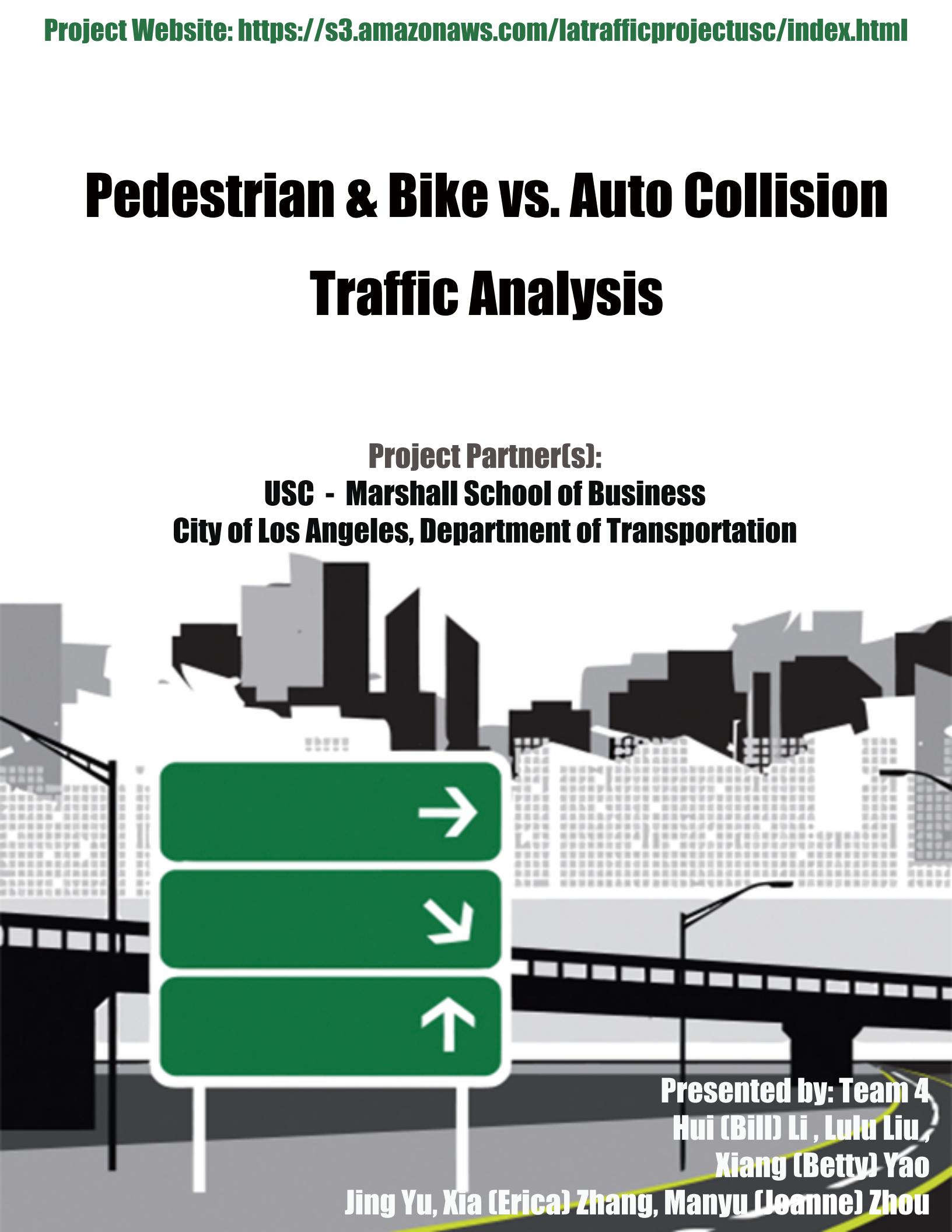


# Pedestrian & Bike vs. Auto Collision

## Traffic Analysis

**Project Partner(s):**  
**USC - Marshall School of Business**  
**City of Los Angeles, Department of Transportation**

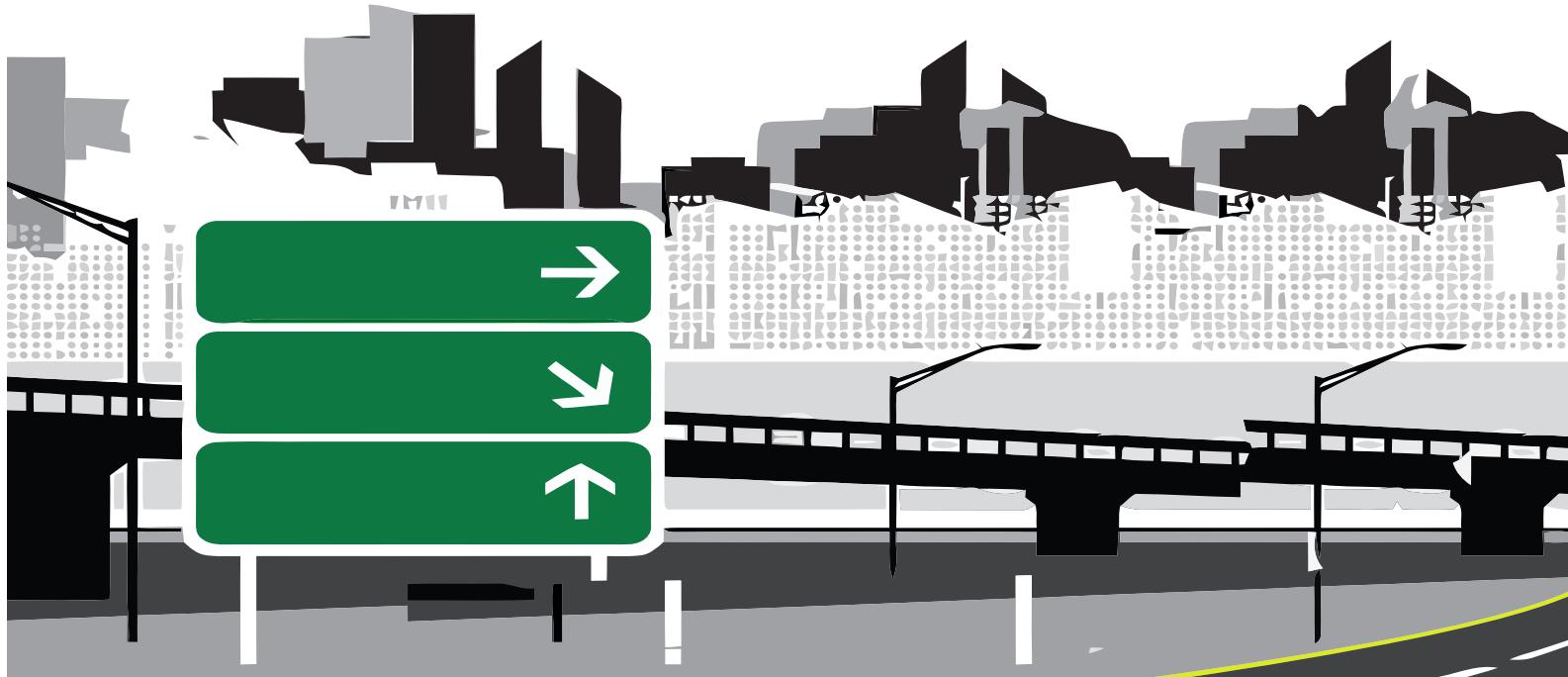


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# Introduction

Los Angeles has ranked high on the lists of cities with the worst traffic for decades. The average rush hour delay per 30-minute journey is 25 minutes. That adds up to an additional 95 hours behind the wheel each year due to traffic jams, according to TomTom<sup>1</sup>. Nonetheless, traffic collisions happen more often in rush hours. Based on such situation, the City of Los Angeles and the University of Southern California undertake a partnership in the use of advanced data analysis techniques to assess traffic collision, traffic engineering data and other analytics factors with the intent of identifying and reducing pedestrian and bicycle vs. auto collisions. Partnerships include USC Marshall School of Business, Information Technology Agency, Department of Transportation and LAPD. Project duration lasts from February to April 2015. The data used for the report is provided by LADOT, and the timeline of the data is from April 2008 to March 2013.

## Purpose

The purpose of the report is to perform a traffic analysis of high-risk intersections and provide corresponding feasible recommendations. The specific objectives are as following:

1. Determine factors/anomalies/patterns in pedestrian and bicycle vs. auto collisions.
2. Provide the Department of Transportation with additional data to assist and expedite traffic engineering modifications and plans to improve safety at high risk locations/intersections.
3. Provide the Department of Transportation with data to facilitate and maximize safety in traffic engineering/planning for new locations/intersections.
4. Provide the Los Angeles Police Department with data to facilitate and maximize the impact of traffic safety/enforcement zones.

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<sup>1</sup> TomTom Traffic Index. Retrieved from [http://www.tomtom.com/da\\_dk/trafficindex/#/city/LOS](http://www.tomtom.com/da_dk/trafficindex/#/city/LOS)

# Approach

The Pedestrian & Bike vs. Auto Collision Analysis report is comprised of multiple sections. The Map Visualization section provide a whole picture of traffic collision in LA; High risk location analysis, Factor of risk Identification analysis, Pedestrian and Bicycle Analysis consolidate information from city traffic data resources and conduct analysis on all aspect of the collision factors; lastly, case study provide a deep investigation on specific intersection. The methodology we applied on this project are the following:

## Visualization Methodology

We used interactive, computer-supported, visual representations of data to amplify cognition and to find out what are the insights in the original collision dataset<sup>2</sup>.

- Information visualization: graphical representations, pattern recognition, and other cognitive skills.
- Data visualization: represents quantitative data, information graphics and statistical graphics from R and Tableau data analysis software<sup>3</sup>.
- Concept visualization: Mindmap, layer chart, decision tree model brianstorm.
- Metaphor visualization: delivery insights in dataset through key characteristics.

## Research Methodology

- Case Study Research: We used Case Study Research Methodology which included quantitative evidence and relied on multiple qualitative sources of evidence from our original Collision dataset. This methodology provides a tool for us to study complex traffic data in KoreaTown Los Angeles area and aimed us finding general recommendations for answering the research questions.

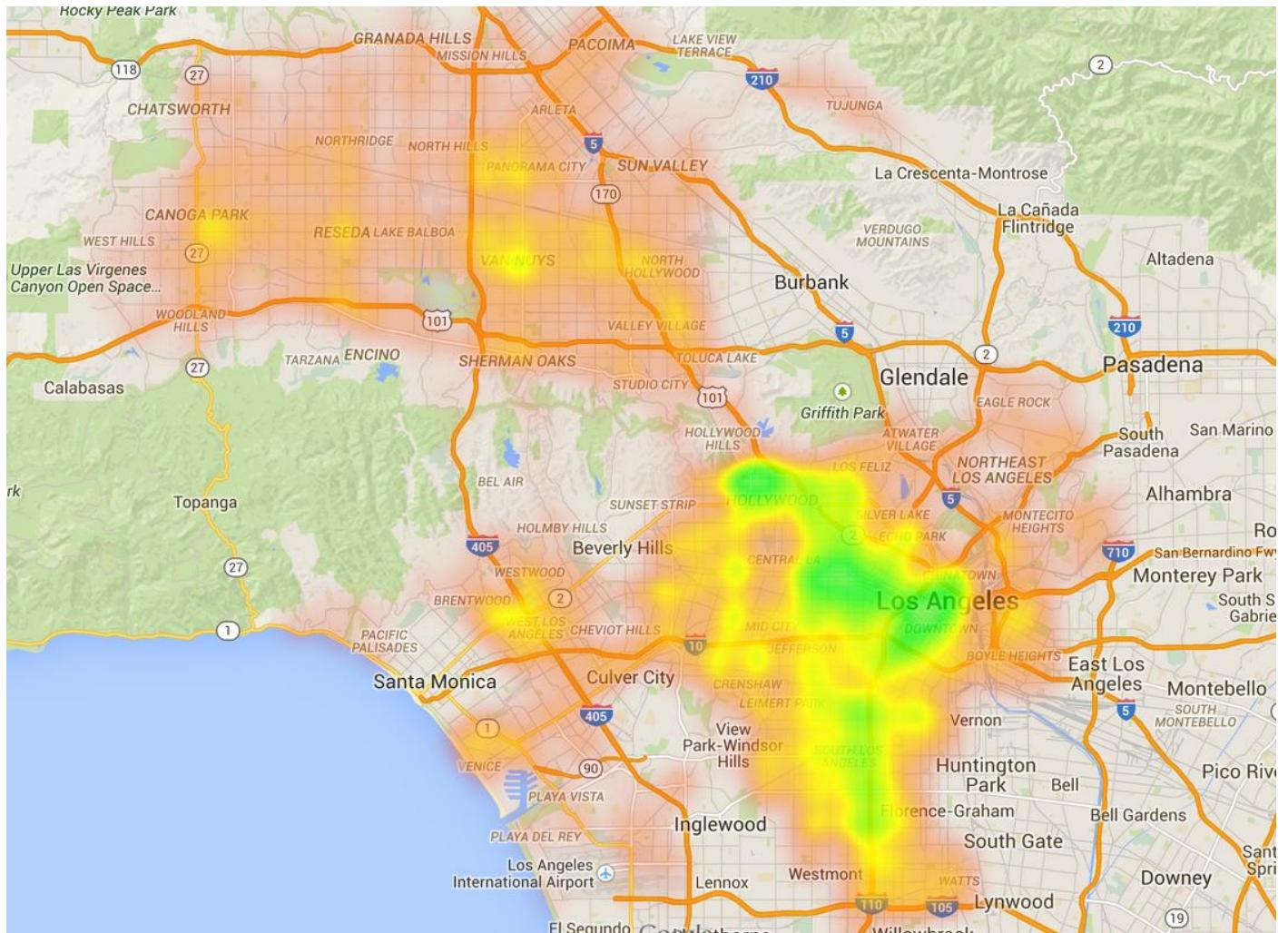
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<sup>2</sup> Alfredo R. Teyyre and Marcelo R. Campo, (2009). “An Overview of 3D Software Visualization”, IEEE Transactions on Visualization and Computer Graphics, vol.15, No.1.

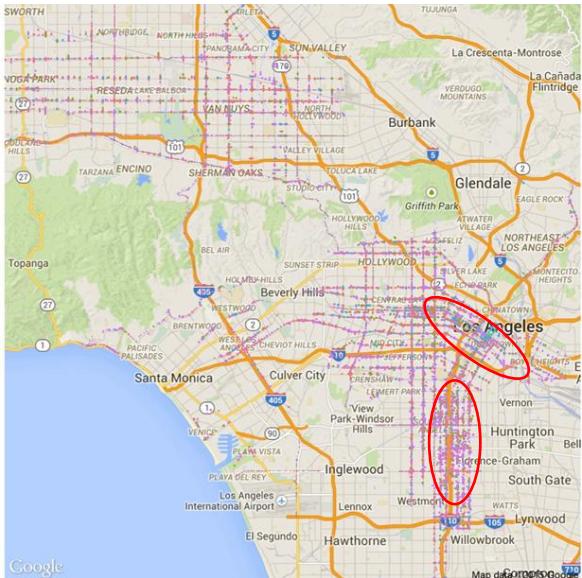
<sup>3</sup> Michael Friendly, (2008). “Milestones in the history of thematic cartography, statistical graphics, and data visualization”, <http://www.math.yorku.ca/SCS/Gallery/milestone/milestone.pdf>.

# Map Visualization

Based on the City of Los Angeles collision data from 2008 and 2013, the overall traffic heat map by frequency of collision happened has been created below. This is an interactive heat map that is capable to zooming into the specific area and road. It can be also shown up by Satellite version when presented as a web page format.

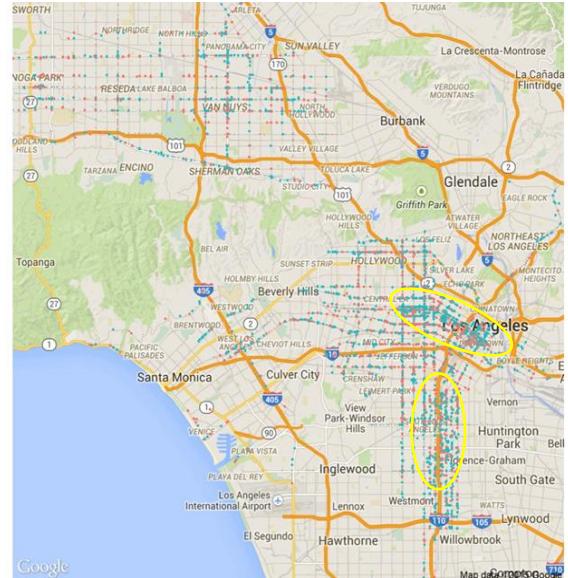


As shown from the heat map, the most high risk area of collision is identified by the bright yellow color. Most traffic collisions happen in Korean town, downtown LA and south Los Angeles. In the next section, we will provide detail information regarding to collision factors and collision type in these areas.



Top 4 Collision Factor Map

(Map data ©2013 Google)



Pedestrians and Bicycle Collision Map

(Map data based on top 20 primary roads, top 20 second roads and roads involved in top 20 highest frequency intersections)

Collision factor map above demonstrates the top 4 most common primary collision factors, which are Auto R/W Violation, Driving Under Influence, Traffic Signals and Signs and unsafe speed. The red circle is the most risky area that had most collision from 2008 to 2013. These areas turn out to be Koreatown area, downtown LA and south LA.

Filtering on only Pedestrian and Bicycle collision, the collision pattern does not change too much compared to the Collision Factor Map. We can see from the Pedestrians and Bike Collision Map that Koreatown and LA area are also the most risky area for Pedestrians and bicyclist. On the other hand, if you look down to south LA, auto collision happened more frequent than Pedestrians and bicyclist involved collision.

# High Risk Location

## High Risk Intersections

In order to conduct more detailed investigation on very high risk intersections, we made the intersection frequency analysis table based on the original data from the location table. This table is calculated by the primary road and secondary road matches and identifies only the across road frequency greater than 70 from 2008 to 2013.

The top three intersections with the highest frequency of collision are La Brea Avenue & Rodeo Road, Manchester Avenue & Figueroa Street(N), Pacific Coast Highway & Temescal Canyon Road and Sherman Way & Sepulveda Blvd.

**Analysis of Cross Road Frequency (>70)**

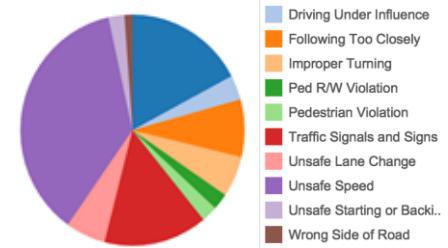
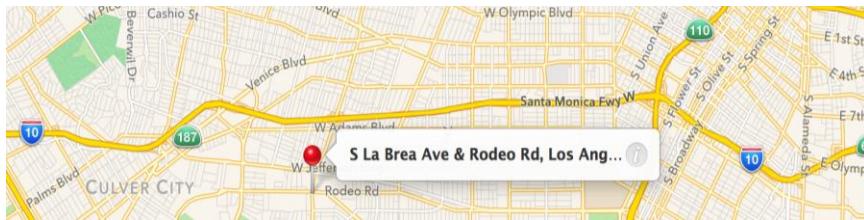
Primary Road	Second Road	
SUNSET BOULEVARD	LA BREA AVENUE	75
SHERMAN WAY	COLDWATER CANYON AVE..	91
	SEPULVEDA BOULEVARD (..)	95
	BELLAIRE AVENUE	85
	WOODMAN AVENUE	81
	VAN NUYS BOULEVARD	79
	WHITSETT AVENUE	77
VICTORY BOULEVARD	COLDWATER CANYON AVE..	72
LA BREA AVENUE	RODEO ROAD	105
	ADAMS BOULEVARD (N)	82
CRENSHAW BOULEVARD	ADAMS BOULEVARD	86
	STOCKER STREET	83
RESEDA BOULEVARD	VANOWEN STREET	80
MANCHESTER AVENUE	FIGUEROA STREET (N)	95
	BROADWAY	80
	MAIN STREET	80
	HOOVER STREET	79
	VERMONT AVENUE (1)	75
BURBANK BOULEVARD	SEPULVEDA BOULEVARD	77
PACIFIC COAST HIGHWAY	VERMONT AVENUE	74
	TEMESCAL CANYON ROAD	108
	SUNSET BOULEVARD	79
SLAUSON AVENUE	VERMONT AVENUE	81
	WESTERN AVENUE	71
HIGHLAND AVENUE	PAT MOORE WAY	89
	FRANKLIN AVENUE (1)	82
TAMPA AVENUE	NORDHOFF STREET	71
Primary Road	Second Road	
LA BREA AVENUE	RODEO ROAD	105
MANCHESTER AVENUE	FIGUEROA STREET (N)	95
PACIFIC COAST HIGHWAY	TEMESCAL CANYON ROAD	108
SHERMAN WAY	SEPULVEDA BOULEVARD (..)	95

The top 4 high risk intersections

# Top 4 High Risk Intersections Analysis

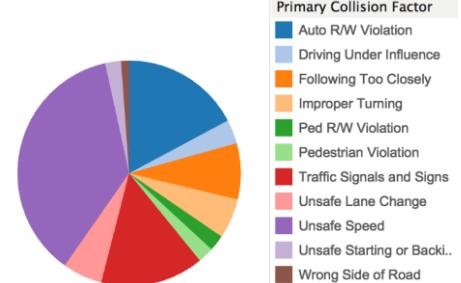
## La Brea Avenue & Rodeo Road

Below is the google map location pin for the intersection with La Brea Ave & Rodeo Road. This intersection is next to Culver City area and located in the intersection of busy commercial area. The pie chart describes that a large portion of the 105 collisions is caused by Auto R/W Violation and unsafe speed.



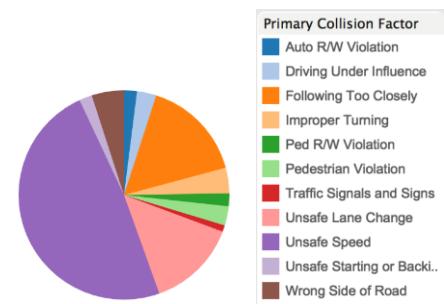
## Manchester Avenue & Figueroa Street(N)

The intersection of Manchester Ave and Figueroa Street (N) had 95 collision records from the whole database. It is only two blocks from the busy I-110 Highway and locate in an extremely busy commercial areas. The primary collision factors are unsafe speed, Auto R/W Violation, Traffic Signals and Signs and following too closely. In order to improve the traffic situation, we should place the speed calculator beside the road to remind drivers slow down at this area and we could also put up signs like “Caution: high traffic area”.



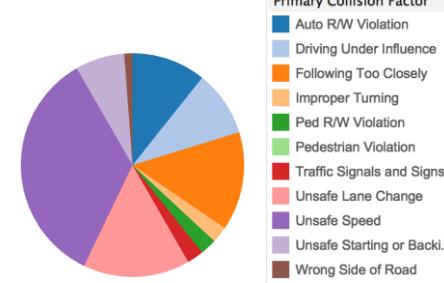
## Pacific Coast Highway & Temescal Canyon Road

This intersection is located near Santa Monica beach area and on the California 1 highway. Most of the collision happened because of unsafe speed and unsafe lane change. This is one of the most high risk intersections in Santa Monica and it is on the way to beach area. The car speed at this areas are very high. It will be helpful if LAPD can place traffic lights to limit high speed.



## Sherman Way & Sepulveda Blvd

The intersection of Sherman Way & Sepulveda Blvd is located at Van Nuys. It has a very similar situation with the intersection of Manchester ave & Figueroa Street(N). It is mainly because of unsafe speed and unsafe lane change. This intersection is right off highway 405.



## High Risk Road Analysis

Besides looking at the high risk intersections, we explored a deep analysis upon high risk road instead. According to the frequency analysis, the top five primary roads that have the highest frequency of collision are WESTERN AVE, SUNSET BLVD, VERMONT AVE, FIGUEROA ST, and SEPULVEDA BLVD. The top five second roads are FIGUEROA ST, OLYMPIC BLVD, PICO BLVD, VERMONT AVE, and WESTERN AVE. We then did the following frequency analysis tables based on collision type, collision day of week, and collision factor.

## Top Five Primary Road Analysis

**Collision Type:** Broadside, Head-on, Hit Object, Overturn., Rear-End, Sideswipe accounts for the most traffic collisions.

### Top 5 Primary Road Collision Type

Primary Road	Collision Type						
	Broadside	Head-On	Hit Object	Overtur...	Rear-End	Sideswipe	Vehicle - Pedestrian
WESTERN AVENUE	858	183	181	12	867	599	252
SUNSET BOULEVARD	801	181	292	34	760	516	194
VERMONT AVENUE	808	165	156	18	820	508	268
FIGUEROA STREET	783	153	151	15	583	540	198
SEPULVEDA BOULEVARD	712	149	209	20	714	449	132

**Collision Day of Week:** Friday and Saturday are the riskiest days for Western Ave and Sunset Blvd; Tuesday and Friday are the riskiest days for Vermont Ave, Figueroa St and Sepulveda Blvd.

### Top 5 Primary Road Collision Day of Week

Primary Road	Collision Day of Week						
	Sunday	Monday	Tuesday	Wednes..	Thursday	Friday	Saturday
WESTERN AVENUE	421	382	372	402	388	471	516
SUNSET BOULEVARD	389	379	376	341	373	464	457
VERMONT AVENUE	373	370	406	369	367	422	439
FIGUEROA STREET	339	308	362	352	341	386	335
SEPULVEDA BOULEVARD	245	356	392	363	323	392	314

**Collision Factor:** Majority of the collisions happened on these 5 roads are due to unsafe speed and auto R/W violations.

### Top 5 Primary Road Collision Factor

Primary Road	Primary Collision Factor										
	Unsafe Speed	Auto R/W Violation	Unsafe Lane Change	Driving Under Influence	Traffic Signals and Signs	Following Too Closely	Wrong Side of Road	Improper Turning	Ped R/W Violation	Pedestrian Violation	Unsafe Starting or Backing
WESTERN AVENUE	714	654	215	202	187	184	138	120	105	88	63
SUNSET BOULEVARD	603	627	223	185	173	248	99	171	74	66	64
VERMONT AVENUE	657	612	178	173	214	191	102	144	92	104	58
FIGUEROA STREET	572	517	184	150	187	76	98	175	89	67	80
SEPULVEDA BOULEVARD	566	496	182	163	206	194	79	133	47	47	39

## Top Five Second Road Analysis

**Collision Type:** Broadside, Rear-end, and Sideswipe are the top 3 type of collision

### Top 5 Second Road Collision Type

Second Road	Vehicle -					
	Broadside	Head-On	Hit Object	Overturne..	Rear-End	Sideswipe
FIGUEROA STREET	409	97	93	3	389	372
OLYMPIC BOULEVARD	377	68	67	5	295	249
PICO BOULEVARD	326	47	63	1	277	287
VERMONT AVENUE	402	99	95	4	335	318
WESTERN AVENUE	419	101	77	3	291	262
						158

**Collision Day of Week:** Friday and Saturday are the riskiest days for Figueroa St, Pico Blvd and western avenue; Friday is the riskiest day for Vermont Ave; Wednesday to Friday are the riskiest days for Olympic Blvd.

### Top 5 Second Road Collision Day of Week

Second Road	Collision Day of Week						
	Sunday	Monday	Tuesday	Wednesd..	Thursday	Friday	Saturday
FIGUEROA STREET	197	194	191	203	191	216	267
OLYMPIC BOULEVARD	138	153	168	175	175	175	161
PICO BOULEVARD	142	150	157	144	145	188	183
VERMONT AVENUE	214	174	195	211	186	242	194
WESTERN AVENUE	203	184	180	163	184	205	192

**Collision Factor:** Majority of the collisions happened on these 5 roads are due to unsafe speed and auto R/W violations.

### Top 5 Second Road Collision Factor

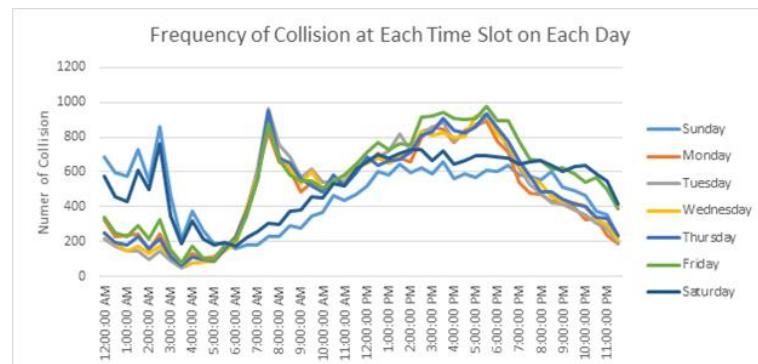
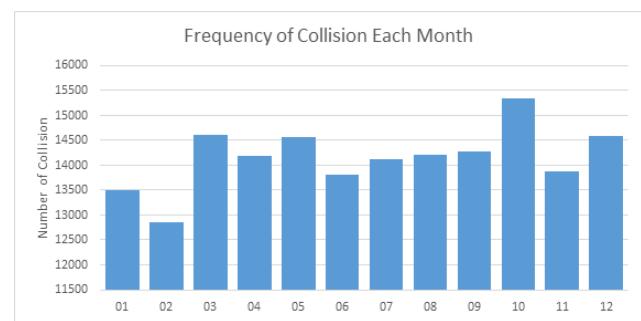
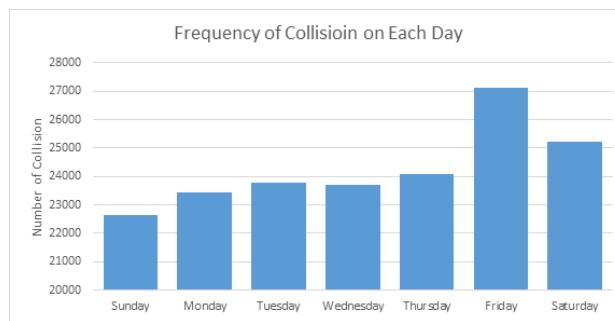
Second Road	Primary Collision Factor										
	Unsafe Speed	Auto R/W Violation	Traffic Signals and Signs	Unsafe Lane Change	Unsafe Starting or Backing	Driving Under Influence	Improper Turning	Wrong Side of Road	Following Too Closely	Ped R/W Violation	Pedestrian Violation
FIGUEROA STREET	367	255	121	116	100	95	87	64	52	37	34
OLYMPIC BOULEVARD	199	242	92	74	77	70	81	65	82	41	24
PICO BOULEVARD	190	215	77	74	82	53	74	65	80	41	44
VERMONT AVENUE	307	301	94	72	73	93	76	73	51	71	61
WESTERN AVENUE	270	300	92	60	70	80	74	71	54	67	52

# Factors of Risk Identification

After we have detected the high risk intersections/area on the map, we followed to explore a big picture of the factors of risk that contributes to the collisions in these location. Factors may include surrounding conditions such as time, weather, direction and lighting, as well as personal violation as the primary collision factor describes. Additionally, we will break down our analysis to detailed primary collision factor, injury situation. For this report, we will emphasize our analysis based on the location in order to better identify the causes involved in the collision.

## Condition Analysis

First of all, we conducted a thorough analysis upon surrounding conditions. Most of the accidents happened on dry ground, clear or cloudy weather. As for the timeline analysis, the data shows that Friday has the most collision throughout the week, and October has the most collision throughout the year. After divided all the records into 48 timeslots, which half an hour is an interval, we plotted the frequency of collision at each time slot by day and found some interesting points. Clearly from the graph we can see that Monday to Friday have similar patterns that morning peaks take place around 7 to 8 am, and there is an increasing of accidents happened throughout afternoon and afternoon peaks take place 5 to 6 pm. This is consistent with morning, and afternoon rush hours. However, the collision patterns on weekends are quite different. The most collision accidents happen at 3 am and there is a quite steady trend through daytime.



More important causes led to a collision we want to take an eye on might be the primary collision factors given in the data. That the top five collision factors are listed as Unsafe Speed, Auto R/W Violation, Traffic Signals and Signs, Driving Under Influence, and Improper Turning. The top three collision type are Broadside, Rear-End, and Sideswipe.

Primary Collision Factor	
Unsafe Speed	40,809
Auto R/W Violation	33,930
Traffic Signals and Signs	13,357
Driving Under Influence	12,555
Improper Turning	9,077
Unsafe Lane Change	8,652
Unsafe Starting or Backing	8,278
Following Too Closely	8,170
Wrong Side of Road	7,772
Unknown	5,286
Ped R/W Violation	5,231
Pedestrian Violation	4,396
Other Improper Driving	4,111
Not Stated	2,756
Improper Passing	2,014
Other Hazardous Movement	1,480
Other Than Driver or Ped	1,203
Other	540
Other Than Driver	161
Hazardous Parking	91
Impeding Traffic	52
Other Equipment	30
Brakes	18
Lights	17
Fell Asleep	4

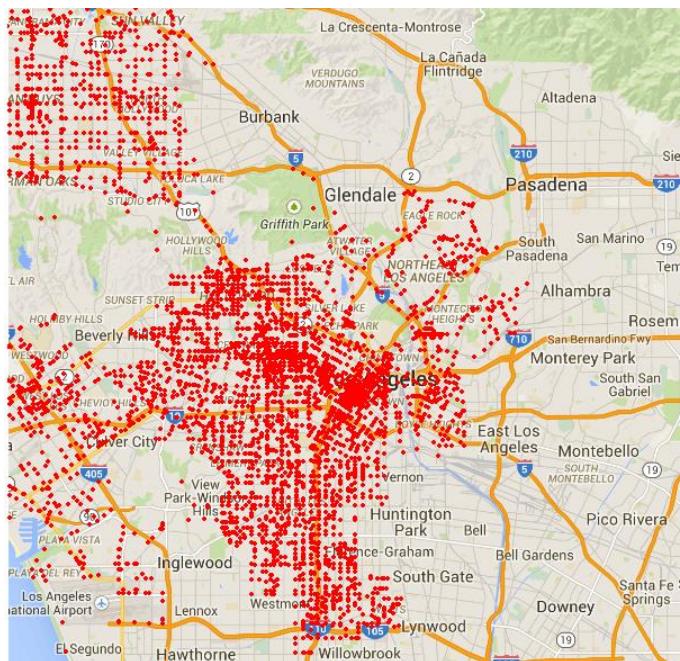
  

Collision Type	
Broadside	50,304
Rear-End	42,924
Sideswipe	37,001
Hit Object	14,355
Vehicle - Pedestrian	12,955
Head-On	11,445
Overturned	978
Other	28

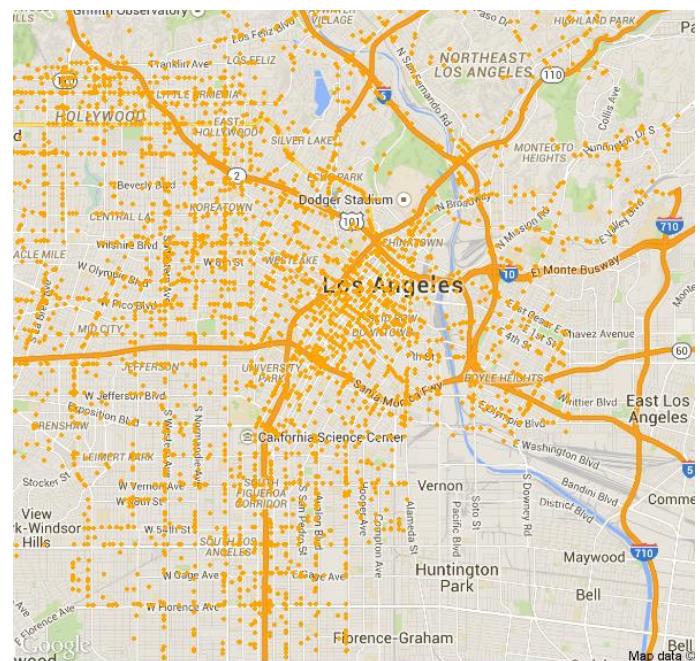
## Collision Factor Analysis

To have a broad picture of how high frequency collision factor spread over the map, we performed a detailed analysis to identify the locations built on specific collision factors. As we discovered, the top four primary collision factors are Unsafe Speed, Auto R/W Violation, Traffic Signals and Signs, and Improper Turning.

The bottom left map pictures all the collision happened due to traffic signals and signs. Although the dots are dispersed all over, we are able to identify that there are several clusters, which are west Downtown LA, Koreatown, and the intersections of Highway 110 and 105. The bottom right map cluster appears in west side of Downtown LA, that best explains the fact that west Downtown LA has a large number of one-way roads and complex intersection infrastructures.

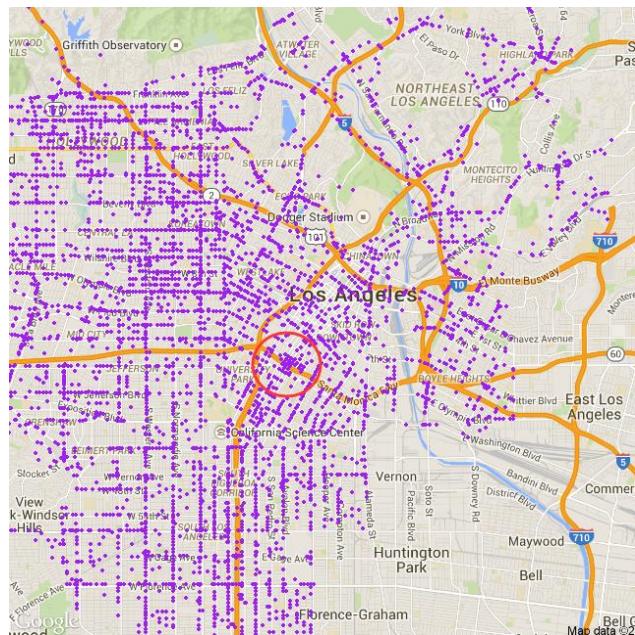


collision due to Traffic Signals and Signs map

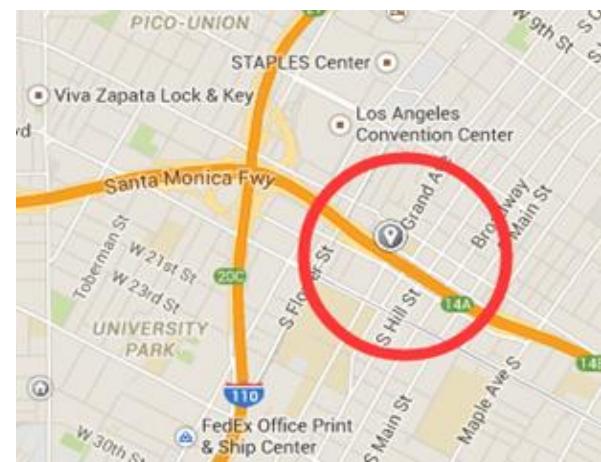


collision due to Improper Turning map

After zooming in the collision map due to Auto R/W Violation, we can detect that an obvious cluster with highest degree of injury aggregated is around Santa Monica Freeway (Interstate 10) near Exit 14A.

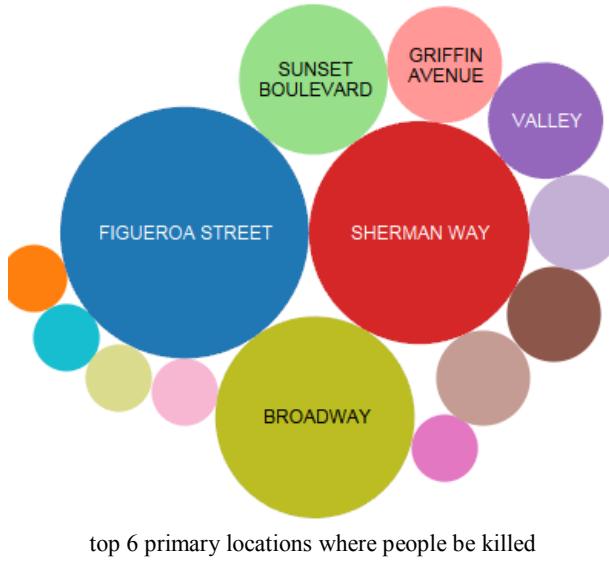


collision due to Auto R/W Violation map (filtered by people hurt and killed)



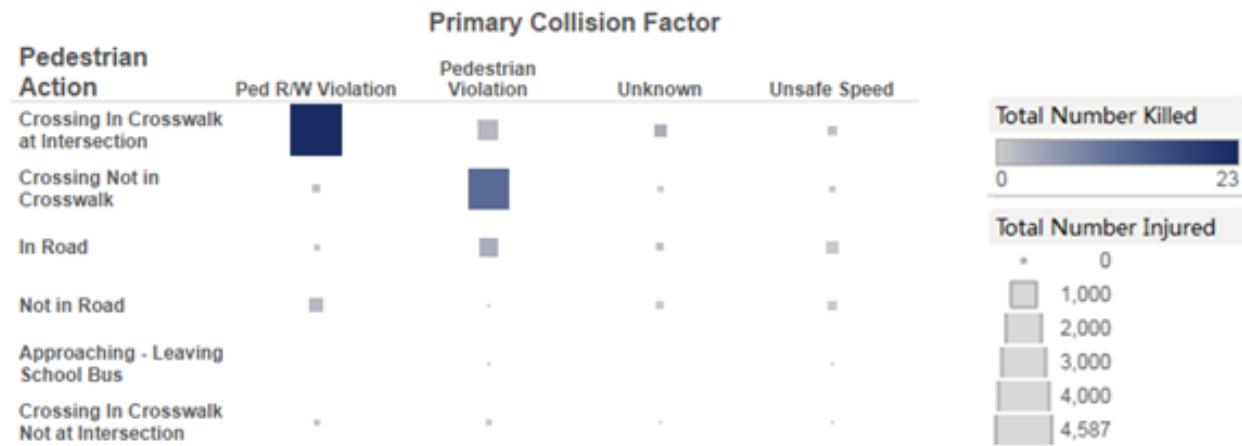
# Injury Analysis

After we joint the injury table and location table, we can easily see that most injuries happened on several major roads. As shown in the bubble graph below, FIGUEROA ST, SHERMAN WAY, BROADWAY, SUNSET BLVD, GRIFFIN AVE, and VALLEY BLVD are the most dangerous primary locations that involved with most severe traffic collisions which caused most people killed.



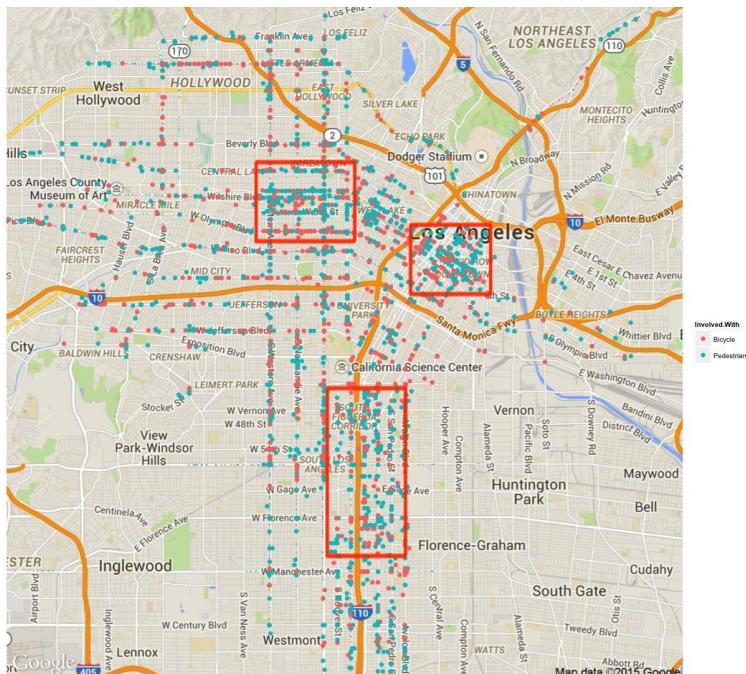
The following table is the number of people killed and injured counts based on collision factor and pedestrian actions. Pedestrian R/W Violation when pedestrian is crossing in crosswalk at intersection counts for the most dangerous behavior that leads to hurt in traffic collisions.

People Killed and Injured Counts based on Collision Factors and Pedestrian Actions



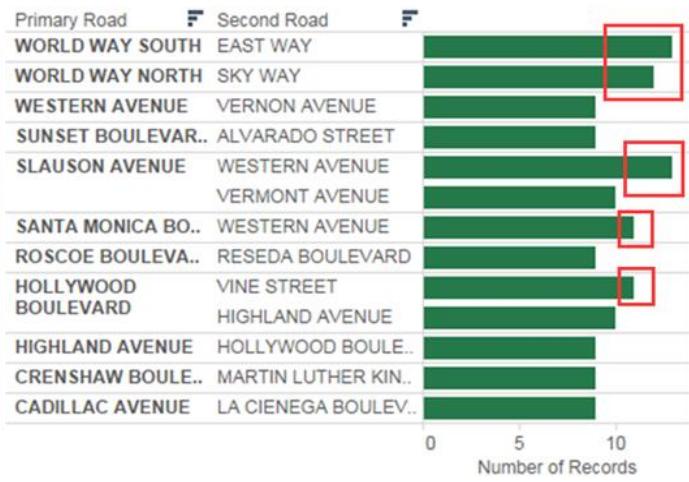
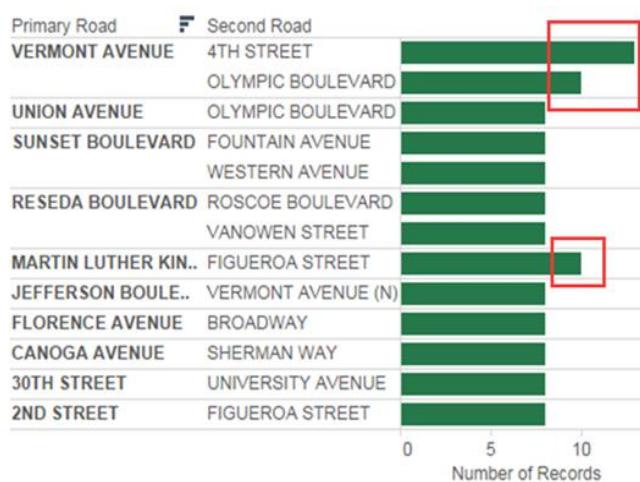
# Pedestrian and Bicycle Analysis

Narrowing down to only pedestrian and bicycle involved collision, the pedestrian and bicycle focused collision location map has created below. In the red box, we have easily identify the area where pedestrian and bicycle involved collision happened most frequently. As it shared a very similar pattern with the overall auto collision map, the top three high risk area are Koreatown, LA downtown and south LA.



(Map data based on top 20 primary roads, top 20 second roads and roads involved in top 20 highest frequency intersections)

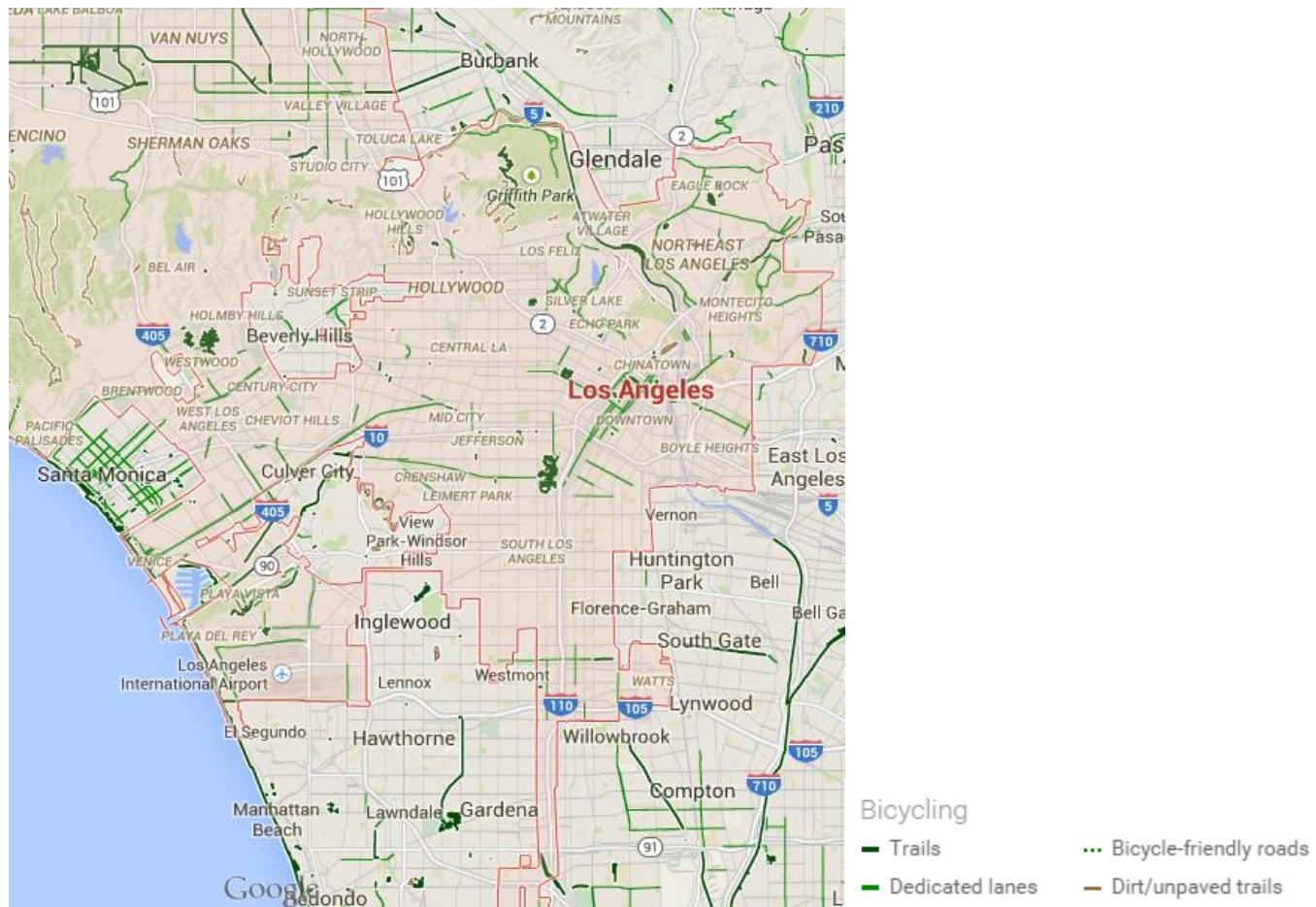
## Analysis of Bicycle Involved Collisions (Frequency>7) Analysis of Pedestrian Involved Collisions (Frequency>9)



The intersection of Slauson Ave & Western Ave and World Way South & East Way are the two most risky intersection for Pedestrian. The intersection of Vermont Ave & 4th Street is the most frequent collision location for bicycle involved collision.

## Bicycling Analysis

Below is the Bicycling Maps of City of Los Angeles. The black line identifies bicycle trails without auto traffic. The red line indicates Dirt/unpaved trails which are off-road dirt paths. The green line is dedicated lanes which are roads that are shared with cars and have a separate bike lane. The soft line demonstrate the roads that don't have a bike lane but are recommended for cyclists.

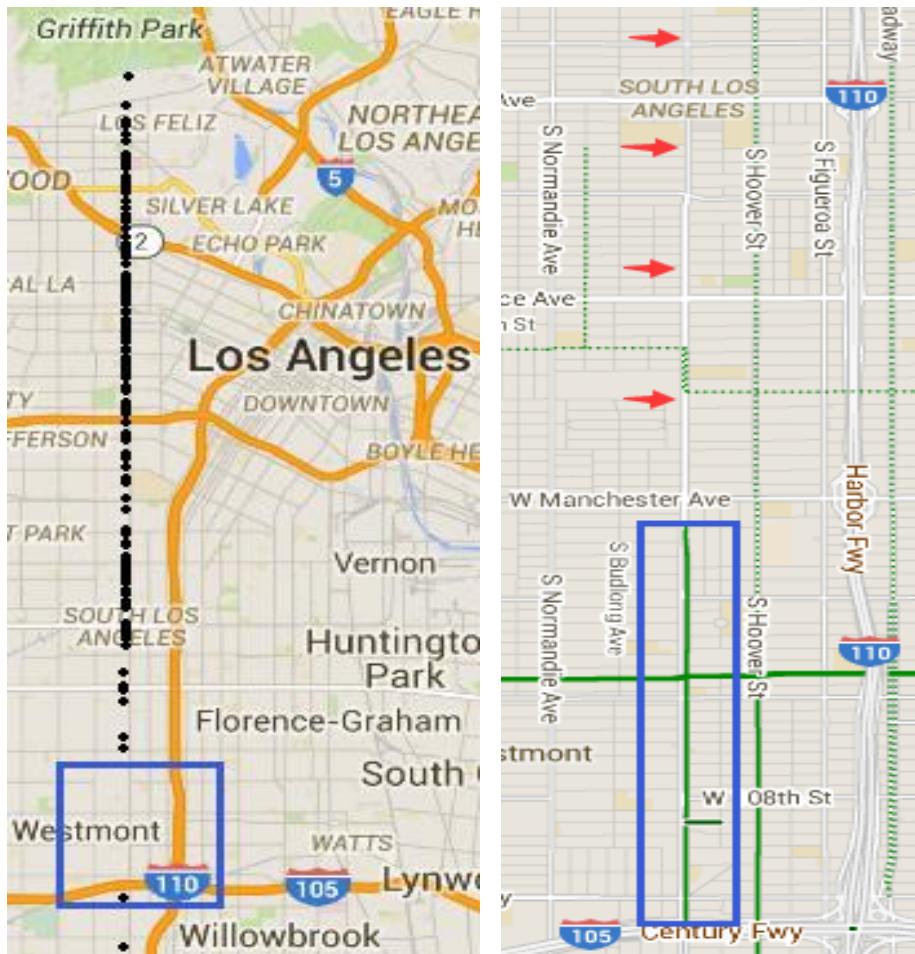


(From Google Maps)

Comparing to Santa Monica and the Southeast region of Los Angeles County, City of Los Angeles doesn't have many dedicated lanes for cyclists. Especially in the Koreatown which has very high population density, there's seldom trails, dedicated lanes or bicycle-friendly roads for cyclists.

## Bicycle-Involved Collisions with Highest Frequency

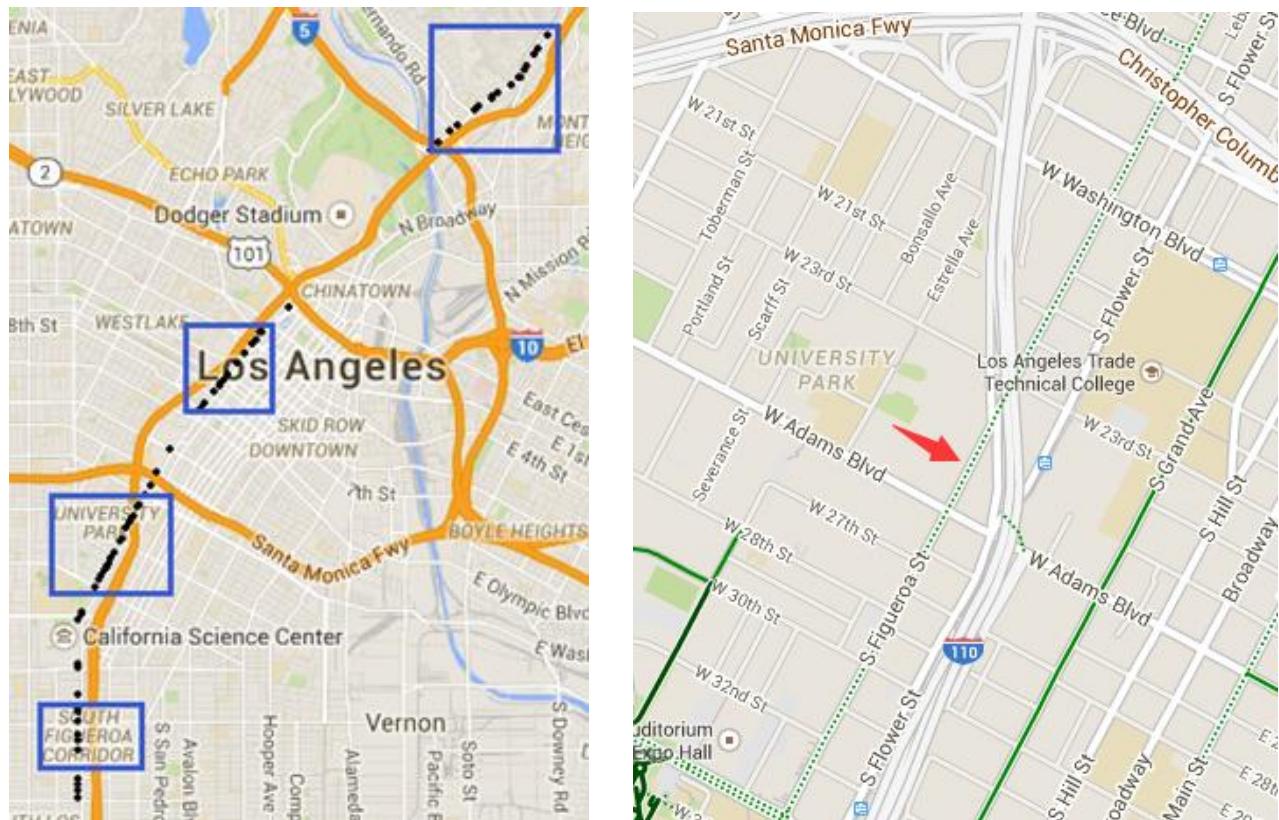
### Vermont Avenue



As shown in the left map, Vermont Avenue has many traffic collision related to bicycles from north to south. This is due to the lack of any types of bicycle lanes (bicycle-friendly lanes or dedicated lanes). There's only one place (highlighted in blue squares in both two maps) that nearly has no collision records. This region is also the only region that has separate bicycle lanes for cyclists on Vermont Avenue.

In order to improve safety of Vermont Avenue, we suggest LADOT to construct bicycle-friendly lanes between Santa Monica Fwy and W Martin Luther King Jr Blvd on Vermont Avenue and construct the separate bicycle lanes on the rest of Vermont Avenue, especially in Central LA.

## Figueroa Street

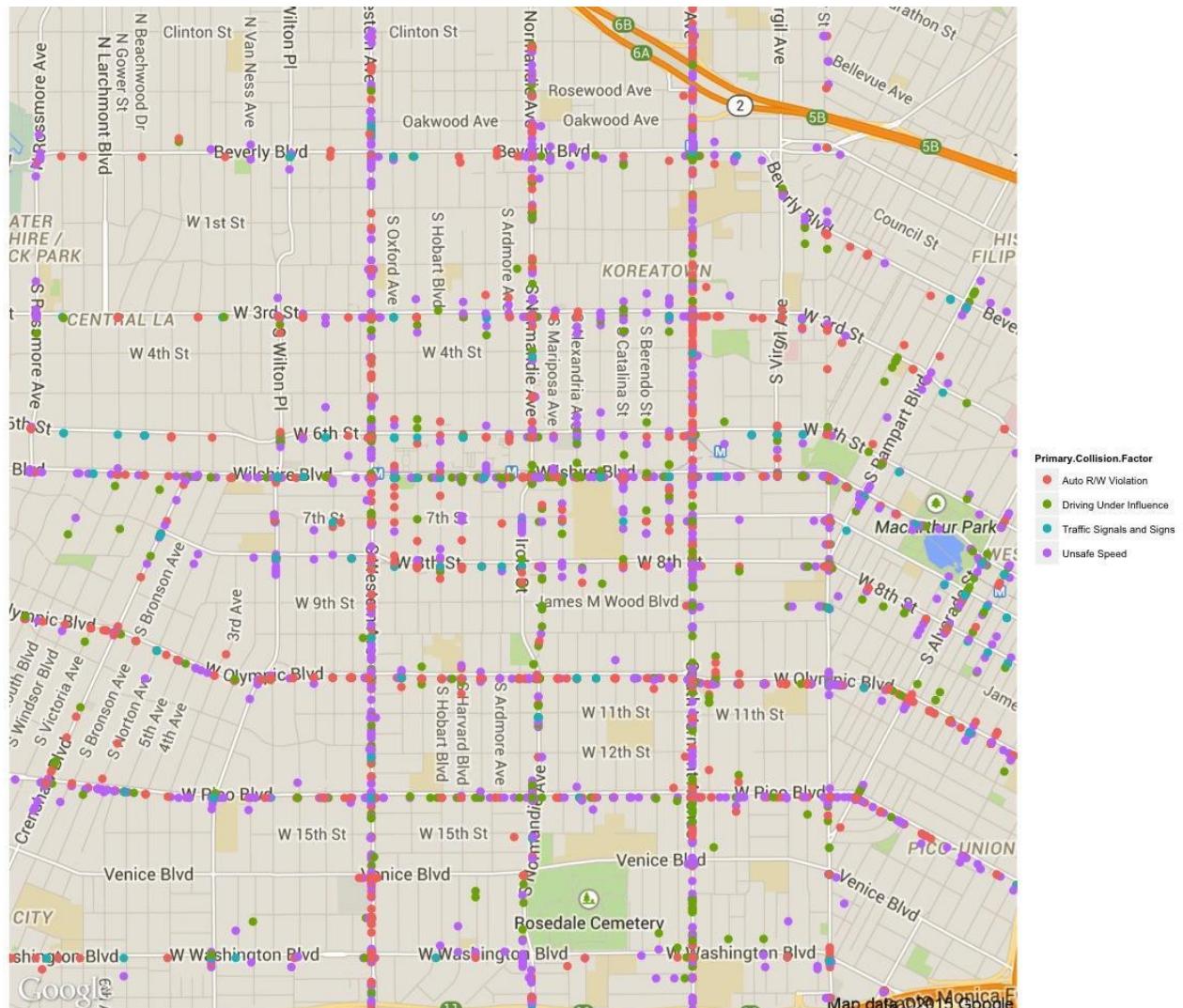


As shown in the left map, traffic collisions happened in four regions that Figueroa Street crosses through. They are the Northeast Los Angeles region, Downtown Los Angeles region between w 3rd street and w 8th street, University Park and South Figueroa Corridor. Based on extra information from Google's bicycling maps, we find that the most dangerous lanes of Figueroa near downtown area are the dedicated lanes which require cyclists to share the lane with cars.

To improve the safety of these area, we recommend LADOT to reconstruct and replace the bicycle-friendly road between W 33rd St and Venice Blvd to dedicated lane that has separate bicycle lane in Figueroa Street.

# **Case Study Research**

In this case study, we would like to focus on Koreatown region, one of the most high risk area. To obtain an overall understanding of Koreatown collision, Koreatown Collision Factor Map show below. Vermont Ave., Western Ave., Wilshire Blvd. and Olympic Blvd. are four most high collision frequency roads based on the collision factor map below.

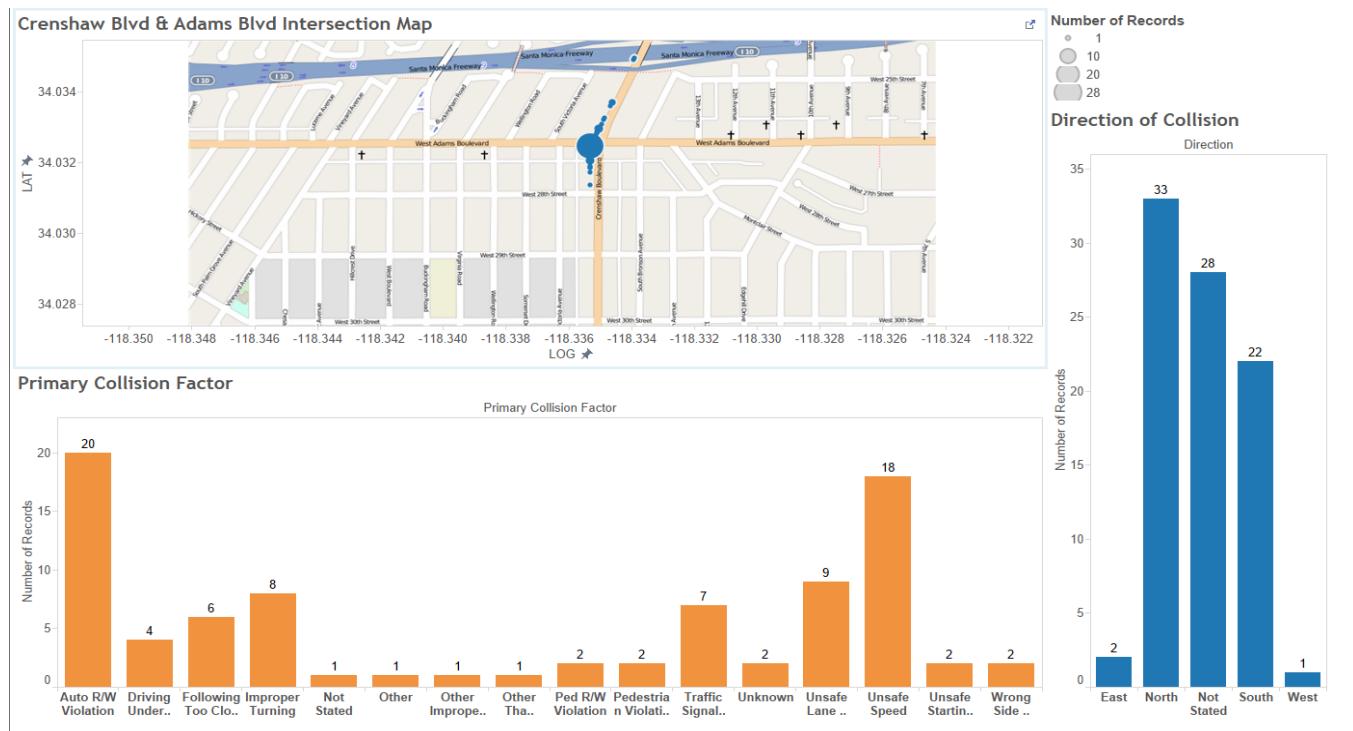


(Map data based on top 20 primary roads, top 20 second roads and roads involved in top 20 highest frequency intersections)

# Case Study: Crenshaw Blvd & Adams Blvd

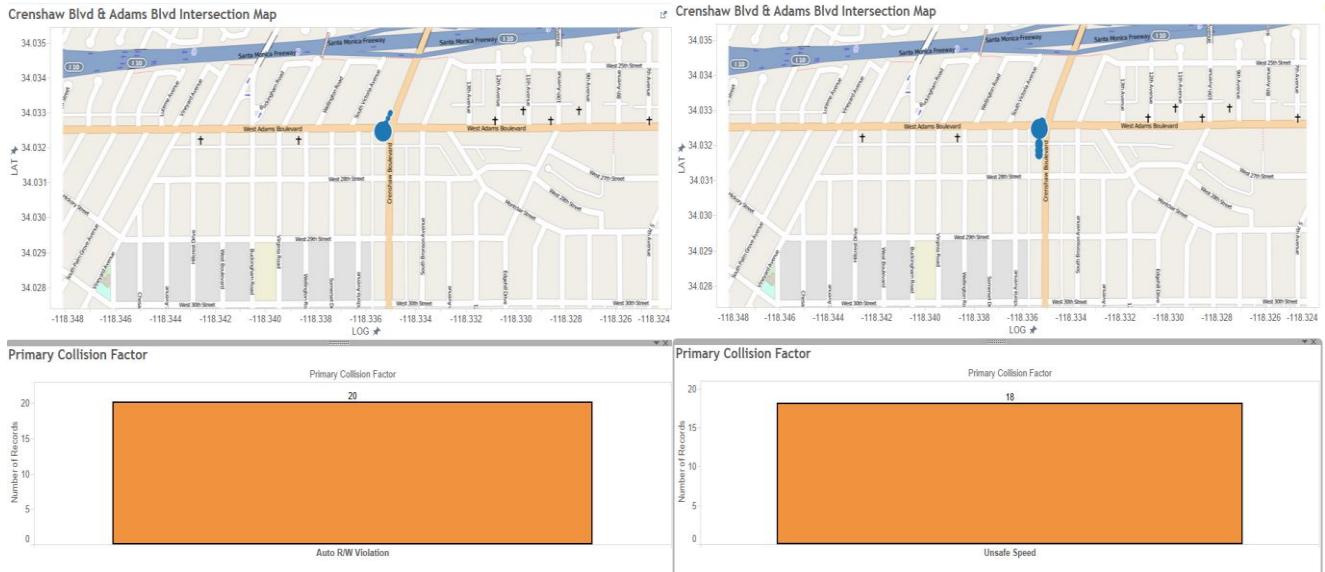
In this case study, we choose one High Frequency Intersection, Crenshaw Blvd and Adams Blvd as an example to provide more detailed investigations on this specific intersection. We will analyze the street view, the primary collision factors and the direction of the intersection.

Details analysis on Crenshaw Blvd and Adams Blvd:



Most accidents happened on the intersection of Crenshaw Blvd and Adams Blvd from the GPS graph and primary factors below we could capture following key findings:

- Unsafe speed, auto R/W violation, Unsafe lane change, and improper turning are main collision factors on Crenshaw Blvd and Adams Blvd.
- The intersection of Crenshaw Blvd and Adams Blvd has gas station from each direction. Auto R/W Violation happens mostly on the north side of Crenshaw Blvd and unsafe speed mostly occurs on the south side of Crenshaw Blvd.
- Changing decision to make it to gas station might cause unsafe lane change and improper turning.



Finally, we have the following recommendation and insights:

- The complexity of the street and inconspicuous signals might be the main reasons lead to collision. Especially with four gas stations around.
- Considering decrease the number of entrance for gas stations in order to lower the chance of sudden stop and unsafe lane change.
- Set solid barrier on Crenshaw Blvd on the way close to intersection in order to decrease improper turning and auto R/W violation.

# Recommendations

After the location map analysis, high risk intervention analysis, condition analysis, collision factor analysis, injury analysis and pedestrian & bike analysis, there is a series of recommendations below:

- Public Transportation Encourage

- Improve the Safety Environment of Public Transportation

One of the key issues that people in City of Los Angeles don't choose public transportation is due to the safety issue. People complain about meeting crazy people in the public transportation and worry about their safety. Bus drivers should be trained to deal with such emergency issue. In the meanwhile, building the good image of LA public transportation by social media such as twitter and Facebook is also of great importance and will have impact on young people living in Los Angeles.

- Set up Public Transportation Promotion System

It's also necessary to create the atmosphere and culture that people regard taking public transportation as a natural part of life. Although the City of Los Angeles have several types of public transportation such as Dash and Metro, the connection and transfer convenience between these public transportation systems is not good enough. Therefore, combination of these public transportation systems should be concerned.

- New Infrastructure

- Bicycle Lanes Construction

In comparison with other big cities such as NYC, City of Los Angeles still lacks a lot of bike lanes. For those streets with greatest number of bicycle-involved collisions, such as Sunset Blvd, Western Avenue and Vermont Blvd, there's nearly no bicycle-friendly lanes at all. City of Los Angeles should complement more bicycle lane construction projects according to the degree of urgency and necessity based on collision frequency.

- Traffic Signals and Signs

Based on general analysis, Koreatown and Downtown LA have greatest numbers of traffic collisions related to traffic signals and signs issue. For traffic signals issue, cameras can be installed on necessary intersections to capture auto violation and also be utilized to warn potential violation behaviors.

- Data Collection Improvement

- Provide Zip Code or Official Region Names along with GPS Data

Zip code and Official region names can help the collision visualization process. Patterns and Clusters in terms of specific administrative districts are more likely to be detected.

- Avoid Ambiguous Names of Roads

For example, 101ST STREET, 101ST STREET(W), and 101ST STREET(N) should be re-categorized into only two classes for the accuracy of future data analysis.

- Keep the consistency of Records

For example, in injury table, “number killed” are not all records of consecutive years. This lack of records may impede timeline related analysis of injury data.

- Rush Hour Policies

- Temporary limit based on odd-and-even license plate can be implemented to improve traffic congestion during rush hours. From another perspective, public transportation should have discount to commuters during rush hours to encourage them choosing public transportation instead of private cars.

- Patrol/Police Distribution

- Based on high risk timeline and location analysis reports, Patrol/Police should be distributed accordingly to avoid certain violations and deal with traffic collisions in time.