Connected Corridors
Face-to-Face Meeting

Tuesday, August 6th, 2019
1:30 – 3:30 pm
Pasadena
Agenda

- 1:30 - 2:00 – Program Review
- 2:00 - 2:20 – Call for Projects Update
- 2:20 – 2:50 – Cal Poly Presentation
- 2:50 – 3:20 – Response Plan Metrics
- 3:20 - 3:30 – Closing
  - Next Meeting at Monrovia – Tuesday September 17th
  - (Monrovia, Duarte, Caltrans, County, Arcadia, Pasadena)
MAHMOUD HAJJAR - Corridor Manager

Mahmoud graduated with a Bachelor of Science Degree in Civil Engineering from the University of Oklahoma in 1981. After graduation, Mahmoud worked in the private sector as a Geotechnical Engineer.

He began his career with Caltrans District 7 in 1990 in the Division of Construction, where he worked as a Resident Engineer performing Construction Management. He joined the Division of Traffic Operations in 1995 as a lead engineer.

Mahmoud lives in San Dimas with his wife and three daughters.
Schedule Discussion – System Testing

- We anticipate system launch in the second half of next year
  - Goal – Ready for the ITS World Congress in LA in October 2020

- We anticipate system testing starting in January
  - All C2C interfaces (sans McCain) completed in October
  - ATMS upgrade moved to production end of August
  - Testing of ability to set plans on bench controllers in September
  - Ability to generate response plans in November based on input from ATMS
  - Kapsch initial release ready in December
  - System testing in January
  - Possible production testing on selected routes where ITS elements are available in first/second quarter 2020
Systems Engineering Next Steps

- Design Documents – Details of interfaces and implementations
- Hardware/Software – Building the system
- Integration – Subsystems will come on line this year
Summary
Freeway Data Quality

- Core I-210 sensor availability recovered from 19-day outage
- Great results at this time

I-210 PM 22.6 - 25
- EB 80.0% --- good
- WB 92.9% --- great

I-210 PM 25 - 43.25
- EB 92.7% --- great
- WB 95.8% --- great

SR-134 PM 11.4 - 13.5
- EB 95.9% --- great
- WB 96.6% --- great

I-605 PM 22.93 - 28
- NB 89.4% --- very good
- SB 82.7% --- very good
Response Plans

- **Signal plan review and validation**
  - Pasadena has installed plans along Corson and Maple
  - Arcadia and LA County have agreed to begin bench testing of plans
  - Bench testing will check for valid plans
  - We will also bench test ability to set a plan and to return to normal operation

- **New structure for response plan building**
  - Nicely captures multi-route plans in playbooks and pages
  - Reviewing process to generate these playbooks and pages
Response Plan Data Model
C2C Networking

- We designed, built, and deployed a C2C network connection monitor, including a dashboard. This is running for the Development environment.

- This is very high level and just checks if we can connect from the cloud to each C2C endpoint.

- Several network-related hiccups occurred in July, including some D7 TMC VPN server service interruptions and a RIITS outage. We worked with stakeholder partners on resolution of these issues.

- No progress with D7 TMC IT & RIITS personnel regarding the establishment of secure user access to the ICM application.
High Level Network Monitoring Utility
High Level Network Monitoring Utility
Arterial Data Quality

- **Arcadia’s TCS server and the IEN**
  - We continue to collect and process data from these two data sources.
  - A weekly detector health report for Arcadia is sent to the AMS team.

- **KITS**
  - We updated the data quality report on the TMDD messages from LACO.
  - We plan to send this report to Kimley Horn this week.

- **Data Hub**
  - We are retrieving TMDD Inventory and Status messages 24/7 and save them to a local MongoDB for analysis and modeling purposes.
Detector configuration update for Arcadia

- We found a number of changes had been made since the last update of detector configuration in Mid 2017.
- We generated the latest detector inventory from the data retrieved from the data hub.
- We then used it to update/correct the detector configuration file and sent the revised version to the AMS team.
- We also generated a new set of historical data (24hrs) for the detectors in Arcadia using the data collected in Year 2019 for modeling and calibration purposes.
Keeping track of network changes

- Network/plan changes happen frequently
  - New elements
  - Changes sensor configuration
  - New plans
  - Roadway changes

- Knowing the correct state of the network and the ITS elements is essential to estimation, prediction, data quality determination, response plan generation and visualization
Aimsun Model

- **Some statistics:**
  - 2579 signal control plans
  - 7312 detectors
  - Over 1000 lane miles of roadway
  - 4242 road sections
  - 1748 nodes
  - 395 trip origin / destination nodes
General Model Updates

- **Migrated from Aimsum 8.2.4 to Aimsun 8.4.1**
  - Provides more refined capability for modeling behavior during incidents
  - Fix a few bugs

- **Network geometry**
  - Updated the geometric modeling of metered ramps to improve vehicle behavior under high flows when meter is green balled or off

- **Reference flow data**
  - Updated the PeMS flow data used as reference for calibration (to account for improved detection and detection issues being fixed)
  - February-April 2019 period used as primary source of information
General Model Updates

- **Ramp meters**
  - Updated the timing parameters of meters on San Gabriel, Altadena, Hill and Lake on-ramps on I-210 WB to reflect recent operational changes
    - Changes first noticed through increased flow processed through ramps in PeMS
    - Later confirmed with the reception of new timing sheets from Caltrans
  - Waiting on Caltrans to provide updated timing sheets for rest of corridor
    - Most sheets used for modeling were obtained in 2016

- **New arterial data available for calibration**
  - We use to see how accurate the model has previously been on arterials
C2C Interface Implementations - Status

KITS
Transparity
TransSuite
Sign Vendor
Caltrans ATMS

DSS
Data Hub
TSS Model Interface (Optional)

Kapsch
Parsons
Telegra

TMDD Tested Interface

TMDD Tested Interface

TMDD Tested Interface

TMDD Tested Interface

KITS
Transparity
TransSuite
Sign Vendor
Caltrans ATMS
Systems Integration

- **Arcadia**
  - Data acquisition technical testing completed
  - Data analysis report completed. One important issue found.
  - Determining how to fix this issue.
  - Bench testing planned for completion in September
  - Working on response plan termination process

- **LA County**
  - Data acquisition technical testing completed
  - Data issues report in review. Several items for discussion.
  - Bench testing planned for completion in September
  - Termination process agreed upon

- **Pasadena**
  - Approved high level design. Awaiting updates to detail design, verification plan, test endpoint from McCain.
Systems Integration

- **TSMSS**
  - Have tested ability to read data
  - Configuration data should be loaded by end of month
  - Bench testing planned to be completed by end of September

- **ATMS**
  - ATMS modified to support I-210 CC system – May 2019
  - Parsons and PATH working together to support arterial event testing
  - Software updates occurring based on testing
  - Testing is ongoing
  - ATMS needs to be moved to production for us to test with real data
  - Termination process agreed upon for CMS signs, ramp metering in discussion
Systems Development

- **Ongoing system development**
  - Upgraded to MongoDB clusters – data reliability and persistence requirement
  - Improving workflow processing and orchestration (incident lifecycle management workflows, Corridor Management System/Data Hub process communication – should be in test this month
  - Fixed inventory messages structure and fixed an issue with data received without time zone information

- **Improve release frequency – Permits rapid response to problems**
  - Working on allowing release of individual micro-services on demand instead of full subsystems (DH, DSS) every release. Much easier to coordinate and assemble releases.

- **Improve deployment capabilities**
  - Create environment for verifying infrastructure as code, reduce disruption to developers
I-210 Integrated Corridor Management
Kapsch Update

Tim O’Leary
August 6, 2019
I-210 CALTRANS Pilot

EcoTrafiX

- Product Status

- Interface Status
EcoTrafiX Product Status

- In progress:
  - Provide import/export access to EcoTrafiX Response Plans
  - Align lane status (clear/blocked) with ICM arterial movements
  - Tailor agency Response Plan voting
EcoTrafiX Interface Status

- Publish Events to Hub – ready to integrate with DSS
- Receive Events – simulated until ATMS is available in AWS
- Response Plans – ready to receive from DSS
- Traffic Signals live from Arcadia & some LA County signals
- DMS – receiving from Hub
- Ramp Meters – receiving from Hub (simulated from ATMS)
- Response Plan Item Execution – ready to integrate with TMCs
EcoTrafiX Status

Interface

- Integrated
- Ready to integrate
- In development

TMCs
- Arcadia
- LA County
- Others

Caltrans ATMS
- Ramp Meter Commands
- Center Active
- Voting
- Events
- Response Plans

EcoTrafiX (CMS)
- Ramp Meters
- DMS
- Signal Controllers
- Response Plans
- DMS Commands
- Signal Controller Commands

PATH HUB
EcoTrafiX Status

Next Steps

- EcoTrafiX send Events to HUB
- Integrate with PATH’s Hub
- DSS send Response Plans to EcoTrafiX
- Integrate with CALTRANS ATMS
- ATMS send Events to EcoTrafiX/HUB
- EcoTrafiX exchange Voting with ATMS
- EcoTrafiX send Response Plans to ATMS
- EcoTrafiX exchange Center Active with ATMS
Thank You!

Kapsch TrafficCom

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I-210 Connected Corridors
Face-to-Face Meeting

City of Pasadena,
Grand Conference Room, 100 N Garfield Avenue,
Pasadena, CA 91101
Tuesday, August 6, 2019
1:30 – 3:30 pm
Agenda

- I-210 CC Arterial Systems Improvement Project
  System Consulting Services – Scope

- Expected Timeline

- Status of 9 procurement package

- Next Steps
## Project Objective

- Assist Caltrans D7 to manage the execution of the 9 arterial ITS improvement projects

<table>
<thead>
<tr>
<th>#</th>
<th>Package Description</th>
<th>Contract #</th>
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<tr>
<td>1</td>
<td>Bluetooth – Iteris Velocity</td>
<td>07A4470</td>
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<td>New Controller Cabinets</td>
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<td>4</td>
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<td>Awarded, in Progress</td>
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<td>6</td>
<td>Video Detection System</td>
<td>07A4481</td>
<td>Awarded, in Progress</td>
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<td>7</td>
<td>Data Communication Module and Video Detection Software Upgrade</td>
<td>07A4601</td>
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<td></td>
<td></td>
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<td>Integration - Under DPAC Review</td>
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<td>Static Signs – Caltrans, in Progress</td>
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<td>9</td>
<td>Environmental Stations with Air Quality Sensors and Open Data Systems</td>
<td>07A4388</td>
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## Project Area

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<th>Package Description</th>
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<th>City of Pasadena</th>
<th>City of Arcadia</th>
<th>City of Monrovia</th>
<th>City of Duarte</th>
<th>LA County</th>
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Project Area (cont.)
UPDATE ON
PACKAGES 1-9
# Target Timeline - 6 awarded Packages

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<th>2019</th>
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<td>Equipment Procurement &amp; Delivery</td>
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<td>Test Plan/Procedure</td>
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<tr>
<td>Training</td>
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Soft Launch of I-210 CC System (Est.)
## Target Timeline - 3 Unawarded Packages

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<th>2020</th>
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Hard Launch of I-210 CC System (Est.)
## Update on 9 Packages

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| 1     | Bluetooth – Iteris Velocity | 07A4470 PTM  | • NTP: 7/10/2018  
• Kick-off Meeting: 7/30/2018  
• Submittal Approved: 8/16/2018  
• Installation & Testing Completed on 5/29 & 5/30/2019  
• Accepted by Arcadia  
• Documents Submitted  
• Completed |
| 2     | Bluetooth – BlueToad  | 07A4477 DBX  | • NTP: 7/10/2018  
• Kick-off Meeting: 7/30/2018  
• Submittal Approved: 10/12/2018  
• Installation QC checklist & Test Procedure: Submitted for Stakeholders’ Review  
• LA County: VM server configured on 5/15/2019; scheduling field installation  
• Pasadena: Physical server to be procured and configured  
• Expected to be completed: September 2019 (80%) |
### Update on 9 Packages (cont.)

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</table>
| 3      | New Controller Cabinets    | 07A4603     | • Disqualified: Bids came above the SB limit (314k).  
• Procurement Package revised per Stakeholder comments on Pkg. 5  
• Cancelled by DPAC in the week of Mar 15, 2019  
• Revised package (reduce reference, service contract not engineering contract) being reviewed by DPAC  
• Expected to be advertised: Aug, 2019  
• Expected to be completed: First Quarter, 2020 |
| 4      | Communication Upgrades     | 07A4479 Kanaan Construction | • NTP: 7/13/2018  
• Kick-off Meeting: 7/30/2018  
• Submittal & RFI Approved: 5/6/2019  
• Equipment procured  
• Installation QC checklist & testing plan being prepared  
• Installation to be scheduled  
• Expected to be completed: October 2019 (80%) |
Update on 9 Packages (cont.)

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| 5      | Firmware/Timing Plan Updates/Controller Upgrades | 07A4480 CPE, Inc | • NTP: 7/17/2018  
• Kick-off Meeting: 7/30/2018  
• Submittal Reviewed but Required Equipment changed per Stakeholder Comment  
• Contractor revised price estimate ($115,695.80) lower than original amount ($171,600.00) – being reviewed by stakeholders  
• To present to DPAC for approval  
• Expected to be completed: October 2019 (80%) |
### Update on 9 Packages (cont.)

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| 6      | Video Detection System  | 07A4481       | • NTP: 7/10/2018  
• Kick-off Meeting: 7/30/2018  
• 10/9/2018: Conducted Site Survey  
• 10/18/18: Submittal approved  
• Installation:  
  • 18 out of 22 installations are completed (2 LA County, 5 Monrovia, 3 Arcadia, 8 Pasadena)  
  • 3 locations in Duarte – pull boxes & conduits are full; City will fix  
  • 1 location in Pasadena: conduit too small. Contractor provided cost estimate  
• Expected to be completed: September 2019 (90%) |
| 7      | Data Communication Module and Video Detection Software Upgrade | 07A4601       | • Disqualified: Bids came above the SB limit (314k).  
• Originally cancelled by DPAC;  
• Revised Package (service contract not IT contract) being reviewed by DPAC for further consideration  
• Expected to be awarded: Aug, 2019  
• Expected to be completed: First Quarter, 2020 |
## Update on 9 Packages (cont.)

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| 8      | Advanced Traveler Information Systems                                         | N/A        | • Divided to 3 parts:  
  - DMS Procurement – being reviewed by DPAC  
  - Integration – being reviewed by DPAC  
  - Static Sign Procurement - ordered by Caltrans Maintenance Group, may take up to 6 months  
  • Expected to be awarded: Aug, 2019  
  • Expected to be completed: Second Quarter, 2020 |
| 9      | Environmental Stations with Air Quality Sensors and Open Data Systems (ODS)   | 07A4388    | Cal Poly Pomona  
• NTP: 6/29/18  
• Kick-off Meeting: 7/12/18  
• Environmental stations  
  • Roadside study done  
  • Field installation done – 6/7/19  
  • Collect data and analyze data - ongoing  
• ODS  
  • CPP continuously coordinates with PATH  
• Expected to be completed: Dec 2019 (80%) |
Next Steps

- Package 2: Review Test Procedure; schedule installation in LA County; Procure & configure server in Pasadena
- Package 3: Tracking status
- Package 4: Prepare documentation
- Package 5: Review revised scope & cost estimate
- Package 6:
  - Follow up with Duarte on the pullbox/conduit fixing progress
  - Review cost estimate (RFI # 4) for 1 location in Pasadena
- Package 7: Tracking status
- Package 8: Tracking status
- Package 9: Support coordination
Thank You and Questions?
ENVIRONMENTAL IMPACT EVALUATION FOR I-210 CONNECTED CORRIDOR PILOT PROJECT

PROGRESS REPORT

XUDONG JIA, PH.D., PE; XINKAI WU, PH.D.; CAL POLY POMONA
ALLEN CHEN, PE; GEROMAR, HASTA; LEILA SY; CALTRANS DISTRICT 7

AUG. 06, 2019
Tasks

- To evaluate the air quality before and after the deployment of the CC project, the project needs to collect high frequency data including:
  - Toxic gases (CO, NO, NO2, O3, SO2, CO2);
  - Particulates (PM1, PM2.5, PM10);
  - Meteorological data (temperature and relative humidity); and
  - Potential traffic data (traffic flow, vehicle types, speed, etc.).

- Other specific features include:
  - Allow remote access for customized data collection and configuration through Linux system;
  - Support 3G/4G cellular communication through multiple carriers;
  - Low power usage;
  - Support to use solar panel power;
  - An integrated device that supports data collection and transmission;
  - Portable;
  - Provide ready-to-mount for easy implementation;
  - Provide a camera for field condition monitoring;
  - Provide unique feature of traffic data collection (optional); and
  - Low-cost.
Device: iAQBox

- iAQBox (intelligent Air Quality measure Box)
- A Roadside Air Quality Measurement Device, customized from CLR Analytics Inc.
- Fulfill all required functions
- Portable
- Low-cost
- Solar power supported
iAQBox: Overview

- Wind speed & direction, camera
- PM2.5 & PM10 detector
- Temperature & Humidity detector
- Waterproof box
- Built-in battery
- 12V Solar charge controller
- 12V to 5V Voltage converter
- Raspberry pi 3b
- GPS Module
- USB3.0 4Port Hub
- 5V Relay
- Gas detectors for CO, CO2, O3, SO2, NO, NO2
**Database Architecture**

- **Data Collection**
  - iAQBox air quality monitoring station

- **Data Receiving and Processing**
  - AWS Kinesis
  - AWS Lambda function
  - AWS DynamoDB

- **Data Publishing**
  - AWS Lambda function
  - AWS S3
  - AWS API gateway
Field Installation - Mounting on CCTV Poles

- Electricity Power Support
- Potential Ethernet Support
Locations: Two CCTV Poles

Location 1: I-210WB/Carmelo FT452/PM28.09

Location 2: I-210EB W/O Myrtle Ave CCTV-455
Installation Diagram
Field Installation - Mounting on CCTV Poles
Real-Time Data: opendatasym.com
Data Statistics: Real-Time Data

The image shows a web interface for an Open Data System, with a focus on real-time data statistics. A graph displays the CO2 concentration at a specific air station (0027). The measurement and concentration data are provided, with CO2 being the primary focus. The interface includes options for other measurements such as CO, NO, NO2, O3, SO2, PM2.5, PM10, temperature, humidity, pressure, and wind speed.
Data Statistics: Historical Data
Next Step: Associate with Traffic Data
Thank You and Questions?
Response Plan Metrics
Modeling and Evaluation Metrics

- We now have a calibrated model
- We have initial response plans (including signal timing)
- We now what to run these response plans in simulation and compare the before and after metrics
- In order to do so we need to define the metrics we wish to use in evaluating the incidents
- We then need to generate these metrics from the model
- This is a discussion of those metrics, their generation parameters, and an example of running them on a response plan
Response Plan Evaluation Metrics

- **Potential performance metrics**
  - **Demand**
    - Vehicle-miles traveled (VMT)
  - **Mobility**
    - Vehicle-hours of travel (VHT)
    - Average delay
    - Average speed
    - Average travel time
    - Length of congestion/queue along a given roadway
    - Congestion period related to incident
  - **Productivity**
    - Traffic volumes (network, ramps, road sections, etc.)
    - Level of service at intersections
  - **Reliability**
    - Travel time variability
    - Planning time index
  - **Safety**
    - Incident data
Response Plan Evaluation Metrics

- **Metrics that can easily be extracted from simulation results**

  - **Demand**
    - Vehicle-miles traveled (VMT)

  - **Mobility**
    - Vehicle-hours of travel (VHT)
    - Average delay
    - Average speed
    - Average travel time
    - Length of congestion/queue along a given roadway
    - Congestion period related to incident

  - **Productivity**
    - Traffic volumes (network, ramps, road sections, etc.)
    - Level of service at intersections

  - **Reliability**
    - Travel time variability
    - Planning time index

  - **Safety**
    - Incident data

  *Person-based metrics can also be estimated using assumed vehicle occupancy rates*

  *Statistics variability can only be measured if executing multiple runs*
Issues with remaining metrics

Congestion period related to incident

- Can be difficult to determine in a network setting through simple mathematical data processing
- Results may vary depending on section of roadway or area considered
- How to determine deviation from normality, particularly for incidents occurring during peak periods?
- How to handle simultaneous incidents at different locations
- RECOMMENDATION: Warrant further investigation
Issues with remaining metrics

Level of service at intersections

- Average approach delay compiled for each node in Aimsun
- However, analysis only covers links directly connected to node
  - Issue where length of links differ significantly across approaches
  - Full queue may not be adequately captured on all approaches
- Possible to fix calculation using data outputs, but may require extensive analysis setup
- RECOMMENDATION: Inquire with TSS on available options
Response Plan Evaluation Metrics

- **Issues with other metrics leading to their potential exclusion**
  - Planning time index (Time to go from point A to B)
    - Highly correlated to **travel time variability**
    - Only relevant for specific paths
    - Would need to calculate an index for a specific pair of origin-destination nodes that may not be representative of all traffic
    - **RECOMMENDATION:** Simply consider travel time variability
  - Incident data
    - Simulation models do not produce accidents
    - **Incident risk estimation models** can be used, but accuracy would need to be demonstrated
    - **RECOMMENDATION:** Do not consider safety in response recommendations, unless adequate model can be provided
Extraction of Simulation Metrics
Extraction of Metrics from Simulations

- Aimsun stores simulated output statistics in a SQL database

- Database contains information for specific
  - Links
  - Nodes
  - Origin/destination nodes
  - Detectors

- Database can be queried using free SQL analysis tools
Extraction of Metrics from Simulations

- **Link metrics** than can easily be extracted from SQL database
  - Vehicle input count
  - Vehicle exit count
  - VMT
  - VHT
  - Average speed
  - Average travel time
  - Incurred delay (relative to travel time at speed limit)
  - Number of stops
  - Total time spent stopped
  - Size of virtual queue (vehicles unable to enter link from an origin node)
  - Average wait time in virtual queue
Filters can be applied to the stored data to restrict analyses to:

- Entire network
- Links belonging to a specific type of roadway (freeway, ramp, local street, etc.)
- Links/nodes belonging to a specific area
- Specific type of device (detector, signal, etc.)

Filters are simple comma-delimited lists that can be edited in Excel.
Extraction of Simulation Output Metrics

- **Data filters defined so far**
  - Links belonging to **freeway network**, with the following information associated with each link:
    - Freeway association (I-210, SR-134, I-605)
    - Direction of travel (EB, WB, NB, WB)
    - Link type (mainline, HOV, off-ramp, on-ramp, freeway connector)
    - Start milepost
  
  - Links identifying the **start of on-ramps and end of off-ramps**, with the following information:
    - Ramp type (on-ramp, off-ramp)
    - Milepost associated with start or end of ramp
  
  - Links belonging to a **specific area** of network (See zones on next slide)
Extraction of Simulation Output Metrics

- Defined analysis areas - Zones

- Area boundaries based on current set of possible detours
- Areas intentionally overlaps – Can be merged in the analysis
- Areas will also be defined to cover each city
Back of Congestion Search
Incident Creator API was modified to search for the back end of congestion upstream of a given location along the I-210

Search paths:

- **I-210 EB:**
  - Primary scan to end of modeled freeway
  - 2nd scan along SR-134 EB if congestion reaches I-210/SR-134 interchange

- **I-210 WB:**
  - Primary scan to end of modeled freeway
  - 2nd scan along 605 NB if congestion reaches I-210/I-605 interchange
Back of Congestion Search

- **Current search criteria** – *to be changed if needed*
  - Consider a segment to be part of the congestion area is
    - Speed < 30 mph
    - OR
    - Density > 90 veh/mile/lane
    - Flow < 1000 veh/hr/lane *(about half of capacity)*
  
- To account for areas with higher speeds or low density due to shockwaves, short breaks in congested areas are ignored
  - Maximum break between congestion area: 1.0 mile

Should we use 25 or 20 mph to focus on areas with high congestion?

Should we use 0.75 or 0.50 mile?
**Back of Congestion Search**

### Search result examples

**I-210 WB**

**Starting Point:**
I-210 WB between Huntington and Santa Anita

**End of Congestion:**
I-210 WB just downstream of Buena Vista off-ramp

<table>
<thead>
<tr>
<th>Section</th>
<th>Length (mi)</th>
<th>Speed (mph)</th>
<th>Flow (veh/hr)</th>
<th>Density (veh/hr/mi)</th>
<th>Break (mi)</th>
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<tbody>
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</tr>
</tbody>
</table>

***** End of congestion: Section 22383 - Mileposts: 32.43 -> 35.77 (3.33 miles)

**I-605 NB**

**Starting Point:**
I-605 NB / I-210 WB merge

**End of Congestion:**
Split on connector between I-210 EB and I-210 WB branches

<table>
<thead>
<tr>
<th>Section</th>
<th>Length (mi)</th>
<th>Speed (mph)</th>
<th>Flow (veh/hr)</th>
<th>Density (veh/hr/mi)</th>
<th>Break (mi)</th>
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</table>

***** End of congestion: Section 22339 - Mileposts: 28.10 -> 27.39 (0.71 miles)
Evaluation Example 1
Incident

- Incident blocking 3 lanes on I-210 WB near Huntington
  - HOV lane
  - 2 left main lanes

- Occurring at 8:00 AM

- Weekday

- Duration: 1 hour

- Following slides show density
Incident Evaluation

- **Initial Conditions @ 8 AM**

  - I-210 WB congested from Pasadena to Monrovia
  - Congestion in Azusa
Incident Response

Increased green time along route (Cycle 120s → 150s)

Ramp metering set to green ball

Huntington on-ramp set to green AFTER INCIDENT to help flush local traffic

Strategy: Provide added capacity along Huntington/Colorado
→ Favor Huntington off-ramp traffic over WB through

We are not using Santa Anita as per Arcadia’s request

Information Signs
Traffic Congestion

- **Without response @ 9 AM**
  - Less congestion downstream due to lanes blocked

- **With response @ 9 AM**
  - Reduced congestion on local streets
  - Virtual queue 1415 veh (1.34 mi)
  - Virtual queue 1080 veh (1.02 mi)
Traffic Congestion

- Without response @ 9:30 AM
  - Virtual queue 2381 veh (~2.25 mi)
  - Some leftover congestion from increased local traffic

- With response @ 9:30 AM
  - Virtual queue 1897 veh (~1.80 mi)
Traffic Congestion

- **Without response @ 10 AM**
  - Virtual queue 2767 veh (~2.62 mi)

- **With response @ 10 AM**
  - Virtual queue 2302 veh (~2.18 mi)
Ramp Count Deltas – End of 1st Hour

60 min into incident
45 min into response

Overall +115
Huntington +131
Myrtle -88
Mountain +35
Buena Vista +3
Mt Olive +22
Irwindale +12

Outflow reduction at Myrtle due to more vehicles attempting to exit at Huntington
Outflow reduction at upstream exits due to more vehicles being able to exit Huntington or Myrtle.
Response Evaluation – End of 1st Hour

- Impact on VMT, VHT and delay, 8 AM → 9 AM

Zones 5-6-7
- VMT: -143 veh-mi (-0.1%)
- VHT: -98 veh-hrs (-1.1%)
- Delay: -106 veh-hrs (-2.0%)

NOTE: Zones overlap

Zone 4
- VMT: +336 veh-mi (+0.6%)
- VHT: -40 veh-hrs (-1.0%)
- Delay: -51 veh-hrs (-2.7%)

Zone 5
- VMT: +386 veh-mi (+0.8%)
- VHT: -90 veh-hrs (-2.2%)
- Delay: -111 veh-hrs (-4.2%)

Zone 6
- VMT: +145 veh-mi (+0.3%)
- VHT: -49 veh-hrs (-1.3%)
- Delay: -59 veh-hrs (-2.3%)

Zone 7
- VMT: -436 veh-mi (-0.5%)
- VHT: -17 veh-hrs (-0.3%)
- Delay: -10 veh-hrs (-0.3%)
Impact on VMT, VHT and delay, 8 AM → 10 AM

**Zone 4**
- VMT: +1070 veh-mi (+0.9%)
- VHT: +153 veh-hrs (+2.2%)
- Delay: +123 veh-hrs (+3.4%)

**Zone 5**
- VMT: +456 veh-mi (+0.5%)
- VHT: -187 veh-hrs (-2.3%)
- Delay: -204 veh-hrs (-3.9%)

**Zone 6**
- VMT: +327 veh-mi (+0.4%)
- VHT: -246 veh-hrs (-3.2%)
- Delay: -255 veh-hrs (-5.0%)

**Zone 7**
- VMT: +907 veh-mi (+0.5%)
- VHT: -370 veh-hrs (-2.8%)
- Delay: -390 veh-hrs (-4.5%)

**Zones 5-6-7**
- VMT: +1262 veh-mi (+0.5%)
- VHT: -434 veh-hrs (-2.4%)
- Delay: -465 veh-hrs (-4.0%)

Increased VMT, reduced VHT → Reduced congestion

NOTE: Zones overlap
Response Evaluation – End of 1st Hour

- Impact on freeway operations, 8 AM → 9 AM

**I-210 WB: I-605 → Incident**
- VMT: +142 veh-mi (+1.2%)
- VHT: +9 veh-hrs (+0.5%)
- Delay: +6 veh-hrs (+0.4%)

VMT / VHT (Avg speed): 6.8 mph → 6.9 mph

**I-210 WB: East of I-605**
- VMT: +40 veh-mi (+0.2%)
- VHT: +14 veh-hrs (+0.9%)
- Delay: +14 veh-hrs (+1.2%)

VMT / VHT (Avg speed): 12.7 mph → 12.6 mph
Virtual Queue: -51 veh (-0.0 mile)

**I-605 NB**
- VMT: -170 veh-mi (-2.3%)
- VHT: -9 veh-hrs (-1.6%)
- Delay: -5 veh-hrs (-1.2%)

VMT / VHT (Avg speed): 13.2 mph → 13.1 mph

Increased VMT and VHT, similar speed
→ Delay increase due to freeway processing more vehicles
Response Evaluation – End of 2nd Hour

- Impact on freeway operations, 8 AM → 10 AM

**I-210 WB: I-605 → Incident**
- VMT: -332 veh-mi (-1.1%)
- VHT: +63 veh-hrs (+1.7%)
- Delay: +71 veh-hrs (+2.4%)
- VMT / VHT (Avg speed): 8.3 mph → 8.1 mph

**I-210 WB: East of I-605**
- VMT: +500 veh-mi (+1.2%)
- VHT: -238 veh-hrs (-6.8%)
- Delay: -248 veh-hrs (-8.5%)
- VMT / VHT (Avg speed): 10.7 mph → 11.6 mph
- Virtual Queue: -467 veh (-0.4 mile)

**I-605 NB**
- VMT: -14 veh-mi (-0.1%)
- VHT: +49 veh-hrs (+3.6%)
- Delay: +50 veh-hrs (+4.6%)
- VMT / VHT (Avg speed): 10.1 mph → 9.8 mph

*Decreased VMT, increased VHT → Increased congestion partly due to measures to flush local traffic*

*Increased VMT, reduced VHT and virtual queue → Reduced congestion*
General Observations

- **Overall observation:**
  - Delay Reduction with increased VMT
  - Queue length decreased
  - This is at rush hour so this is a difficult environment

- **Significant benefits typically obtained from continuing response after incident has cleared**
  - Traffic signals along detour kept in operation for 15-30 minutes
  - Ramp meters at key on-ramps set to green to prevent automatic flow reduction while the freeway queue is being processed

- **Allows traffic on local street to get back quicker on freeway**
  - Additional delay savings
General Observations

- VMT will often go up in corridor up as vehicles are pushed on longer routes

- Use of longer routes will tend to increase VHT
  - Objective: Reduce delay significantly to overcome the increase in VHT

- Freeway delay savings may be eaten up by delay increase on local streets

- VHT and delay increases may simply be the result of more vehicles traveling on a section of road
  - Need to focus on delay per vehicle

- VMT and VHT do not measure safety benefits that result from keeping traffic moving better and having shorter queues
  - Less impatient drivers → Increased safety?
Strategy: Provide added capacity along Huntington to absorb inflow from Myrtle, Mountain and Mt Olive

Penalize Huntington exit

Does not help left turn onto Huntington
Response Evaluation – End of 2nd Hour

- Impact on freeway operations, 8 AM → 10 AM

**I-210 WB: I-605 → Incident**
- VMT: -191 veh-mi (-0.6%)
- VHT: +51 veh-hrs (+1.4%)
- Delay: +55 veh-hrs (+1.9%)
- VMT / VHT (Avg speed): 8.3 mph → 8.1 mph

**I-210 WB: East of 605**
- VMT: +1311 veh-mi (+3.2%)
- VHT: -175 veh-hrs (-4.6%)
- Delay: -202 veh-hrs (-7.0%)
- VMT / VHT (Avg speed): 10.7 mph → 11.6 mph
- Virtual Queue: -665 veh (-0.60 mile)

**I-605 NB**
- VMT: -331 veh-mi (-2.3%)
- VHT: +116 veh-hrs (+8.4%)
- Delay: +123 veh-hrs (+11.5%)
- VMT / VHT (Avg speed): 10.1 mph → 9.1 mph

Decreased VMT, increased VHT
→ Increased congestion partly due to measure to flush local traffic

VMT Increase, reduced VHT, reduce virtual queue → Reduced congestion
Evaluation Example 2
Same Incident – Different Response

- **Same Incident**

- **Different Strategy:**
  - Provide added capacity along Huntington to absorb inflow from Myrtle, Mountain and Mt Olive
  - Penalize Huntington exit
  - Does not help left turn onto Huntington
Incident Response – End of 1st Hour

**Strategy:** Provide added capacity along Huntington to absorb inflow from Myrtle, Mountain and Mt Olive

→ Penalize Huntington exit
→ Does not help left turn onto Huntington

**Increasing Green Time along Route** (Cycle 120s → 150s)

**Ramp Metering Set to Green Ball**

**Huntington Meter Set to Green After Incident to Help Flush Local Traffic**

**Arcadia Asked Not to Send Traffic up Santa Anita**

**Information Signs**

**Increase WB Green to Facilitate Freeway Exit** (Cycle 90s → 135s)

**Signals in Opposite Direction also Changed to Help Traffic on Short Blocks Under the Freeway**
Traffic Congestion

- Without response @ 9 AM
  - Less congestion downstream due to lanes blocked
  - Virtual queue 1415 veh (~1.34 mi)

- With response @ 9 AM
  - Reduced congestion on local streets
  - Virtual queue 1128 veh (~1.07 mi)
Traffic Congestion

- Without response @ 9:30 AM
  - Virtual queue: 2381 veh (~2.25 mi)

- With response @ 9:30 AM
  - Virtual queue: 2057 veh (~1.95 mi)
Traffic Congestion

- **Without response @ 10 AM**
  - Virtual queue 2767 veh (~2.62 mi)

- **With response @ 10 AM**
  - Virtual queue 2107 veh (~2.00 mi)
Ramp Counts – End of 1st Hour

60 min into incident
45 min into response

Overall +90
Huntington -304
Myrtle +310
Mountain -3
Buena Vista +30
Mt Olive +55
Irwindale +2

Outflow at Huntington constrained by signal and congestion on Huntington
Ramp Counts – End of 2nd Hour

Overall +201
Huntington -447
Myrtle +634
Mountain -92
Buena Vista +33
Mt Olive +275
Irwindale -202
Response Evaluation – End of 1st Hour

- Impact on VMT, VHT and delay, 8 AM → 9 AM

**Zones 5-6-7**
VMT: -335 veh-mi (-0.3%)
VHT: -4 veh-hrs (-0.1%)
Delay: -6 veh-hrs (-0.1%)

**NOTE:** Zones overlap

**Zone 4**
VMT: +287 veh-mi (+0.5%)
VHT: +79 veh-hrs (+2.2%)
Delay: +65 veh-hrs (+3.4%)

**Zone 5**
VMT: +212 veh-mi (+0.5%)
VHT: +35 veh-hrs (+0.9%)
Delay: +22 veh-hrs (+0.8%)

**Zone 6**
VMT: +129 veh-mi (+0.3%)
VHT: +23 veh-hrs (+0.6%)
Delay: +13 veh-hrs (+0.5%)

**Zone 7**
VMT: -428 veh-mi (-0.4%)
VHT: -4 veh-hrs (-0.1%)
Delay: +2 veh-hrs (+0.1%)
Response Evaluation – End of 2\textsuperscript{nd} Hour

- Impact on VMT, VHT and delay, 8 AM $\rightarrow$ 10 AM

**Zones 5-6-7**

- VMT: +2260 veh-mi (+0.9%)
- VHT: -569 veh-hrs (-3.1%)
- Delay: -634 veh-hrs (-5.5%)

Increased VMT, reduced VHT $\rightarrow$ Reduced congestion

**NOTE:** Zones overlap

**Zone 4**
- VMT: +1288 veh-mi (+1.6%)
- VHT: +173 veh-hrs (+2.6%)
- Delay: +113 veh-hrs (+3.1%)

**Zone 5**
- VMT: +1033 veh-mi (+1.1%)
- VHT: -331 veh-hrs (-4.1%)
- Delay: -373 veh-hrs (-7.2%)

**Zone 6**
- VMT: +1364 veh-mi (+1.5%)
- VHT: -299 veh-hrs (-4.0%)
- Delay: -344 veh-hrs (-6.7%)

**Zone 7**
- VMT: +1722 veh-mi (+0.9%)
- VHT: -439 veh-hrs (-3.3%)
- Delay: -481 veh-hrs (-5.6%)
Response Evaluation – End of 1st Hour

- Impact on freeway operations, 8 AM → 9 AM

**I-210 WB – Incident to I-605**
- VMT: -264 veh-mi (-2.5%)
- VHT: +7 veh-hrs (+0.4%)
- Delay: +13 veh-hrs (+0.9%)
- VMT / VHT (Avg speed): 6.8 mph → 6.7 mph

**I-210 WB: East of I-605**
- VMT: -211 veh-mi (-1.0%)
- VHT: -38 veh-hrs (-2.2%)
- Delay: -33 veh-hrs (-2.7%)
- VMT / VHT (Avg speed): 12.7 mph → 12.9 mph
- Virtual Queue: -120 veh (-0.1 mile)

**I-605 NB**
- VMT: -70 veh-mi (-0.9%)
- VHT: +23 veh-hrs (+4.0%)
- Delay: +25 veh-hrs (+6.1%)
- VMT / VHT (Avg speed): 13.2 mph → 12.6 mph
Response Evaluation – End of 2nd Hour

- Impact on freeway operations, 8 AM → 10 AM

**I-210 WB: I-605 → Incident**
- VMT: -191 veh-mi (-0.6%)
- VHT: +51 veh-hrs (+1.4%)
- Delay: +55 veh-hrs (+1.9%)

VMT / VHT (Avg speed): 8.3 mph → 8.1 mph

**I-210 WB: East of 605**
- VMT: +1311 veh-mi (+3.2%)
- VHT: -175 veh-hrs (-4.6%)
- Delay: -202 veh-hrs (-7.0%)

VMT / VHT (Avg speed): 10.7 mph → 11.6 mph
Virtual Queue: -665 veh (-0.60 mile)

**I-605 NB**
- VMT: -331 veh-mi (-2.3%)
- VHT: +116 veh-hrs (+8.4%)
- Delay: +123 veh-hrs (+11.5%)

VMT / VHT (Avg speed): 10.1 mph → 9.1 mph

- Decreased VMT, increased VHT
  → Increased congestion partly due to measure to flush local traffic

VMT Increase, reduced VHT, reduce virtual queue → Reduced congestion
Thank You
and
Next Meeting
(Suggest Tuesday September 17th at Monrovia)