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Think Forward

Analyzing Driver Behavior at the Micro Level

presented to

2016 Transport-Tech Summit

November 15, 2016

presented by

Cambridge Systematics, Inc.

Michalis Xyntarakis

Vassili Alexiadis

Overview

- Data Collection Effort in Berkeley California
  - » Real Time Kinematic GPS + Inertial Measurement Unit (IMU)
  - » Multimode radars
  - » Video cameras, Controller Area Network (CAN) Bus
  - » Variables in the collected data
  - » Examples of collected data
  - » Next steps & data release timeline
- Measures of driver behavior at the microscopic/trajectory level

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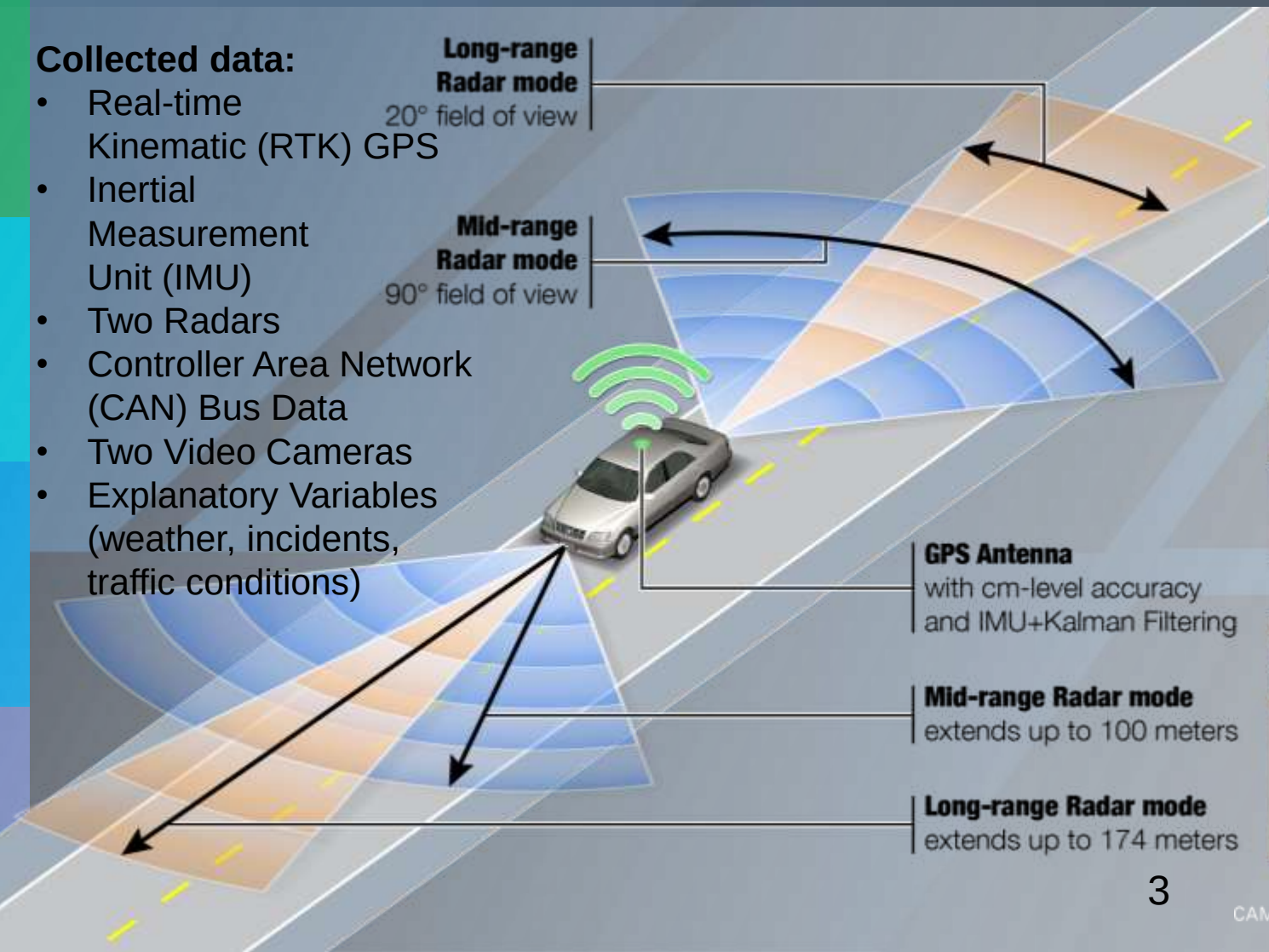
Instrumented Vehicle (IV)

Collected data:

- Real-time Kinematic (RTK) GPS
- Inertial Measurement Unit (IMU)
- Two Radars
- Controller Area Network (CAN) Bus Data
- Two Video Cameras
- Explanatory Variables (weather, incidents, traffic conditions)



Rear view of vehicle

Side view of vehicle

Front view of vehicle

Data Collection Site

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Data Collection Objectives

Collect data for both car following & lane changing behavior under different conditions to investigate:

- Incidents & weather
- Arterial vs freeways
- Intra-driver behavior
- Inter-driver behavior
- Validate a car-following traffic simulation

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Driver Schedule

April 2016

10	11	12	13	14	15	16
	Driver 1 3-6 PM		Driver 1 3-6 PM		Driver 1 3-6 PM	
17	18	19	20	21	22	23
	Driver 2 3-6 PM		Driver 2 3-6 PM	Driver 3 3-6 PM	Driver 3 3-6 PM	
24	25	26	27	28	29	30
			Driver 2 3-6 PM	Driver 3 3-6 PM	Driver 3 3-6 PM	

May 2016

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4	5	6	7
	Driver 2 1-4 PM	Driver 3 3-6 PM	Driver 1 1:45-4:45 PM	Driver 2 3-6 PM	Driver 2 3-6 PM	
8	9	10	11	12	13	14
		Driver 1 3-6 PM	Driver 1 1-4 PM	Driver 3 1-4 PM	Driver 2 3-6 PM	
15	16	17	18	19	20	21
	Driver 1 3-6 PM					
22	23	24	25	26	27	28

- 3 drivers
- 60 hours in total
- 95 circuits in total
- Driver 1: 7 days, 21hrs
- Driver 2: 7 days, 21hrs
- Driver 3, 6 days, 18hrs

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Raw Collected Data
(approximately every 50 milliseconds)

GPS & Inertial Measurement Unit	Radars (up to 128 objects)	Vehicle Controller Area Network (CAN) Bus	Video
Position (cm accuracy)	Range (0.5 meters accuracy)	Brake activation	Forward
Speed	Angle	Throttle %	Rear
Acceleration	**Time Stamp 2**	Speed	**Time Stamp 3**
Heading		RPM	
Time Stamp 1		Turn signals	
		Heading	
		Time Stamp 2	

~2OMB/hour	**~2 GB/hour**	**~10MB/hour**	**~2GB/hour**

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Off-line Calculations on the Data

- Real Time Kinematic corrections & Kalman Filtering on IV Trajectory
- Bit-level radar data decoding
- GPS Time-stamp synchronization & linear interpolation
- Extraction of trajectories from radar tracks
- Calculation of distance along circuit
- Assignment of vehicles to lanes

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Processed Trajectory Data
(every 50 milliseconds)

Instrumented Vehicle
Position (lat, long)
Speed
Acceleration
Heading
Brake activation
Throttle %
RPM
Turn signals
Distance along path
Distance from lane centerline
Lane

Surrounding Vehicles
Position (lat, long)
Distance along path
Distance from lane centerline
Lane

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Driver Logs (Weather & Incidents, Events)

Events (sample)
Collision, 2 cars on shoulder before Ashby exit
Now 3 cars and California Highway Patrol on the shoulder before Ashby
Incident near Ashby cleared. Motorcycle cop ticketing driver at I-80, before merge with I-580
Minor crash, 2 crash on shoulder at Ashby exit. No video
Freeway: truck on shoulder at Ashby, erratic driver in right lane (white Altima) after Ashby. Arterial: right lane still closed
Computer crashed 2 min before end of circuit - data still saved
Truck still on shoulder at Ashby, right lane still closed

Weather
Sunny, windy
Sunny
Partly cloudy
Cloudy (slight drizzle)
Cloudy

Traffic Conditions (sample)
Stop and go after I-580/I-80 merge
Heavy. Queue spillback at San Pablo and 40th
Stop-and-go on I-80, mostly clear on San Pablo
Gridlock on I-80

GPS/IMU Data (+Website Demo)

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I80 North

University Ave

Five sample circuits from a single day

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San Pablo (start)

San Pablo (end)

Five sample circuits from a single day

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Radar Data

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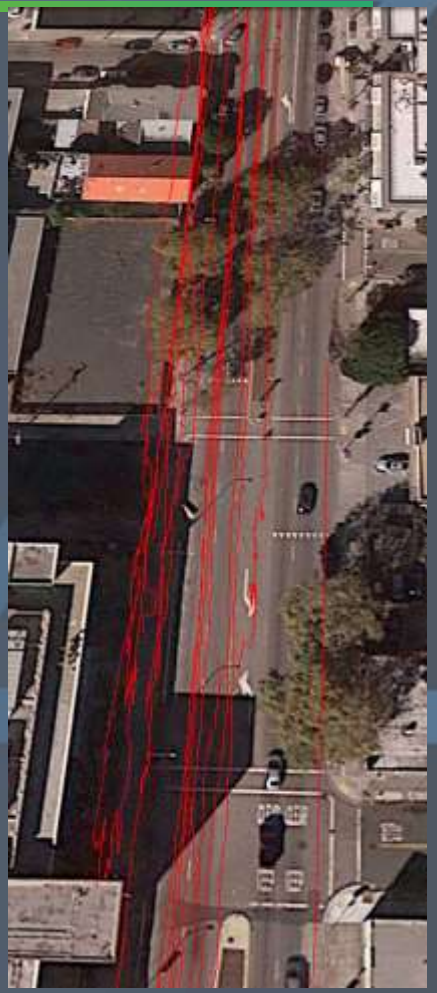
Trajectories Obtained From the Radars (sample)

I-80 & Powell

I-80 & Ashby



San Pablo

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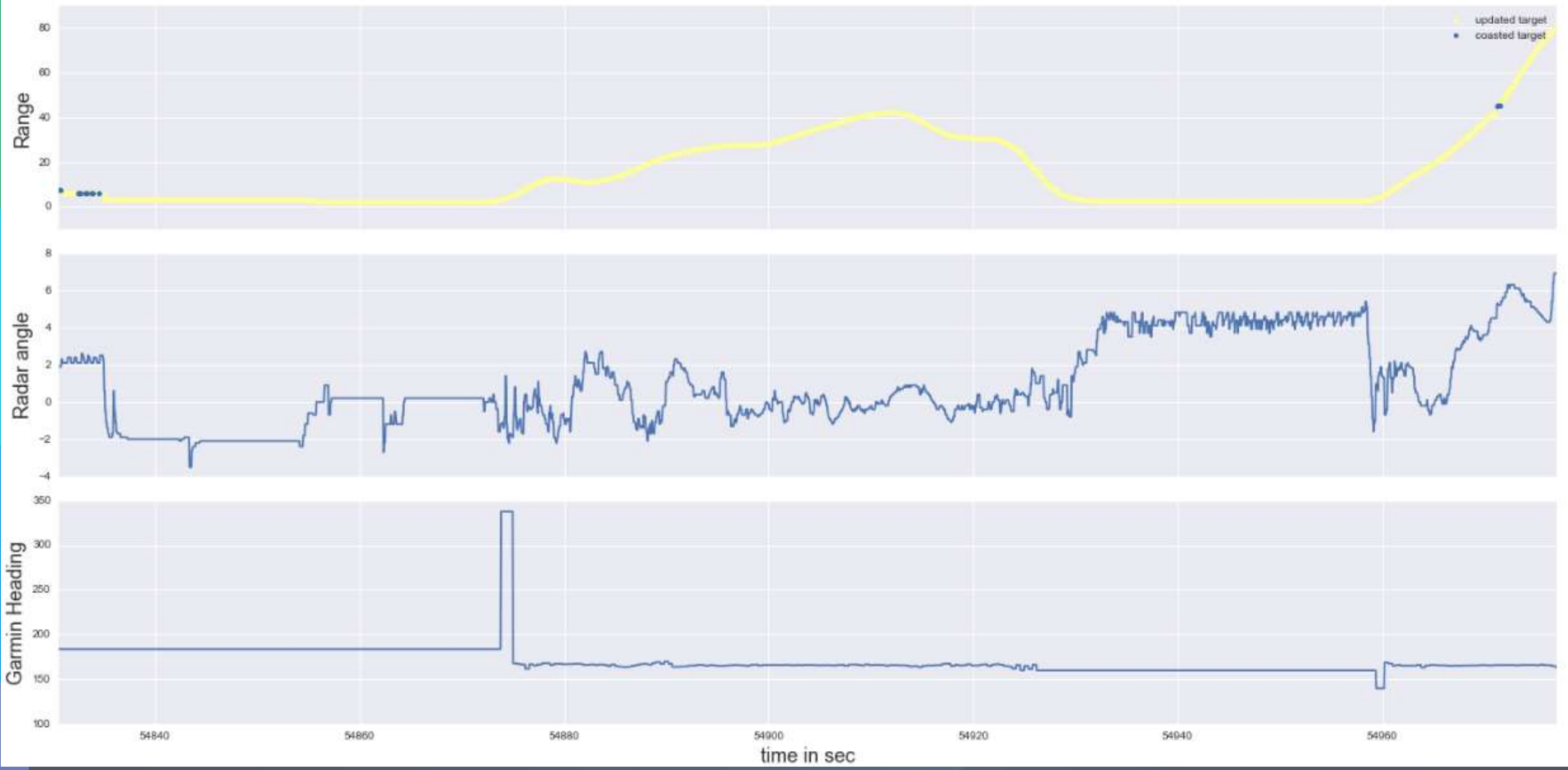
Radar Range and Angle (1/64 Tracks)



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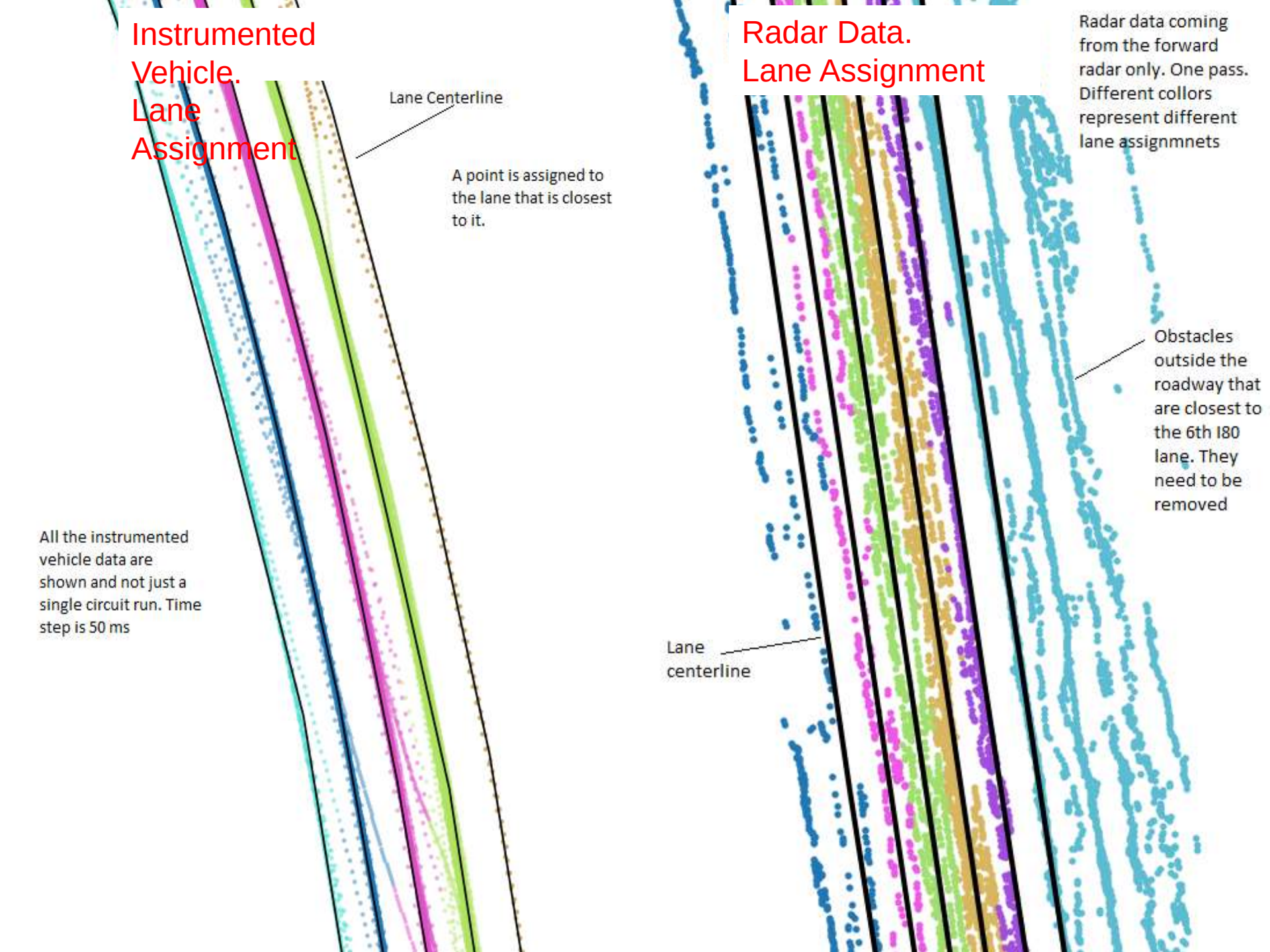
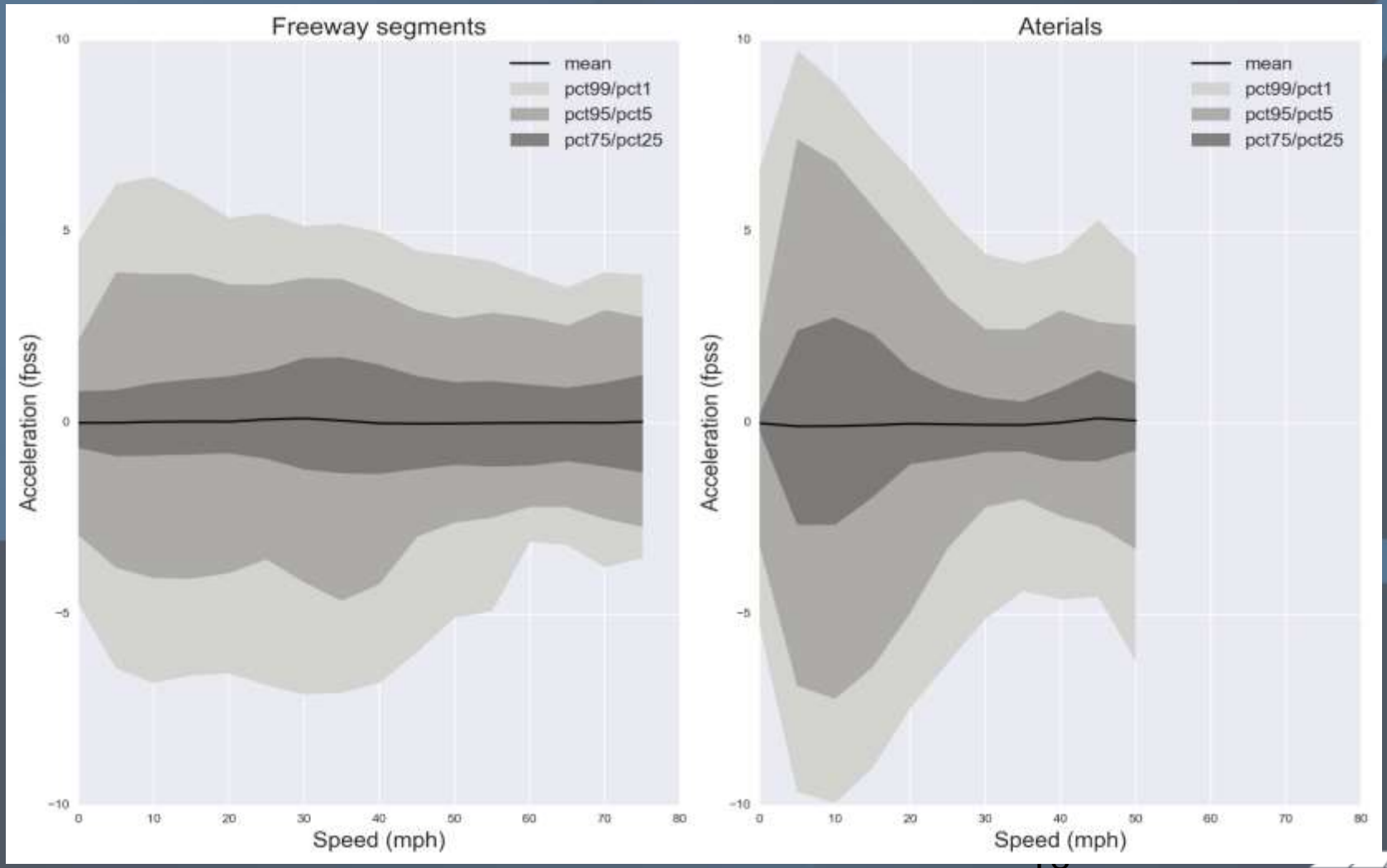

Instrumented Vehicle. Lane Assignment
Lane Centerline
A point is assigned to the lane that is closest to it.
All the instrumented vehicle data are shown and not just a single circuit run. Time step is 50 ms
Radar Data. Lane Assignment
Radar data coming from the forward radar only. One pass. Different collors represent different lane assignmnets
Obstacles outside the roadway that are closest to the 6th I80 lane. They need to be removed
Lane centerline

Acceleration vs Speed (Collected Data)



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Lessons Learned

- Integrated GPS + Inertial Measurement Units are easy to work with
- Radars are not easy to configure
- Radar data require significant post-possessing due to false positives
- Initial design was to build one data acquisition system. Used three in the end
- Data come in asynchronously and not exactly every 50ms
- Low-level C code is required to ensure low latency

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Microscopic Measures of driver behavior calculated at the trajectory level

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Measure	Comments	Prime References or Guidance
Proximity & Safety		
Distance gap	Minimum distance between vehicles. Reveals collisions.	Surrogate Safety Assessment Model
Time to collision	Quantifies risk of collision and aggressive driving	NHTSA ACAS Study, 100-Car Naturalistic Study
Acceleration		
Acceleration range	Determines feasible vehicle dynamics using ranges for physical and comfort limits.	AASHTO, FMCA, Collected data
Acceleration noise	Characterizes smoothness of vehicle movement.	Collected data,
Acceleration jerk	Determines feasible vehicle dynamics and characterizes traveler discomfort	
Lane Changing		
Urgency	Quantifies collision risk for same lane vehicles	NHTSA Naturalistic Lane Changes Study
Severity	Quantifies impact (vehicle cut off) on adjacent lane	NHTSA Naturalistic Lane Changes Study
Lane changes per mile	Driver propensity to change lanes	NHTSA Naturalistic Lane Changes Study
Lane change rate	Reveals lane changing intensity	
Microscopic Fundamental Diagram	Reveals dispersion around ideal traffic flow theory assumptions	Collected Data, NGSIM

Next Steps

- Clean and prepare the data for publication in the Research Data Exchange website
- Expand the microscopic measures presented
- Calculate microscopic measures using the collected trajectory data and publish findings

Questions?

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Contact Information

Michalis Xyntarakis

Contact No. 646 364 5495
email: mxyntarakis@camsys.com

Vassili Alexiadis

Contact No. 510 873 8700
email: valexiadis@camsys.com

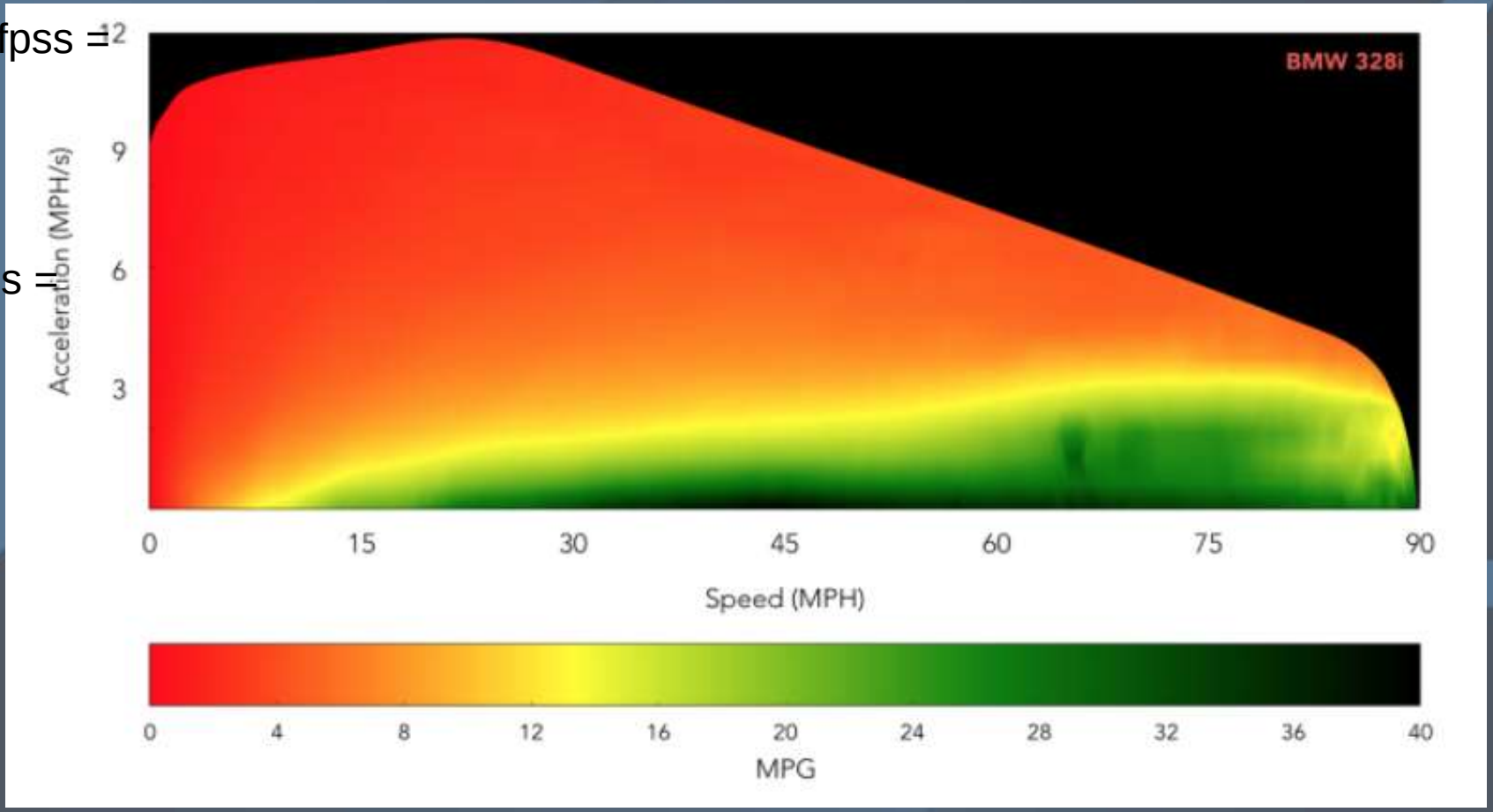
Appendix

http://swdev14.camsys.com/sharktank/test/IVTrajectories.html

Acceleration vs Speed and Fuel Consumption

18 fpss =

9 fpss =



Source 1 https://blog.automatic.com/the-hidden-costs-of-aggressive-driving-7828a9742fdc#.fnsh9iira

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