Smart Broward County Transportation: Using Big Data Analytics and Artificial Intelligence

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Talk Outline

- Smart Societies
- Impact of Technology on Smart Societies
- Broward County Metropolitan Transportation Plan
- Research and Development at University of Florida (with potential applications to Broward County)
  - Analyzing Traffic Signals
  - Video Analysis
  - Incident Detection
  - Smart Intersections
  - Smart Networks
  - Vehicle and Commodity Classification
- Conclusions

Smart Broward County Metro Transportation Plan

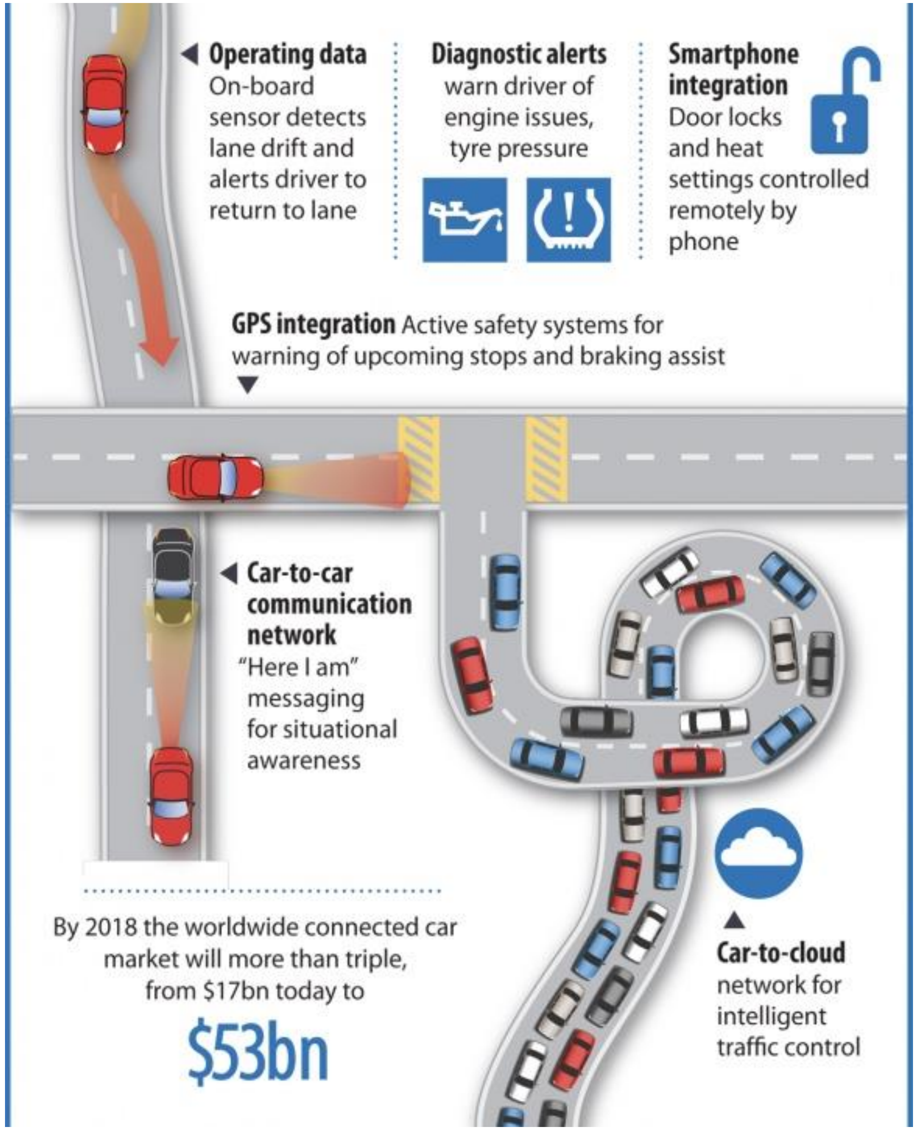
- Serving the **mobility needs of underserved communities** by providing reliable and affordable transportation alternatives
- Break down digital barriers and **improve transparency** for all residents using innovative technology-based solutions
- Manage **traffic congestion and improve safety** by using big data and related technologies
- Use **data driven approaches** for decision making, planning, evaluation and measurement
- Support efficient movement of goods, services and people by using practices that are **environmentally sustainable**
- Stimulate economic prosperity by **improving access to jobs** using expanded mobility access to major job centers
- Enhance **tourist and visitor experience** by providing easy to access information about mobility alternatives

COMMITMENT 2045
move people & goods • create jobs • strengthen communities

BROWARD COUNTY FLORIDA

Source: 2045 Métropolitan Transportation Plan (MTP)

Connected & autonomous vehicles are becoming prevalent



Connected Vehicles
Source: http://gelookahead.economist.com/infograph/car-os/

Convergence Expected in 2025

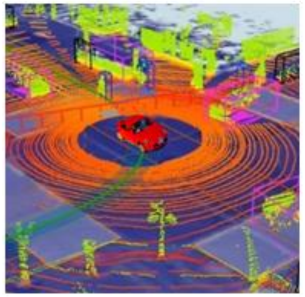
Autonomous Vehicles
Source: Peter Runcie, CSIRO peter.runcie@data61.csiro.au

Communication is going through a revolution

Source: USDOT

Technology convergence will revolutionize transportation, dramatically improving safety and mobility while reducing costs and environmental impacts

- Connected Vehicles
- Vehicle Automation



Connected-Automated Vehicles

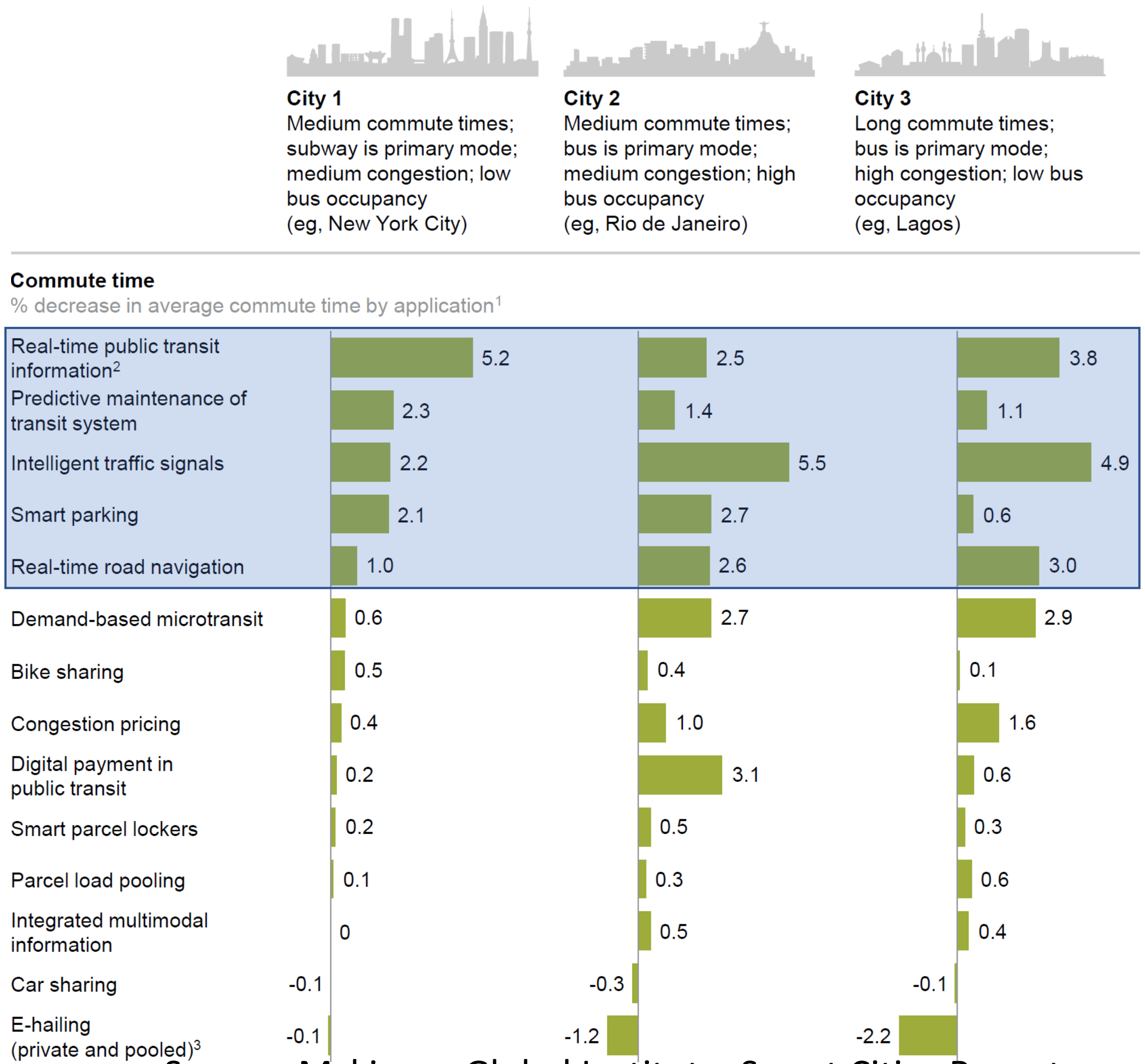
- Internet of Things
- Machine Learning
- Big Data
- Mobility on Demand

Benefits

- Order of magnitude safety improvements
- Reduced congestion
- Reduced emissions and use of fossil fuels
- Improved access to jobs and services
- Reduced transportation costs for gov't and users
- Improved accessibility and mobility

Source: USDOT Smart City Challenge Presentation

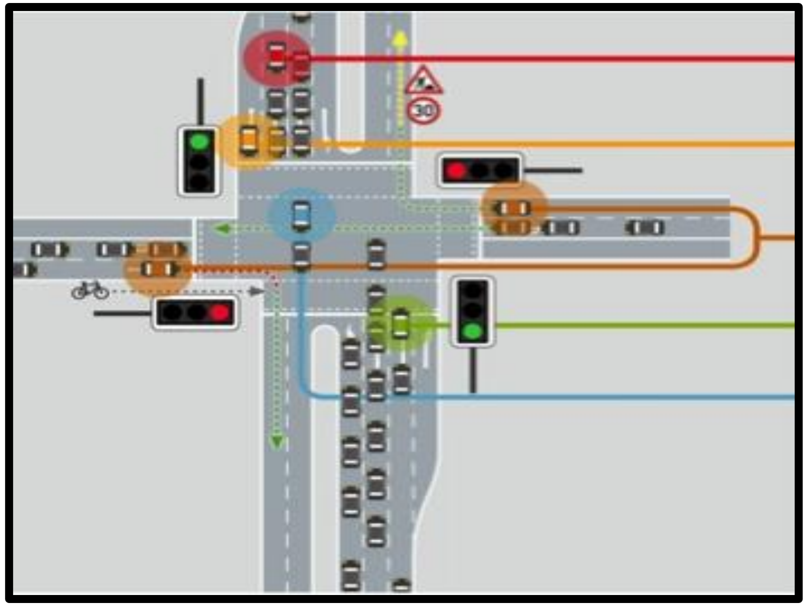
Impact of tech applications on improving mobility



Source: Mckinsey Global Institute, Smart Cities Report

- Real-time public transit information: Real-time information about departure and arrival times.
- Predictive maintenance of transportation infrastructure: Sensor-based monitoring of infrastructure (such as rails, roads, and bridges) so that predictive maintenance can be performed to reduce disruptions.
- Intelligent traffic signals: Improvement of overall traffic flow through dynamic optimization of traffic lights. Give priority to transit and emergency vehicles, public buses, or both.
- Smart parking: Dynamic guidance and variable pricing based on location and availability.
- Real-time road navigation: Real-time navigation tools based on traffic and incidents.

Smarter Transportation Research at UFL



Smarter intersections will be equipped with cameras (including infrared) and/or lidar to collect data

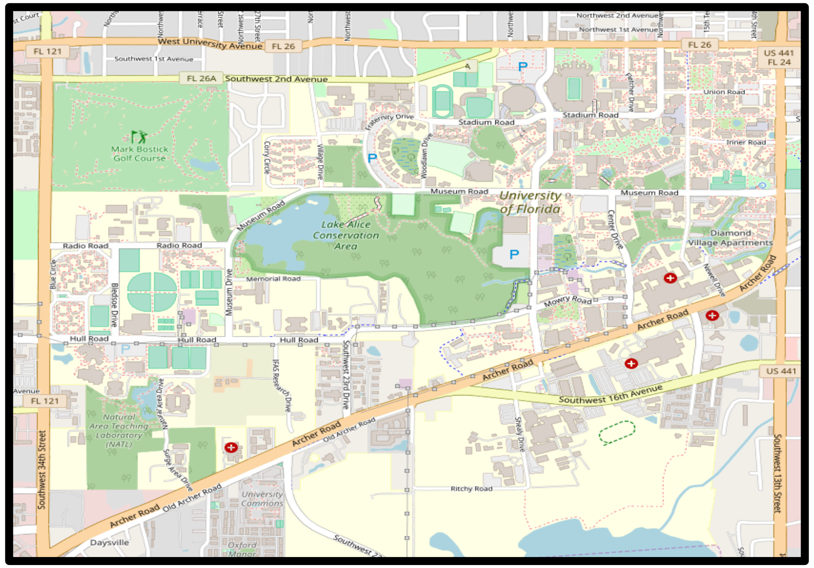
1. Better Pedestrian and Bicyclists Safety by examining the conflict points of the vehicle/pedestrian trajectories (near-misses
2. Better Demand Profiles by understanding real-traffic behavior for more effective signal timing and understanding relationships between existing (loop detector) and new technologies (video).
3. Better SPaT messaging by understanding traffic behavior on the intersections.

Smarter Streets by use of transit buses with forward facing cameras to continuously collect video data from streets (and intersections).

1. Better Pedestrian Safety by detection of jaywalking/ “mid-block crossing” behaviors that are prevalent in university campuses.
2. Better Resource Management by understanding usage of street parking and signage.
3. Better Lane and Street Sign Design by tracking indicator lights, lane-changing maneuvers undertaken in front of the bus.

Funded by National Science Foundation under their Smart Cities Program and Florida Department of Transportation

Smarter Transportation Research at UFL



Smarter Network by sensing data from multiple intersections will enable

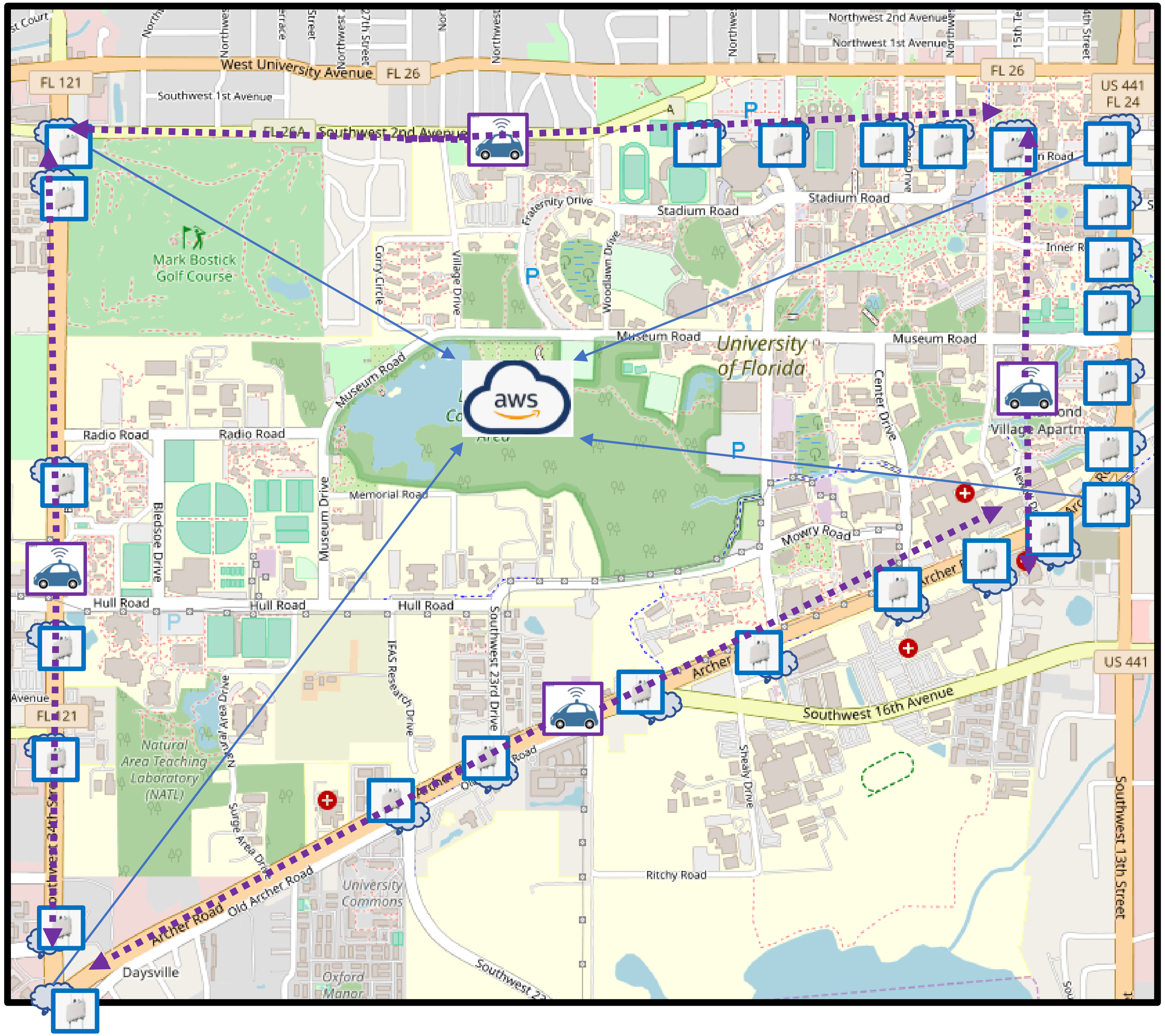
1. Better Incident Detection for alleviating traffic backups and secondary crashes.
2. Better Signal Retiming for different corridors by time of day and day of the week to reflect the changes in network demand.
3. Better System-wide Network Utilization by utilizing a global view of the entire network and historical traffic patterns based, and potential disruptions.

Smarter Interactions with Connected and Autonomous Vehicles by analyzing data collected from CAVs will lead to

1. Improved Safety by effectively managing CAVs.
2. Better Understanding of CAV Behavior and Interaction with Traditional Vehicles.
3. Better Signal Timing and Trajectory Optimization for CAVS.
4. More Accurate Trend Measurements of CAV Penetration.

Funded by National Science Foundation under their Smart Cities Program and Florida Department of Transportation

Trapezium/I-Street project in Gainesville



Trapezium after SPaT project

Data Sharing and ATSPM

Upgraded Linux based 'ATC' Controllers. ATSPM Data sharing to University of Florida and third party (TTS, TrafOps, Live Traffic Data, Connected Signals)

DSRC Radios

Siemens DSRC Radios with MAP and SPaT Broadcast

Added value option

Emergency Vehicle Pre-emption and vehicle OBUs

Trapezium/I-Street project in Gainesville (Additions)

Trapezium after SPaT project

Multiple FishEye Cameras

Full intersection view, streaming cameras with full count, presence and queue detectors

Multiple Lidars

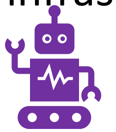
For ground level ground truth verification and ped and bike application

Several In-bus video

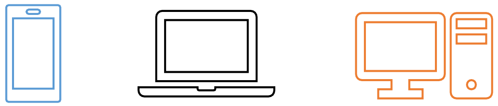
For Dynamic/Vehicle Perspective to supplement Static/Infrastructure.

Edge (Fog) and Cloud Computing

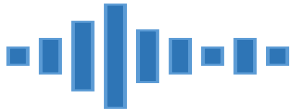
Flexible infrastructure



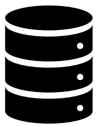
Adapt to changing requirements

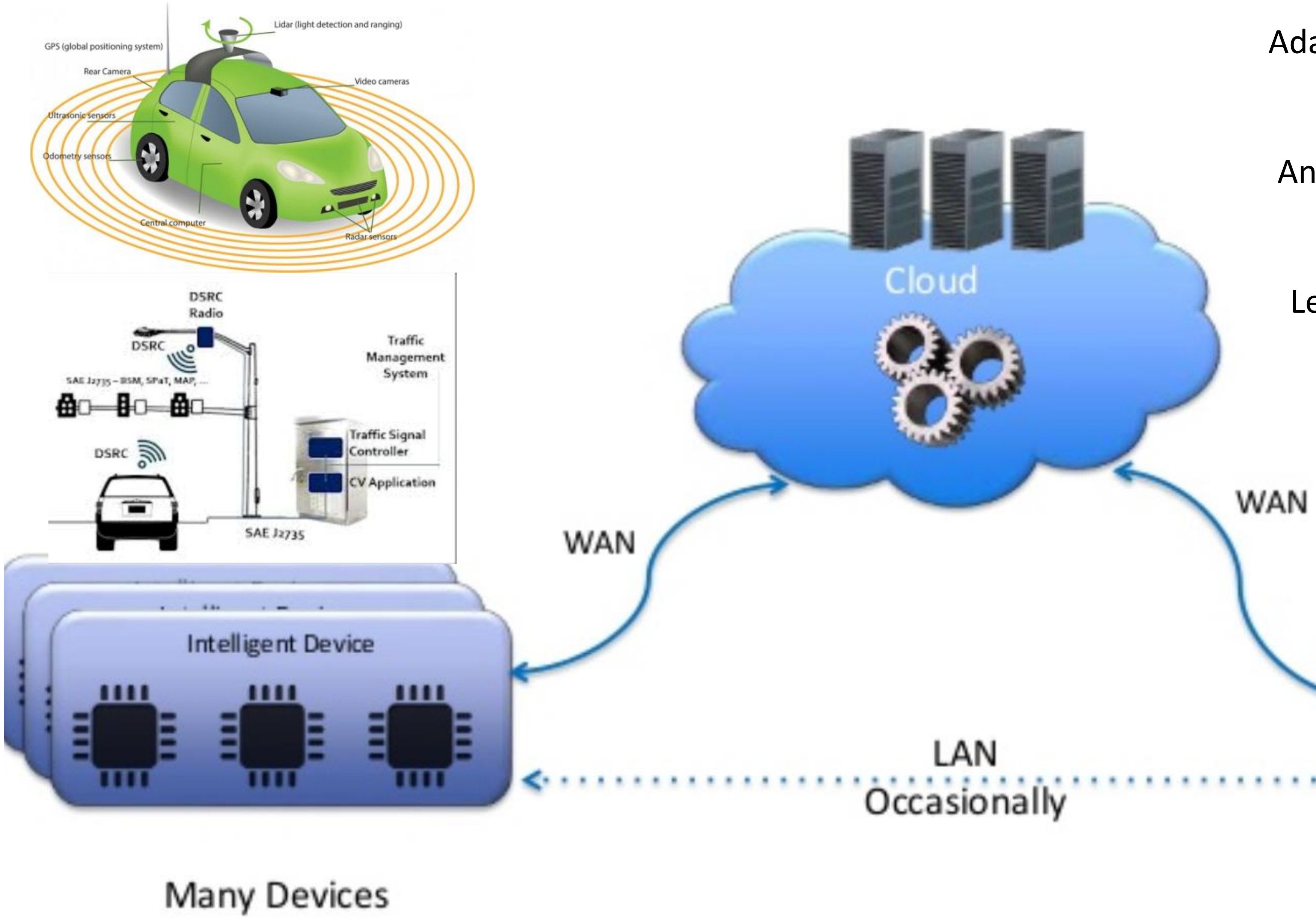


Anywhere, Anytime Availability

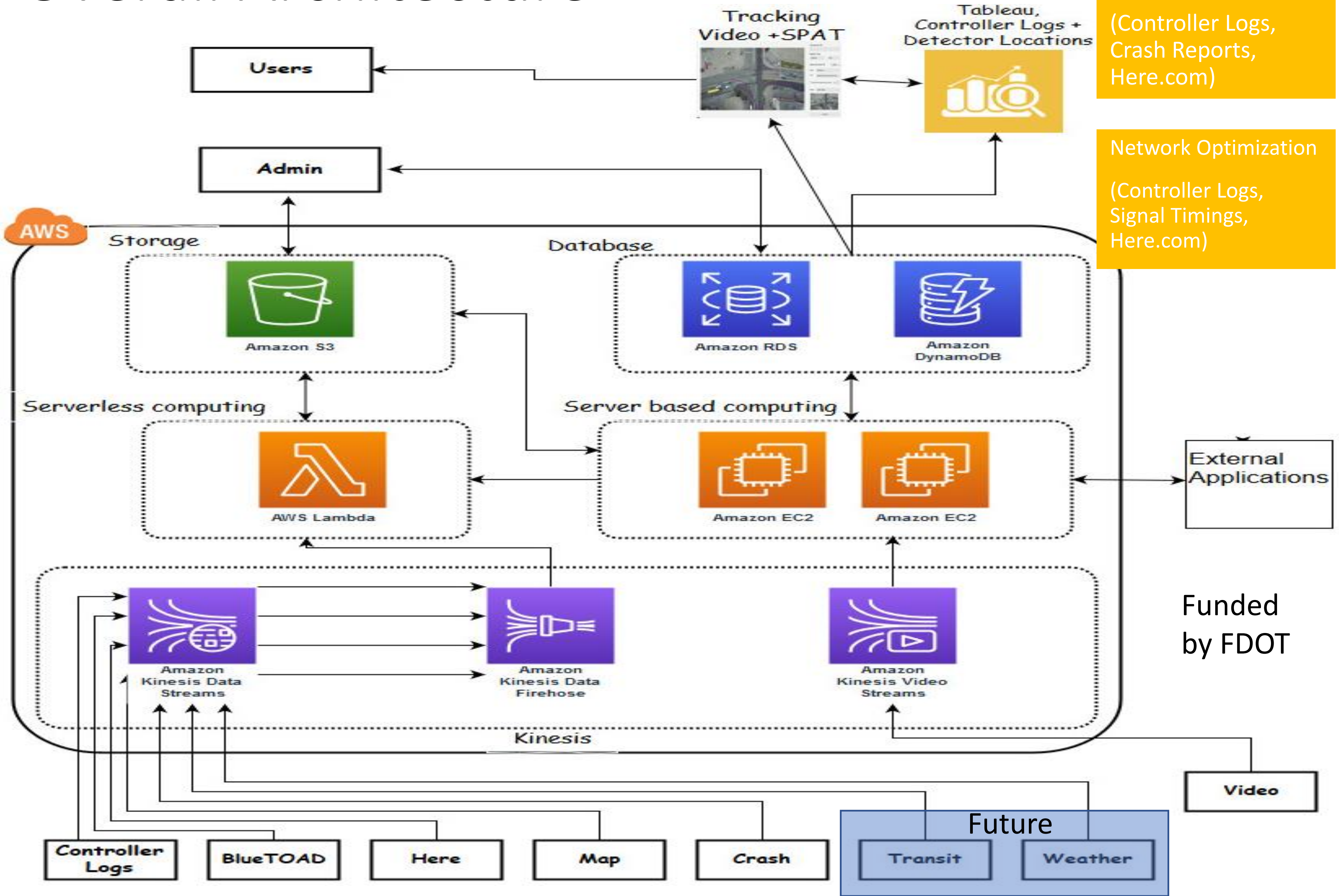


Less Hardware, More Storage





Overall Architecture



Incident Detection

(Controller Logs, Crash Reports, Here.com)

Network Optimization

(Controller Logs, Signal Timings, Here.com)

Funded by FDOT

Controller logs

- Gainesville, Jan 2019 Onwards
- Orlando, Aug 2018 Onwards

Bluetoad

- Gainesville, Jan 2019 Onwards

Crash Data

- Jan 2018 onwards

Video Data

- 2 feeds in Gainesville, Dec 2018 onwards. Option to add more.

Here.com (Probe car) Data

- Gainesville, Jan 2019 onwards

Map, Weather and Transit

Prototyping stage

(Option to add Historical records for Here, Bluetoad, and crash data)

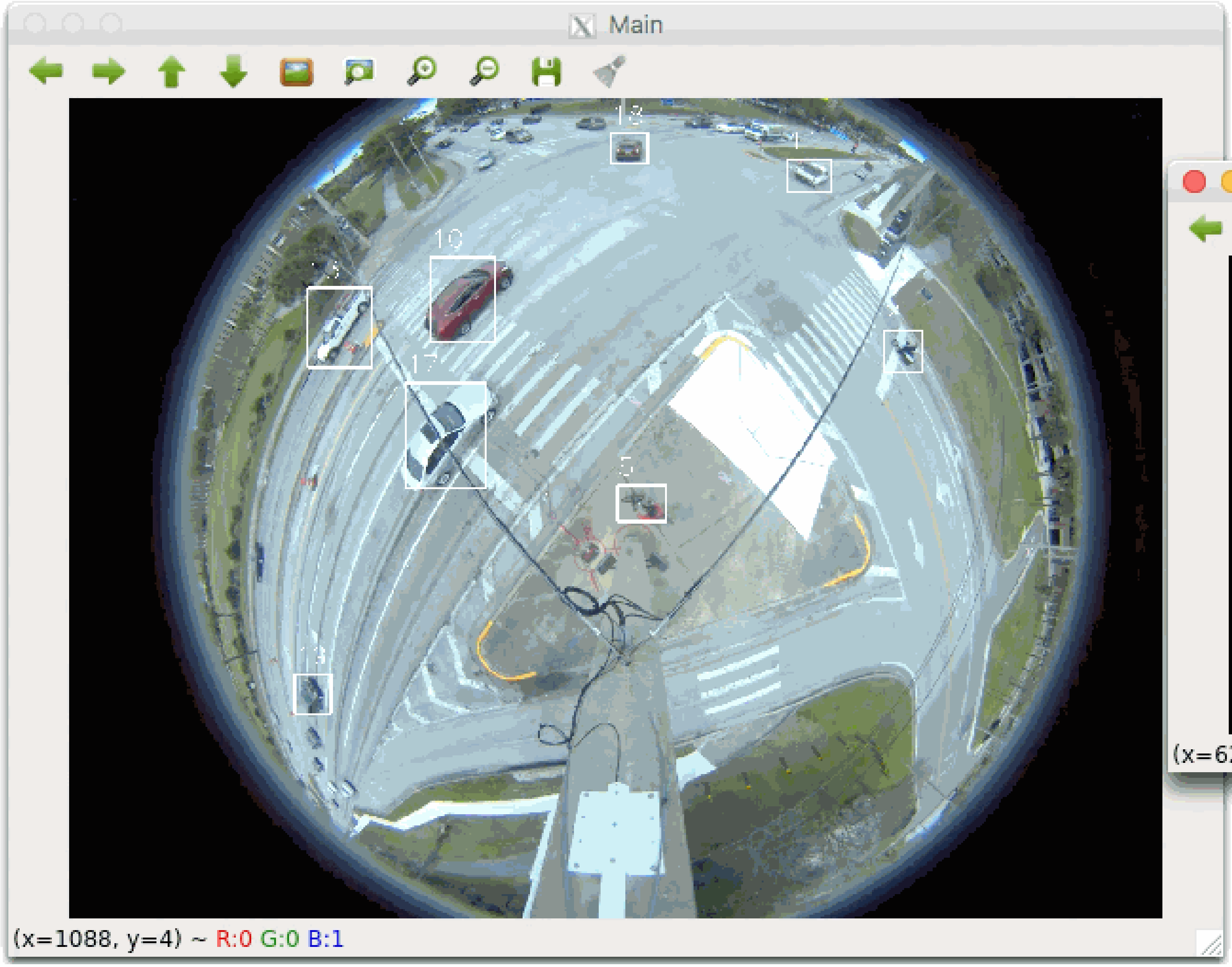
Integrated and Intelligent Data Store

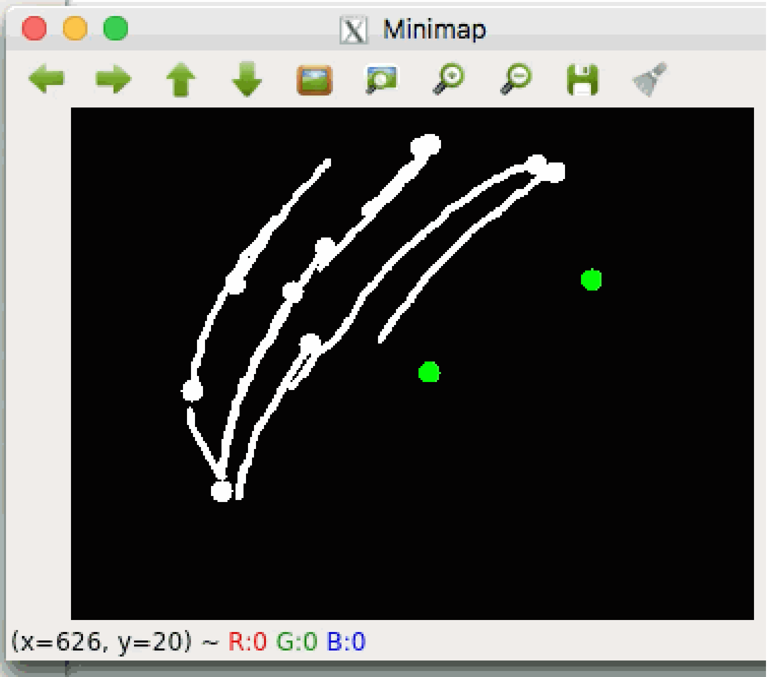
Open data environment containing data from multiple sources

- Monitoring
  - Loop Detectors
  - Video Data
  - PCD data
  - Infrastructure Data
- Evaluation
  - Travel Times
  - Pedestrian Counts
  - Usage of Cross Walks
- Predictive Modeling
  - Incident Detection
  - Response Speed
  - Crash Prediction

- Optimization
  - Signal Optimization
  - Corridor Optimization
  - Network Optimizzation
- Analysis
  - Geographical Analysis
  - Socio Economic Analysis
- Planning and Investments
  - Evaluate ROI
  - Before and After Studies

Real-time Multiple Object Detection

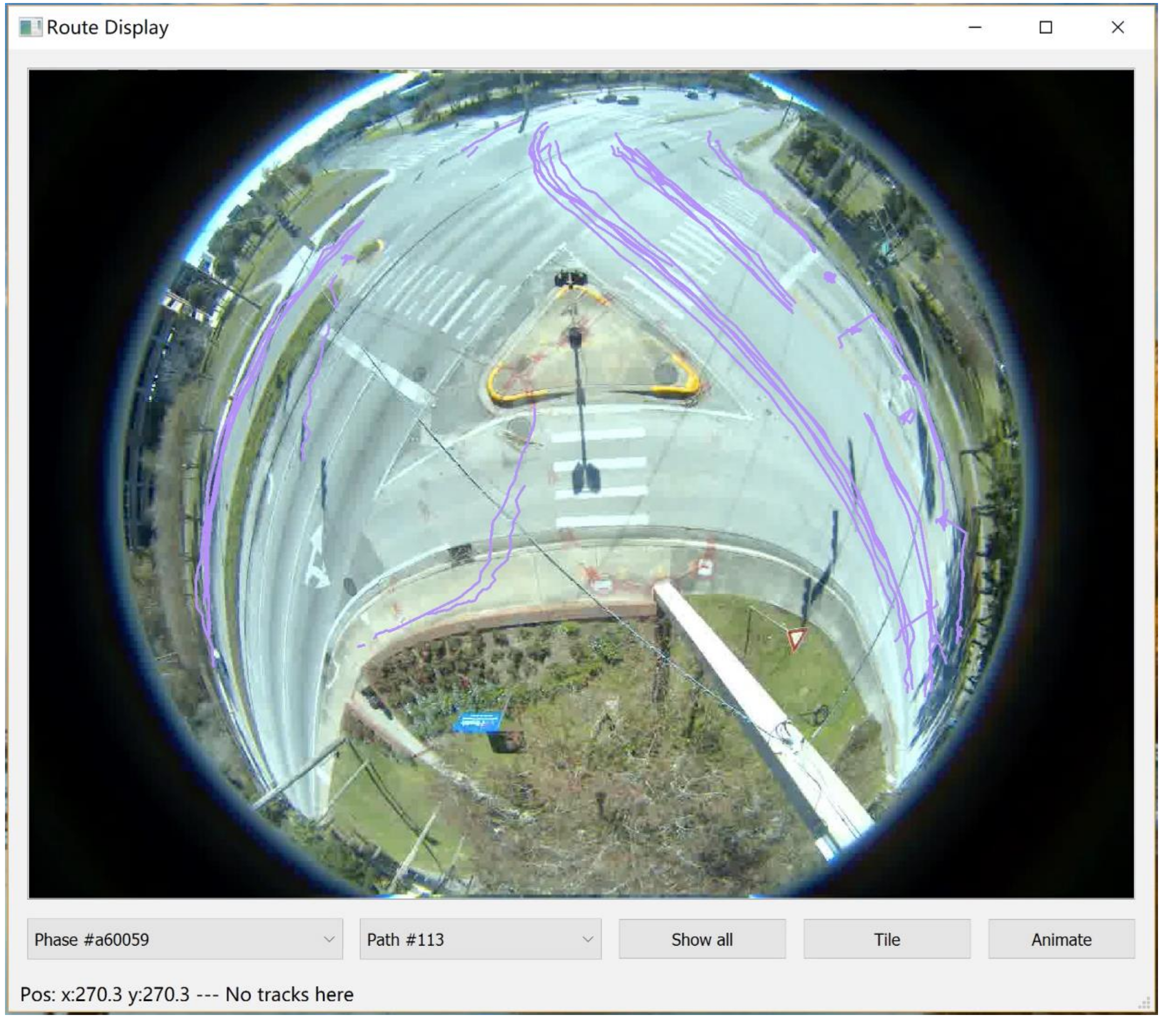




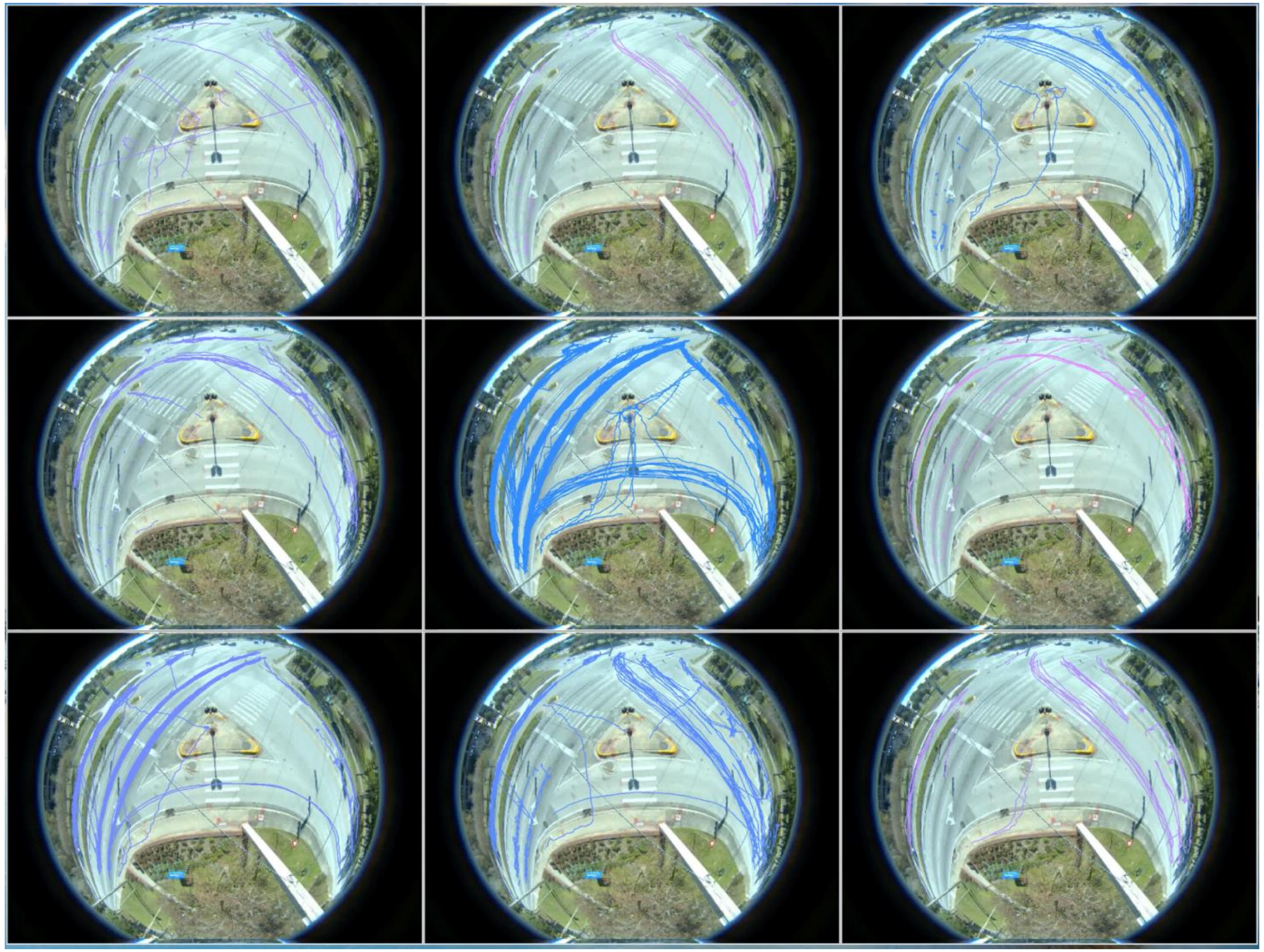
Mini Map Trajectory Demo
White: car
Green: bike/motorbike
Yellow: pedestrian

Funded by Florida Department of Transportation

Real-time Visualization



Single phase visualization



Multiple phase visualization

Anomalous Trajectory Detection

Anomalous Track

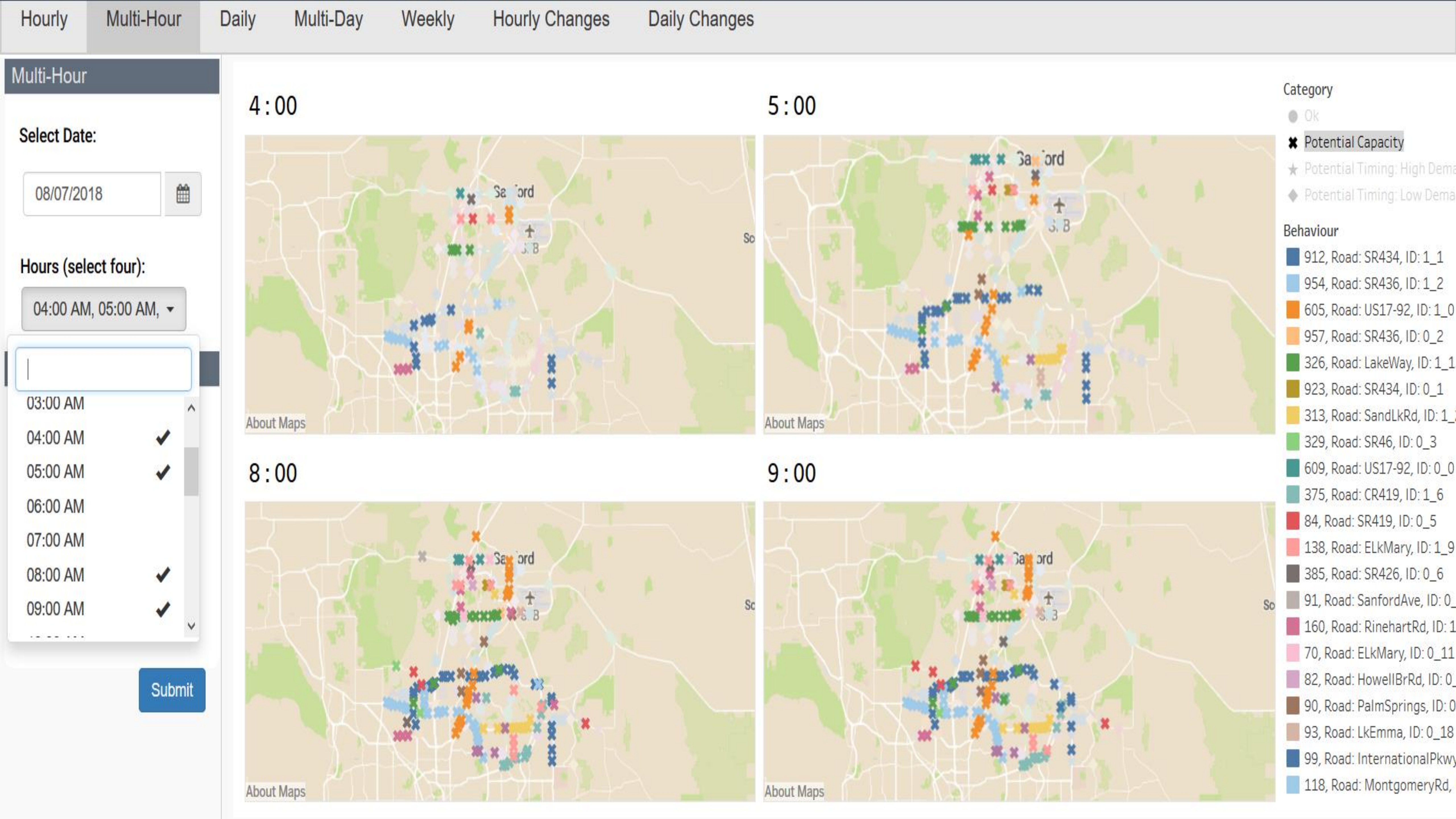
Video

Ranking & Classifying Signalized Intersections

- Controller logs from Gainesville:
- Extract-Transform-Load: Downloaded the data, cleaned and reformatted it.
- Identified Relevant MOE, Computed MOE cycle by cycle.
  - Platooning ratio:
    - The ratio of the number of vehicles arriving
    - during the green time/phase to the proportion
    - of the green interval of the total cycle.
  - Arrivals on Green vs Arrivals on Red: Percentage AOG varies from .25 to .45
  - Split Status: Gap out/Max out/Force off
- Rank Signals based on MOE: Best or worse performing intersections.
- Identify Signal behavior based on high resolution plot.
- Automatic Classification of signals based on behavior.

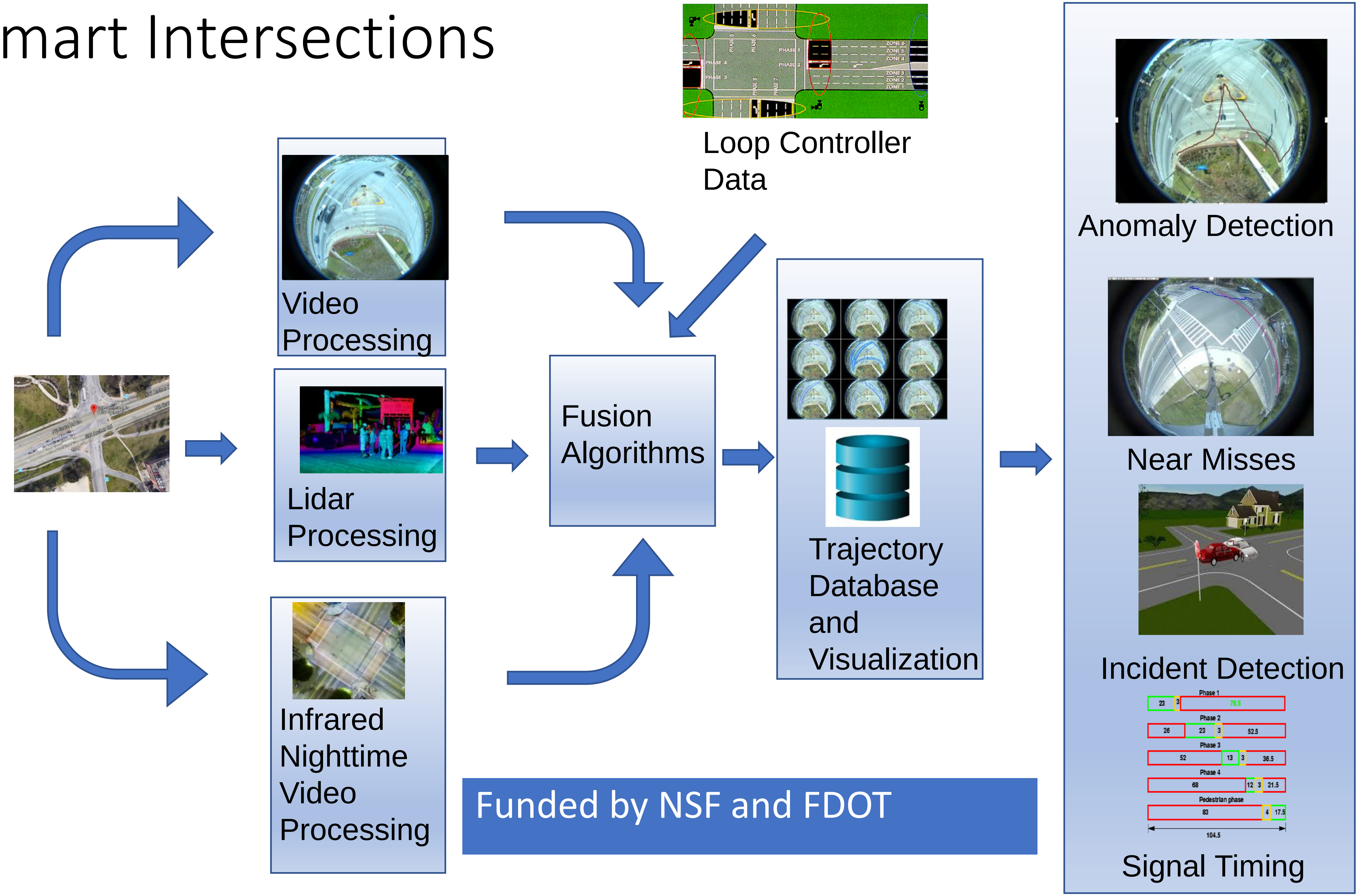
Table 19:1: Relationship between Arrival Type and Platoon Ratio

Arrival type	Range of platoon ratio(R_p)	Default value(R_p)	Progression quality
1	≤ 0.50	0.333	Very poor
2	$> 0.50 - 0.85$	0.667	Unfavorable
3	$> 0.85 - 1.15$	1.000	Random arrivals
4	$> 1.15 - 1.50$	1.333	Favorable
5	$> 1.5 - 2.00$	1.667	Highly favorable
6	> 2	2.000	Exceptional



Hourly
Multi-Hour
Daily
Multi-Day
Weekly
Hourly Changes
Daily Changes
Multi-Hour
Select Date:
08/07/2018
Hours (select four):
04:00 AM, 05:00 AM,
03:00 AM
04:00 AM
05:00 AM
06:00 AM
07:00 AM
08:00 AM
09:00 AM
Submit
4 : 00
5 : 00
8 : 00
9 : 00
About Maps
Category
Ok
Potential Capacity
Potential Timing: High Dema
Potential Timing: Low Dema
Behaviour
912, Road: SR434, ID: 1_1
954, Road: SR436, ID: 1_2
605, Road: US17-92, ID: 1_0
957, Road: SR436, ID: 0_2
326, Road: LakeWay, ID: 1_1
923, Road: SR434, ID: 0_1
313, Road: SandLkRd, ID: 1_
329, Road: SR46, ID: 0_3
609, Road: US17-92, ID: 0_0
375, Road: CR419, ID: 1_6
84, Road: SR419, ID: 0_5
138, Road: ELkMary, ID: 1_9
385, Road: SR426, ID: 0_6
91, Road: SanfordAve, ID: 0_
160, Road: RinehartRd, ID: 1
70, Road: ELkMary, ID: 0_11
82, Road: HowellBrRd, ID: 0_
90, Road: PalmSprings, ID: 0
93, Road: LkEmma, ID: 0_18
99, Road: InternationalPkwy
118, Road: MontgomeryRd,

Smart Intersections



Smart Streets: Artificial Intelligence based Real-time Incident Detection

Challenge

- Detect Traffic Interruptions ASAP (ideally within 100 seconds)
- Simple Volume Based Approaches (e.g. 80% reduction in volume) create too many false alarms (e.g. 10 false alarms for every correct detection)

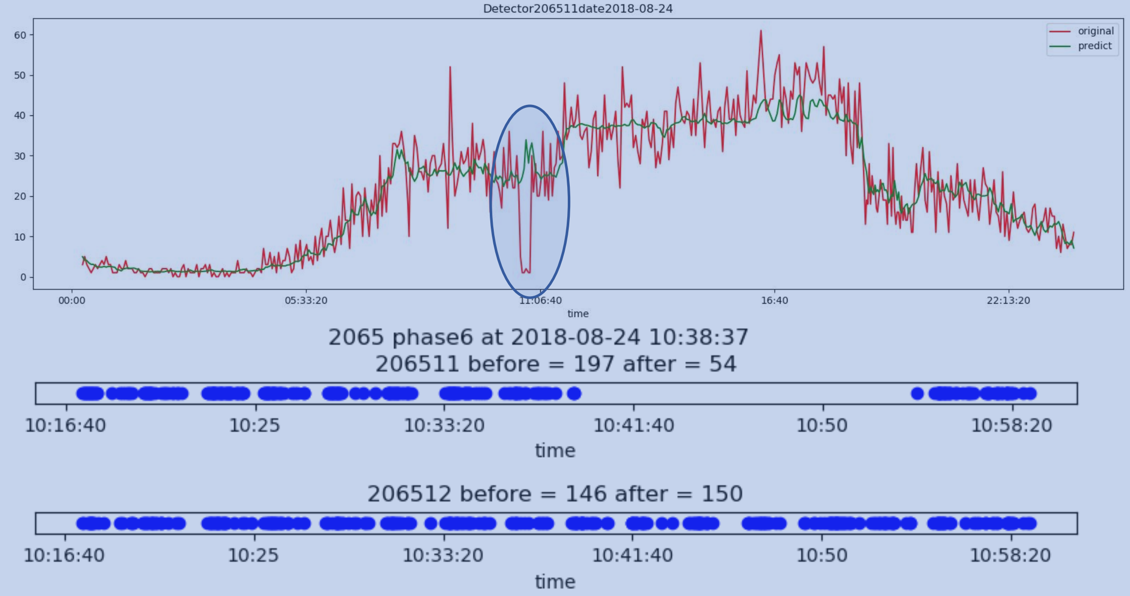
Opportunity

- Newly installed loop detectors allow for arrivals/departures at a deci-second intervals, but generate 20 GB per day for 1000 signals
- Use Bigdata Artificial Intelligence and Machine Learning for detecting all traffic interruptions (80% reduction for 5+ minutes)

- AI based Solutions (Consensus of three experts)
  - Volume Reduction Expert: Predicts traffic volume using last 10 minutes and previous weeks data for the same time window to detect potential reduction
  - Gap Analysis Expert: Learns gap distribution from current and past history to and determine if current gap is abnormal
  - Platoon Analysis Expert: Learn platoon size distribution from recent history and determine if traffic after a small amount of gap is much smaller
- Tested on 90 day historical data collected from 150 “advance” detectors on 25 intersections
- Close to zero missed traffic interruptions
- Average Wait time 110 secs (2-3 false alarms for every 10 correct detections)

Smart Streets: Artificial Intelligence based Real-time Incident Detection

Incident on Detector ID 206511 at 2018-08-24 10:38:37

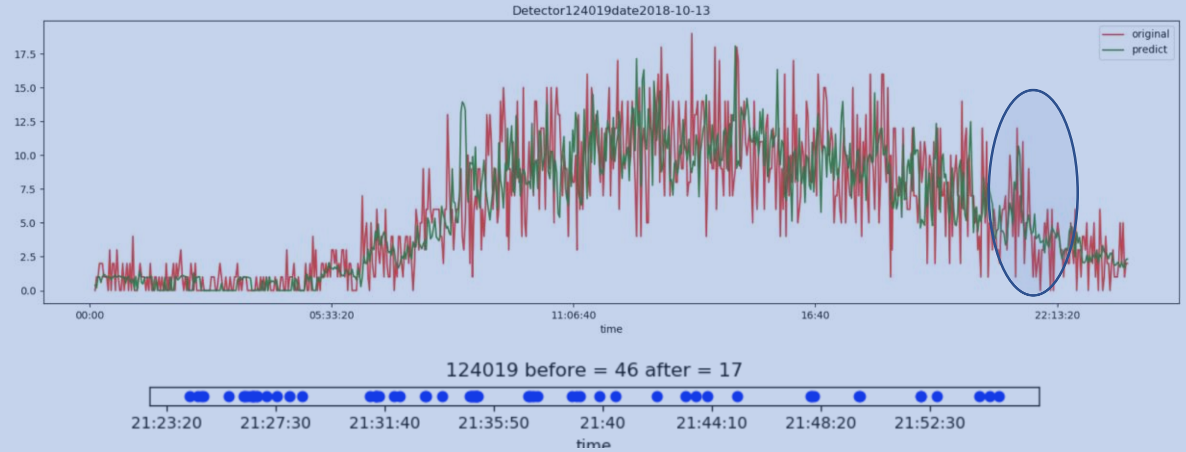


619	88613946	20182282382	Casselberry PD	Long	08/16/2018	4:00 PM	Casselberry	Seminole	KEWANNEE TRL	TALBOT RD	500	East	Off Road	[illegible]
686	87707013	2018TA011560	Lake Mary PD	Long	08/28/2018	8:20 AM	Lake Mary	Seminole	INTERNATIONAL PKWY	W LAKE MARY BLVD	81	North	Sideswipe	[illegible]
687	87707015	2018TA011602	Lake Mary PD	Short	08/28/2018	4:10 PM	Lake Mary	Seminole	BROADMOOR AVE	S COUNTRY CLUB RD	50	East	Rear End	2
688	87707016	2018TA011615	Lake Mary PD	Short	08/28/2018	5:50 PM	Lake Mary	Seminole	LAKE MARY BLVD W	LONGWOOD LAKE MA	600	East	Rear End	[illegible]
689	87707012	2018TA011521	Lake Mary PD	Short	08/27/2018	11:05 AM	Lake Mary	Seminole	LONGWOOD LAKE MAR	W LAKE MARY BLVD	29	South	Rear End	[illegible]
690	87508440	2018TA011482	Seminole Co SO	Short	[illegible]	10:40 AM	Lake Mary	Seminole	INTERNATIONAL PKWY		0		Other	2
[illegible]	[illegible]	[illegible]	Lake Mary PD	[illegible]	08/24/2018	8:58 AM	Lake Mary	[illegible]	W LAKE MARY BLVD	N FOREST BLVD	501	East	Left Turn	2
[illegible]	87707007	2018TA011410	Lake Mary PD	Long	08/24/2018	10:39 AM	Lake Mary	Seminole	I-4	W LAKE MARY BLVD F	210	South	Off Road	[illegible]
693	87237419	[illegible]	[illegible]	Long	[illegible]	1:54 PM	Lake Mary	Seminole	INTERSTATE 4 (STATE F	LAKE MARY BOULEVA	5280	East	Off Road	1
694	87106401	FHPD18OFF085	FHP	Short	08/23/2018	5:30 PM	Lake Mary	Seminole	COUNTY ROAD 46A	COLONIAL CENTER PI	200	East	Rear End	2
695	87707005	2018TA011383	Lake Mary PD	Short	08/23/2018	5:12 PM	Lake Mary	Seminole	N US HIGHWAY 17/92	WELDON BLVD	521	North	Left Turn	2
696	87707003	2018TA011283	Lake Mary PD	Short	08/22/2018	8:07 AM	Lake Mary	Seminole	LAKE MARY BLVD W	LAKE EMMA	200	West	Sideswipe	2
697	87707009	2018TA011307	Lake Mary PD	Short	08/22/2018	2:29 PM	Lake Mary	Seminole	W LAKE MARY BLVD		0		Other	2

Police crash report

Note: Not all traffic interruptions are crashes or reported

Example of a case where volume dip happened but the gap/platoon analysis showed that there is no need for an alarm



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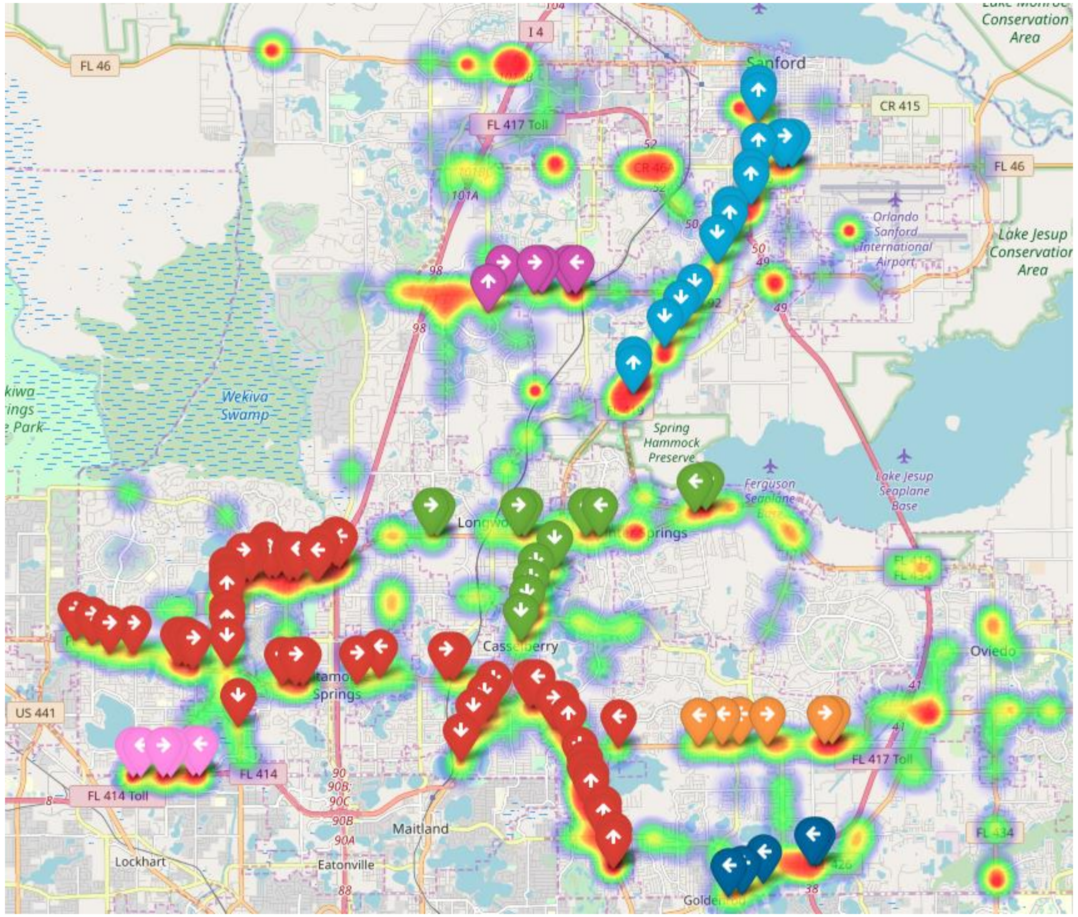
Smart Network (of Arterials)



Historical Analysis

- Day of the week and hour of day patterns of traffic

Real-time Analysis

- Incidents
- Real-time information

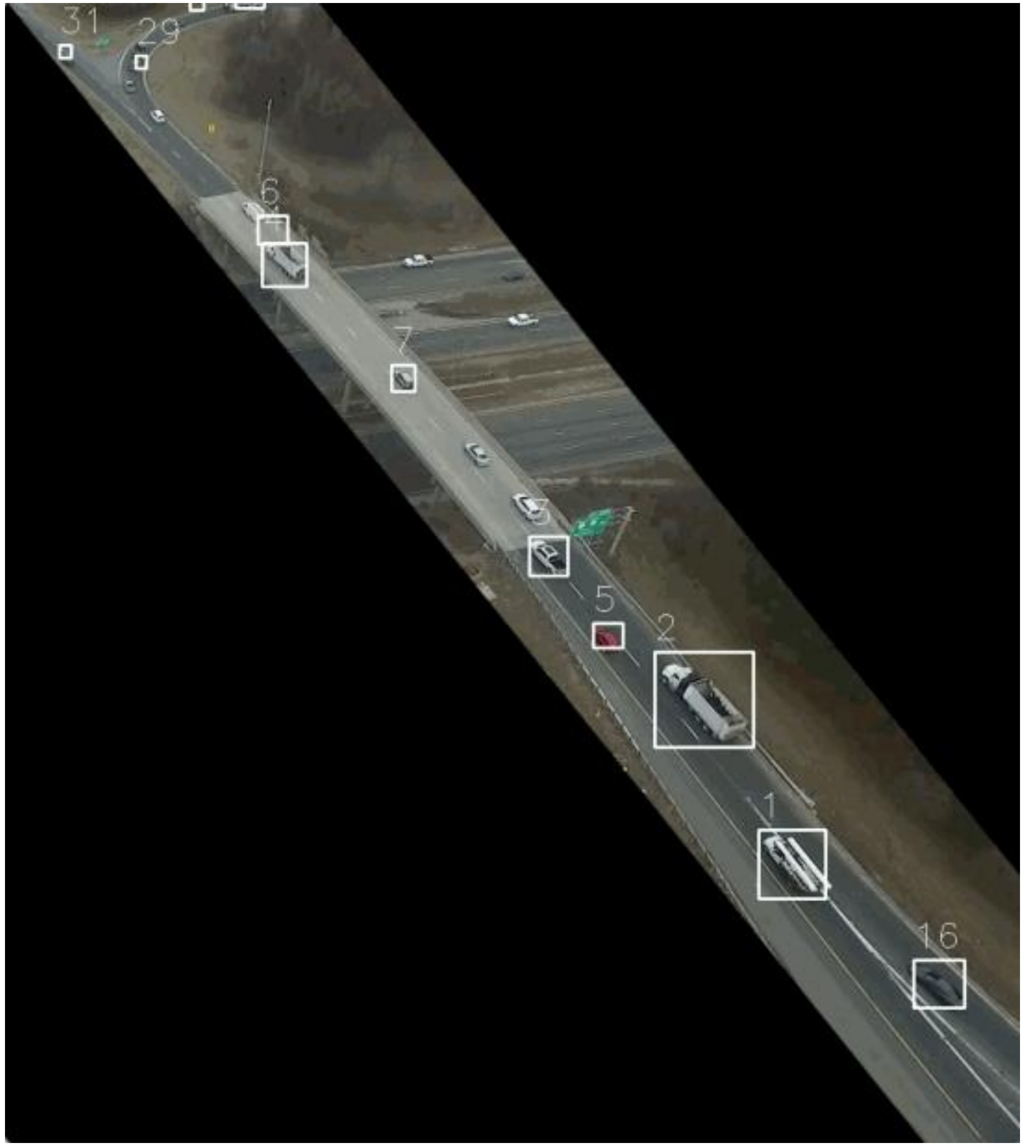
Machine Learning

- Corridor Optimization
- Network Optimization

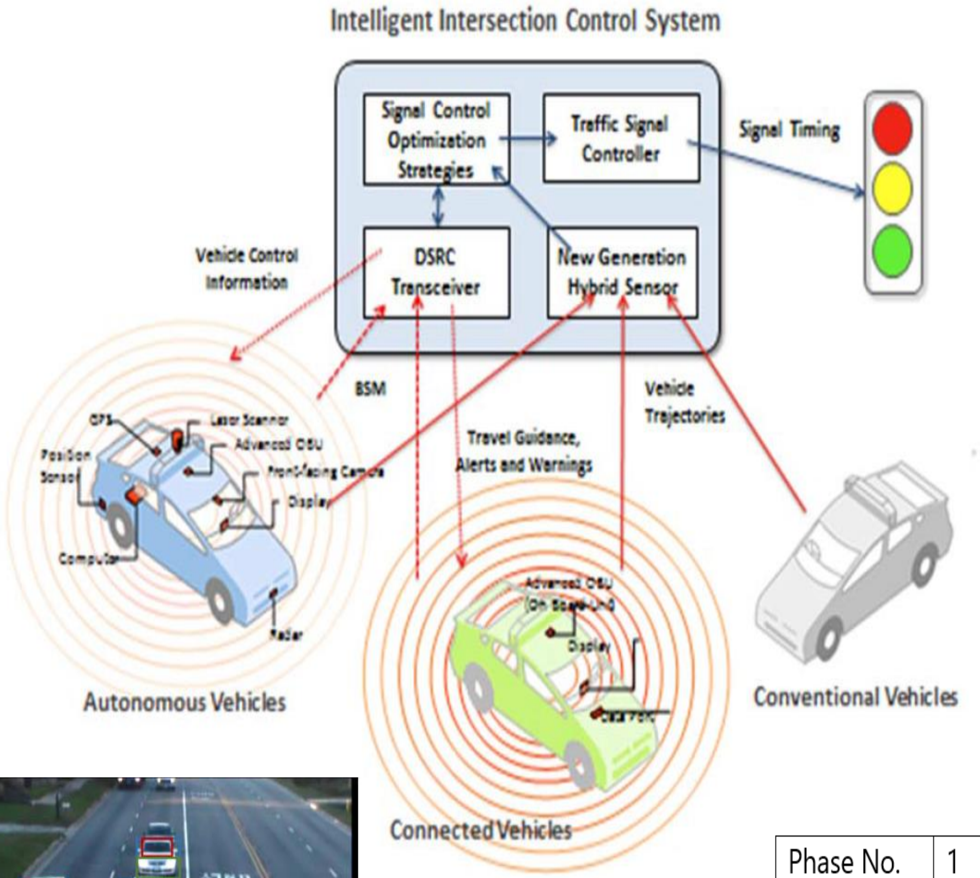
Funded by FDOT

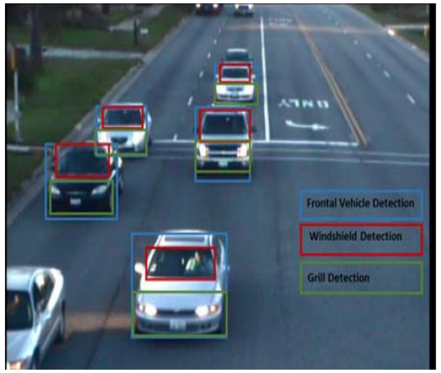
Highway Vehicle Movement Tracking

- Detecting and tracking highway vehicles
- Vehicle speed computation
- Trajectories – O/D, Exit and Enter Locations



AVIAN: Autonomous and Connected Vehicles Intersection Controller (NSF CPS + FHWA+FDOT)

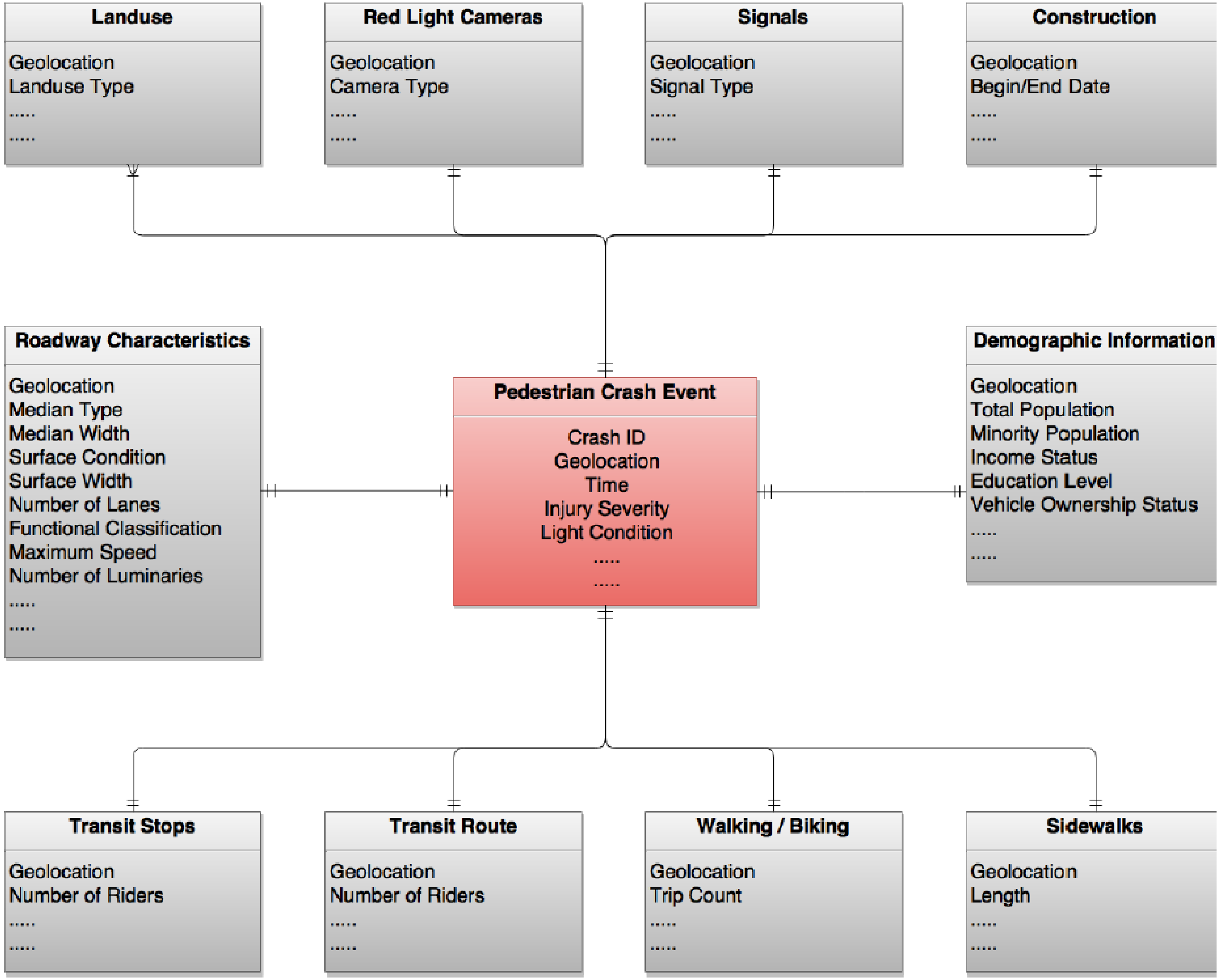


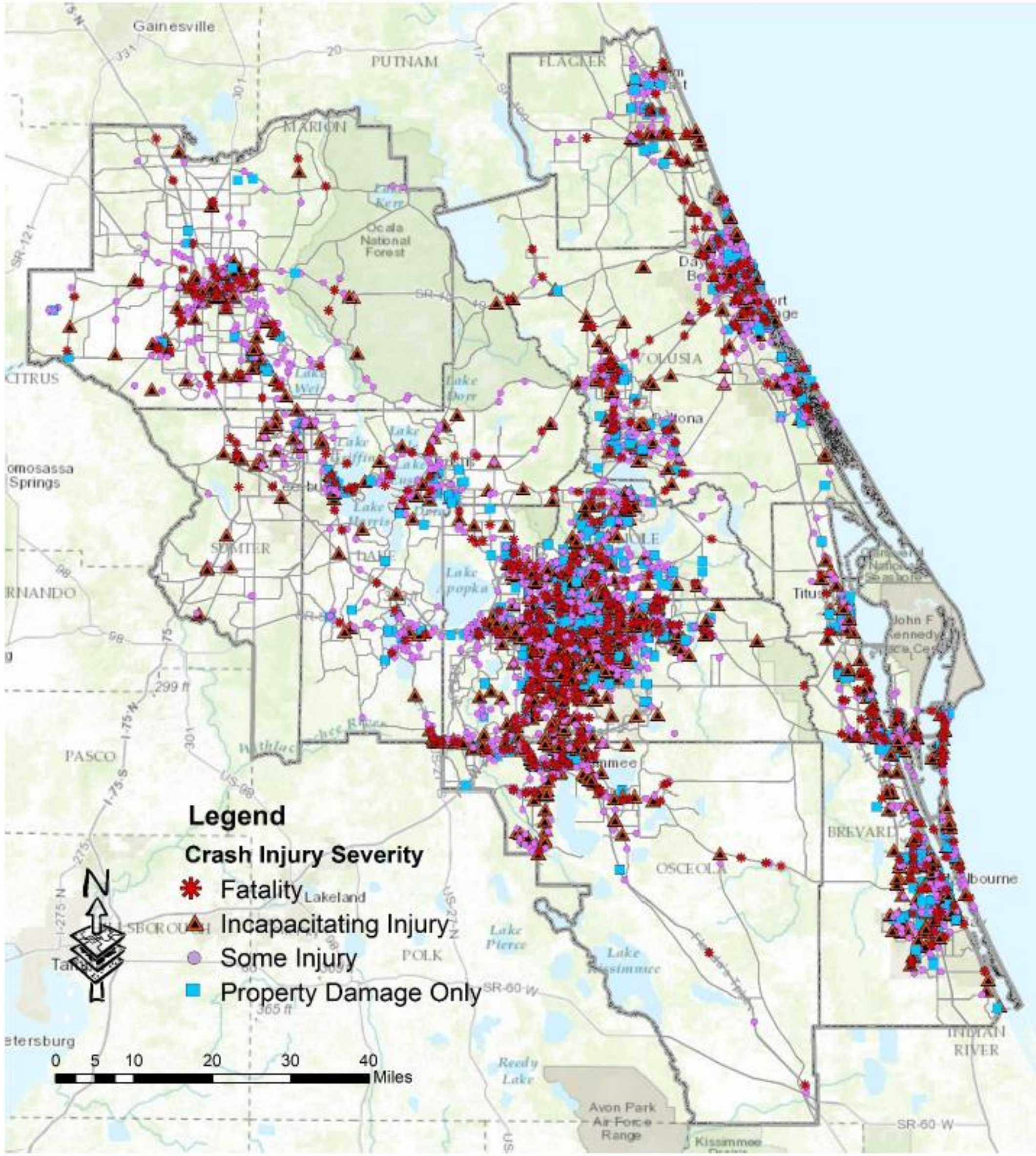


Phase No.	1	2	3	4	5	6
Lane(s)	1	4	2,5	2,3	5,6	3,6
Movements						

Funded by NSF CPS

Predicting and preventing fatal crashes (FDOT D5)





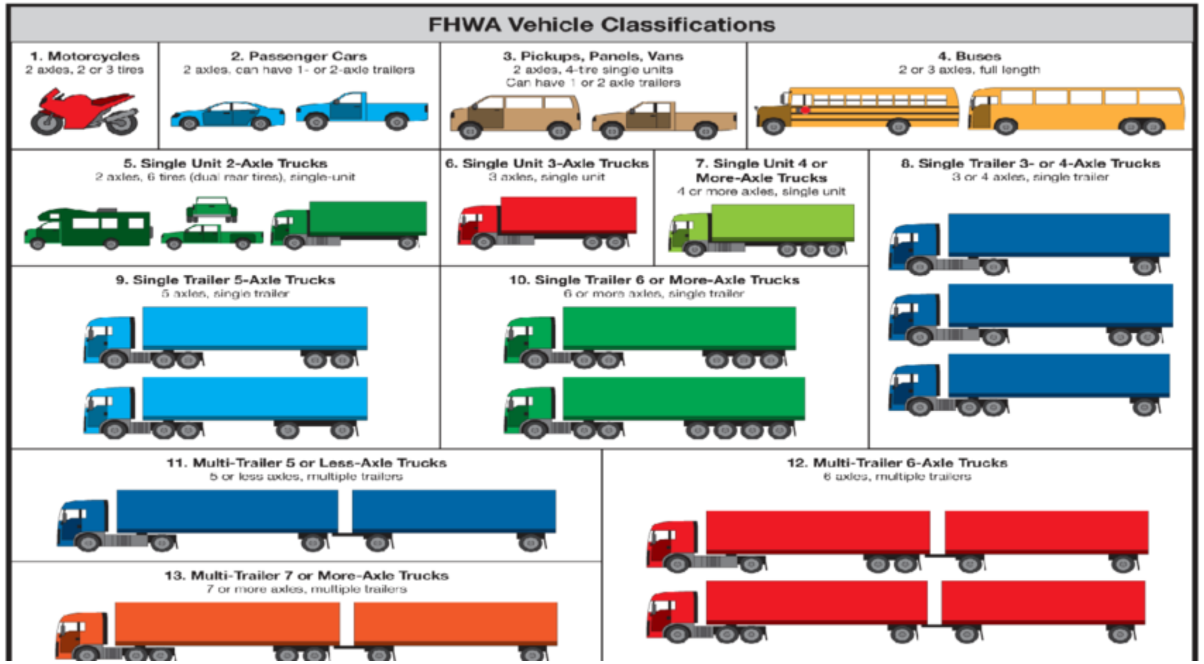
Truck and Commodity Classification Using Machine Learning

**WIM Dataset w/
Truck Attributes & Commodity**

WIM Data + Taxonomy + Commodity + Video + Machine Learning =

Configuration	
Five-axle tractor semitrailer, 3-S2	(59%)
Six-axle tractor semitrailer, 3-S3	(19%)
Nine-axle turnpike double, 3-S2-4	(8%)
Eight-axle B-train double, 3-S3-S2	(7%)

Body type	Typical commodities	Typical industries
Vans/reefers (63%)	• Palletized cargo • Refrigerated goods	• Retail • Produce
Flat decks (16%)	• Equipment • Building supplies	• Construction • Manufacturing
Hoppers (6%)	• Grain • Granular fertilizer	• Agriculture
Tankers (4%)	• Petroleum products • Chemicals	• Petroleum • Chemical
Dumps (6%)	• Aggregate • Grain • Refuse	• Construction • Agriculture
Containers (2%)	• Palletized cargo • Freight of all kinds	• Retail



Logo Recognition – Text Detection

The developed algorithms can achieve a high recall (80+ %) with a competitive recognition accuracy.

Funded by FDOT

Conclusions

- Our current transportation related projects are leveraging novel physical and cyber infrastructure
  - Autonomous and connected vehicle deployment
  - Advanced sensors and cameras through smart intersection
  - Intelligent data stores, cloud computing and artificial intelligence
- With the following objectives
  - Manage traffic congestion and improve safety by using big data and related technologies
  - Use data driven approaches for decision making, planning, evaluation and measurement
  - Support efficient tracking and movement of goods, services and people
- While Working with a number of key stakeholders from city, county and state

UFL Team: Artificial Intelligence and Machine Learning for Transportation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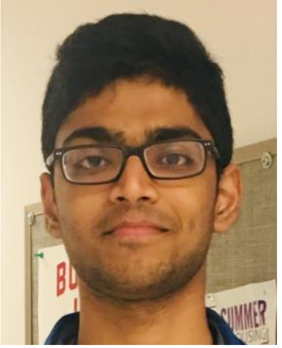
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Big Data Analytics | Cloud Computing | GPU Computing | Computer Vision

Machine Learning | Transportation Applications | Large-Scale Software Development

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