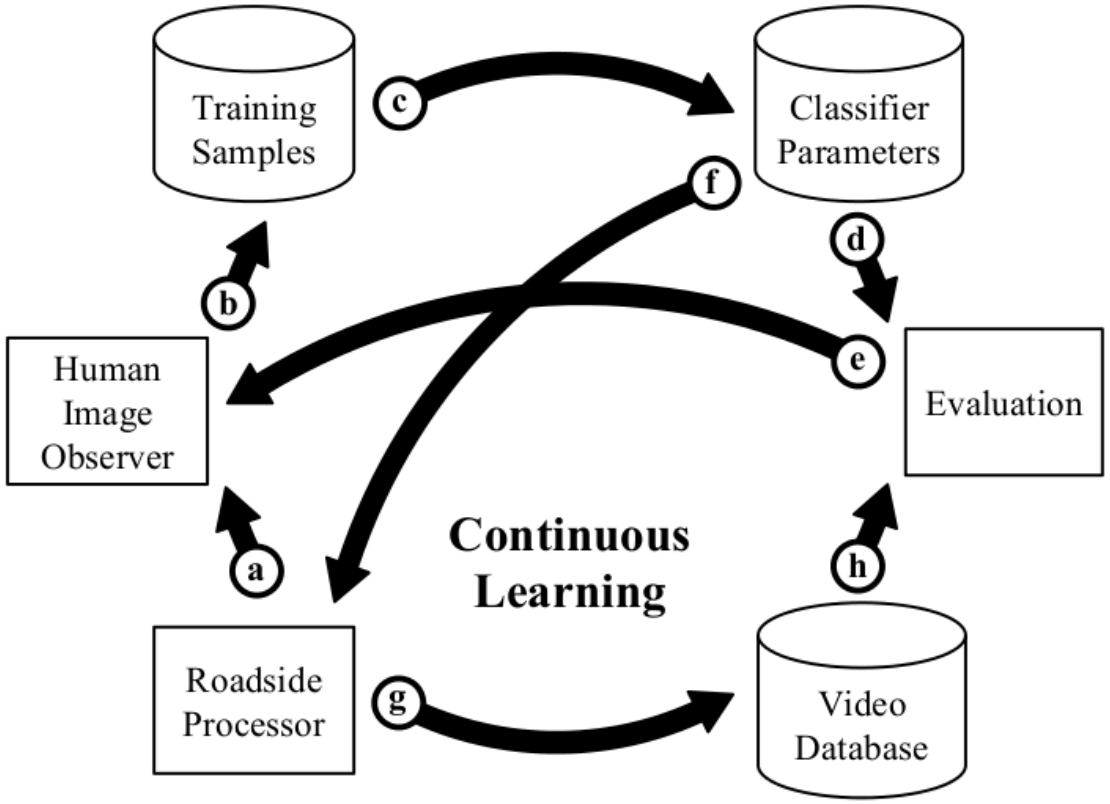
Computer Vision

Verification &
Correction

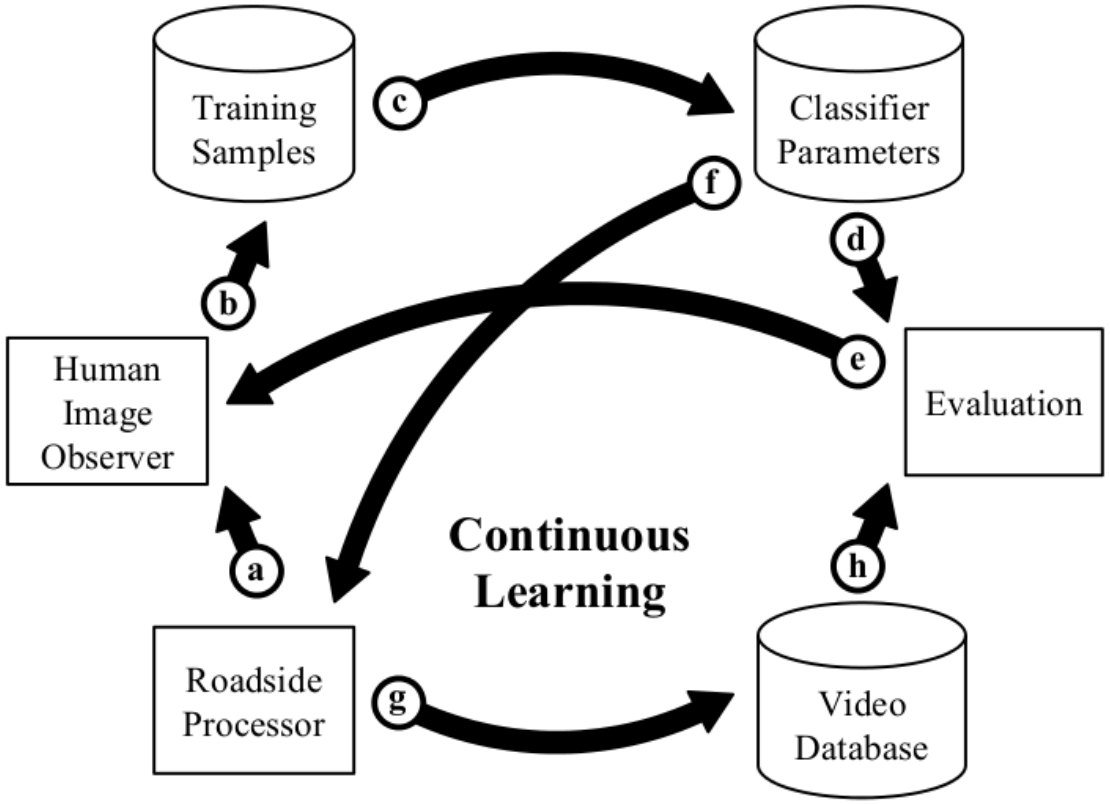
Data out

Training

Continuous Learning



Continuous Learning



Big Data

ImageNet 14,197,122 samples

132 hours of video

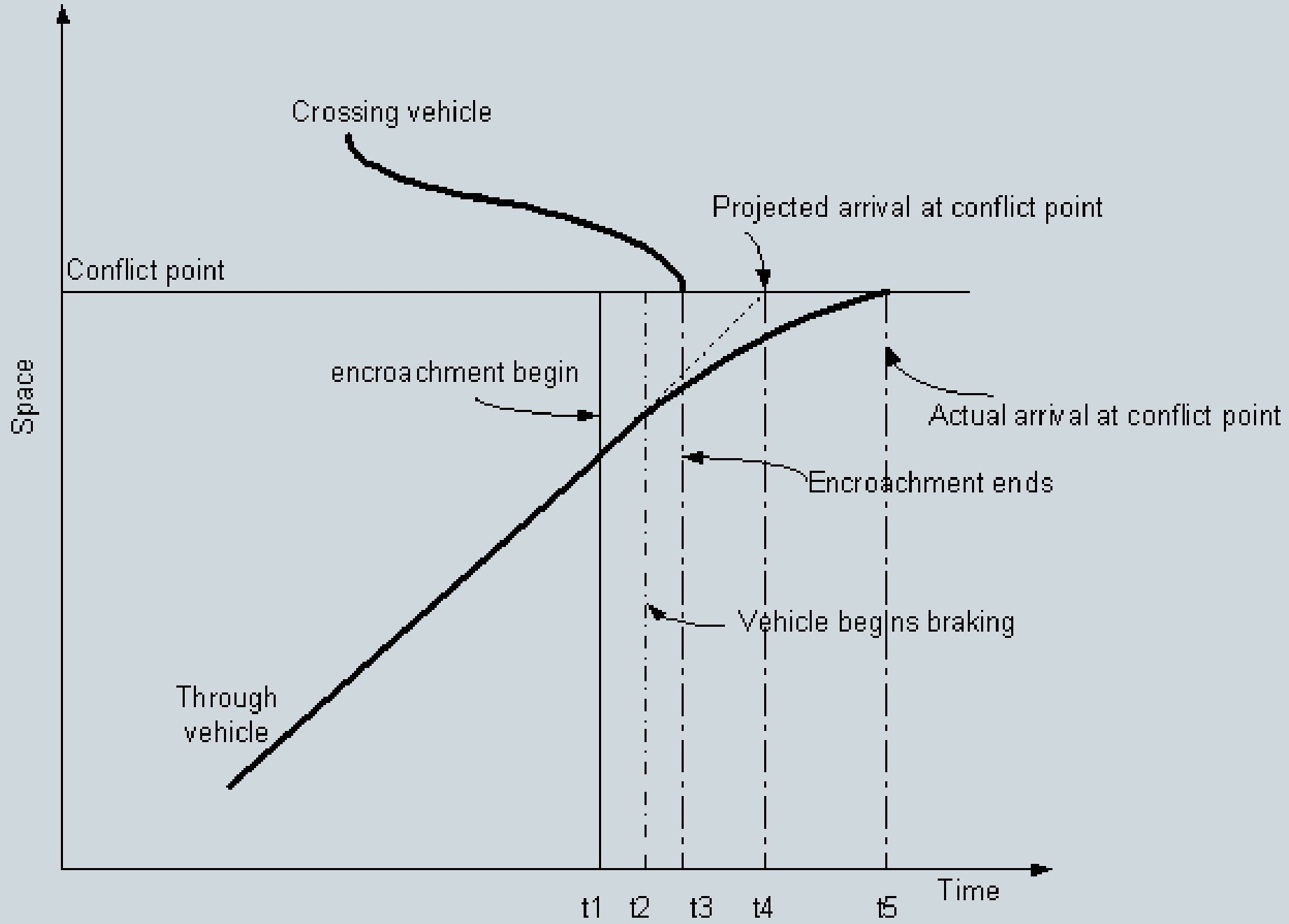
(30 fps)

Miovision

2016 Average over 16,000 hours per week

Peak Season over **10,000** hours in a **day**

UNIVERSITY OF TORONTO


Crossing vehicle
Projected arrival at conflict point
Conflict point
encroachment begin
Actual arrival at conflict point
Encroachment ends
Vehicle begins braking
Through vehicle
Space
Time
t1
t2
t3
t4
t5

Credit: Toronto Star

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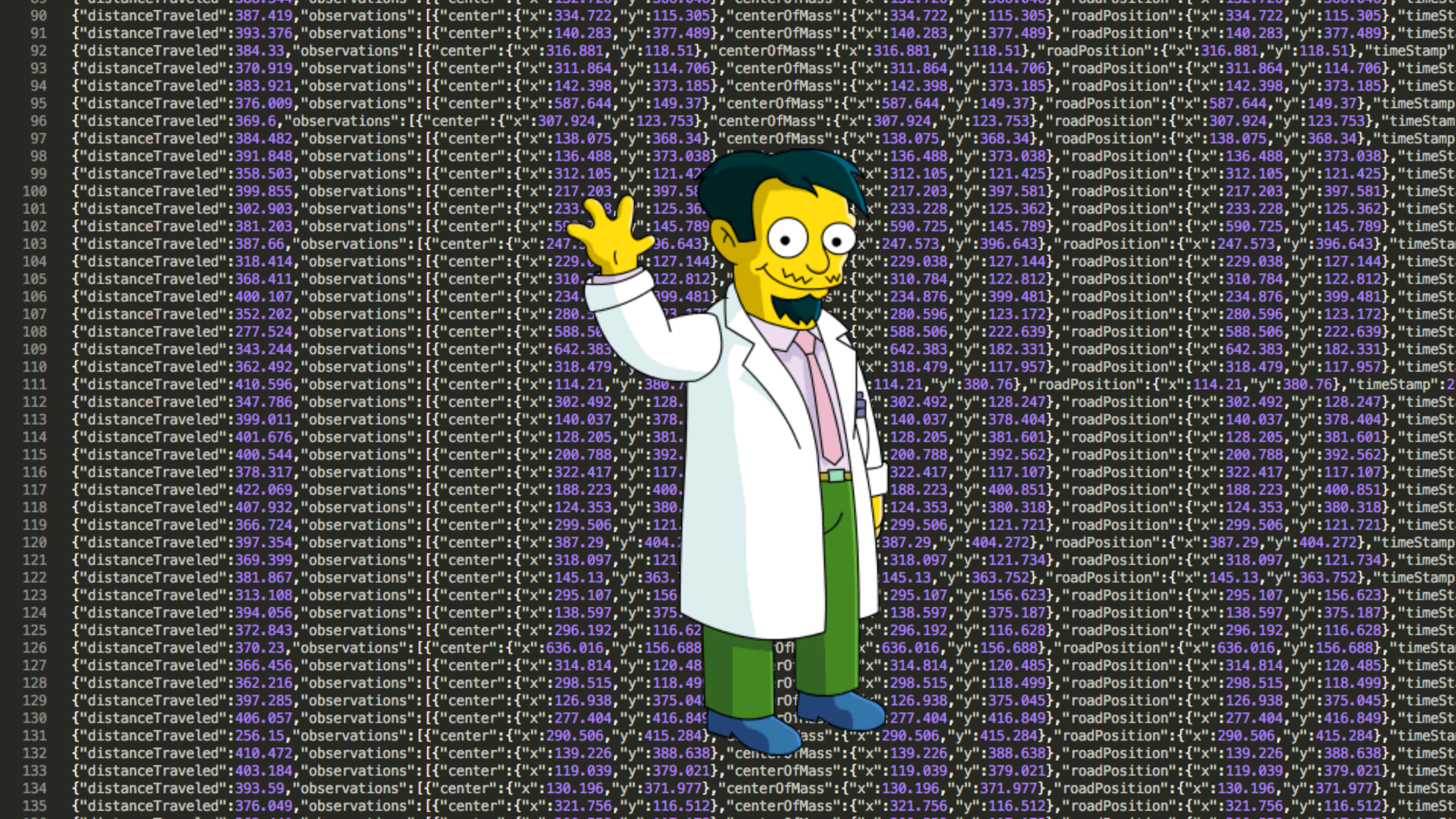
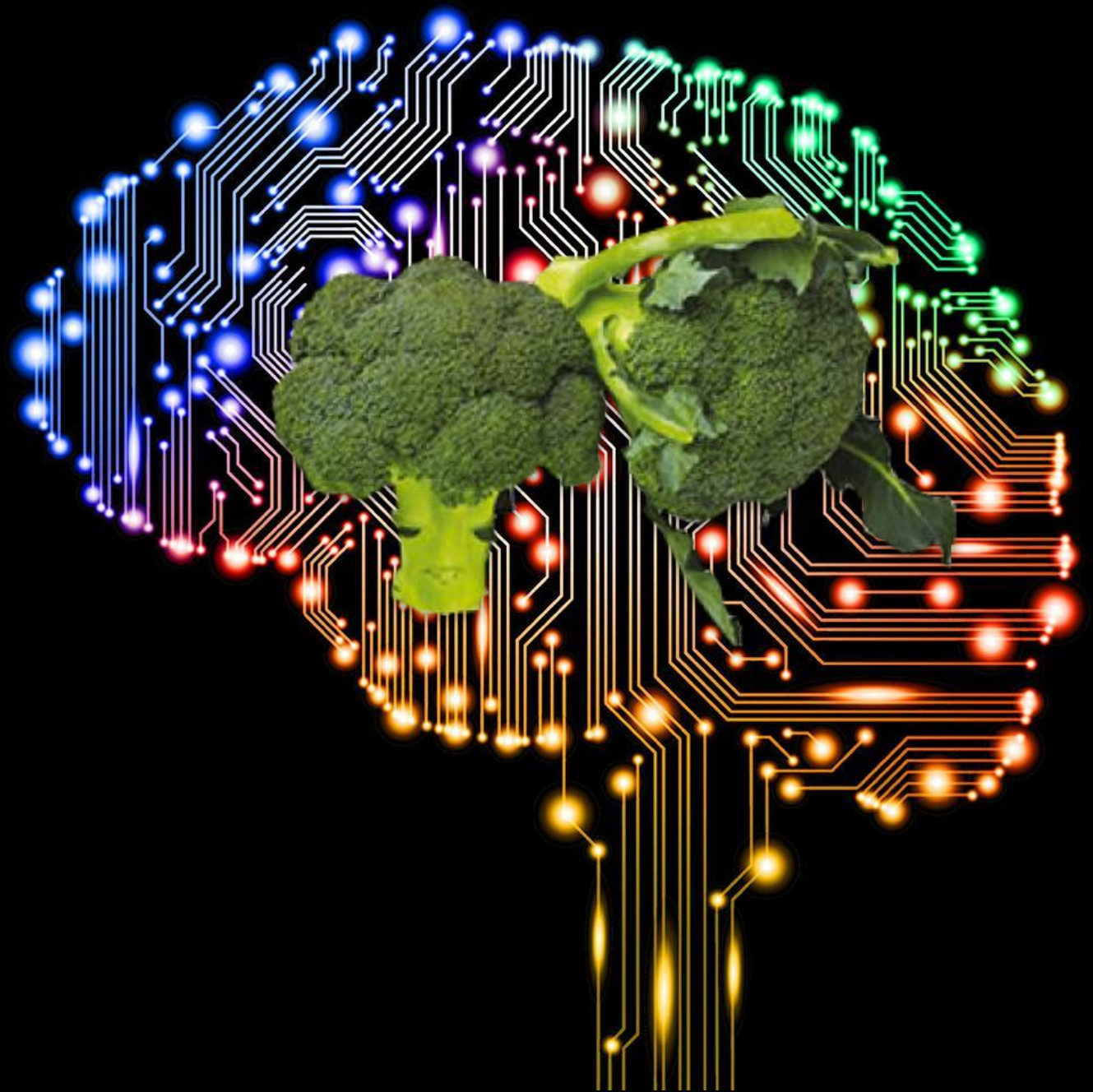




Credit: MIT Technology Review

Credit: AP Photo/Seth Wenig

BriskSynergies
Traffic Unravelled

Charles Chung
CEO
Brisk Synergies

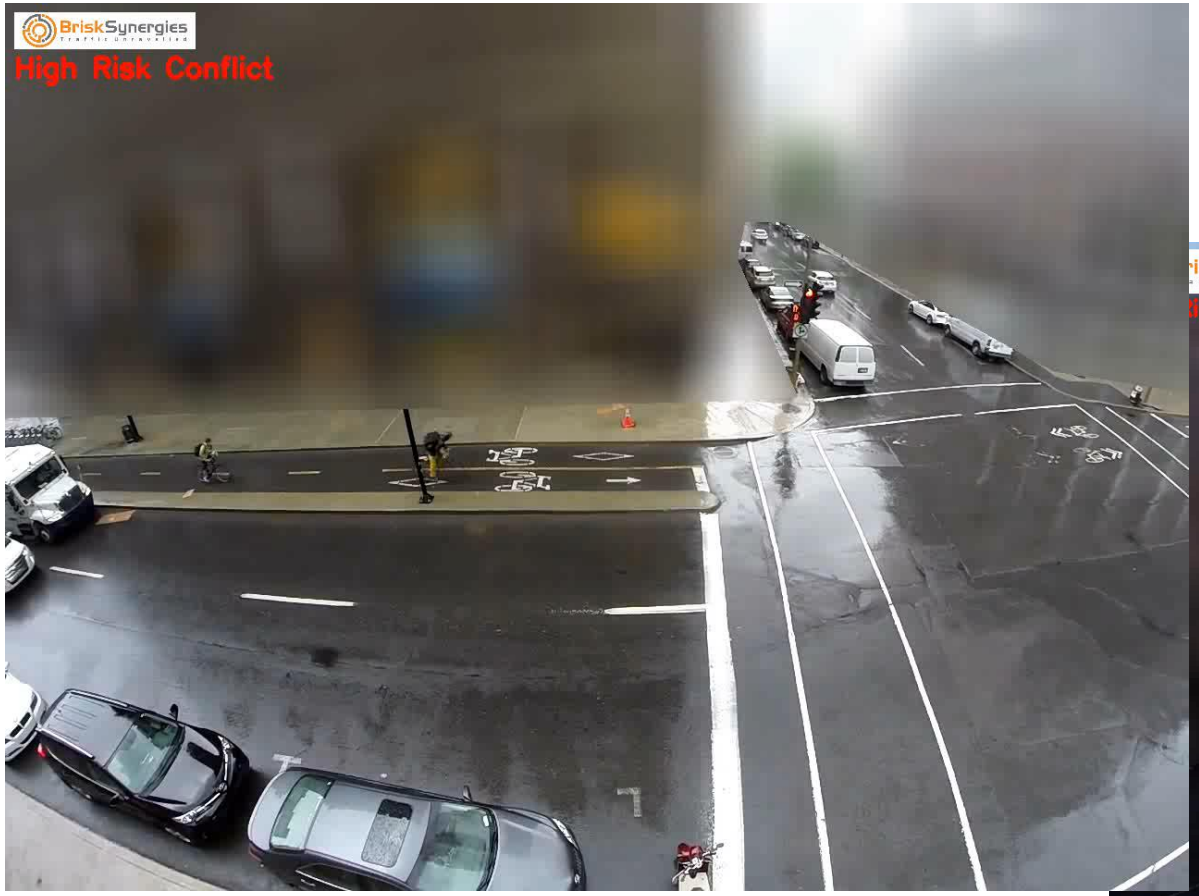
AGENDA

- Company introduction
- Case studies of safety analyses
- Types of deployment
  - On-demand Safety-as-a-Service
  - Continuous traffic monitoring platform

ABOUT BRISK SYNERGIES

- Software firm offers solutions for improving urban mobility and safety
- Leader in automated traffic video safety analysis
- HQ in Waterloo (Ontario), R&D office in Montreal
- Clients: municipalities, DOTs and traffic consulting firms

EXAMPLES OF NEAR MISSES



TORONTO CASE STUDY

Road safety improvement measurements

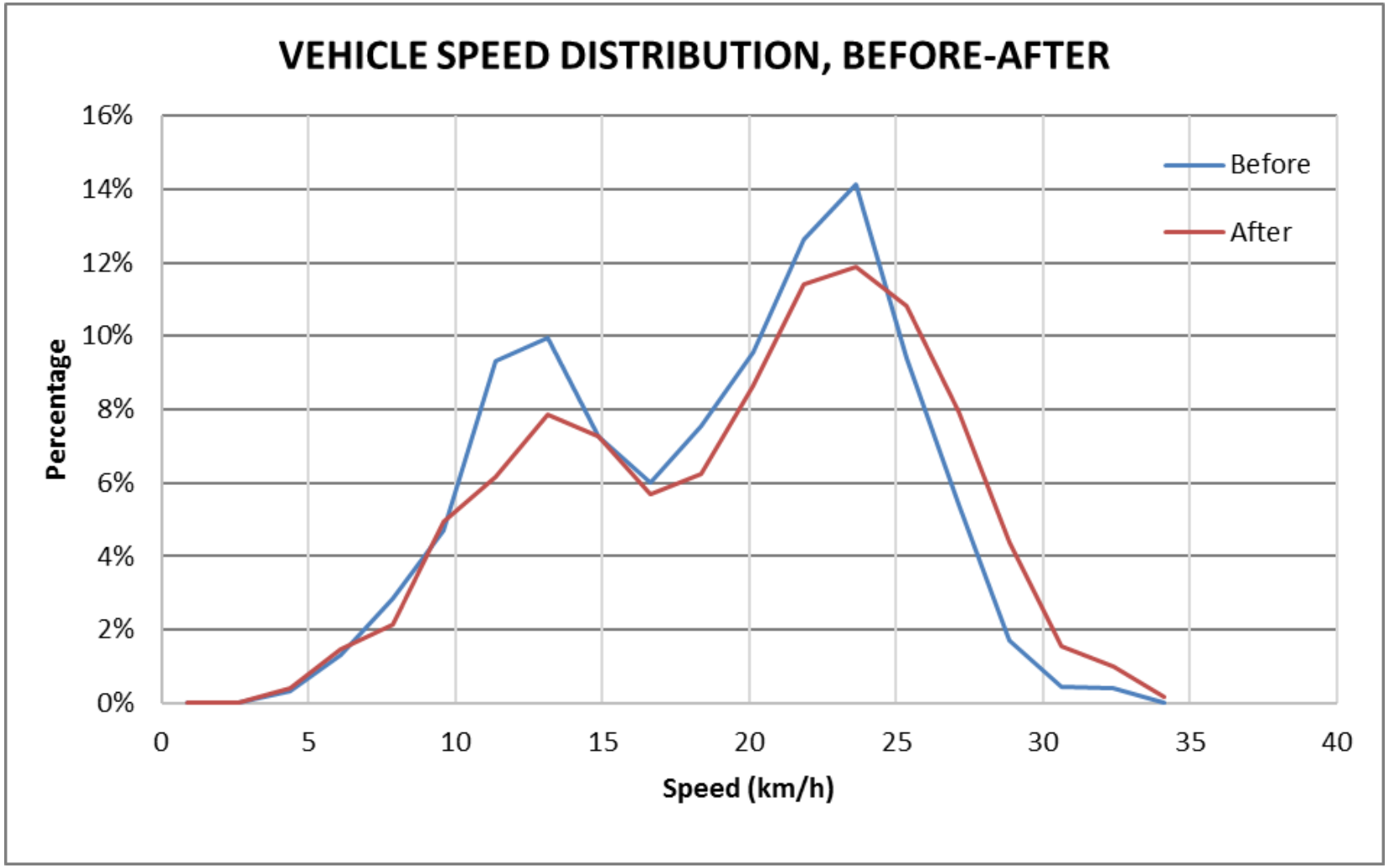
TORONTO CASE STUDY: WIDE CURB RADII

- Location: Davenport / Christie
- In 5 years, 2 fatal collisions & numerous near-misses reported
- Potential cause: high-speed right-turn vehicles
- Put signs with uncertain improvements
- Implemented curb radii reduction with before-after safety study

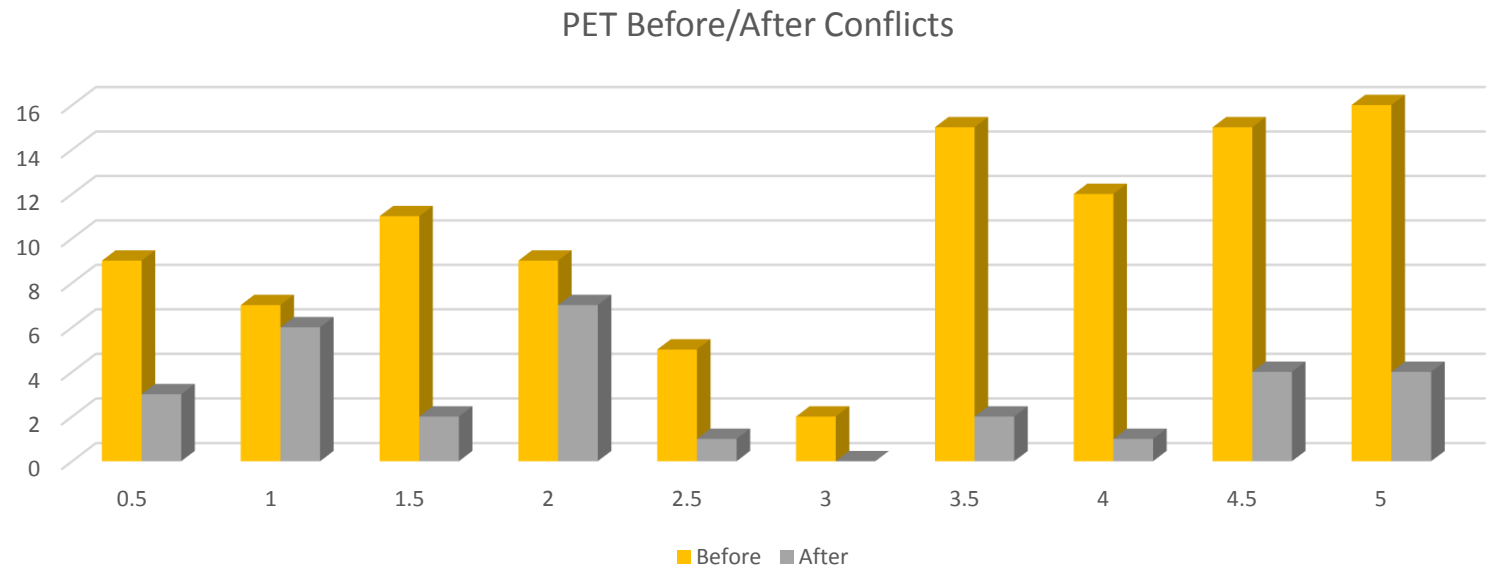
BEFORE AND AFTER ANALYSES

- 6 days of before and after data collected (7am to 7pm)
- Before data collected Aug ‘16
- After data collected Nov ’16

ANALYZED RESULTS: SPEED DISTRIBUTION



ANALYZED RESULTS: CONFLICT ANALYSIS



High risk conflicts (<=1s)

Before:
19 instances

After:
9 instances

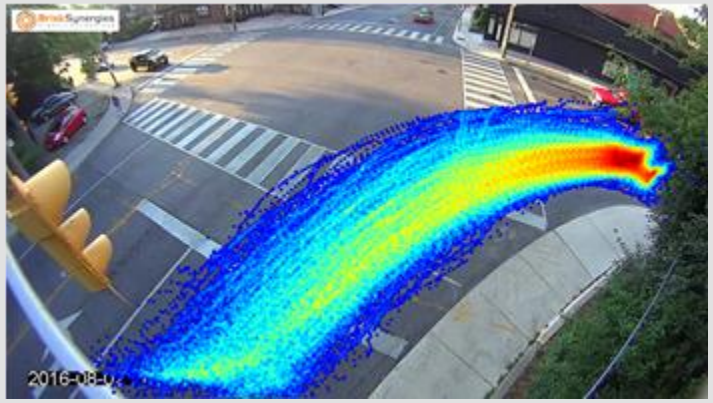
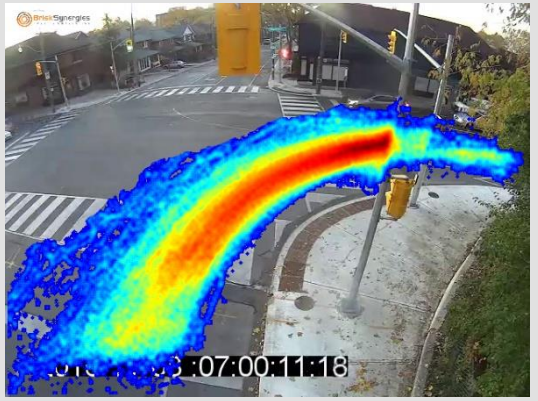
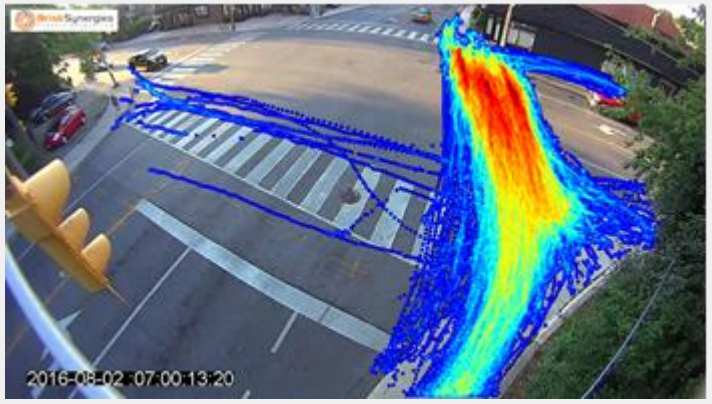
QUANTIFYING IMPROVEMENTS

- Pre-normalized results

	Low Risk Conflict		Medium Risk Conflict		High Risk Conflict	
	Count	Rate	Count	Rate	Count	Rate
Before	58	93,843	24	38,831	19	30,742
After	11	26,465	10	24,059	9	21,653

- High Risk Conflict Rate are reduced by 30%
- Medium Risk Conflict Rate are reduced by 38%
- Low Risk Conflict Rate are reduced by 72%

TRAJECTORY HEATMAPS

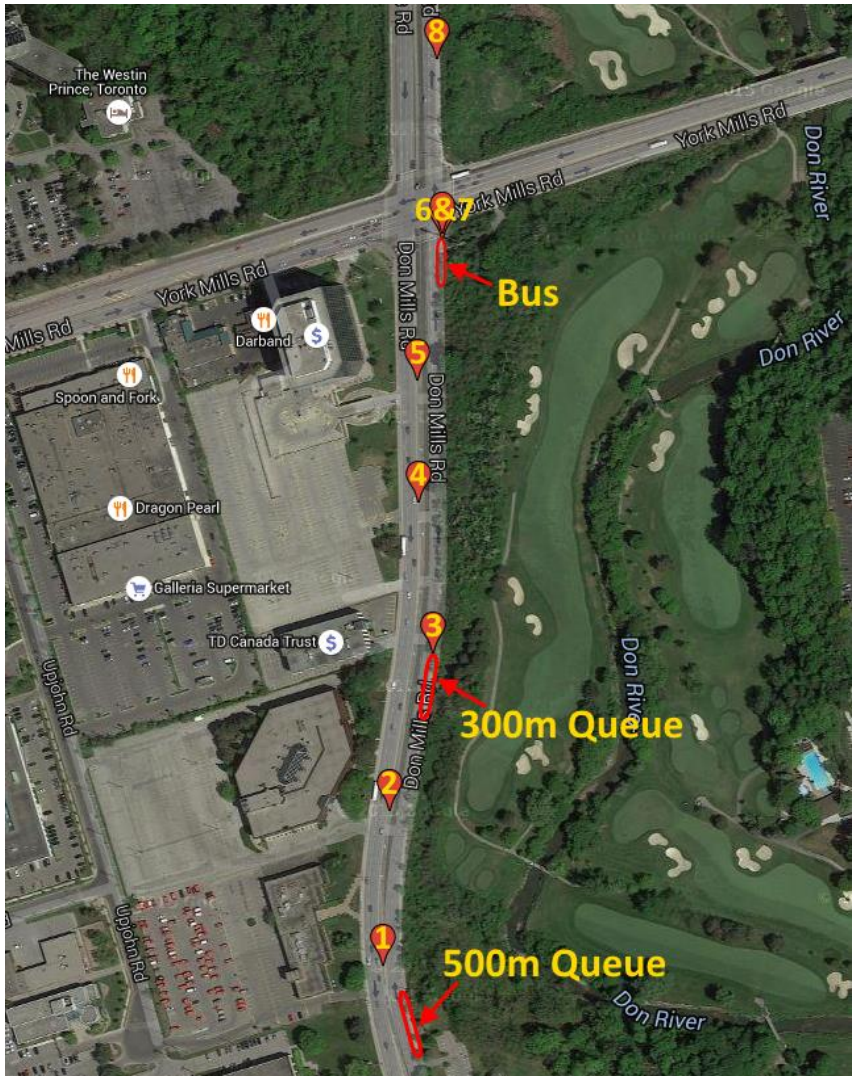
	Before	After
Cars		
Pedestrians		

OTHER SCENARIOS

NYC: FAIL-TO-YIELD DETECTION

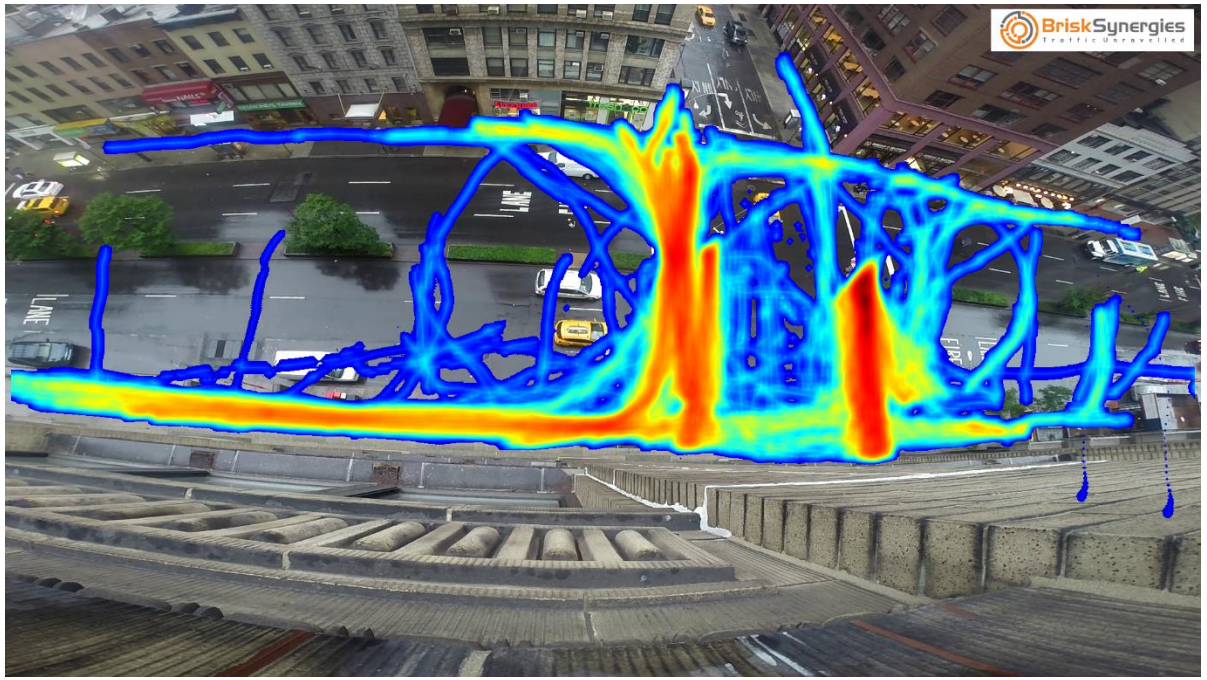
HIGHWAY CONFLICT ANALYSIS

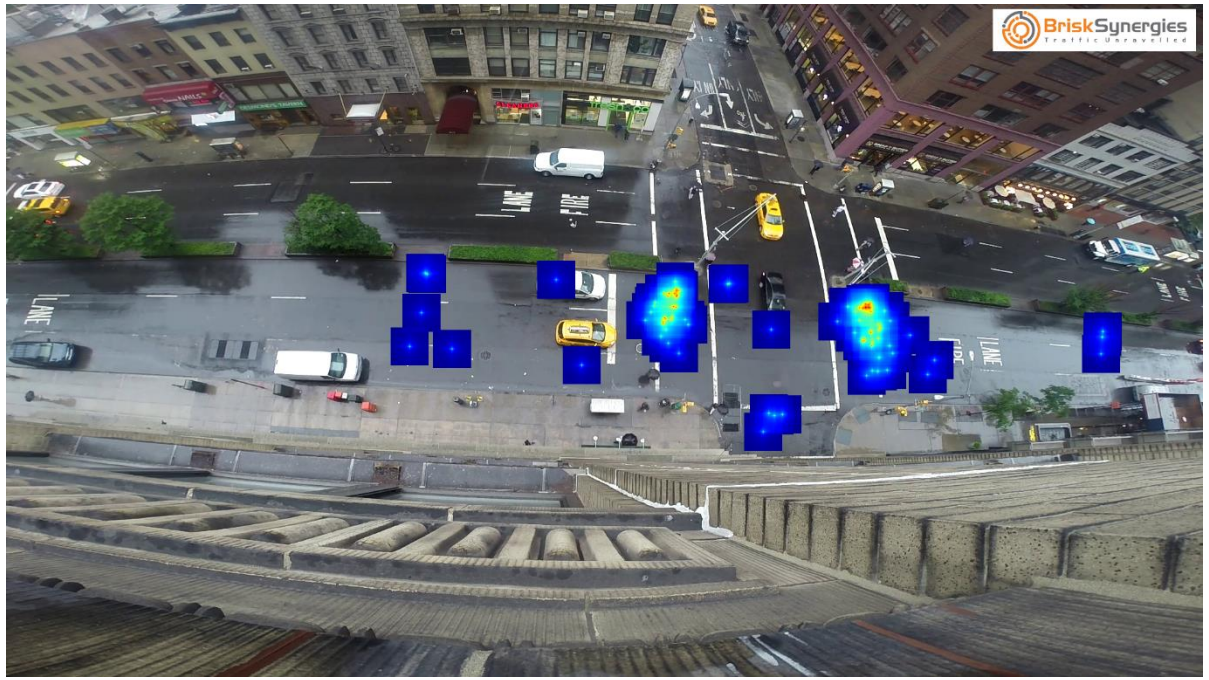
CONGESTION ANALYSIS CASE STUDY



ILLEGAL RIGHT-TURNS

JAYWALKING BEHAVIOURS





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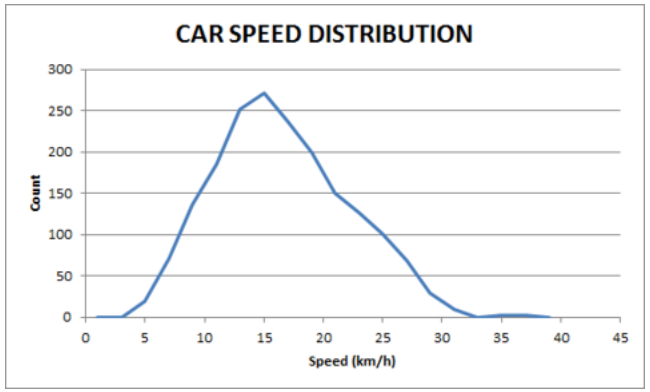
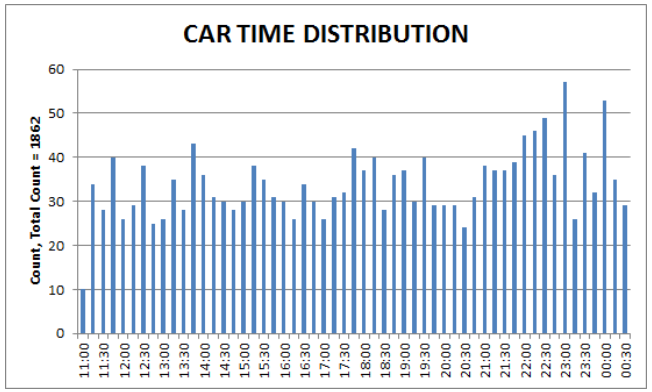
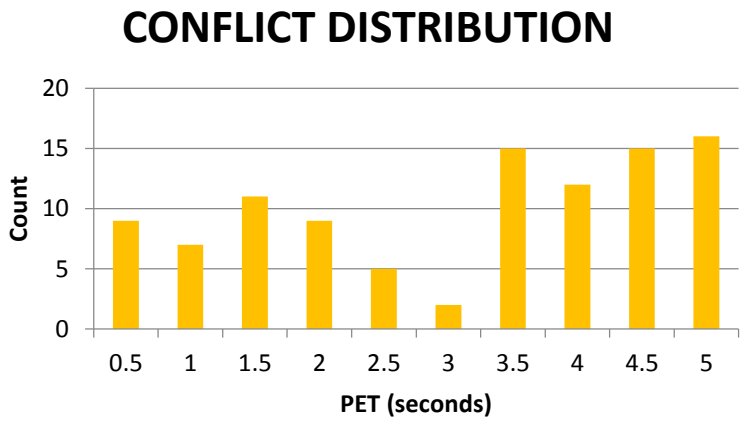
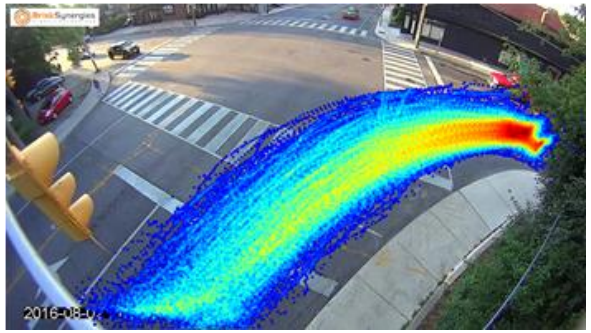






Conflict hotspots

Heatmaps



20-sec Conflict Videos

ON-DEMAND ANALYSIS

On-demand Analysis Service

- Data collection by Brisk
- Speed, count, conflict, etc.
- Result and report in 2 weeks

Traffic Monitoring Platform

- Access connected cameras (TMC)
- Continuous analysis
- Historic results on web

ON-DEMAND ANALYSIS

On-demand Analysis Service

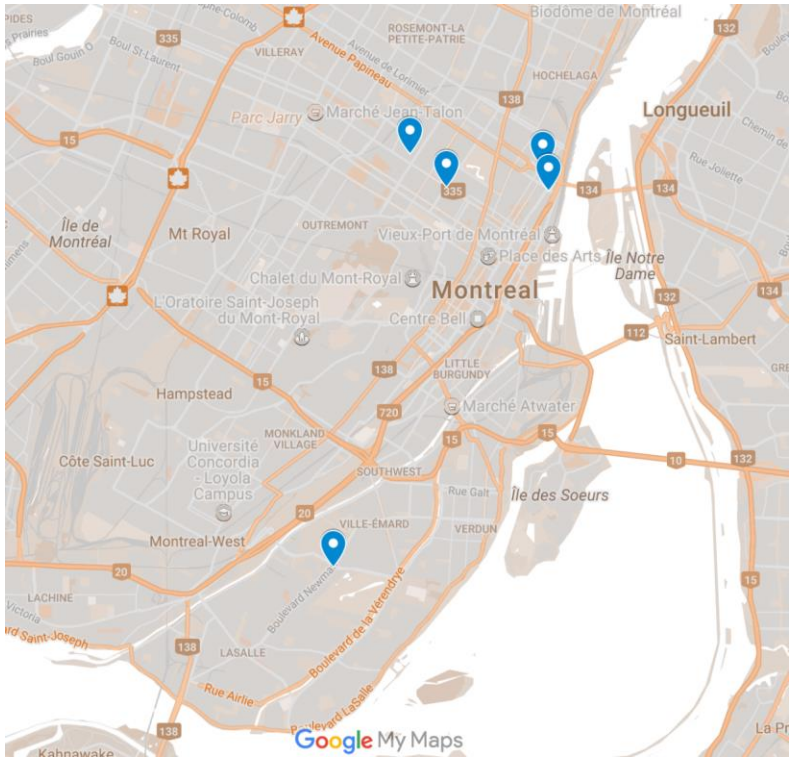
- Data collection by Brisk
- Speed, Count, Conflict, etc
- Result and Report in 2 weeks

Traffic Monitoring Platform

- Access connected cameras (TMC)
- Continuous analysis for years
- Historic results on dashboard

CONTINUOUS MONITORING CASE STUDIES

- City of Montreal
- 5 TMC connected-camera
- 20 scenarios of movement interactions
- Conflict and non-conflict scenarios
- Veh/Veh, Veh/Peds and Veh/Cyclists



CONTINUOUS MONITORING CASE STUDIES

- Roundabout at Region of Waterloo
- Frequent collisions
- Monitors right-of-way violation
- Track improvements of treatments

Franz Loewenherz

Principal Planner

FLoewenherz@Bellevuewa.gov

James Barr

Sr. Product Manager

JBarr@miovision.com

Charles Chung

CEO

Charles.Chung@brisksynergies.com