

U.S. Department of Transportation's Solving for Safety Visualization Challenge

# Real-Time Crash Risk Visualization Tool for Traffic Safety Management

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UCF Smart & Safe Transportation Lab



*"Power Safer Roads for Smarter Cities"*



# System Overview

Power Safer Roads for  
Smarter Cities





# VISUALIZATION TOOLS

## 1. Data-Informed tools

Deep understanding of multiple types of data sources



## 2. Crash risk visualization based on high-level technical merit

Based on multi-level safety algorithms and techniques



## 3. Traffic safety insights and solutions

Real-time, short-term, and long-term suggestions by Artificial Intelligence



## 4. Traffic safety pioneers

Multidisciplinary team with strong transportation safety background



Crash Analysis Reporting System(CARS) 



Fatality Analysis Reporting System(FARS)



Historical Violation Data



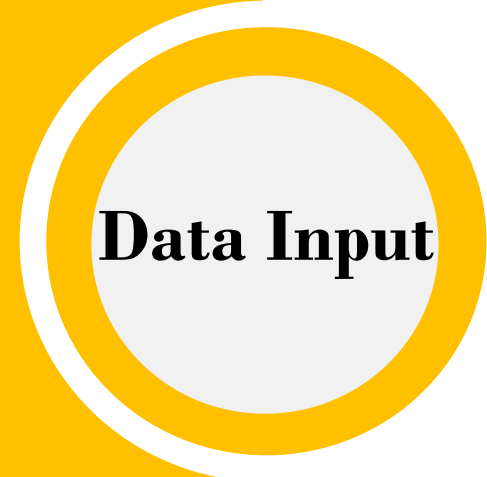
Crash Modification Factors Clearinghouse



Roadway Characteristics



Crowdsourced Data for Pedestrians and Cyclists



SUNGUIDE

- Microwave Vehicle Detection System (MVDS)
- Inductive Loop Detectors
- Automated Vehicle Identification (AVI)
- Bluetooth Detectors
- HERE Data
- CCTV Cameras
- Event Data



Regional Integrated Transportation Information



Automated Traffic Signal Performance Measures

Automated Traffic Signal Performance measures



UCF Shuttles



LYNX Buses



OpenWeatherMap



**Real-time Big Data Input**

- Access to a significant amount of real-time data (**3.5 TB** per year).



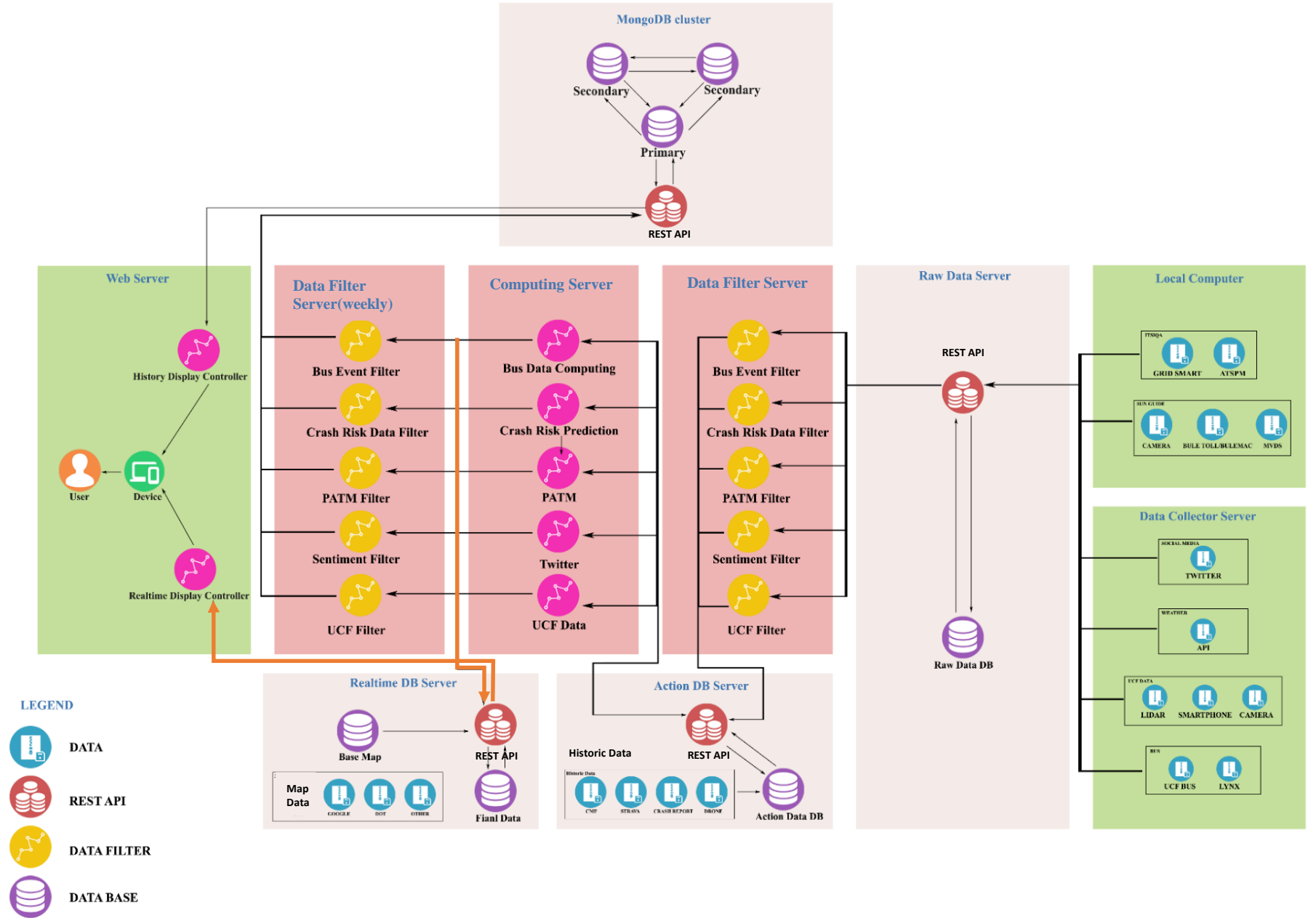
# System Structure

## Databases & Servers

- *Seven databases*
- *Ten servers*

## Base Map

- *938 freeway basic segments*
- *31 freeway weaving segments*
- *294 freeway ramps*
- *1367 arterial segments*
- *514 signalized intersections*





# Traffic Operator

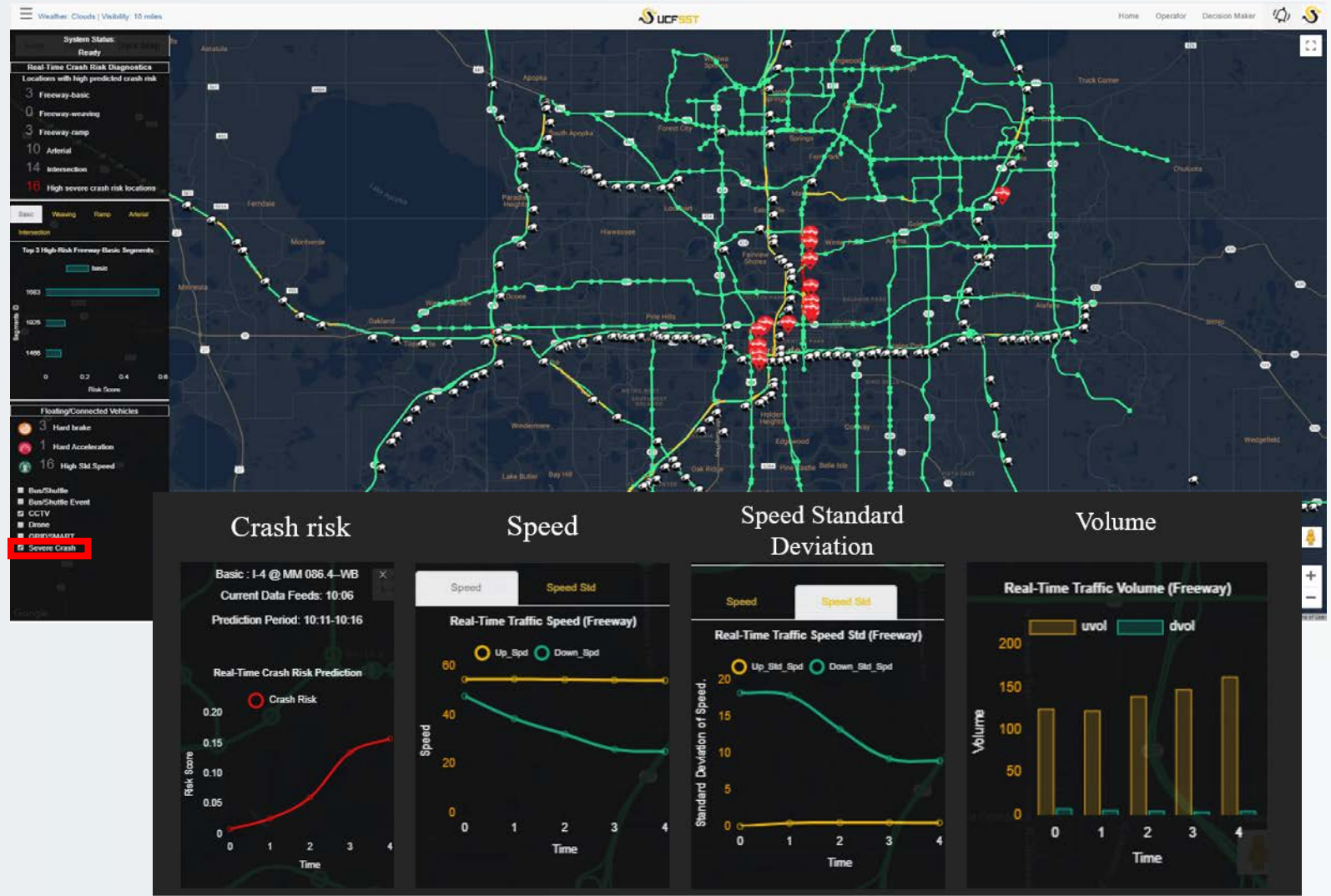
Real-time traffic management

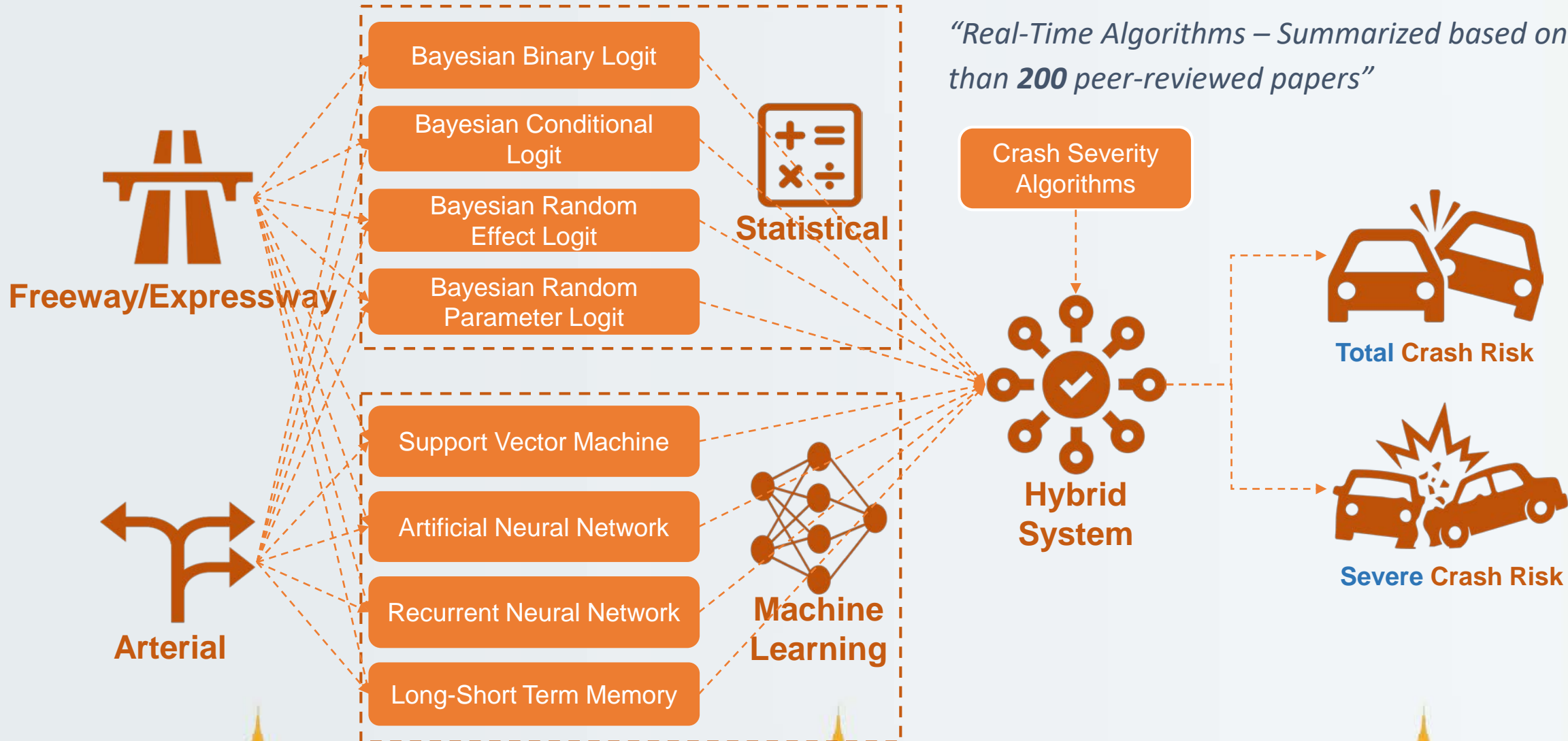




## Real-time crash risk prediction and safety management based on Big Data

- Provide traffic profiles for the selected locations
- Identify high-risk locations with different facility types
- Visualize the locations with high severe crash risk to help the states meet their **Vision Zero** goals





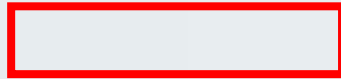
*“Real-Time Algorithms – Summarized based on our more than 200 peer-reviewed papers”*





## Integrate with other data sources

- Real-time weather information
- Videos/Images



CCTV image



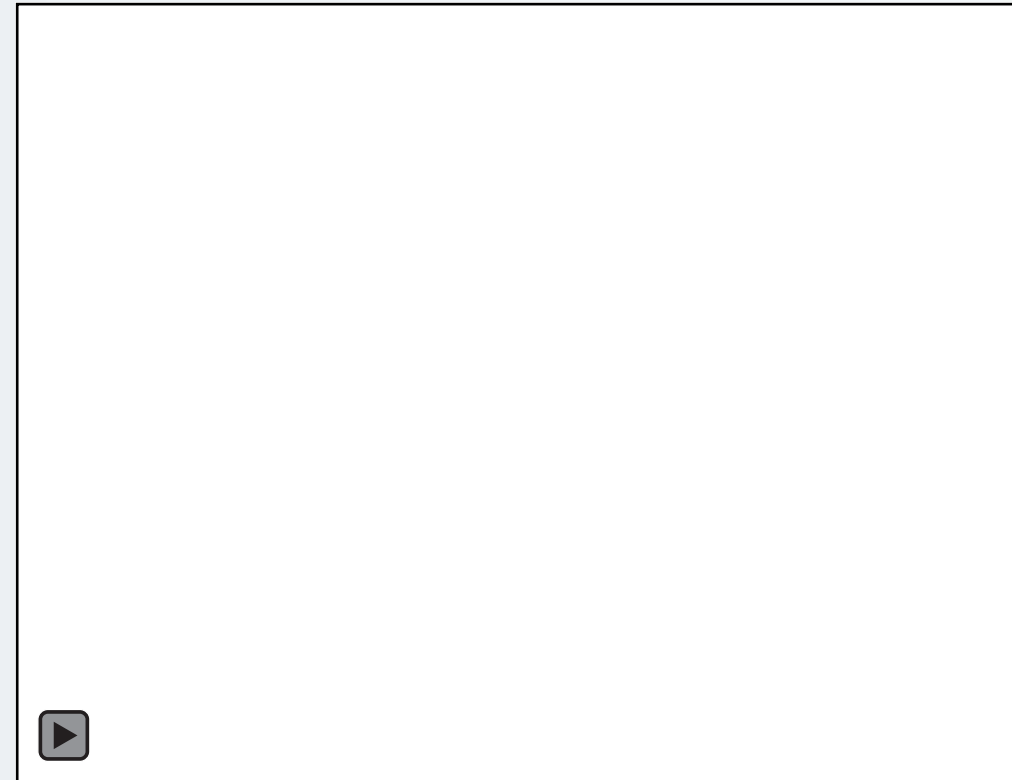
GRIDSMART



UAV

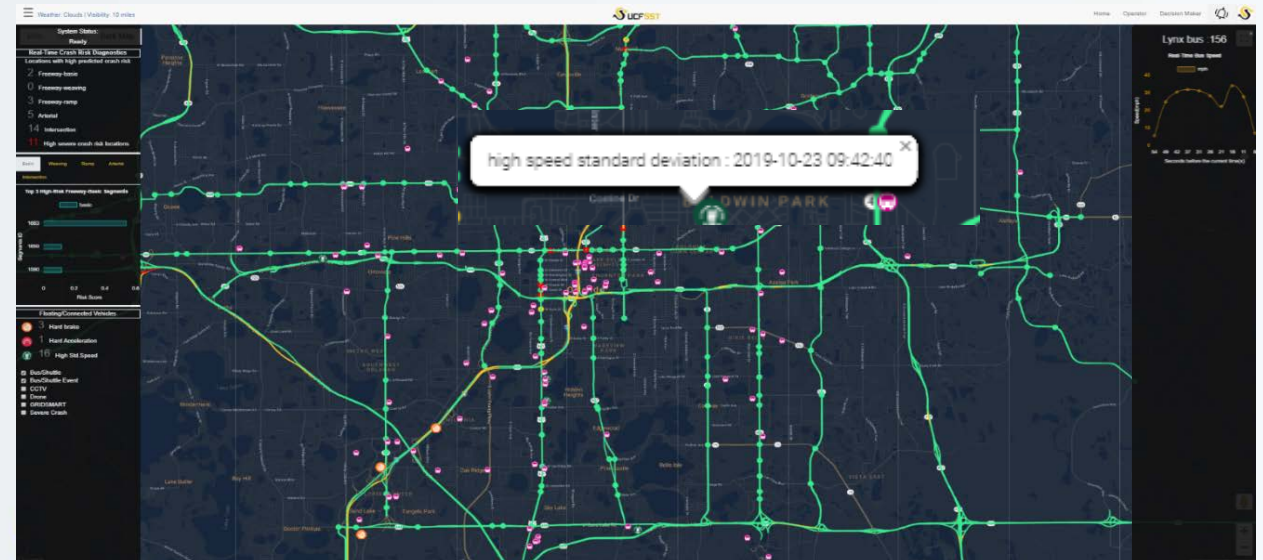
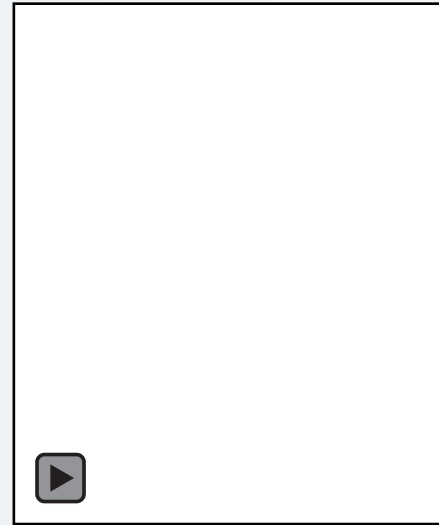
## Generate Pro-active Traffic Management (PATM) strategies

The system takes the forecasted real-time crash risk provided by the ensembled algorithms as the input and provide PATM strategies.



## Critical events based on floating cars

- 300 LYNX® buses and 50 shuttles
- Position, ID, heading and other information of each bus can be obtained in real-time and is updated every 3 seconds
- Identify critical events based on hard acceleration, hard brake, and high speed standard deviation







# Decision makers

Multi-level safety diagnostics





# Multi-Level Crash Diagnostics

## Problem Visualization

**Macro Level**  
Crash Distribution

**Network Level**  
Crash Distribution

**Crash Hotspots**

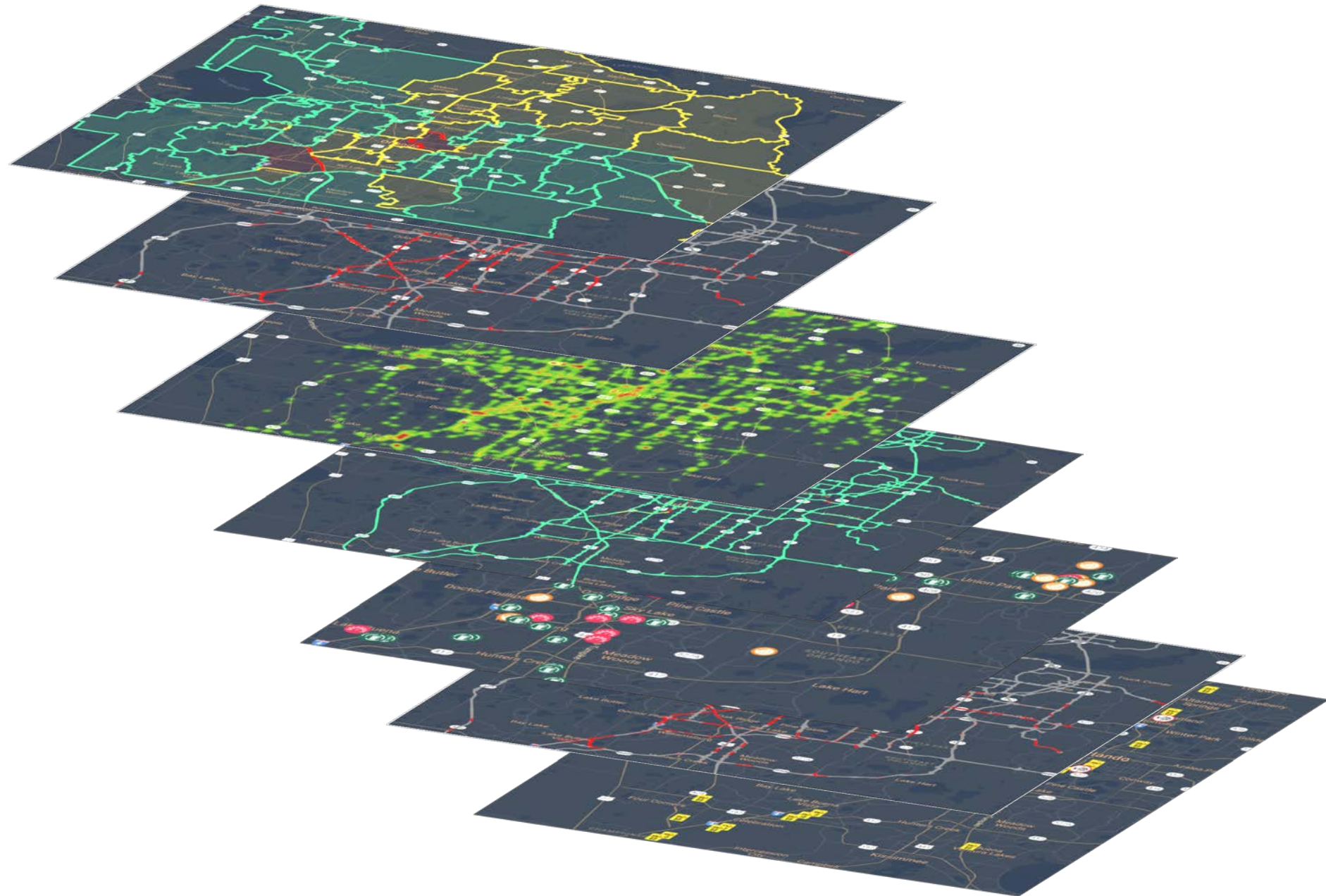
**Historical**  
**Crash Risk**

**Historical**  
**Driving Events**

## Decision Safety Support System

**Suggested**  
**Countermeasures**

**PATM**  
installation/implementation  
recommendations



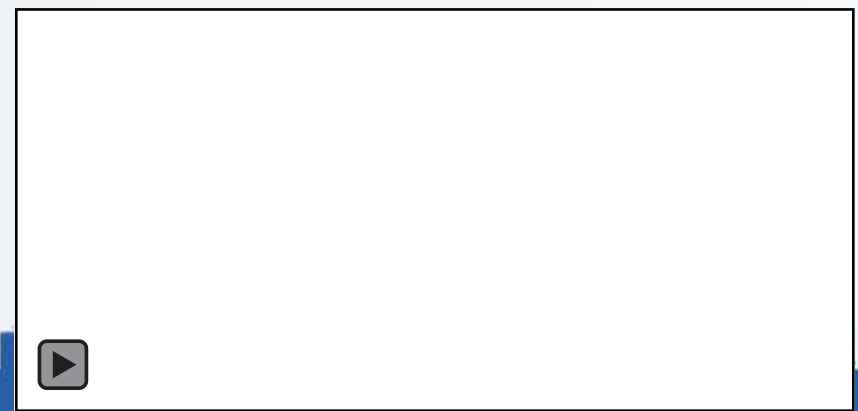
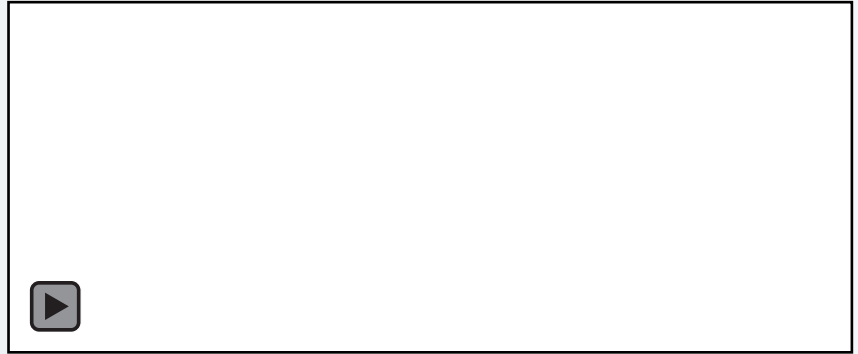
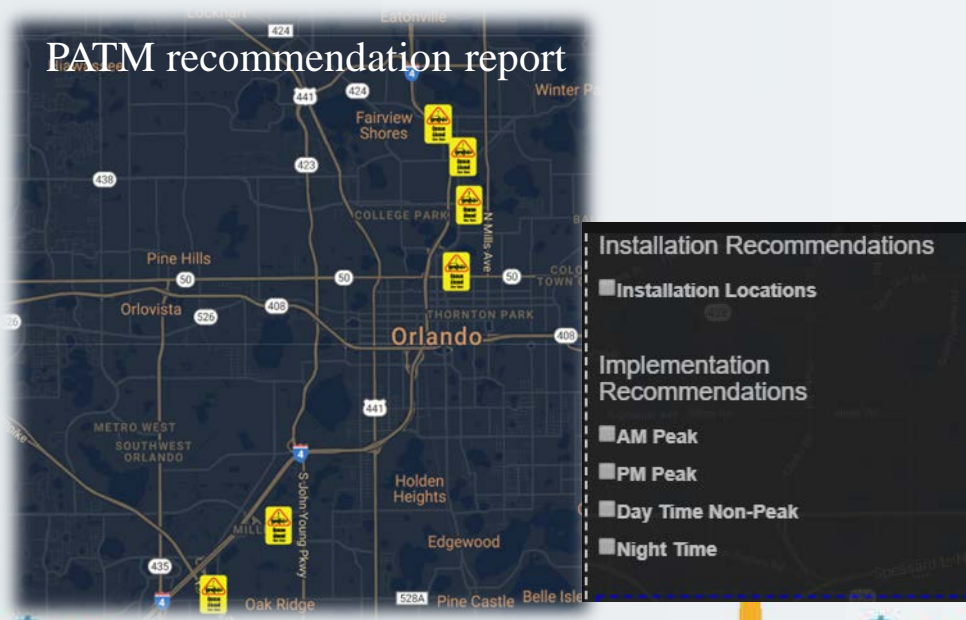
- Plot historical temporal safety conditions based on crashes, predicted crash risks, and critical driving events
- Display PATM installation and implementation recommendations & generate reports

Regional Strategy Implementation Report

Region: Greater Orlando Metropolitan Area

Time Period: 2019-10-16 to 2019-10-23

Segment	Segment I	Time of D.	Strategy T	Strategy	Implementation Frequency
1605	I-4 EB	@ I PM Peak	Queue W	Queue W	112
1664	I-4 WB	@ I PM Peak	Queue W	Queue W	96
2316	I-4 EB	@ I PM Peak	Queue W	Queue W	75
1659	I-4 WB	@ I PM Peak	Queue W	Queue W	55
1502	I-4 WB	@ I PM Peak	Queue W	Queue W	54
1372	I-4 EB	@ I PM Peak	Queue W	Queue W	37
2335	I-4 WB	@ I PM Peak	Queue W	Queue W	35
1814	I-4 WB	@ I PM Peak	Queue W	Queue W	33
2095	I-4 EB	@ I PM Peak	Queue W	Queue W	32
1664	I-4 WB	@ I Night Tim	Queue W	Queue W	344
1605	I-4 EB	@ I Night Tim	Queue W	Queue W	304
2316	I-4 EB	@ I Night Tim	Queue W	Queue W	265
2012	I-4 EB	@ I Night Tim	Queue W	Queue W	264
2095	I-4 EB	@ I Night Tim	Queue W	Queue W	229
1669	I-4 EB	@ I Night Tim	Queue W	Queue W	209
2320	TMS-408	(Night Tim	VSL	Variable S	147
1510	I-4 EB	@ I Night Tim	Queue W	Queue W	144
1415	I-4 WB	@ I Night Tim	Queue W	Queue W	128
1785	I-4 EB	@ I Night Tim	Queue W	Queue W	116
1893	I-4 EB	@ I Night Tim	Queue W	Queue W	111
2215	I-4 EB	@ I Night Tim	Queue W	Queue W	110
2149	I-4 WB	@ I Night Tim	Queue W	Queue W	104
1993	I-4 EB	@ I Night Tim	Queue W	Queue W	101
1664	I-4 WB	@ I Day Time	Queue W	Queue W	310
1605	I-4 EB	@ I Day Time	Queue W	Queue W	208
1800	I-4 WB	@ I Day Time	Queue W	Queue W	125



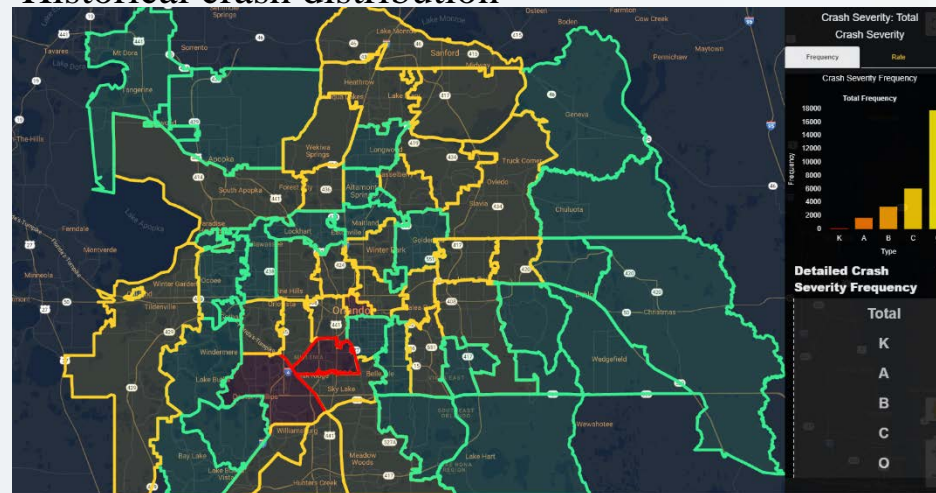


The macro-level analysis includes:

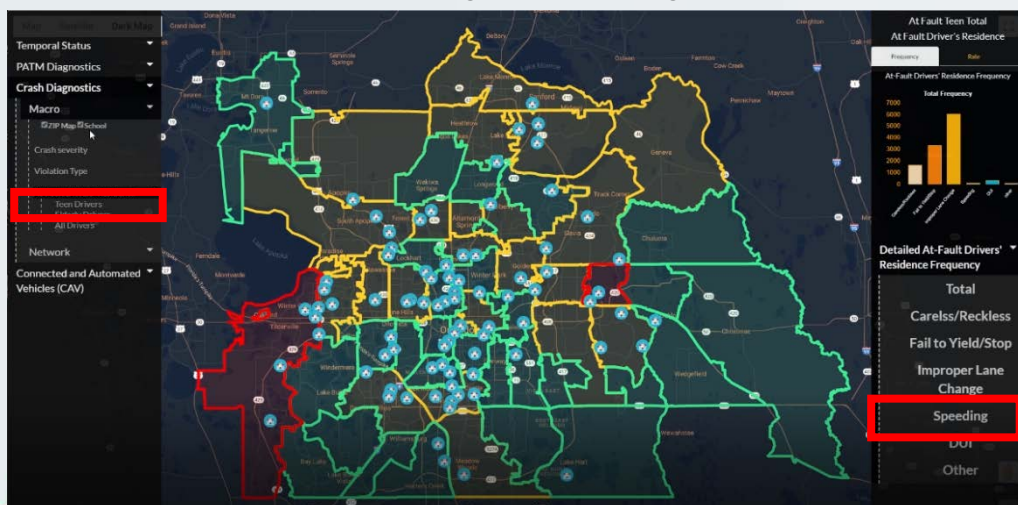
- Crash severity
- Violation
- At-fault drivers' residence

**Area-wide engineering treatments**, education, safety and awareness campaigns, and enforcement strategies could be considered for improving safety at the zones with high risk.

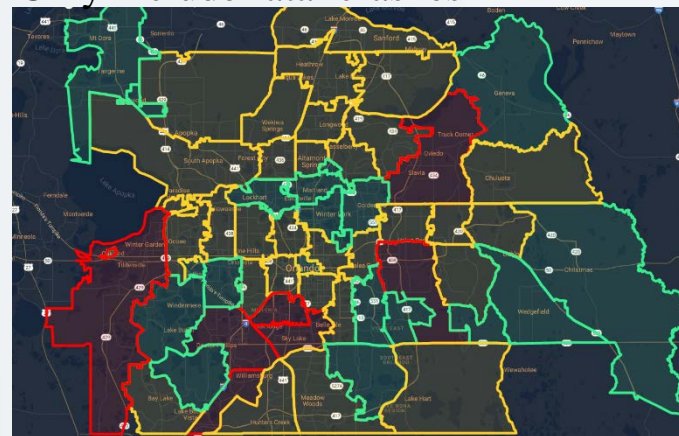
Historical crash distribution



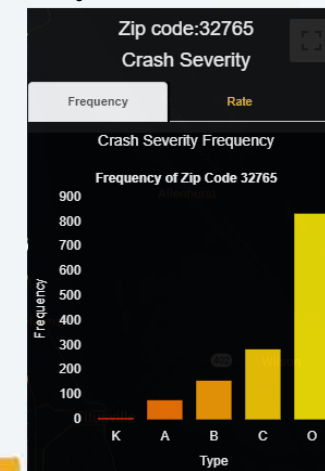
DUI crashes related to teenagers with high school locations



Only include fatal crashes

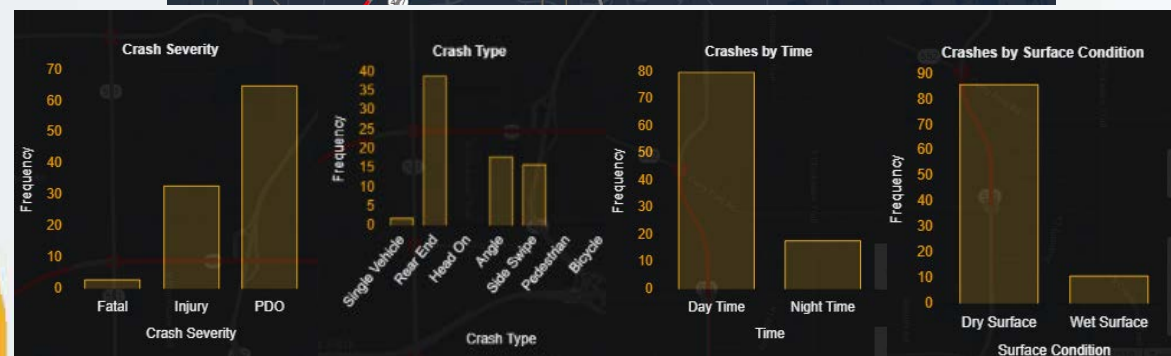
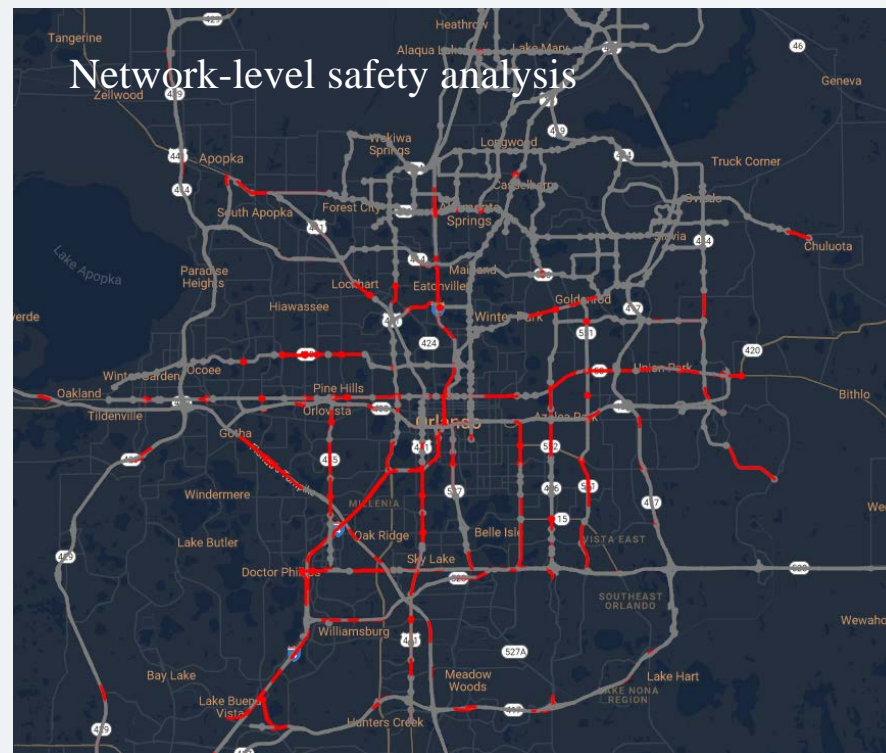


Only for the selected area



Decision safety support system (DSSS) offers **the most efficient countermeasure(s)** utilizing more than **6000 options** based on the “Crash Modification Factors Clearinghouse”.

- Identify locations with the most potential for safety improvement (PSI)
- Provide crash information (i.e. type, severity, time, surface condition)





## Countermeasure recommendation

Select the most efficient countermeasure(s) based on effectiveness and B/C ratio

- Identify the most problematic crash type
- Suggest the appropriate countermeasure for each identified hotspot

Arterial: SR-482 - SR-423/S John Young Pkwy-WB  
 Most Severe Crash Type: Rear-End

**Suggested Countermeasure 1 :**  
 Implement automated speed enforcement cameras  
 Benefit: \$1,258,044  
 Cost : \$115,185  
 B/C : 10.9

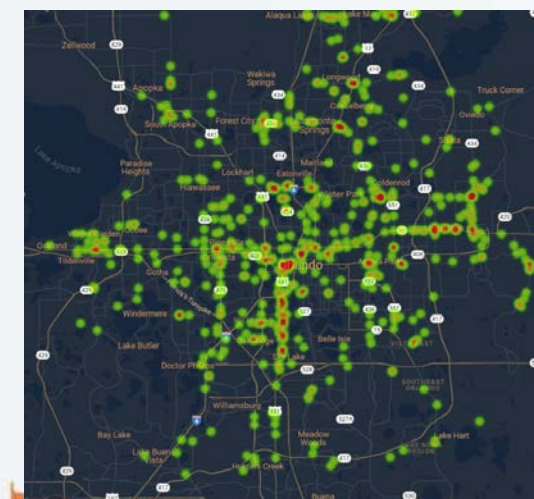
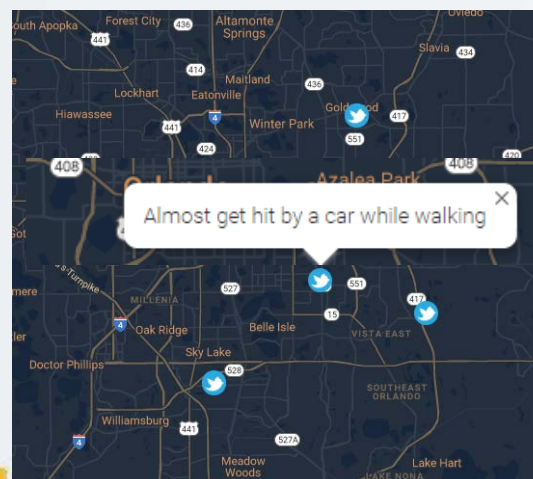
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**Suggested Countermeasure 2 :**  
 Install speed humps  
 Benefit: \$1,123,253  
 Cost : \$2,464  
 B/C : >100

## Social media data

People’s feedback about pedestrian safety from **Twitter** and bicycle exposure from **STRAVA** is also provided to help further understand the non-motorists’ safety status.

## Social Media Data







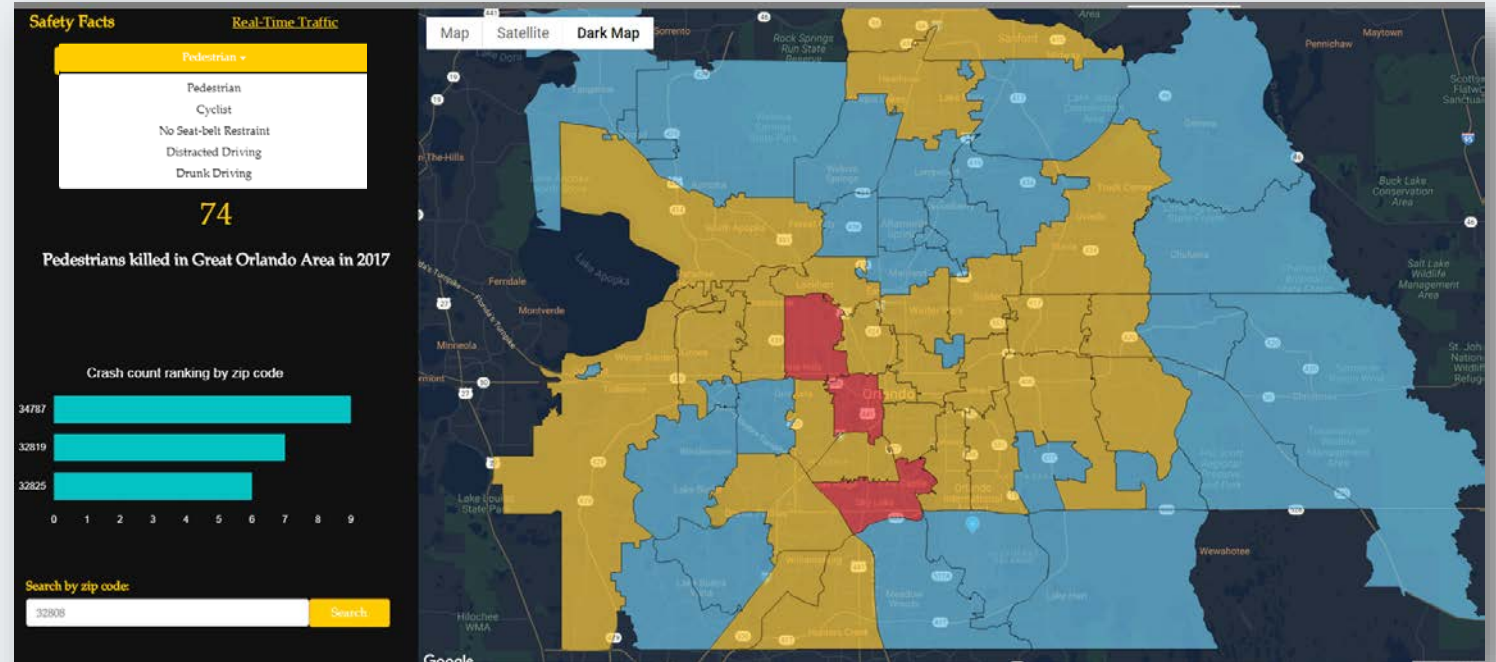
# Public Users

Improve safety Awareness





- Suggest safety advice regarding vulnerable road users and traffic violations
- High risk locations
- Safety facts
- Bike lanes & sidewalks
- School and hospital locations





# System Highlights

Expected Benefits





# ARTIFICIAL INTELLIGENCE

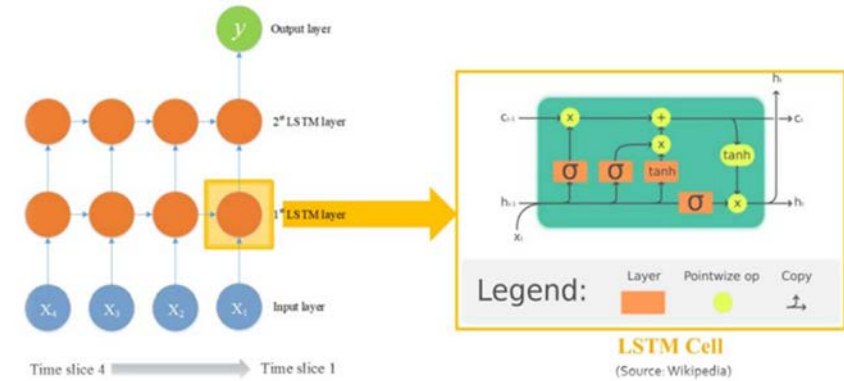
## “Life-saving Solutions by Machine Learning”

- Facility-Specific Real-Time Crash Risk Prediction Algorithms

A multilayer LSTM was developed to predict the crash risk during the next 5-10 minutes based on sequence inputs.

- Proactive Traffic Management Strategies

Provides a visualization of locations where the problem and countermeasure are repeated frequently



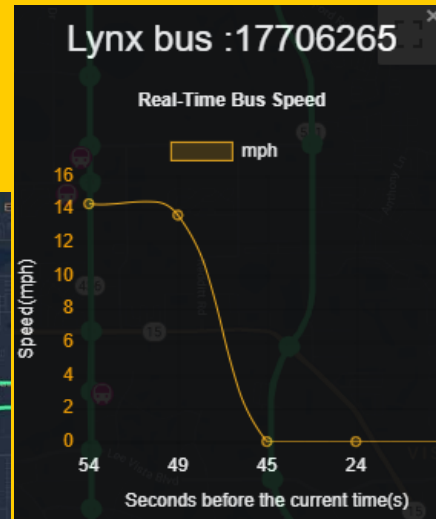
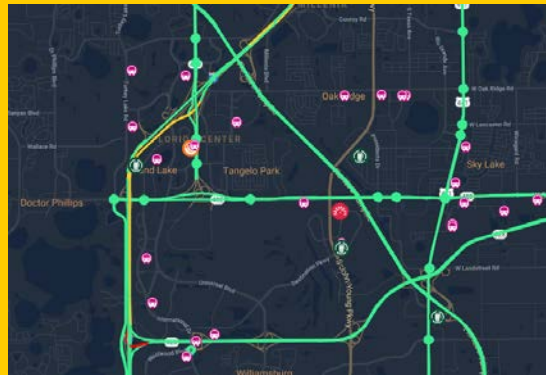
### Public user

Understanding CAVs and the benefits



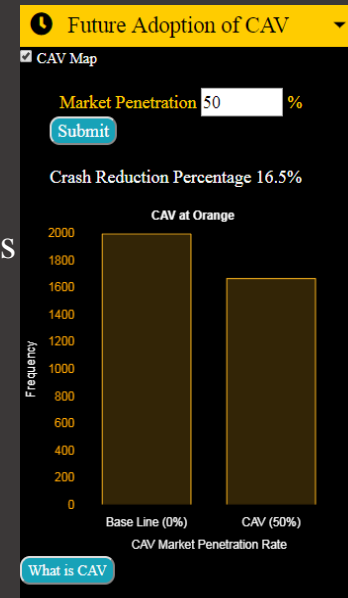
### Operator

Real-time floating vehicle data for Orlando  
Critical driving events



### Decision maker

Estimating Connected and Automated Vehicles (CAVs) impact



# System Characteristics



## Adapt to new data & functions

- Data filters were added for each type of data source in order to process and change it to usable format.
- A dynamic platform that can keep growing and improving for new data and functions.



## Provide maintenance and support

- Users can select one of the following methods to maintain the system:
- The SST team is willing to provide maintenance service and ongoing support of the system to users;
  - The SST team can also work with a third-party (e.g., company or agency) to maintain the system and provide necessary support.



## Web-Based system

- Easier to install, maintain, and keep secure
- Access from anywhere
- Easier to customize and integrate with other components
- Adaptable to scale up or increase workload





# Thank You

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