Arterial data quality and traffic estimation

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Outline

- **Introduction**
- **Cloud-based arterial performance dashboard**
- **Arterial traffic estimation**
- **Conclusion**

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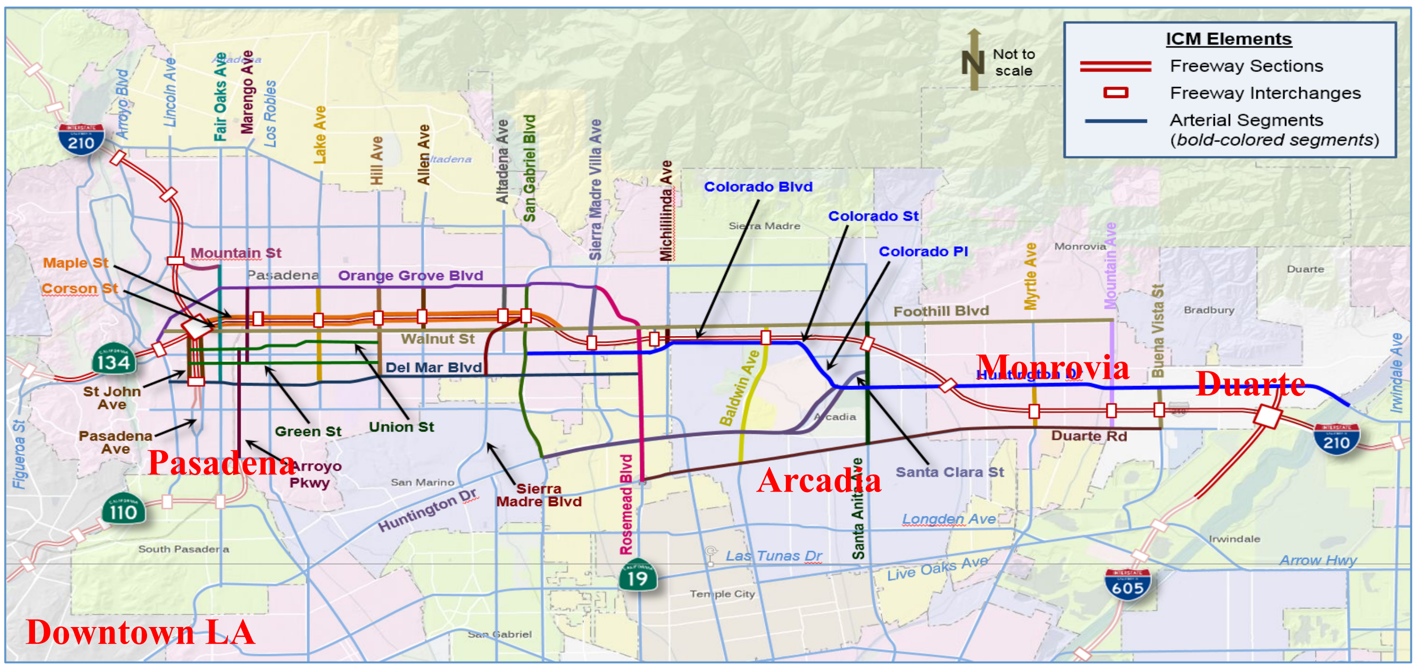
Introduction

The I-210 Connected Corridors Pilot

- **Connected Corridors**
  - A statewide program -- https://connected-corridors.berkeley.edu/home .
  - A total entity made up of people, organization, hardware, and software.
- **The I-210 Pilot in LA**
  - Frequent freeway traffic incidents, good sensing coverage, and some unused capacity in arterials



A Variety of Data Sources

	Source	Information Type	System
Arterial Data	Pasadena	Intersection signal	Pasadena TMC
	Duarte	Intersection signal	County TMC
	Monrovia	Intersection signal	County TMC
	Arcadia	Intersection signal	Arcadia TMC
	LA County	Intersection signal	County TMC
Freeway Data	Caltrans FW Traffic	Loop sensing	Caltrans ATMS
	Caltrans FW Ramps	Ramp meters	Caltrans ATMS
	Caltrans FW CMS	DMS	Caltrans ATMS
	Caltrans Intersections	Intersection signal	TSMSS
	Caltrans Video	Video	via RIITS
	Caltrans FW Lane closure	Lane status	LCS
	Caltrans incident	Incident	Caltrans ATMS
	210 LCS	Lane status	High speed rail system
Transit Data & Other	RIITS Environmental sensing	Environmental	RIITS
	RIITS Transit	Transit	RIITS
	RIITS Video	Video	RIITS
	Gold line transit	Transit	NextBus
	511 (Out only)	Response plan information	
	Bluetooth traffic	Travel time	County TMC

Problem Statement

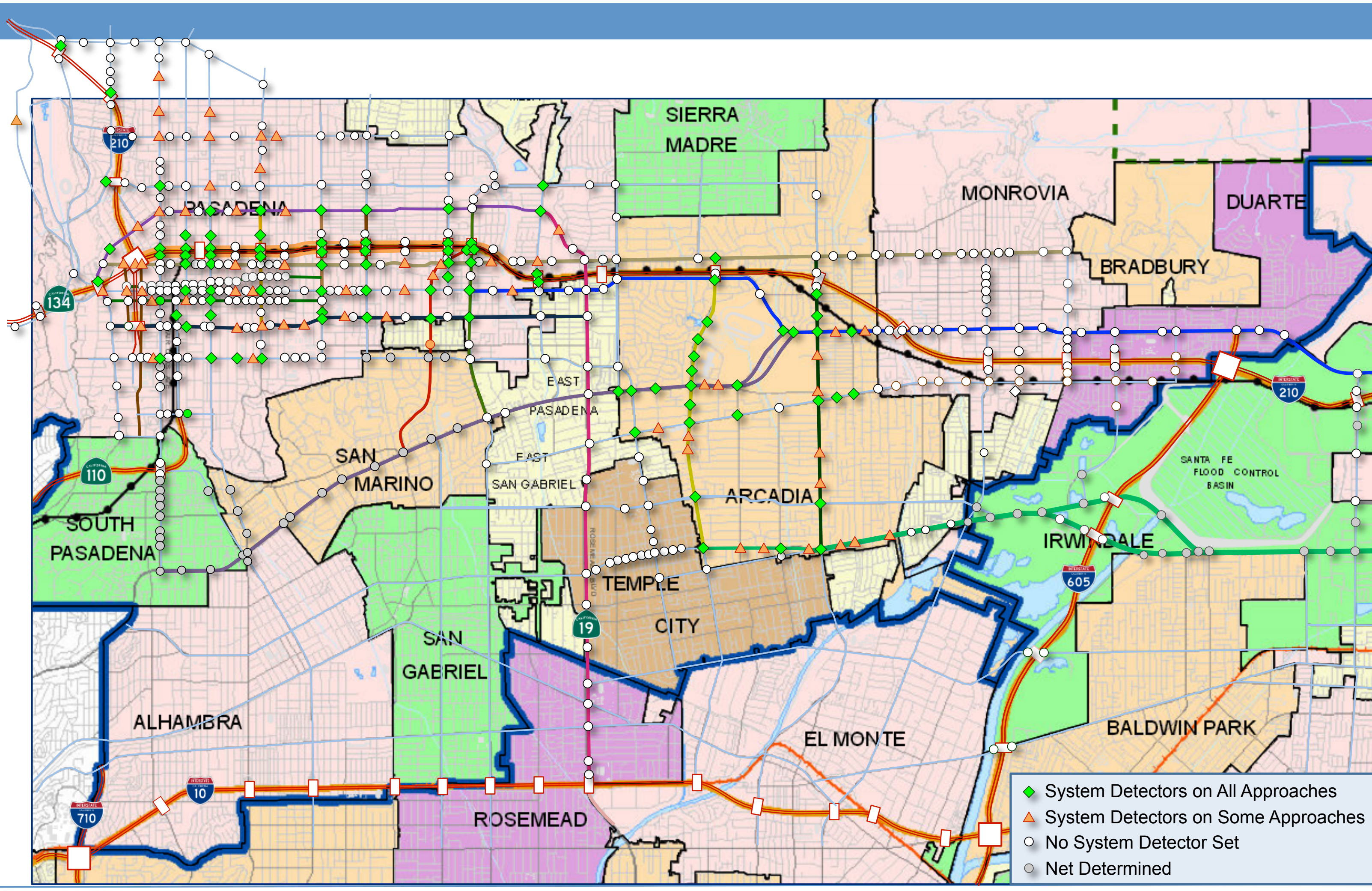
- Freeway data has been well studied.
- However, very limited knowledge of arterial data.
- In this presentation, we try to address the following questions:
  - How can we assess the quality of data from arterial sensors?
    - **Arterial data quality analysis and arterial performance dashboard**
  - How can we use the arterial data to help with traffic modeling and simulation?
    - **Arterial traffic estimation**

Cloud-based Arterial Performance Dashboard

Design Purpose

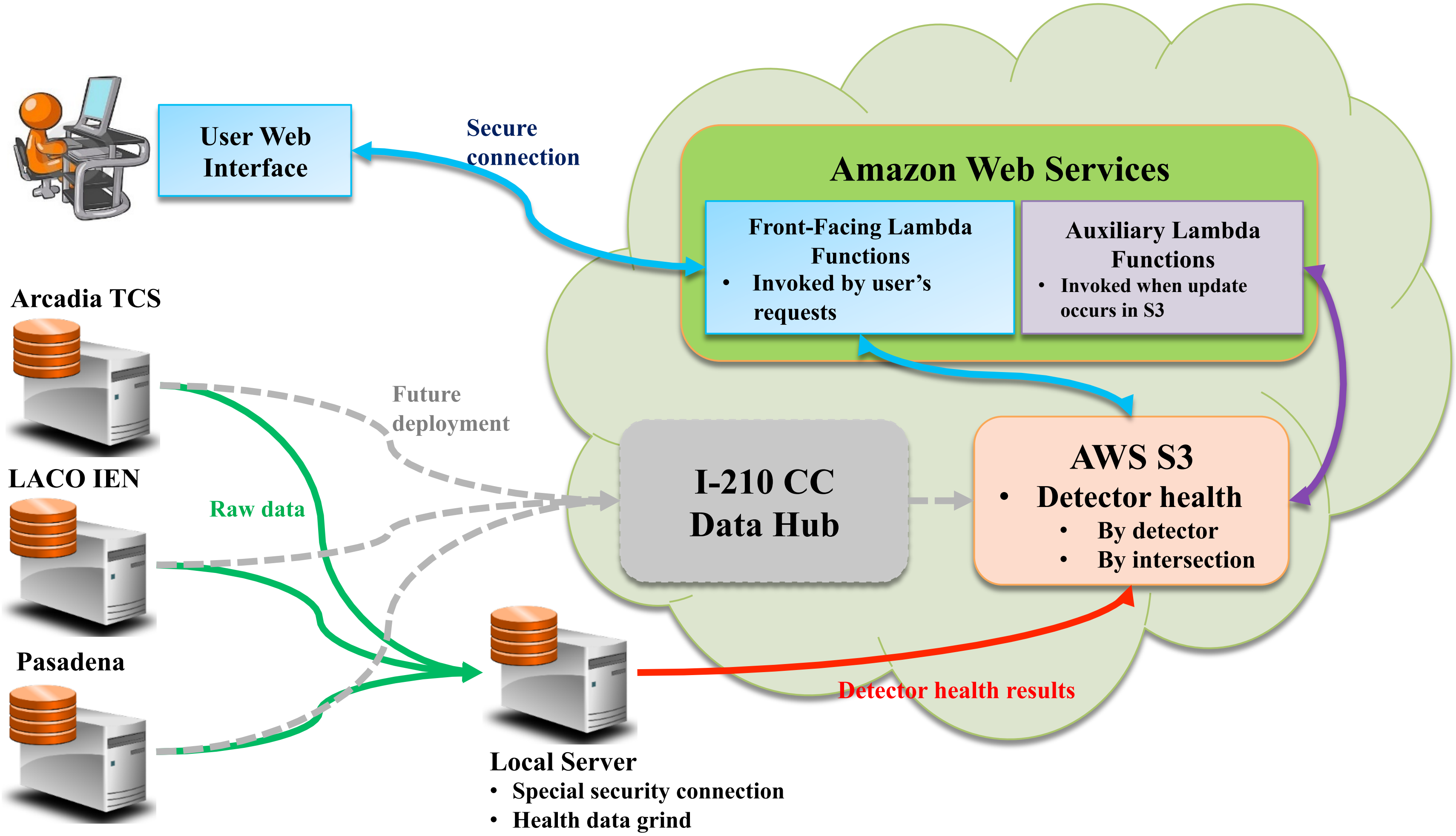
- An interactive tool to assess detector health and data quality.
- Help diagnose potential issues in urban sensor networks.
- Provide data support for model development .
- Is designed for flexibility and scalability.
- Will connect to the cloud-based data hub in the I-210 Connected Corridors project.

Detector Locations: An Overview



Caltrans Metro

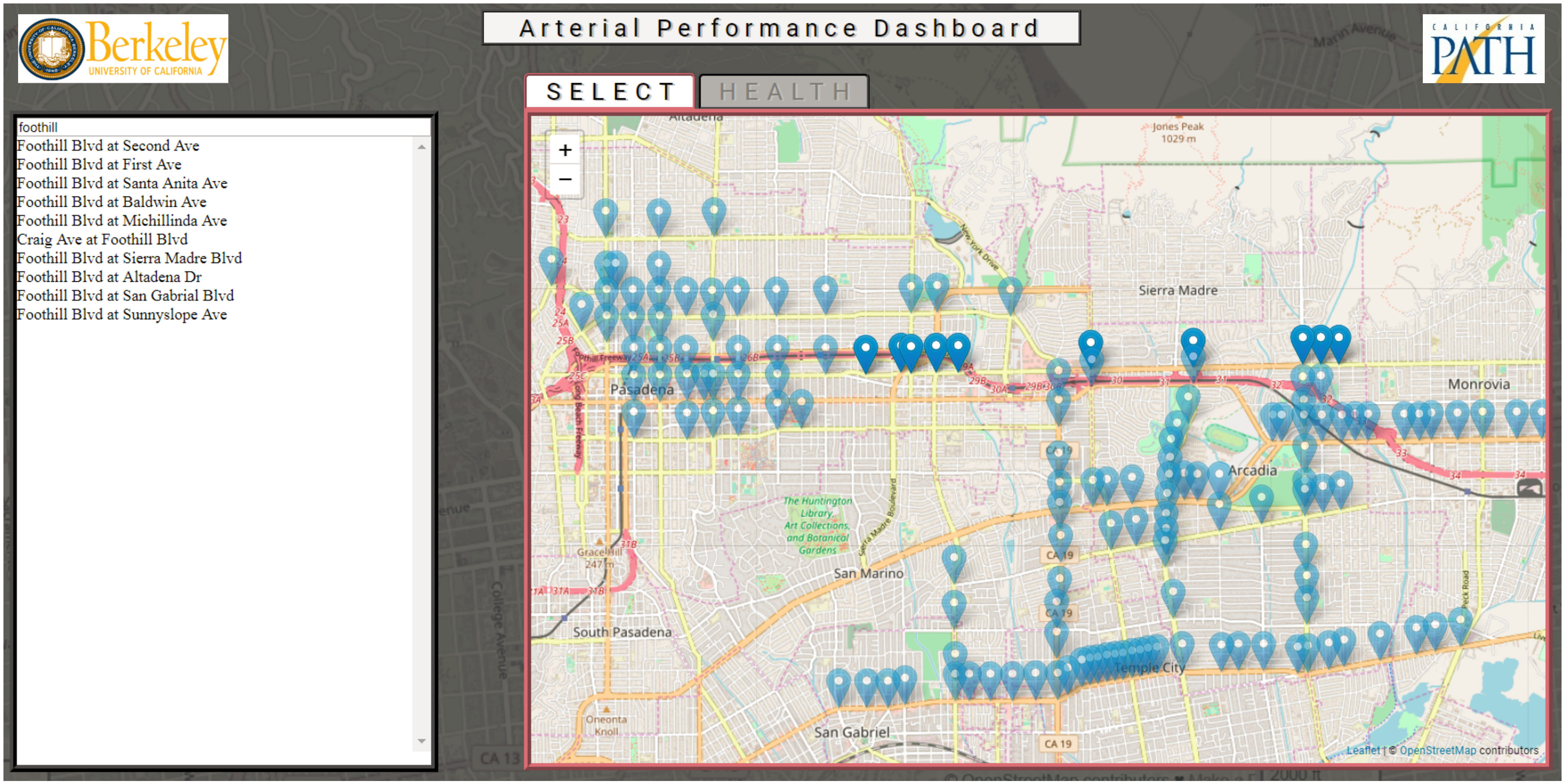
Proposed Architecture



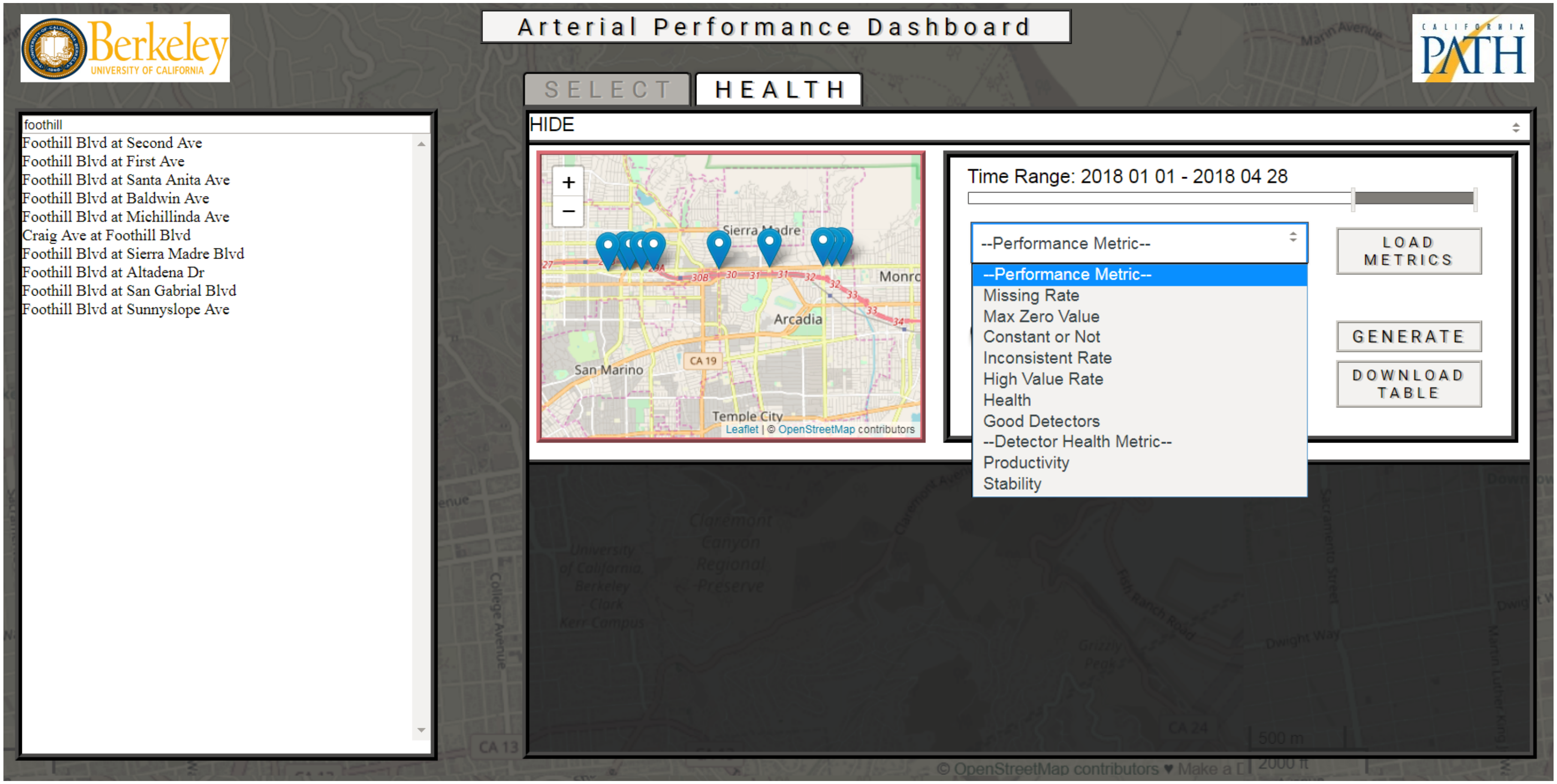
Proposed Performance Metrics

- **Diagnostic states**
  - No Data (Yes/No)
  - Insufficient Data (%)
  - High Values (%)
  - Zero Values (How Long / In hours)
  - Constant Values (Yes/No)
  - Inconsistent Data (%)
  - Good (Yes/No)
- **System performance**
  - Overall health rate (% of "Good" detectors for a given period)
  - Productivity (% of working days for a given period)
  - Stability (# of switches between "Good" and "Bad" for a given period)

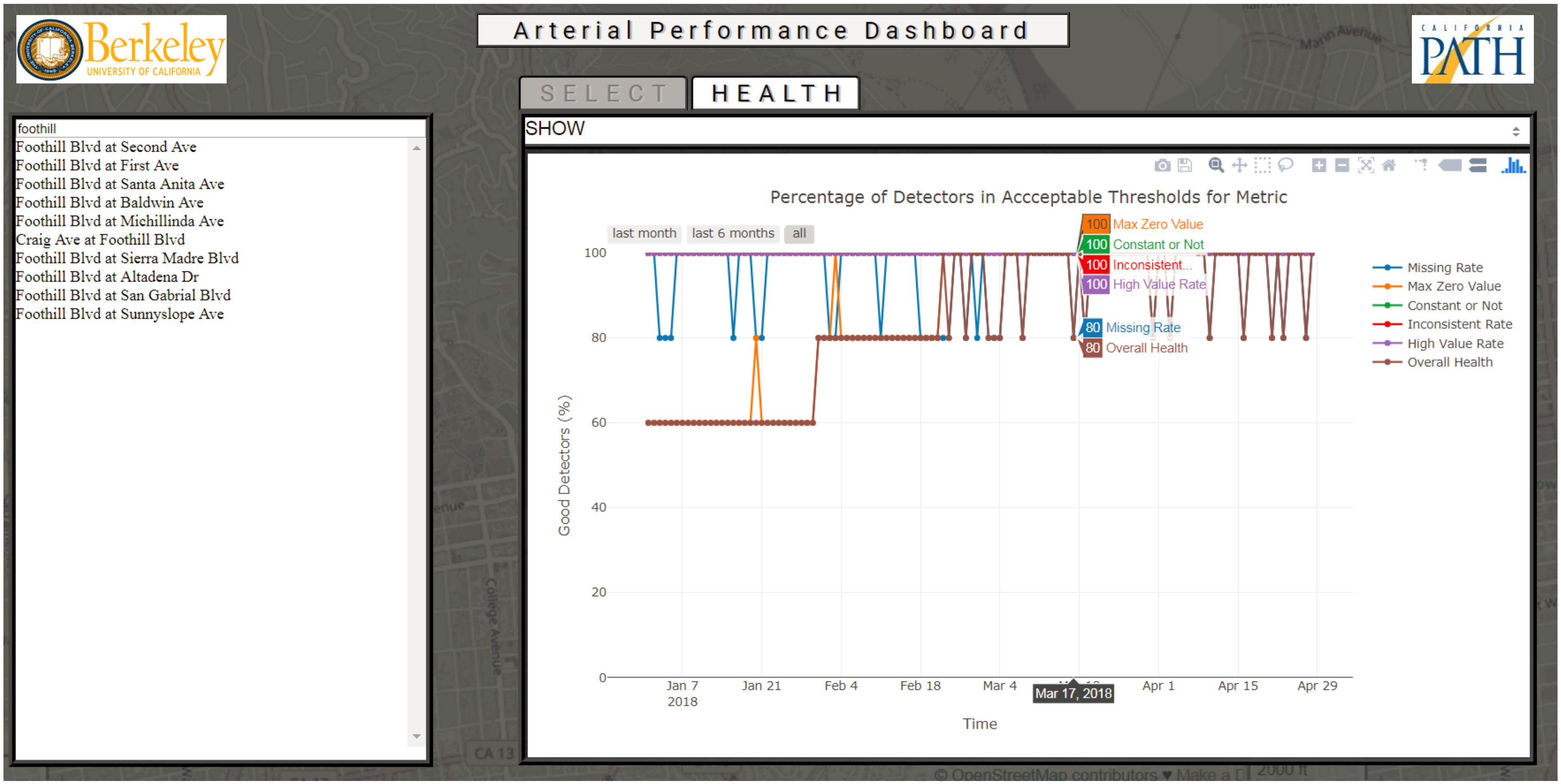
Current User Interface: Select Tab



Current User Interface: Health Tab



Current User Interface: Result Display



Arterial Traffic Estimation

Estimation of Initial Traffic States: Problem Statement

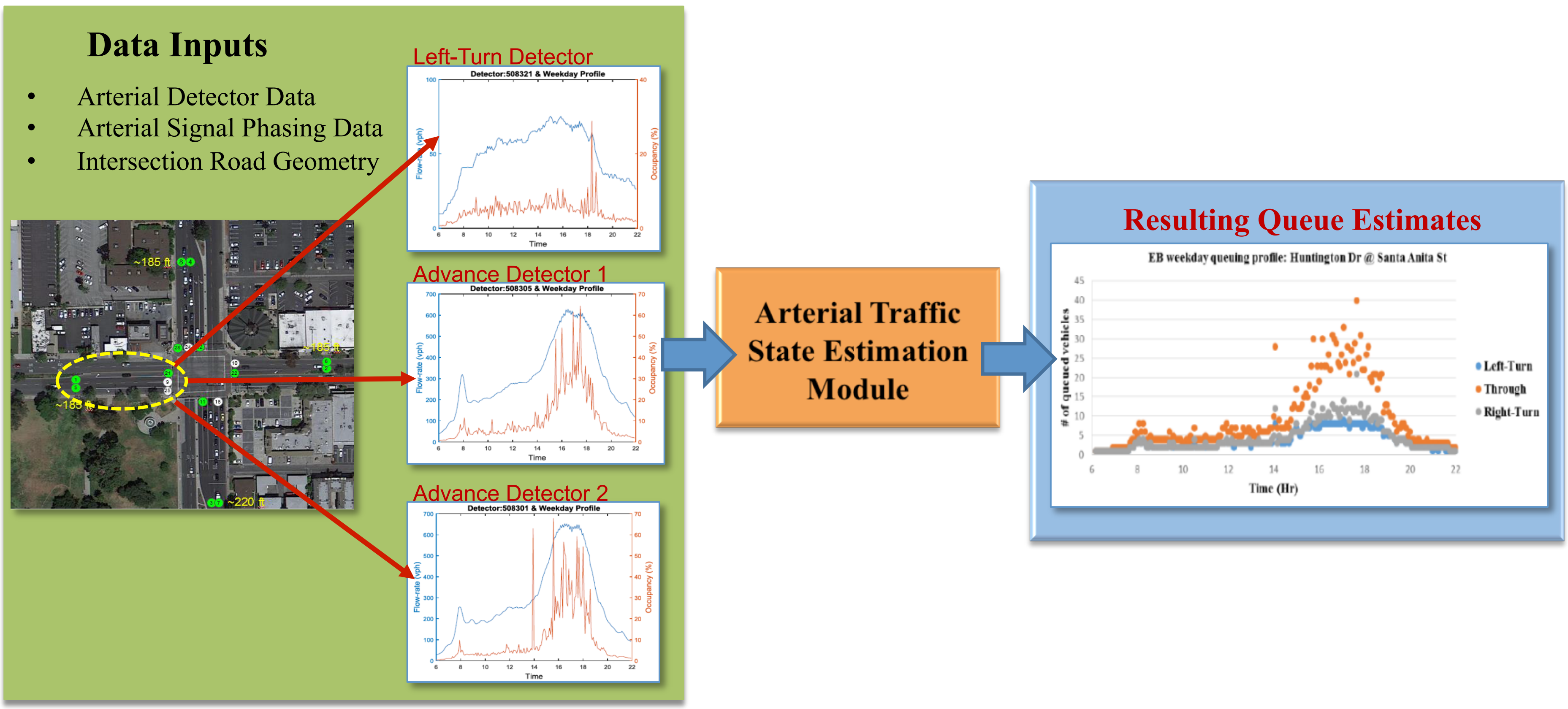
- **In order to manage corridor traffic we need to know the traffic state on the arterial.**
- **Estimation calculates this state using sensors.**
- **Estimation is done through simulation, in which the network is initially empty.**
- **Then, how to generate a set of "Good" traffic states at the beginning of simulation?**
  - A prevailing approach: using a warm-up period
  - Issues:
    - Larger networks→ Longer maximum travel times → Longer warm-up periods → More complicated network inputs & more calibration work to capture the right bottlenecks.

Estimation of Initial Traffic States: Our Solution

- **Our solution: using field observations to reconstruct traffic states**
  - **Assumption: network traffic states are observable.**
    - Get the observations $Y(t)$ at time t.
    - Use these observations to reconstruct the traffic states $X(t)$: i.e., $X(t) = H^{-1}(Y(t))$.
- **The fact: system observability is increasing! (More data)**
  - Good coverage of loop detectors for both freeways and major arterials
  - Penetration rate of probe vehicles is increasing
  - Real-time connection with field controllers

Our Focus: Arterial Traffic State Estimation

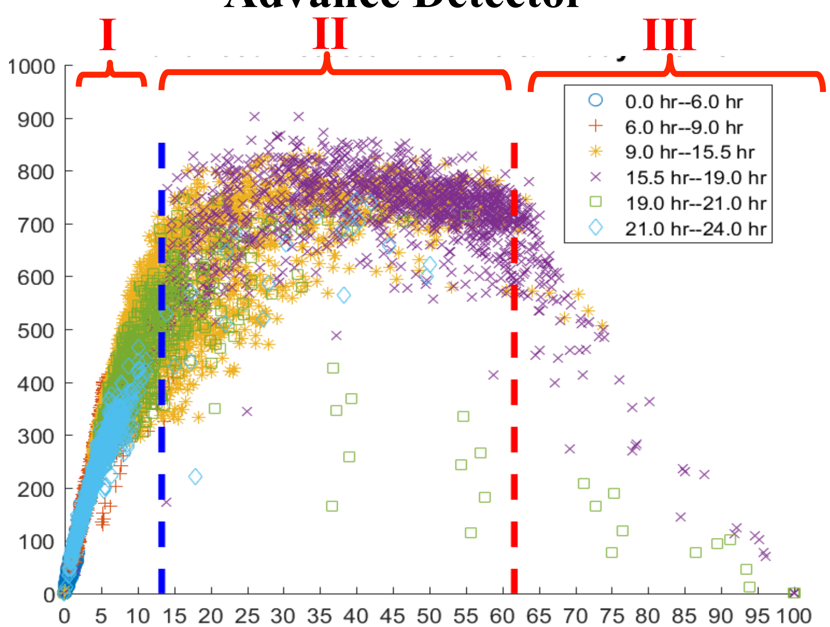
- **Proposed architecture**



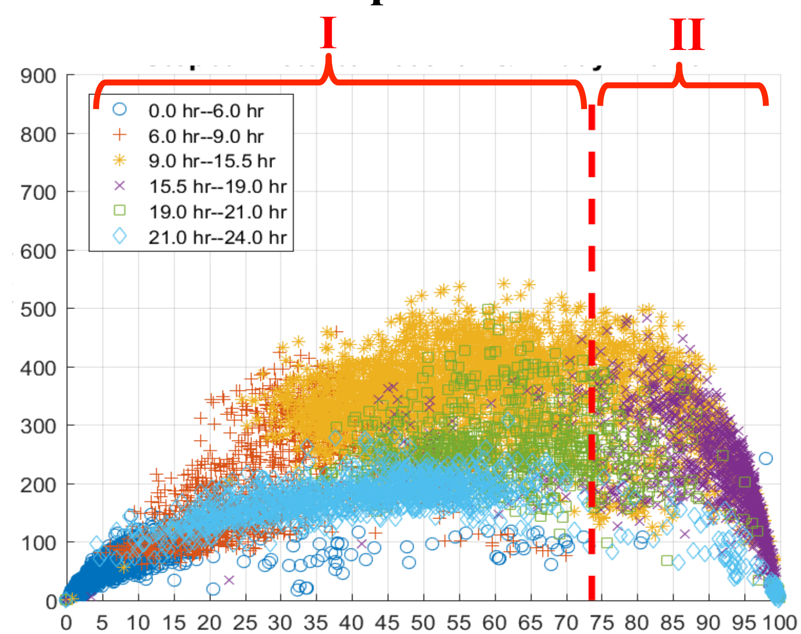
Identification of Traffic States: Key Algorithm

- Occupancy thresholds are ***explicitly*** calculated based on road geometry, sensor placement, signal settings, and vehicle headway.

Advance Detector



Stopbar Detector

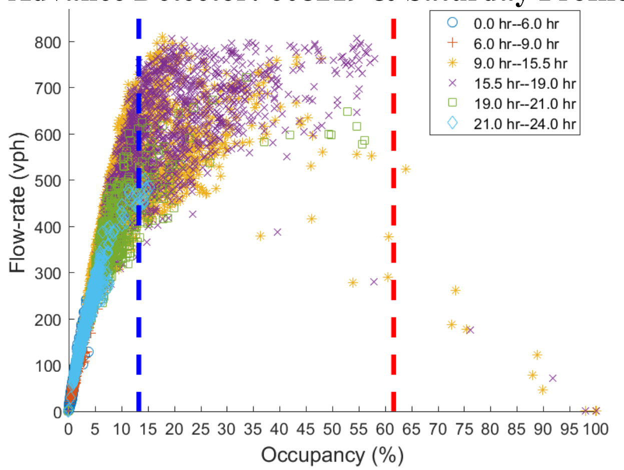


- Regime I: Uncongested (Free-flow)
- Regime II: Congested (Queue forms, but the downstream is free)
- Regime III: Spillback (Queue extends from the downstream)

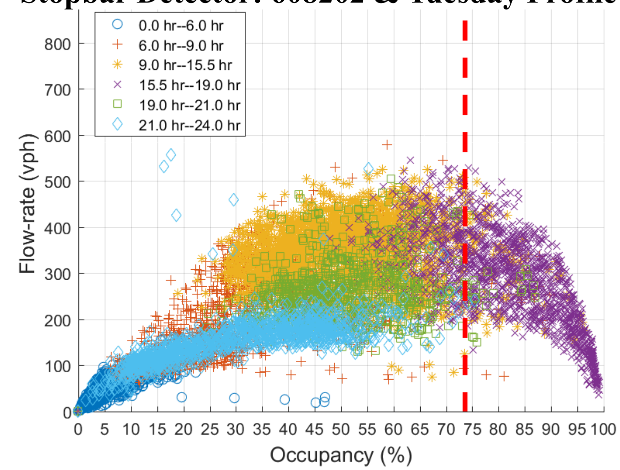
- Regime I : Uncongested
- Regime II : Congested/Spillback

Identification of Traffic States: Field Validation

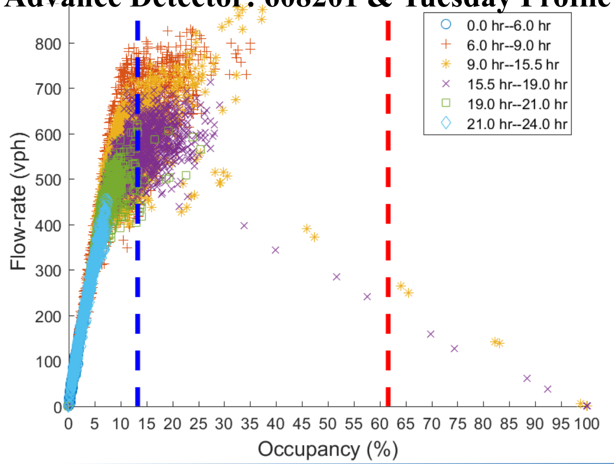
Advance Detector: 608219 & Saturday Profile



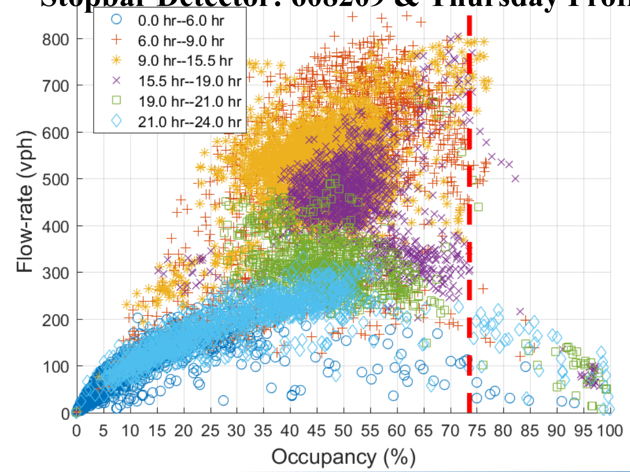
Stopbar Detector: 608202 & Tuesday Profile



Advance Detector: 608201 & Tuesday Profile

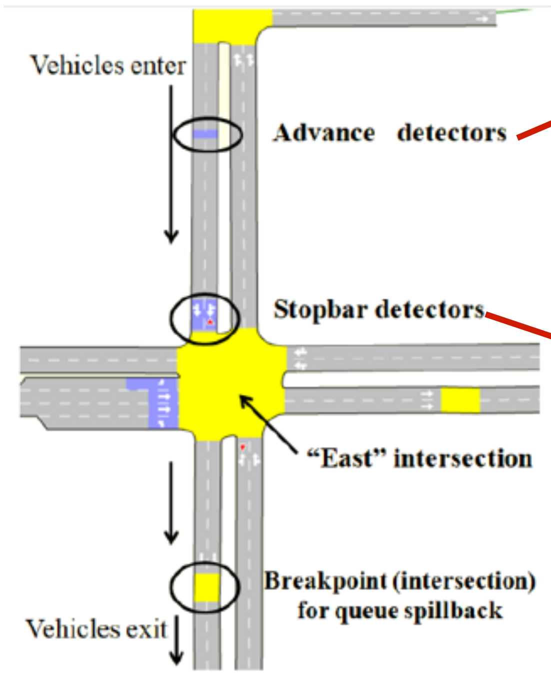


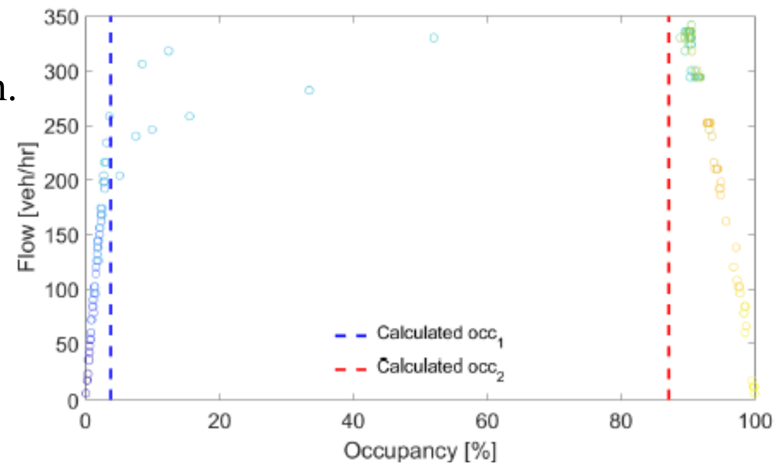
Stopbar Detector: 608209 & Thursday Profile

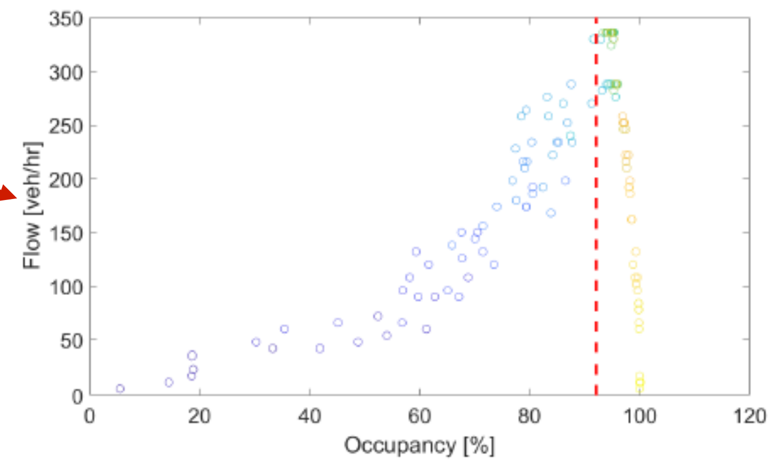


Identification of Traffic States: Simulation Validation

- **Simulation is done using Aimsun**
  - Demand gradually increases to create congestion.
  - Downstream bottleneck is activated for a certain time period to generate queue spillback.







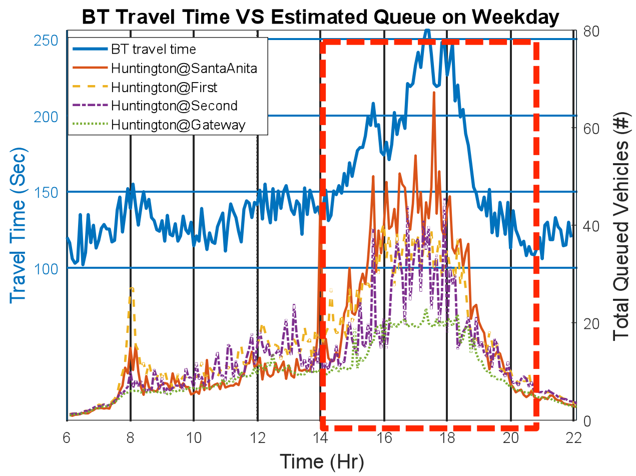
Validation of Queue Estimates: Proposition and Test Site

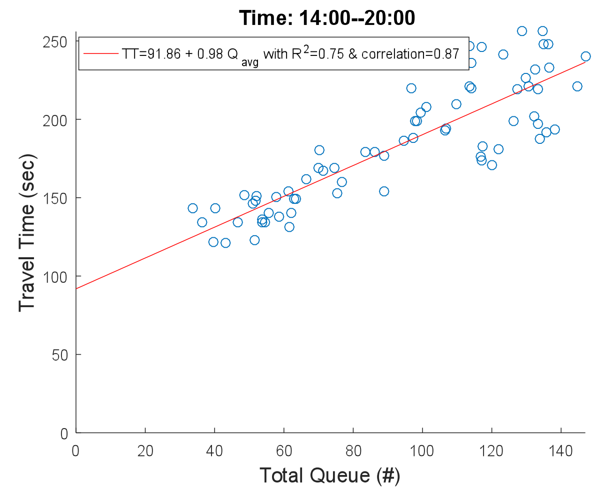
- **Proposition: A linear relation between *Travel Time* and *Total Queue* under traffic congestion, if we assume**
  - Similar intersection geometries and signal settings along an arterial.
  - Two vehicle states (Herman and Prigogine, 1979): either stopped or moving at speed v_0.
  - Traffic delay calculated by the HCM method (HCM, 2000).

- **Test Site**

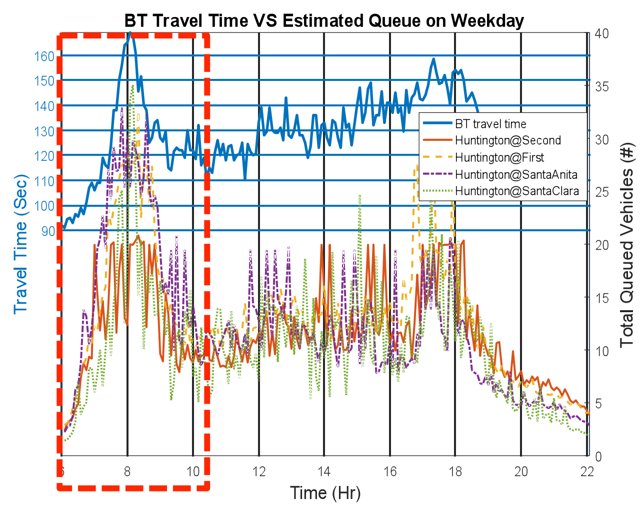
Validation of Queue Estimates: Results

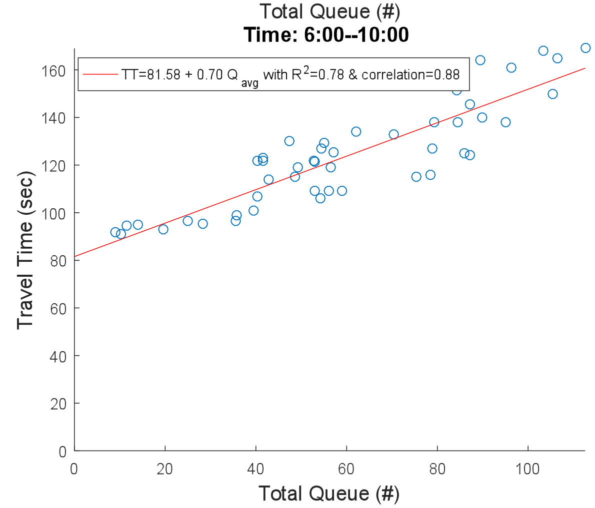
Eastbound





Westbound



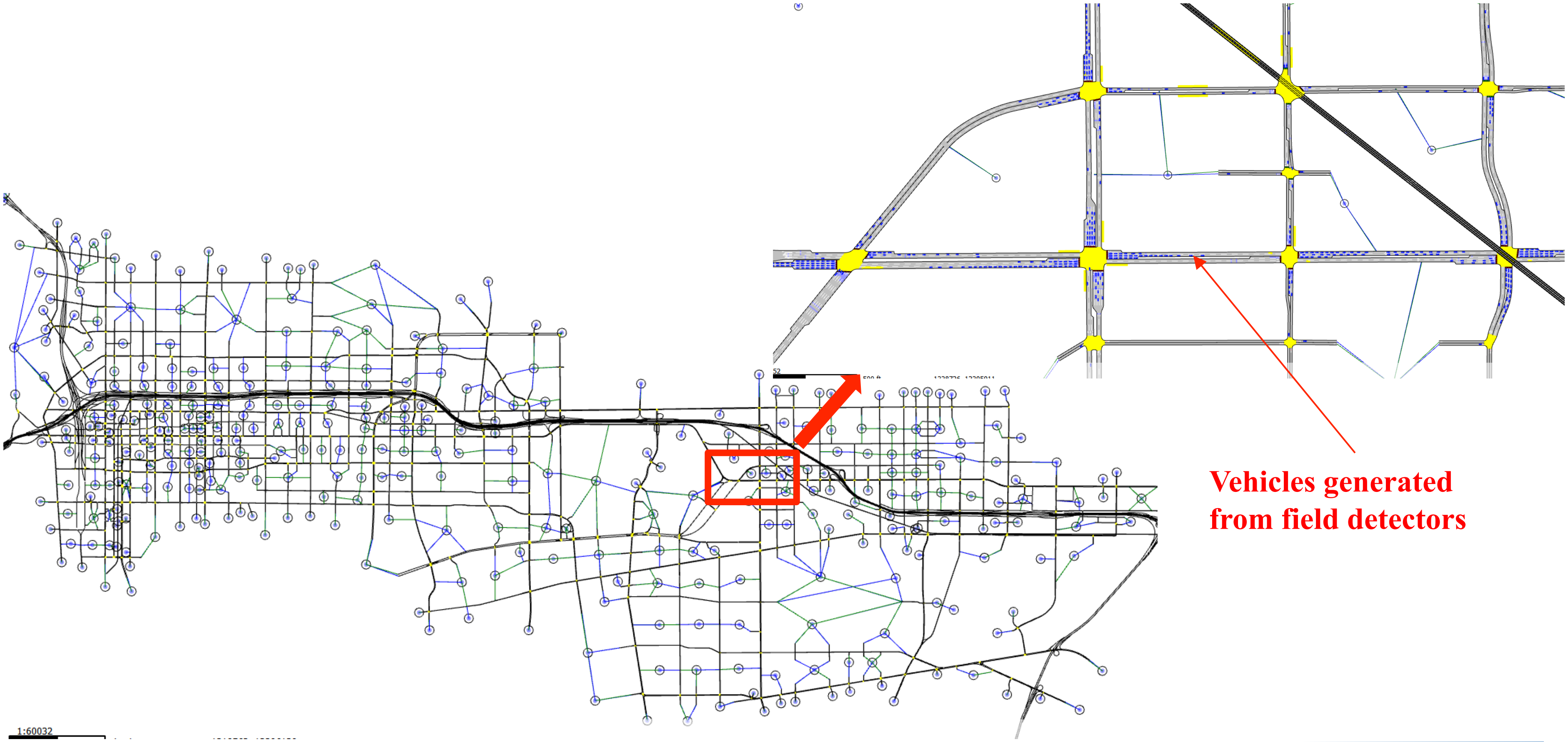


Initial Traffic States in Aimsun: Algorithms

- **Generating simulated vehicles**
  - Conversion: from average queue to both queued and moving vehicles
    - Adjusted using signal settings from the field
  - Vehicle generation: vehicles with attributes of lane ID, turning movement, and OD information
    - Based on the Aimsun network and simulation backup
  - Vehicle assignment
    - Criteria (for each turning movement)
      - Queued vehicles first, and moving vehicles next
      - Vehicle assignment from downstream to upstream
      - When dedicated lanes are full, vehicles are assigned to the adjacent lanes
- **Overwriting active signal phases according to field signal settings**

Initial Traffic States in Aimsun: Application

- The I-210 Connected Corridors Network



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Conclusion

Arterial Data Quality and Traffic Estimation

- **The cloud-based arterial performance dashboard**
  - Is designed for flexibility and scalability.
  - Can be used to evaluate the data quality and monitor the performance of sensor networks.
  - More features will be added in the near future.
- **Arterial traffic state estimation**
  - Has been validated using observations from the field and simulation.
  - Is being applied to the I-210 Connected Corridor Pilot.
  - Will be improved by incorporating probe data in the near future.
- **If you are interested in knowing more about the I-210 Connected Corridors Project, please contact:**
  - PI: Prof. Alex Bayen (bayen@berkeley.edu)
  - Program Manager: Joe Butler (joebutler@path.berkeley.edu)

Thank you!