Enhancing Analysis with Probe-Based Data

Tom Hartmann, P.E., PTOE, IMSA TS II
Kimley-Horn and Associates, Inc.

June 26th, 2018

ITE Joint Western & Texas District Meeting

Kimley»Horn

BIG DATA

- How can we use BIG DATA to enhance traditional analysis?
- Leverage rich data sources instead of manual collection
- Increase statistical significance, reliability, and usability for future applications

Background

Austin TMC

- Kimley-Horn staffs and operates the Austin TMC
  - Provide daily staffing
  - Detect and respond to equipment malfunctions
  - Work daily with signal timing engineers
  - Support the effort to track and report on system performance


CESAR CHAVEZ
W-ST-E
100
ONE WAY
LEFT TURN
YIELD
ON GREEN


TMC SPOC

By The Numbers:

AS OF JANUARY 2017

140 Travel Time Detection Units

998 Traffic Signals

City of Austin Traffic Management Center

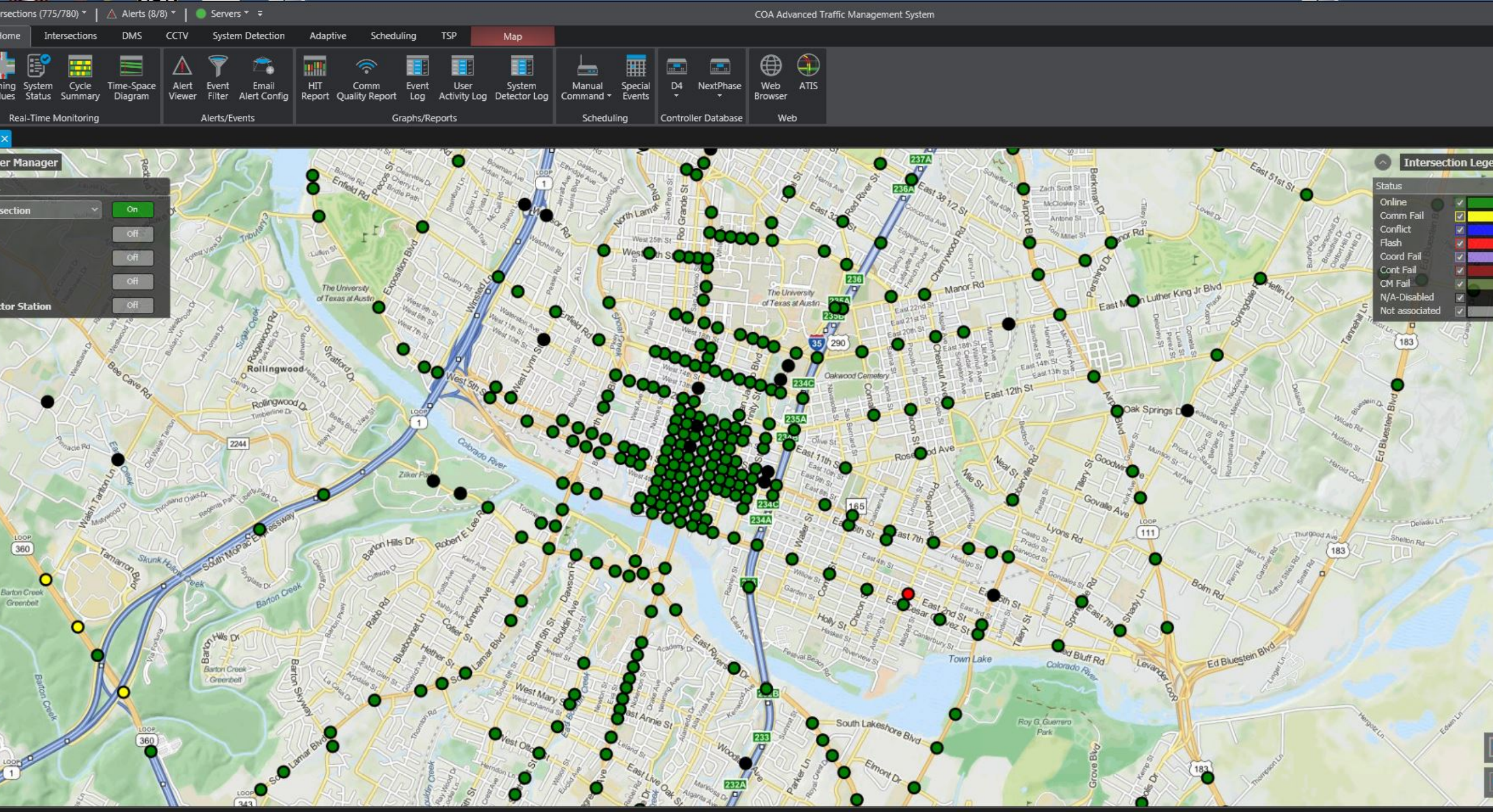
576 School Zone Flashers

53 Pedestrian Hybrid Beacons

291 Monitoring Cameras

13 Dynamic Message Boards

March 2017


rsections (775/780)
Alerts (8/8)
Servers
COA Advanced Traffic Management System
Home
Intersections
DMS
CCTV
System Detection
Adaptive
Scheduling
TSP
Map
System Status
Cycle Summary
Time-Space Diagram
Real-Time Monitoring
Alert Viewer
Event Filter
Email Alert Config
Alerts/Events
HIT Report
Comm Quality Report
Event Log
User Activity Log
System Detector Log
Graphs/Reports
Manual Command
Special Events
Scheduling
D4
NextPhase
Controller Database
Web Browser
ATIS
Web
er Manager
section
On
Off
Off
Off
Off
tor Station
Intersection Lege
Status
Online
Comm Fail
Conflict
Flash
Coord Fail
Cont Fail
CM Fail
N/A-Disabled
Not associated
The University of Texas at Austin
Rollingwood
Oakwood Cemetery
Town Lake
Colorado River
deshpande

Austin TMC Performance Measures

- Collect
- Analyze
- Report

- How can we leverage BIG DATA?

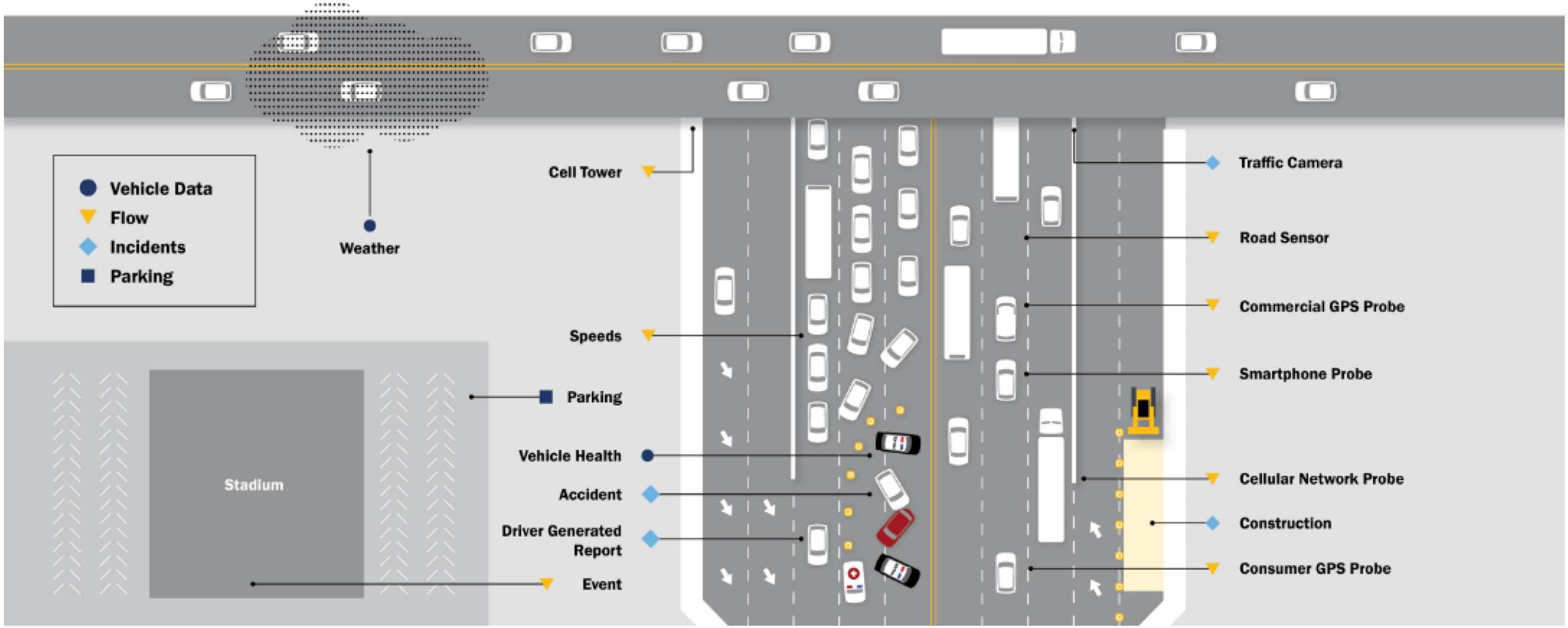
Procurement Objectives

- Analyzing travel-related information along City of Austin arterials.
- Identifying trends in traffic flow along arterials using historical data.
- Supporting freeways and arterial traffic operations.
- Collecting and analyze traffic volume data.
- Using data to report performance.

INRIX

Mining Data On The Road

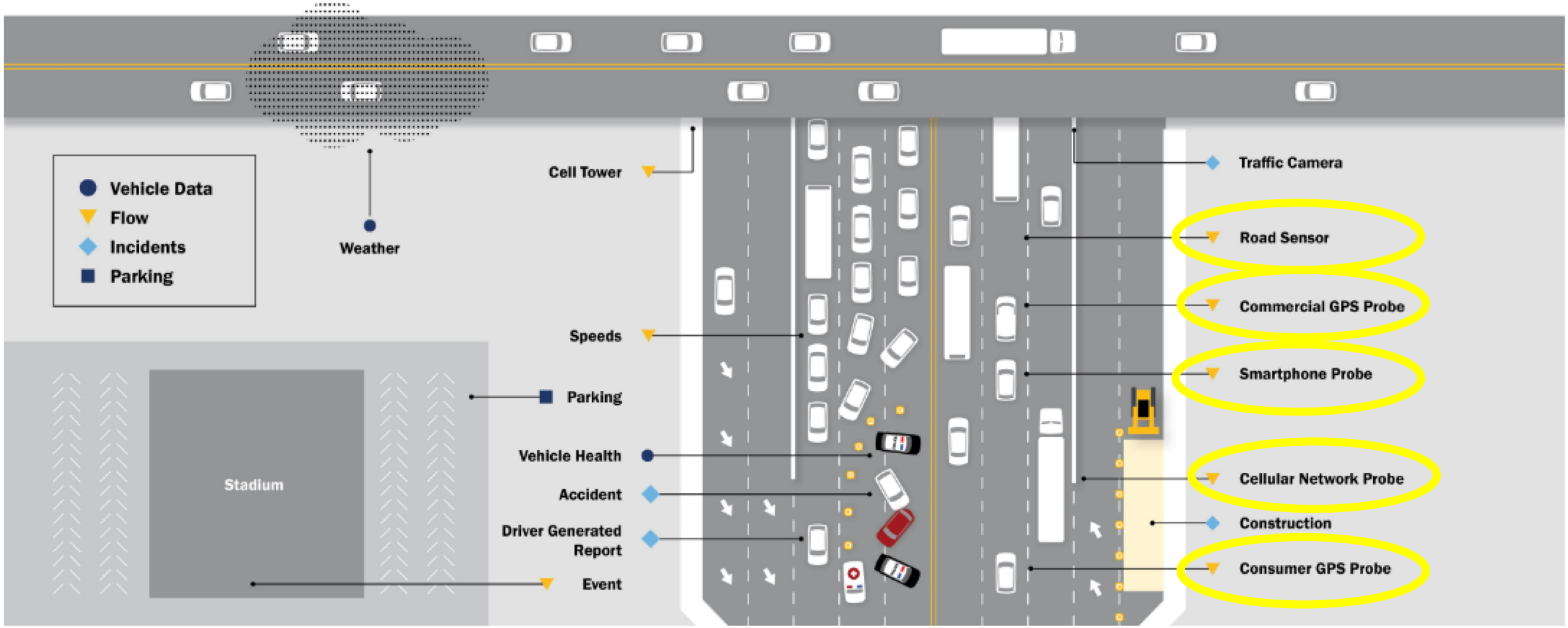
We use a connected network of sensors, devices, car and drivers to develop robust insights



INRIX

Mining Data On The Road

We use a connected network of sensors, devices, car and drivers to develop robust insights

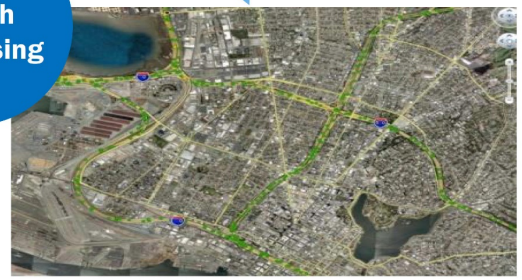


INRIX Data Process

Normalize → **Map Matching** → **Speed Estimation** → **Statistical Refinement**

- GPS Vehicle Probe
- Mobile Probe
- Driver Generated Report
- Road Sensor
- Traffic Camera
- Incidents

Provider Health Processing



Filtering

Spatial Inference

Temporal Inference

INRIX FUSION ENGINE

Optimization

Bayesian Analytics

SOE
Real-time, historical & predictive blending

Aggregate Speed Data from Probes & Sensors

- Collect data from 400+ sources
- Monitor to ensure proper data point – timely and valid
- Place valid data points on a specific road
- Sensor and Provider Health Processing

Snap Probe Data to Road Network

- Filter points based on location, heading, speed
- Locate points within a road segment

Compute Speed Value Based on Data from Over 15 Mins

- Outlier detection to remove statistical anomalies
- Weight data based on source and latency
- Apply "Adaptive Spatial Resolution" to optimize accuracy and relevance

Enhance Precision of Result & Calculate Confidence Factor

- Leverage real-time where possible
- Enhance data to leverage road closures
- Process less than ideal real-time estimates with typical and predictive forecasts

Available Data & Metrics

Data

- Speed
- Travel Time
- Reference Speed
- Historic Average Speed
- Comparative Speed
- Congestion
- Historic Average Congestion

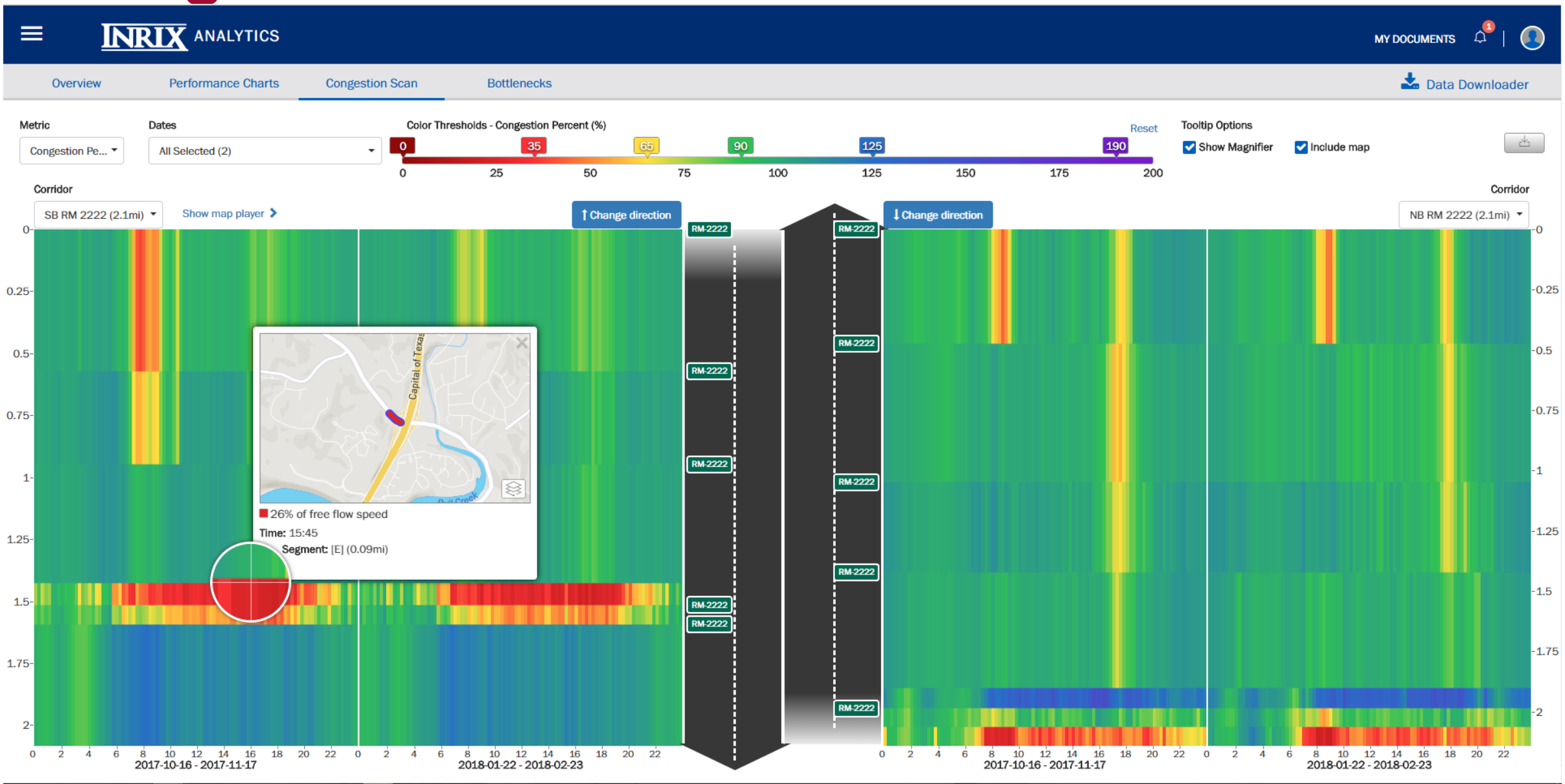
Metrics

- **Speed**
- **Travel Time**
- **Travel Time index**
- Buffer Time
- **Buffer Index**
- Planning Time
- Planning Time Index
- **User Delay Cost**

Available Tools

- Congestion Scan
- Bottleneck Ranking
- **User Delay Cost Analysis**

Congestion Scan



Bottleneck Ranking

Bottleneck Location for "RM 2222 B/A v3": 2017-10-16 - 2017-11-17

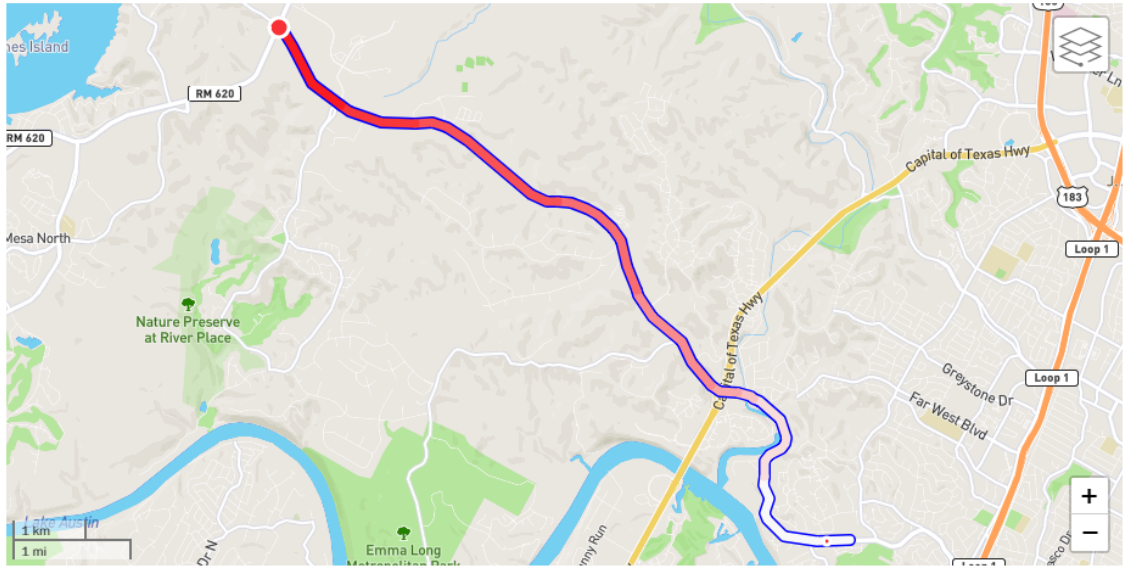
Summary Table

Corridor	Road Name	Intersection	Direction	Impact Factor	Occurrences	Avg Max Duration (min)	Average Max Length (miles)
NB RM 2222	RM-2222 / Ranch Road 2222 / RM 2222 / W Koenig Ln	RM-620 / RM-2222 / Bullick Hollow Rd	W	10699	22	76	3.98
NB RM 2222	RM-2222 / Ranch Road 2222 / RM 2222 / W Koenig Ln	RM-2222 / River Place Blvd	W	1287	7	38	3.01
SB RM 2222	RM-2222 / Ranch Road 2222 / RM 2222 / W Koenig Ln	RM-2222 / City Park Rd	E	1130	7	47	2.14
NB RM 2222	RM-2222 / Ranch Road 2222 / RM 2222 / W Koenig Ln	RM-2222	W	1123	3	77	3.02
SB RM 2222	RM-2222 / Ranch Road 2222 / RM 2222 / W Koenig Ln	RM-2222 / Mount Bonnell Rd	E	117	1	53	1.37

1 to 5 of 11 Entries

Show items 5 1 2 3

RM-2222 / Ranch Road 2222 / RM 2222 / W Koenig Ln



Occurrences

Show 24 hour view

Max Length (miles)	Date	Max Duration (min) 00:00 – 23:59
7.22	-10-31	3h 1m (16:13 – 19:14)
5.38	-11-08	48m (17:04 – 17:52)
4.86	-11-08	51m (18:00 – 18:51)
4.86	-11-14	58m (17:27 – 18:25)
4.5	-11-06	1h 51m (16:46 – 18:37)
4.28	-11-07	2h 9m (16:34 – 18:43)
4.19	-11-13	1h 34m (16:30 – 18:04)
4.19	-11-15	1h 58m (16:28 – 18:26)
4.07	-10-18	1h 50m (16:33 – 18:23)
3.88	-11-09	54m (18:01 – 18:55)
3.86	-10-16	11m (17:26 – 17:37)

User Delay Cost

Monday, October 16, 2017 1:00 AM
Delay cost:
Total: $4.16
Per VMT: $0.01
Hours of delay:
Person-hours: 10m 6s
Vehicle-hours: 8m 15s
Vehicle miles traveled (VMT):
Total: 508 miles
Passenger: 458 miles
Commercial: 51 miles
Delay per VMT: 0.0162 mins / mile
Data validity: 100%
Click the table cell to see links to congestion scans

	12 AM	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	Daily Totals
10/16/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.2K	$0.4K	$0.4K	$0.3K	$0.3K	$0.2K	$0.2K	$0.4K	$0.5K	$0.4K	$3.5K	$6.3K	$1.4K	$0.3K	$0.1K	$0.1K	$0K	$0K	$15.1K
10/17/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.2K	$0.8K	$0.5K	$1.3K	$0.1K	$0.5K	$0.3K	$0.2K	$0.7K	$0.5K	$4.7K	$6K	$2.1K	$0.4K	$0.2K	$0.1K	$0K	$0K	$18.8K
10/18/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.8K	$0.3K	$1K	$0.4K	$0.1K	$0.1K	$0.2K	$0.2K	$0.9K	$0.9K	$5K	$7.6K	$1.9K	$0.2K	$0K	$0K	$0K	$0.1K	$20K
10/19/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.1K	$0.5K	$0.5K	$0.6K	$0.1K	$0.1K	$0.3K	$0.3K	$0.4K	$0.9K	$4.9K	$5.3K	$1.9K	$0.4K	$0.1K	$0.1K	$0K	$0K	$16.6K
10/20/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.1K	$0.4K	$1K	$0.5K	$0.4K	$0.4K	$0.3K	$0.1K	$1K	$0.9K	$4.6K	$2.9K	$0.4K	$0.2K	$0.2K	$0K	$0K	$0K	$13.7K
10/21/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0K	$0.1K	$0.2K	$0K	$0.1K	$0.2K	$0.2K	$0.9K	$0.2K	$0.4K	$0.4K	$0.3K	$0.2K	$0.3K	$0K	$0K	$0K	$0.1K	$3.8K
10/22/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0K	$0.1K	$0.1K	$0.4K	$0.3K	$0.1K	$0.3K	$0.2K	$0.4K	$0.1K	$0.2K	$0K	$0.1K	$0K	$0K	$0K	$0K	$0K	$2.3K
10/23/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.8K	$1.1K	$0.6K	$0.1K	$0.1K	$0.5K	$0.1K	$0.2K	$0.4K	$2.8K	$5.4K	$1.2K	$0.1K	$0.1K	$0K	$0K	$0K	$13.6K
10/24/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.5K	$0.4K	$0.9K	$1K	$0.2K	$0.5K	$0.3K	$0.2K	$0.6K	$0.3K	$4.4K	$5K	$1.3K	$0.4K	$0.1K	$0K	$0K	$0K	$16.3K
10/25/17	$0K	$0K	$0K	$0K	$0K	$0.2K	$0.2K	$0.3K	$0.8K	$0.2K	$0K	$0.1K	$0.1K	$0.2K	$0.7K	$0.8K	$5.1K	$5.6K	$2.1K	$0.3K	$0.1K	$0.2K	$0.1K	$0K	$17.3K
10/26/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.1K	$0.7K	$1.1K	$0.8K	$0.3K	$0.2K	$0.7K	$0.3K	$0.7K	$0.6K	$6.1K	$4.9K	$1.9K	$0.5K	$0.3K	$0.1K	$0K	$0K	$19.5K
10/27/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.2K	$0.7K	$1.2K	$0.6K	$0K	$0.1K	$0.3K	$0.6K	$1.2K	$1.4K	$5.9K	$5.2K	$0.8K	$0.1K	$0K	$0.1K	$0K	$0K	$18.5K
10/28/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0K	$0K	$0K	$0.1K	$0.1K	$0.3K	$0.2K	$0.2K	$0.3K	$0.3K	$0.3K	$1.4K	$0.4K	$0.2K	$0.1K	$0K	$0.1K	$0K	$4.2K
10/29/17	$0K	$0K	$0.1K	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.2K	$0.1K	$0.2K	$0.1K	$0.1K	$0.2K	$0.3K	$0.2K	$0.4K	$0K	$0K	$0.1K	$0K	$0.1K	$2.4K
10/30/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.2K	$0.6K	$0.2K	$0.1K	$0.3K	$0K	$0.2K	$0.7K	$0.5K	$0.4K	$3.1K	$5.2K	$2.4K	$0.7K	$0.1K	$0K	$0K	$0K	$14.8K
10/31/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.1K	$0.6K	$0.8K	$0.5K	$0.4K	$0.6K	$0.4K	$0.6K	$1K	$0.7K	$14K	$24.3K	$9.1K	$2.5K	$0.4K	$0.1K	$0K	$0K	$56.2K
11/01/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.6K	$1.3K	$0.9K	$0.2K	$0.3K	$0.7K	$0.7K	$0.6K	$1K	$4.2K	$5.1K	$2.3K	$0.4K	$0.1K	$0.1K	$0K	$0K	$18.6K
11/02/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.3K	$1.3K	$0.7K	$0.3K	$0.6K	$0.4K	$0.3K	$0.4K	$0.5K	$3.1K	$2.9K	$0.9K	$0.4K	$0.2K	$0.1K	$0K	$0K	$12.6K
11/03/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.4K	$0.8K	$1.4K	$0.7K	$0.1K	$0.2K	$0.6K	$1K	$1.1K	$1.7K	$4.5K	$2.7K	$0.7K	$0.3K	$0.1K	$0.1K	$0K	$0K	$16.6K
11/04/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.1K	$0.1K	$0.1K	$0.2K	$0.2K	$0.2K	$0.3K	$0.1K	$0.4K	$0.2K	$0.5K	$0.3K	$0.2K	$0K	$0.1K	$0K	$0K	$3.1K
11/05/17	$0K	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.1K	$0.3K	$0.2K	$0.3K	$1K	$0.4K	$0.2K	$0.4K	$0.1K	$0K	$0.1K	$0K	$0K	$0.1K	$0K	$0K	$3.4K
11/06/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.8K	$1K	$0.8K	$0.3K	$0.3K	$0.2K	$0.5K	$0.6K	$0.5K	$2.8K	$6.8K	$3.2K	$0.3K	$0.1K	$0K	$0K	$0K	$18.5K
11/07/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.2K	$0.5K	$1.3K	$0.8K	$0.1K	$0.5K	$0.3K	$0.5K	$1K	$0.9K	$4.3K	$8K	$3.6K	$0.6K	$0.1K	$0.1K	$0K	$0K	$22.7K
11/08/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.2K	$0.9K	$1.2K	$0.7K	$0.4K	$0.5K	$0.6K	$0.5K	$0.6K	$0.7K	$6.3K	$11.6K	$5K	$0.6K	$0.1K	$0.3K	$0K	$0K	$30.2K
11/09/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.3K	$0.9K	$1.2K	$0.7K	$0.2K	$0.2K	$0.2K	$0.5K	$0.3K	$0.7K	$4.6K	$7.3K	$4.9K	$0.3K	$0.1K	$0.1K	$0K	$0K	$22.7K
11/10/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.3K	$0.6K	$0.8K	$0.7K	$0.2K	$0.3K	$0.5K	$0.5K	$1.7K	$1K	$4.4K	$3.9K	$0.9K	$0.3K	$0.1K	$0.1K	$0.3K	$0.1K	$16.9K
11/11/17	$0K	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.1K	$0.2K	$0.2K	$0.4K	$0.6K	$0.9K	$0.4K	$0.5K	$0.4K	$0.4K	$0.2K	$0.3K	$0.3K	$0.2K	$0.1K	$0K	$5.3K
11/12/17	$0.1K	$0K	$0K	$0K	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.8K	$0.6K	$0.8K	$0.1K	$0K	$0.5K	$0.5K	$0.1K	$0.1K	$0K	$0.1K	$0K	$0K	$3.9K
11/13/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.2K	$0.5K	$0.7K	$0.6K	$0.5K	$0.1K	$0.4K	$0.2K	$0.6K	$0.5K	$4.2K	$7.9K	$1.8K	$0.7K	$0.1K	$0K	$0K	$0K	$19.3K
11/14/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.1K	$0.5K	$1K	$0.7K	$0.2K	$0.4K	$0.3K	$0.3K	$0.9K	$0.4K	$5.3K	$8.2K	$2.6K	$0.2K	$0.2K	$0.1K	$0K	$0K	$21.5K
11/15/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.2K	$0.5K	$1.1K	$0.8K	$0.1K	$0.1K	$0.3K	$0.4K	$0.5K	$0.4K	$5K	$7.1K	$2.4K	$0.5K	$0.3K	$0K	$0K	$0K	$19.9K
11/16/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.6K	$0.8K	$0.6K	$0.2K	$0.3K	$0.4K	$0.4K	$1K	$0.4K	$4.1K	$5.8K	$2.2K	$0.2K	$0.1K	$0.1K	$0K	$0.1K	$17.4K
11/17/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.4K	$0.4K	$0.9K	$0.9K	$0.1K	$0.2K	$0.1K	$1K	$1K	$1.8K	$3.6K	$2.1K	$0.9K	$0.2K	$0K	$0.1K	$0.1K	$0K	$13.9K
Hourly Totals	$0.3K	$0.1K	$0.2K	$0.1K	$0.1K	$2.1K	$5.7K	$14.9K	$24.4K	$17.8K	$6.6K	$9.4K	$12.1K	$14.5K	$20.4K	$21.2K	$123K	$166.5K	$59.7K	$12.1K	$4.1K	$2.5K	$1.1K	$0.7K	Grand Total $519,505.71

I-95 Corridor Coalition

INRIX Real-Time and Historic Traffic Flow

LIVE NOW

For Roadway Performance Planning: INRIX was chosen as the most accurate, affordable, and comprehensive real-time traffic provider by the I-95 Corridor Coalition.

HIGHLIGHTS:

- Covered 40,000 centerline miles of roadway (8,000 freeway) across 11 states.
- Exceeded all 42 validation checks throughout 11 states and a full range of scenarios.
- INRIX continuously improved data quality across the 6 year span of the VPP.

Data Accuracy

✓ RECOMMENDED	SHOULD BE TESTED	✖ NOT RECOMMENDED
• <= 1 signal per mile	• 1 to 2 signals per mile	• >= 2 signals per mile
• AADT > 40,000 vpd (2-way)	• AADT 20K to 40K vpd (2-way)	• AADT < 20K (2-way) - low volume
• Limited curb cuts	• Moderate number of curb cuts	• Substantial number of curb cuts
Principal Arterials	Minor Arterials	Major Collectors
Likely to be accurate…	Possibly accurate, test …	Unlikely to be accurate…

- Other studies have found probe-based data to be similarly accurate to Bluetooth probe data
- Δ of more interest than absolute values

Applications

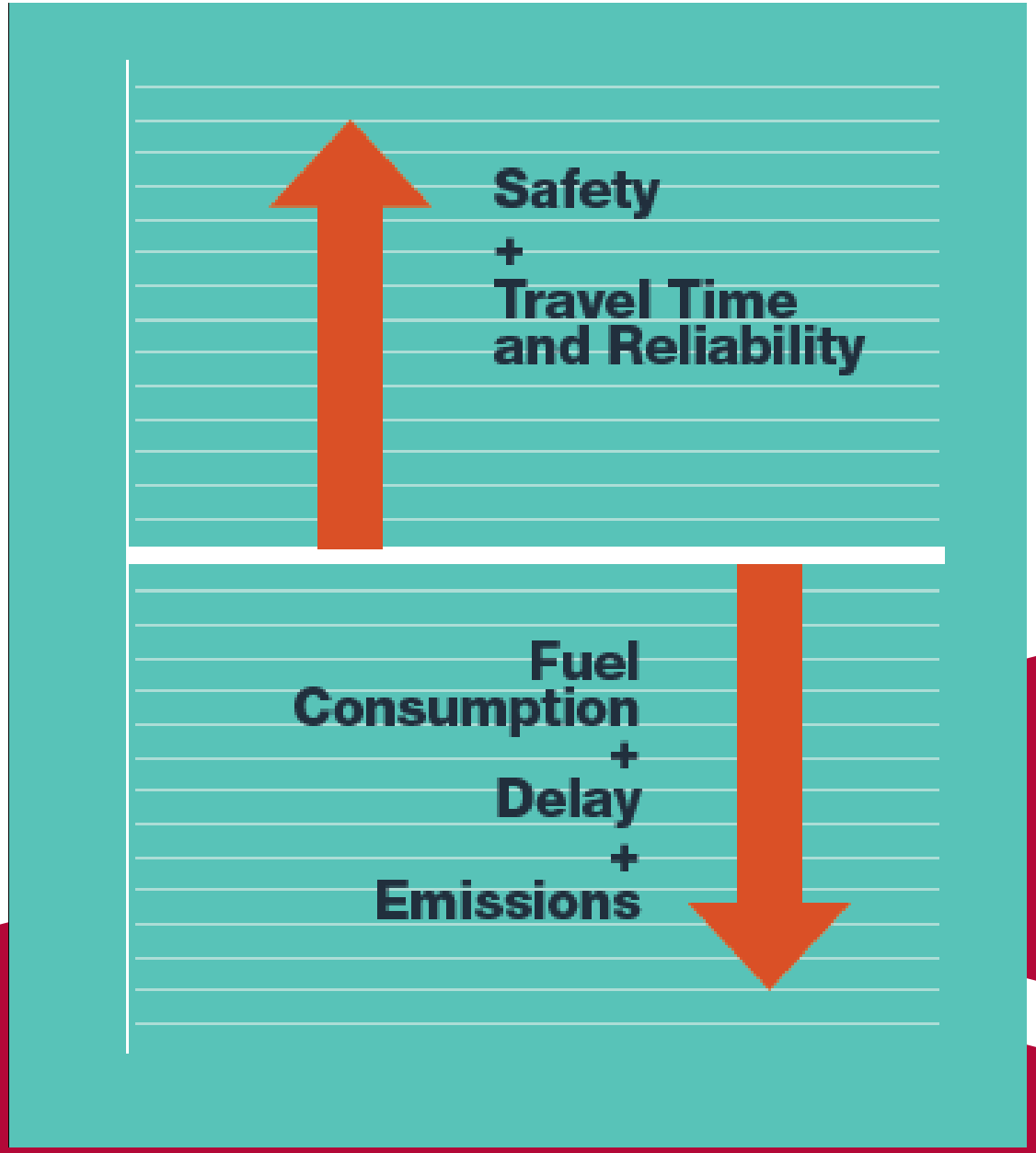
- **Comparing signal timing efforts with before/after studies**
- Monitoring the system in real time
- **Evaluating impacts of TMC operations**
- Identifying trends
- Analyzing queues
- Quantifying benefits and costs
- **Quantifying delay in terms of costs**
- Deep statistical analysis (e.g. reliability)
- Supplementing or replacing travel time runs
- Speed studies
- Other metrics that can be used to communicate effectively with the public or decision-makers

Applications in Austin

Before & After Studies

Austin's Retiming Effort

- Retime signals every 3 years
  - ~350 signals/year
- Standard Goal – 5% reduction in travel time
  - Improve progression
  - Minimize side street delay



Methodology

- Goals
  - Estimate signal performance *before* and *after*
  - Determine success of retiming effort
  - Quantify benefits
- Old way – floating car travel time runs
  - 3 weekday peaks
  - 5 runs each peak each direction
  - 4 MOEs (TT, Speed, Stops, Delay)
- New way – probe-based data
  - 3 weekday peaks
  - 2 months of data
  - 10 MOEs

Measures of Effectiveness

Traditional MOEs

- Travel time (seconds)
- Speed (miles per hour)
- Travel time index
- Delay

Advanced

- Travel Time Confidence Interval
- Speed Confidence Interval
- Travel Time Index Confidence Interval
- Buffer Time
- Planning Index
- User Delay Cost

RM 2222 Corridor
1.8 miles
7 intersections


RM 2222 Corridor
1.8 miles
7 intersections
861
689
536
991
992
870
Bell Mountain Dr
Vaught Ranch Rd
Long Canyon Dr
2 Coves Dr
Halbert Dr
Anaqua Dr
Rusty Fig Dr
Beauford Dr
Ledge Dr
Creekbluff Dr
Wallace Cove
Wallace Dr
N Capital of Texas Hwy
Lakemoore Dr
Laurelwood Dr
Driftwood Dr
Lemonwood Dr
Lakewood Dr
Back Trail Dr
Smokey Valley
Cat Creek Trail
Ladera Norte
Far W Blvd
Gato Path
Valburn Dr
360
Google Earth

Retiming Effort

- City of Austin Staff implemented January 2018
- Balanced delay among all approaches
- Maximized progression on RM 2222
- Optimized sequences
- Weekday peaks only
- Existing cycle lengths maintained

Analysis Periods

Before

- October 16th – November 17th, 2017
- One full month
- Prior to implementation
- Avoided
  - Thanksgiving (November 23rd, 2017)
  - Christmas (December 24th & 25th, 2017)
  - New Year's Eve (December 31st, 2017)
  - New Year's Day (January 1st, 2018)
- University of Texas in session
- Austin ISD in session

After

- January 22nd – February 23rd, 2018
- One full month
- After implementation
- University of Texas in session
- Austin ISD in session

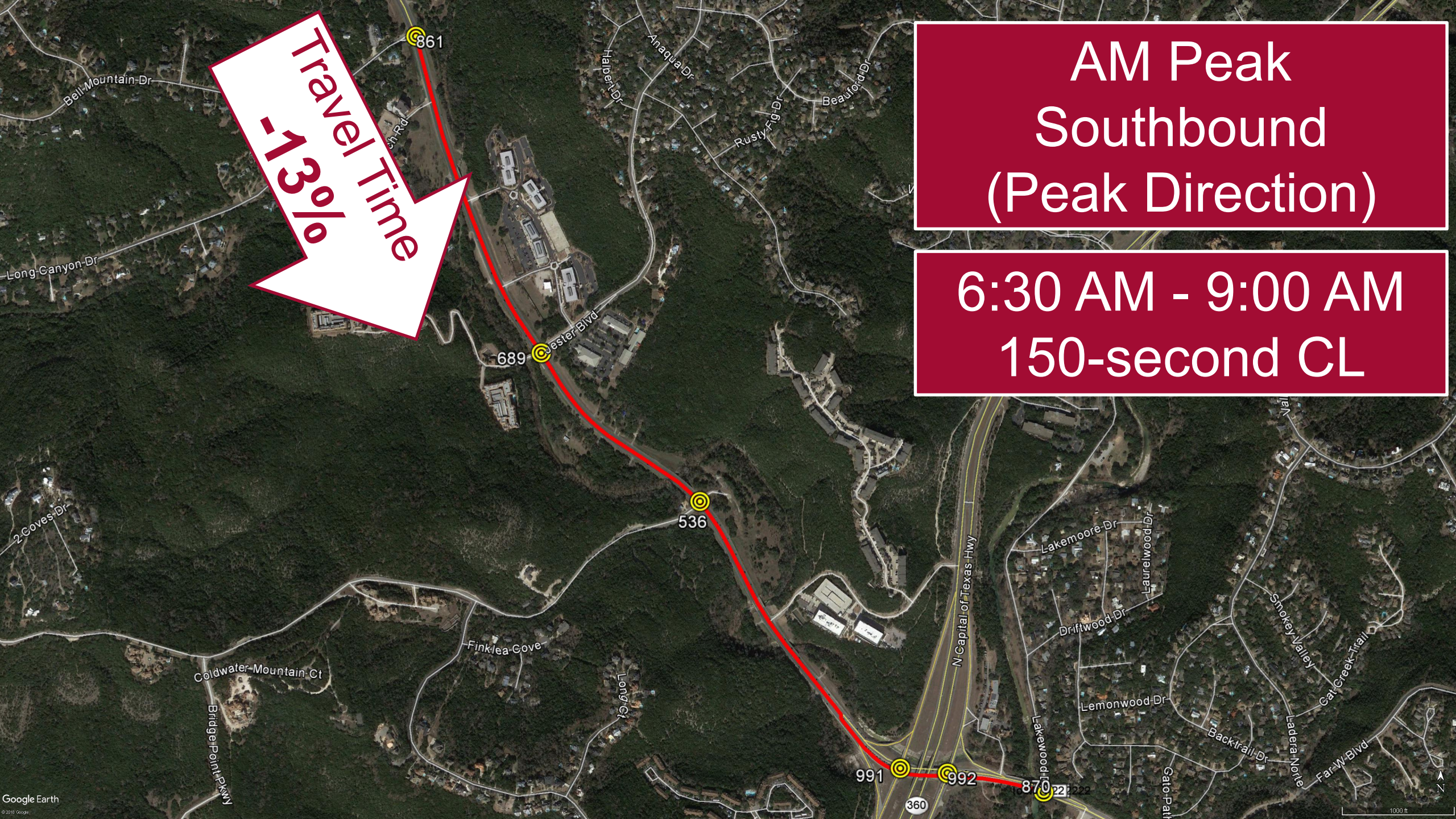
Analysis Periods

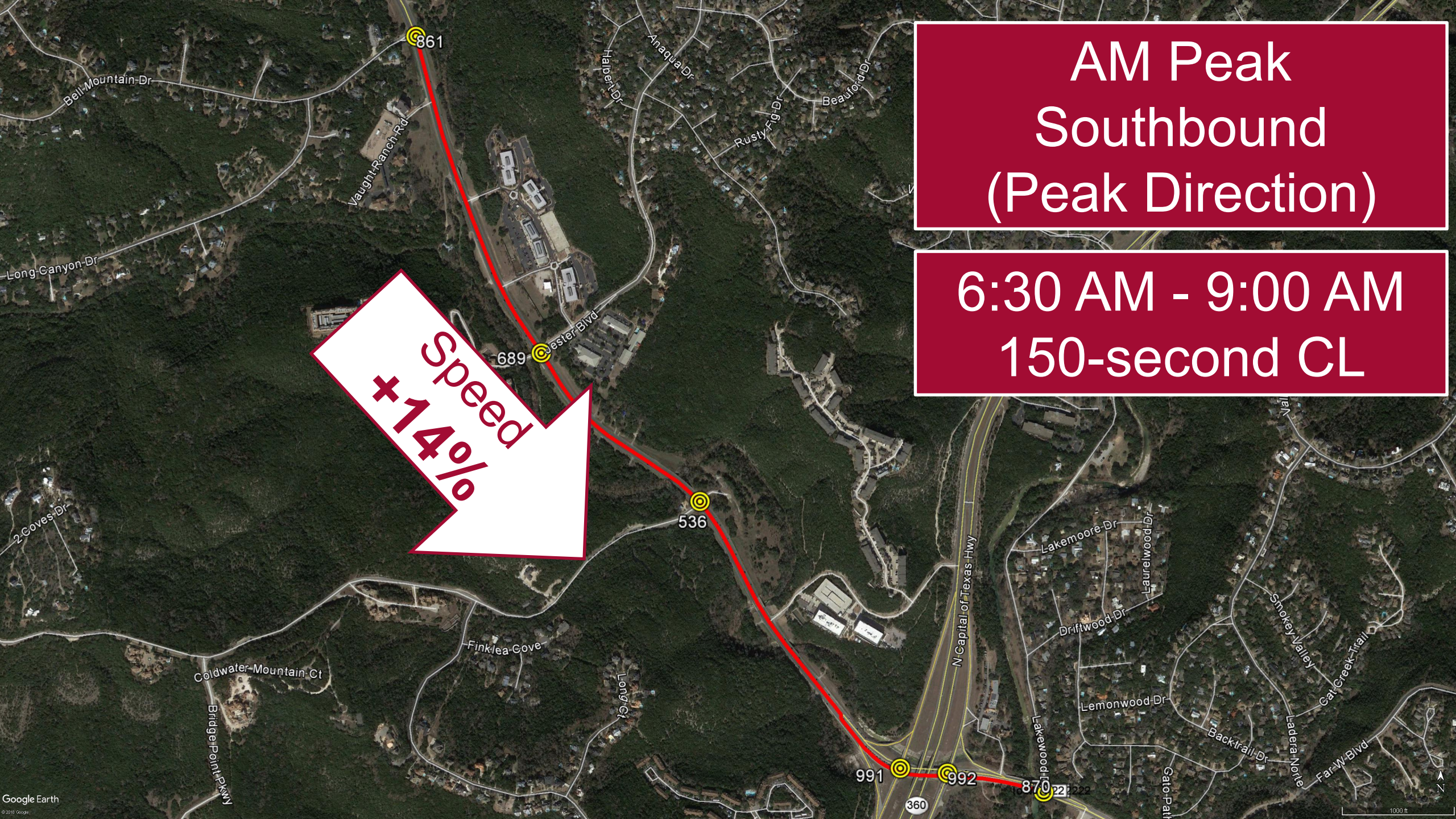
- Weekends are excluded from the City's annual signal retiming project.

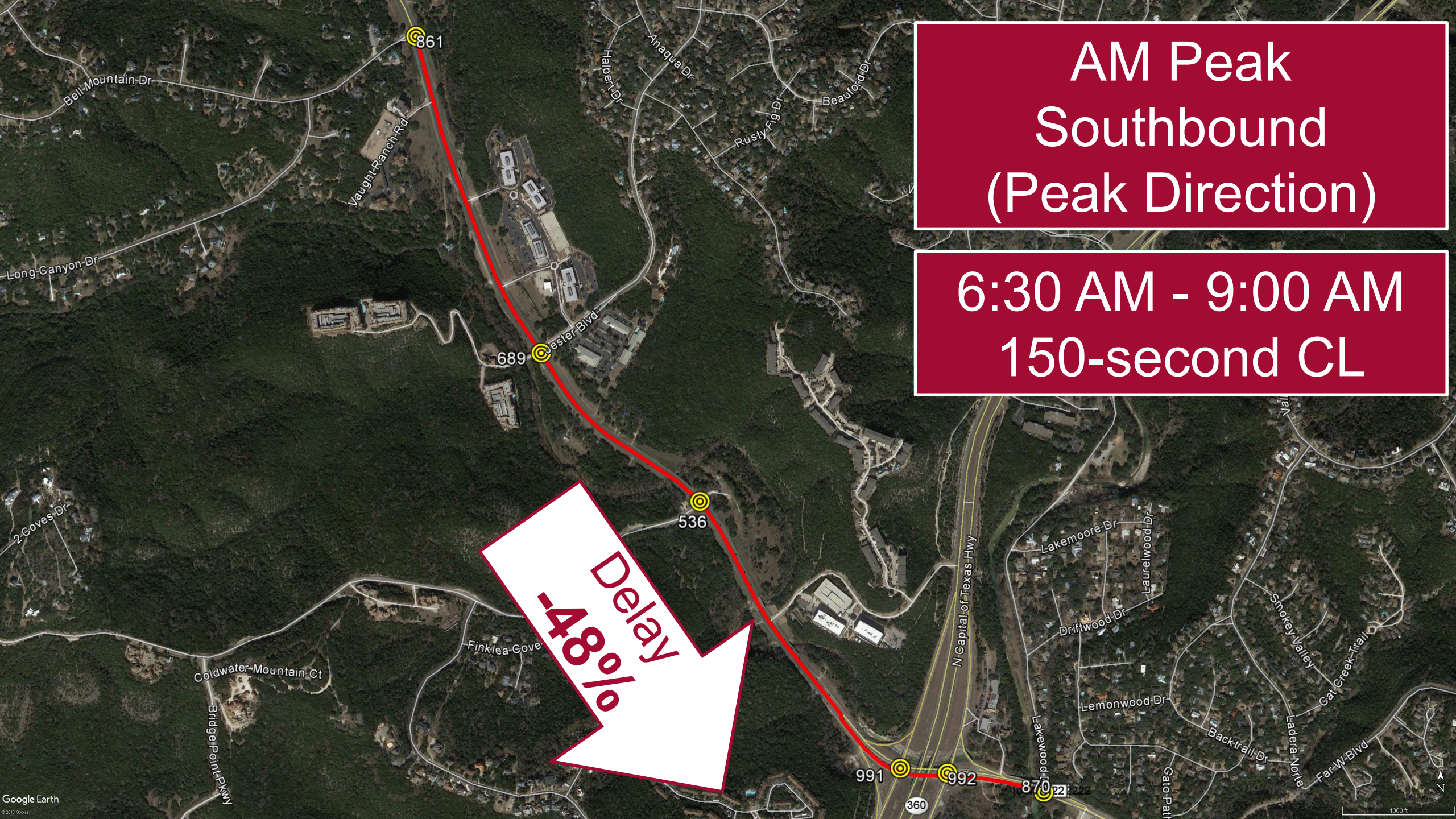
- The City of Austin's standard assumed peak hours were used for analysis:
  - AM peak period: 6:30 AM - 9:00 AM
  - MD peak period: 9:00 AM – 3:30 PM
  - PM peak period: 3:30 PM - 7:00 PM

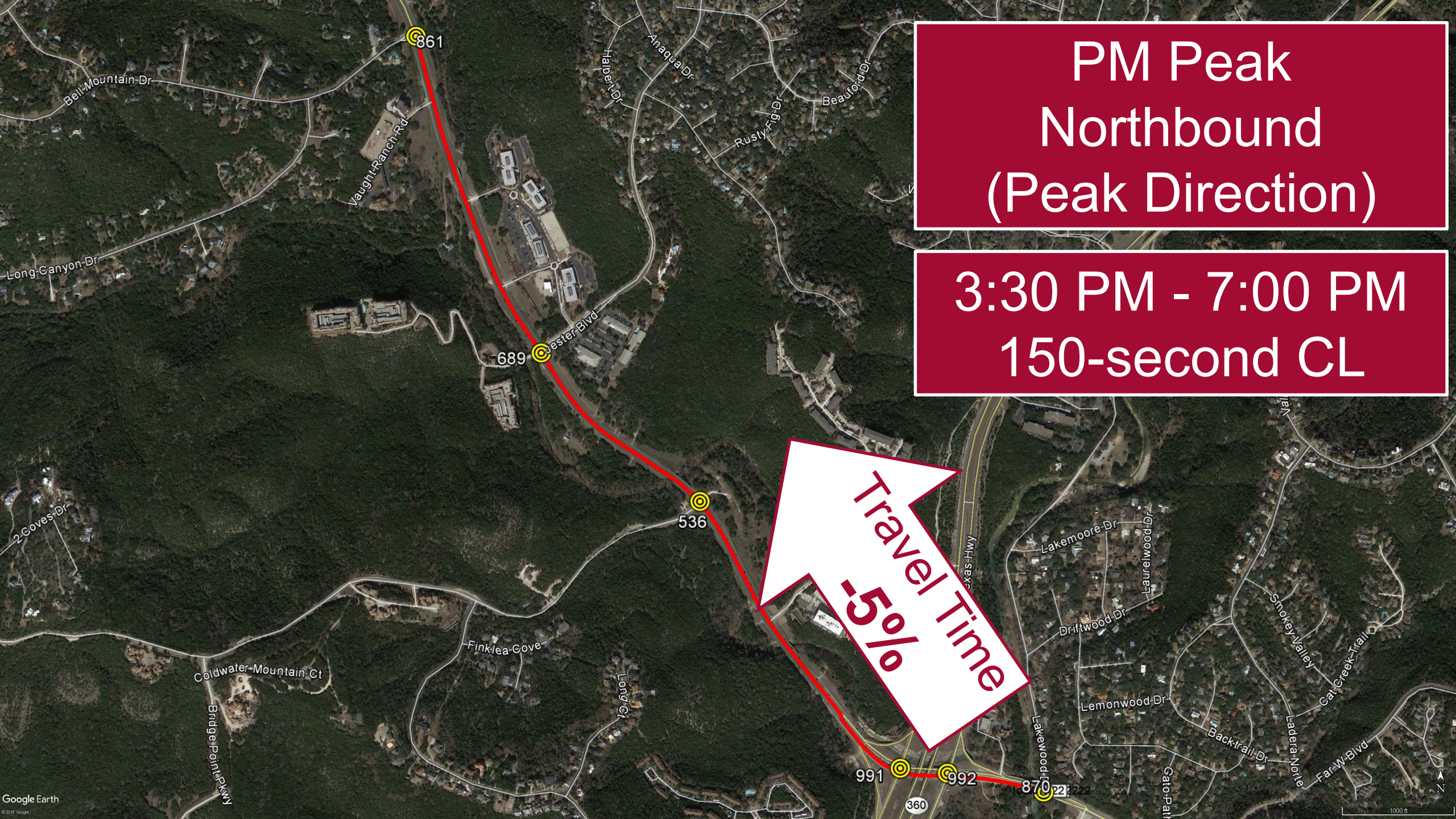
Analysis and Results – Traditional MOEs

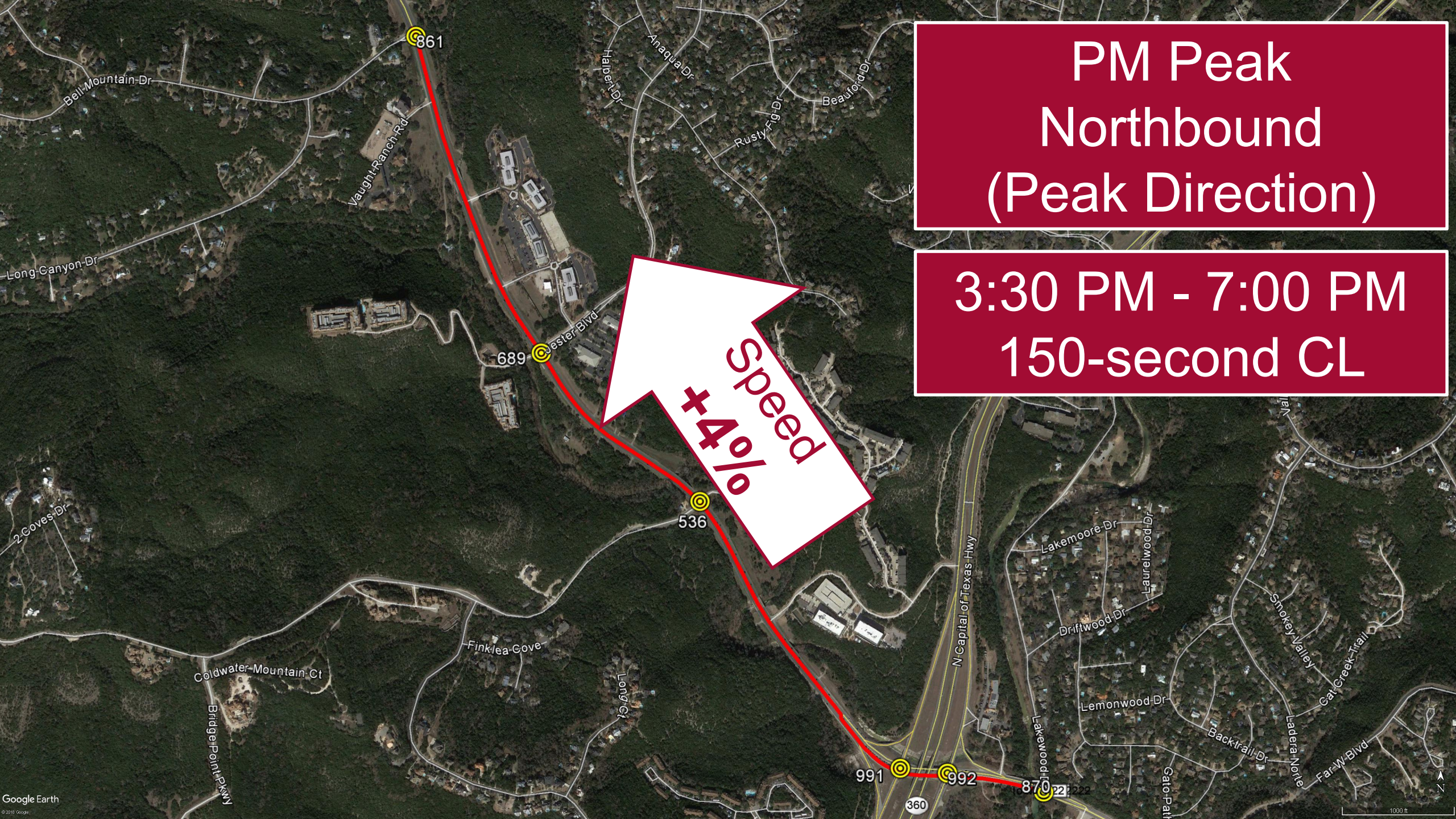
- Travel Time
- Speed
- Travel Time Index
- Delay

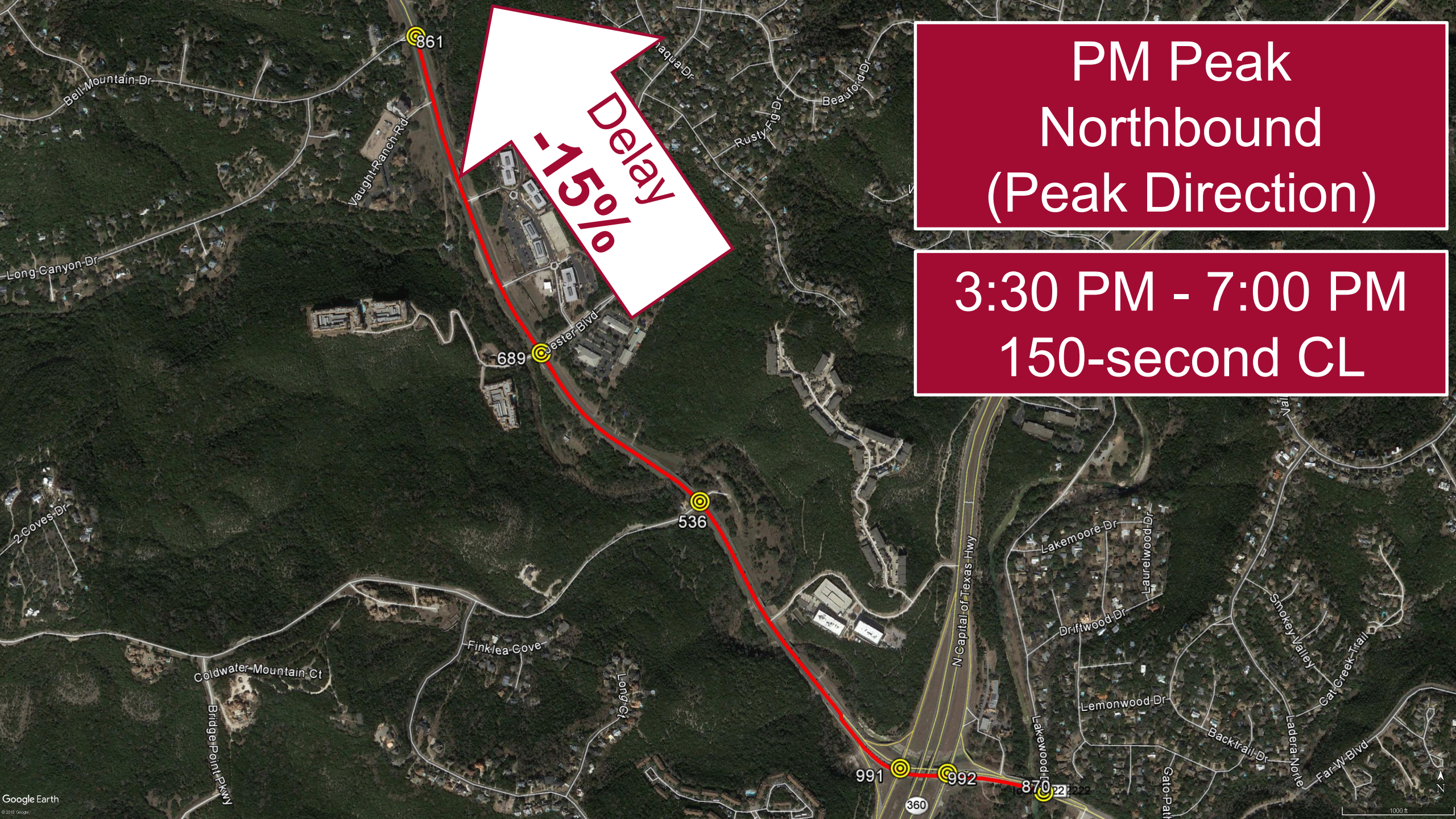

Travel Time
-13%
AM Peak
Southbound
(Peak Direction)
6:30 AM - 9:00 AM
150-second CL
861
689
536
991
992
870
Bell Mountain Dr
Long Canyon Dr
2 Coves Dr
Coldwater Mountain Ct
Bridge Point Pkwy
Finklea Cove
Long Ct
Halbert Dr
Anaqua Dr
Rusty Fig Dr
Beauford Dr
Lester Blvd
N Capital of Texas Hwy
Lakemoore Dr
Laurelwood Dr
Driftwood Dr
Lemonwood Dr
Lakewood Dr
Backtrail Dr
Smokey Valley
Cat Creek Trail
Ladera Norte
Far W Blvd
Gato Pati
360
Google Earth


AM Peak
Southbound
(Peak Direction)
6:30 AM - 9:00 AM
150-second CL
Speed
+14%
861
689
536
991
992
870
Bell Mountain Dr
Vaught Ranch Rd
Halbert Dr
Anaqua Dr
Rusty Fig Dr
Beauford Dr
Long Canyon Dr
Chester Blvd
2 Coves Dr
Finklea Cove
Coldwater Mountain Ct
Bridge Point Pkwy
Long Ct
N Capital of Texas Hwy
Lakemoore Dr
Laurelwood Dr
Driftwood Dr
Lemonwood Dr
Lakewood Dr
Smokey Valley
Cat Creek Trail
Backtrail Dr
Ladera Norte
Far W Blvd
Gato Pati
360
Google Earth


AM Peak
Southbound
(Peak Direction)
6:30 AM - 9:00 AM
150-second CL
Delay
-48%
861
689
536
991
992
870
Bell Mountain Dr
Vaught Ranch Rd
Long Canyon Dr
Halbert Dr
Anaqua Dr
Rusty Fig Dr
Beauford Dr
Chester Blvd
2 Coves Dr
Coldwater Mountain Ct
Bridge Point Pkwy
Finklea Cove
N Capital of Texas Hwy
Lakemoore Dr
Laurelwood Dr
Driftwood Dr
Lemonwood Dr
Lakewood Dr
Smokey Valley
Cat Creek Trail
Backtrail Dr
Ladera Norte
Far W Blvd
Gato Pati
360
Google Earth


PM Peak
Northbound
(Peak Direction)
3:30 PM - 7:00 PM
150-second CL
Travel Time
-5%
861
689
536
991
992
870
Bell Mountain Dr
Vaught Ranch Rd
Halbert Dr
Anaqua Dr
Rusty Fig Dr
Beauford Dr
Long Canyon Dr
Chester Blvd
2 Coves Dr
Finklea Cove
Coldwater Mountain Ct
Bridge Point Pkwy
Long Ct
Texas Hwy
Lakemoore Dr
Laurelwood Dr
Driftwood Dr
Lemonwood Dr
Lakewood Dr
Smokey Valley
Cat Creek Trail
Backtrail Dr
Ladera Norte
Far W Blvd
Gato Pati
360
Google Earth


PM Peak
Northbound
(Peak Direction)
3:30 PM - 7:00 PM
150-second CL
Speed
+4%
861
689
536
991
992
870
Bell Mountain Dr
Vaught Ranch Rd
Halbert Dr
Anaqua Dr
Rusty Fig Dr
Beauford Dr
Long Canyon Dr
Chester Blvd
2 Coves Dr
Finklea Cove
Coldwater Mountain Ct
Bridge Point Pkwy
Long Ct
N Capital of Texas Hwy
Lakemoore Dr
Laurelwood Dr
Driftwood Dr
Lemonwood Dr
Lakewood Dr
Smokey Valley
Cat Creek Trail
Backtrail Dr
Ladera Norte
Far W Blvd
Gato Pati
360
Google Earth


PM Peak
Northbound
(Peak Direction)
3:30 PM - 7:00 PM
150-second CL
Delay
-15%
861
689
536
991
992
870
Bell Mountain Dr
Vaught Ranch Rd
Long Canyon Dr
Rusty Fig Dr
Beauford Dr
Chester Blvd
2 Coves Dr
Finklea Cove
Coldwater Mountain Ct
Bridge Point Pkwy
Long Ct
N Capital of Texas Hwy
Lakemoore Dr
Laurelwood Dr
Driftwood Dr
Lemonwood Dr
Lakewood Dr
Smokey Valley
Cat Creek Trail
Backtrail Dr
Ladera Norte
Far W Blvd
Gato Pati
360
Google Earth

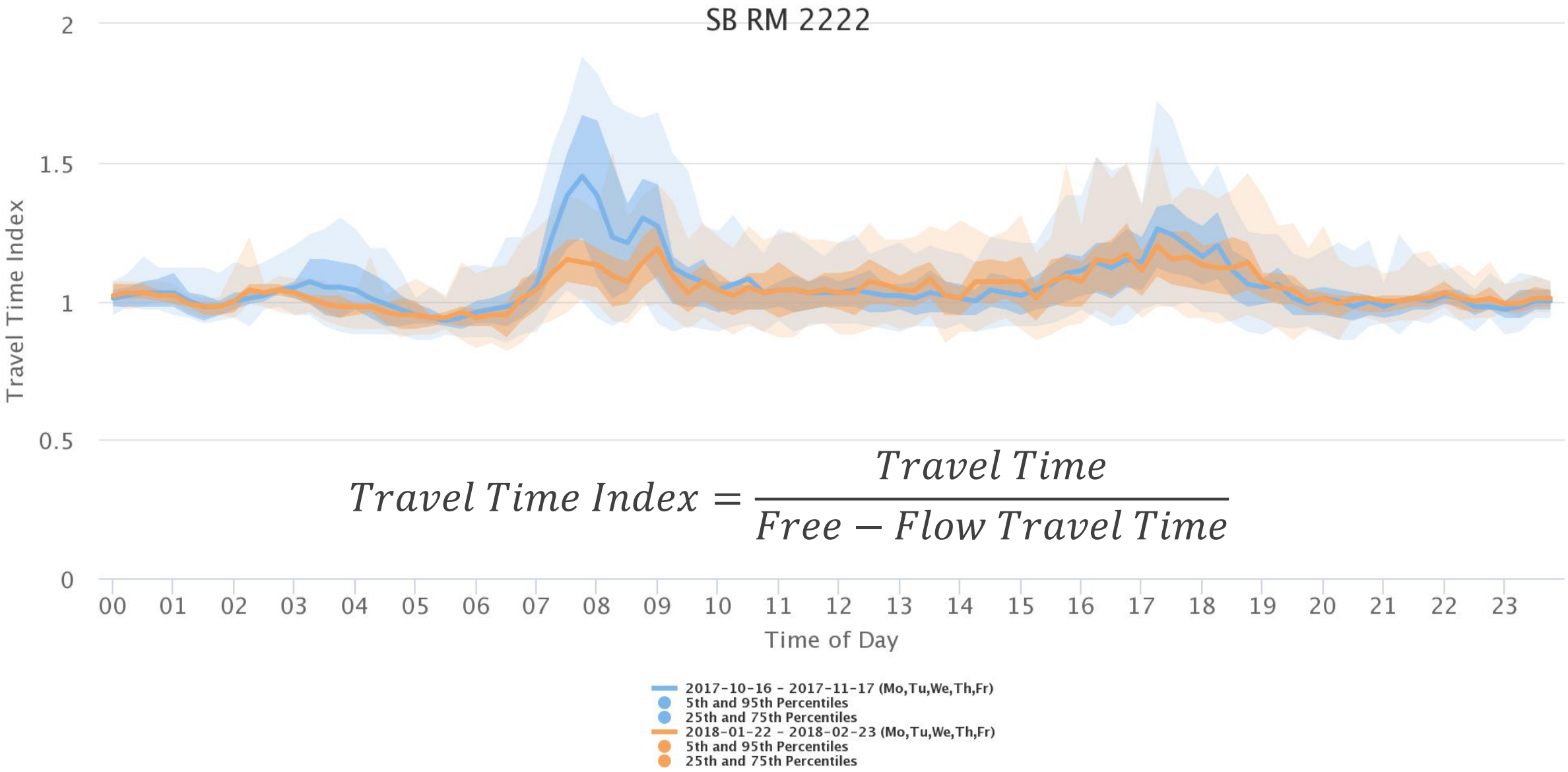
Advanced MOEs

- Deeper analysis of signal retiming efforts
- Signal retiming can also improve reliability
- Δ confidence intervals (CI) of the MOEs
- CI = 95th percentile - 5th percentile.

Analysis and Results – Advanced MOEs

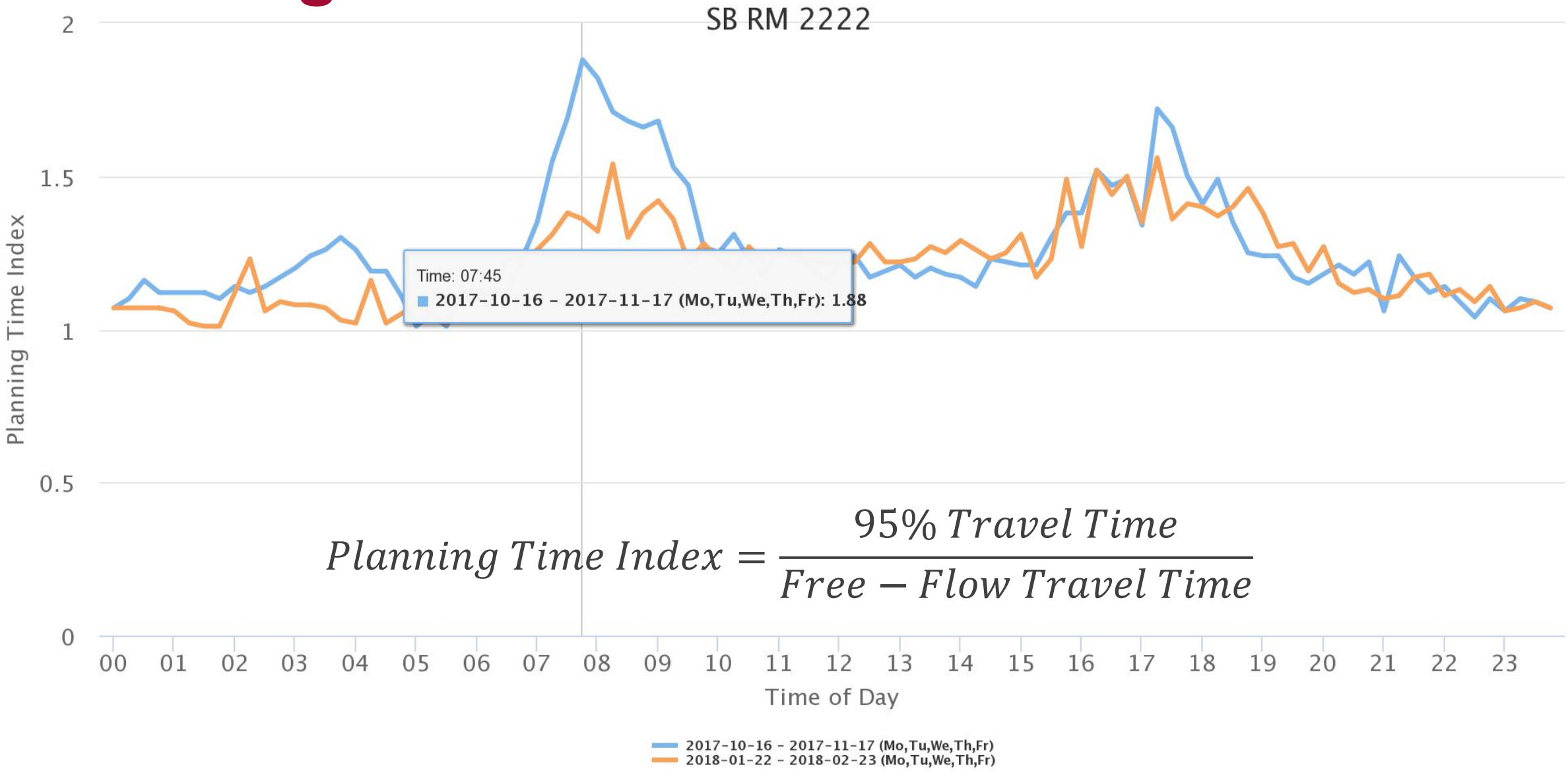
- Travel Time Confidence Interval
- Speed Confidence Interval
- Travel Time Index Confidence Interval
- Buffer Time
- Planning Index

Travel Time Index



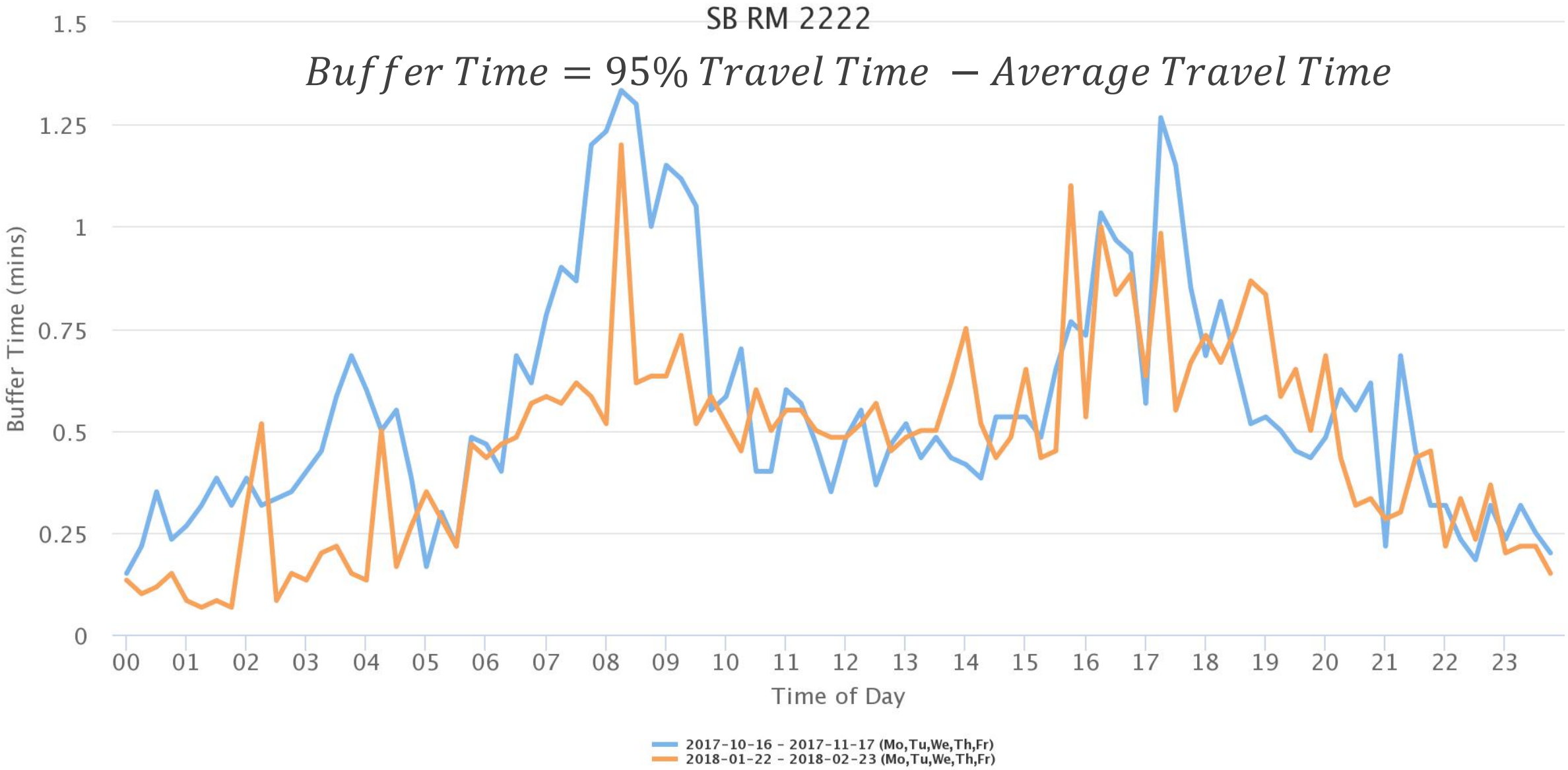
$$Travel\ Time\ Index = \frac{Travel\ Time}{Free - Flow\ Travel\ Time}$$

Planning Time Index

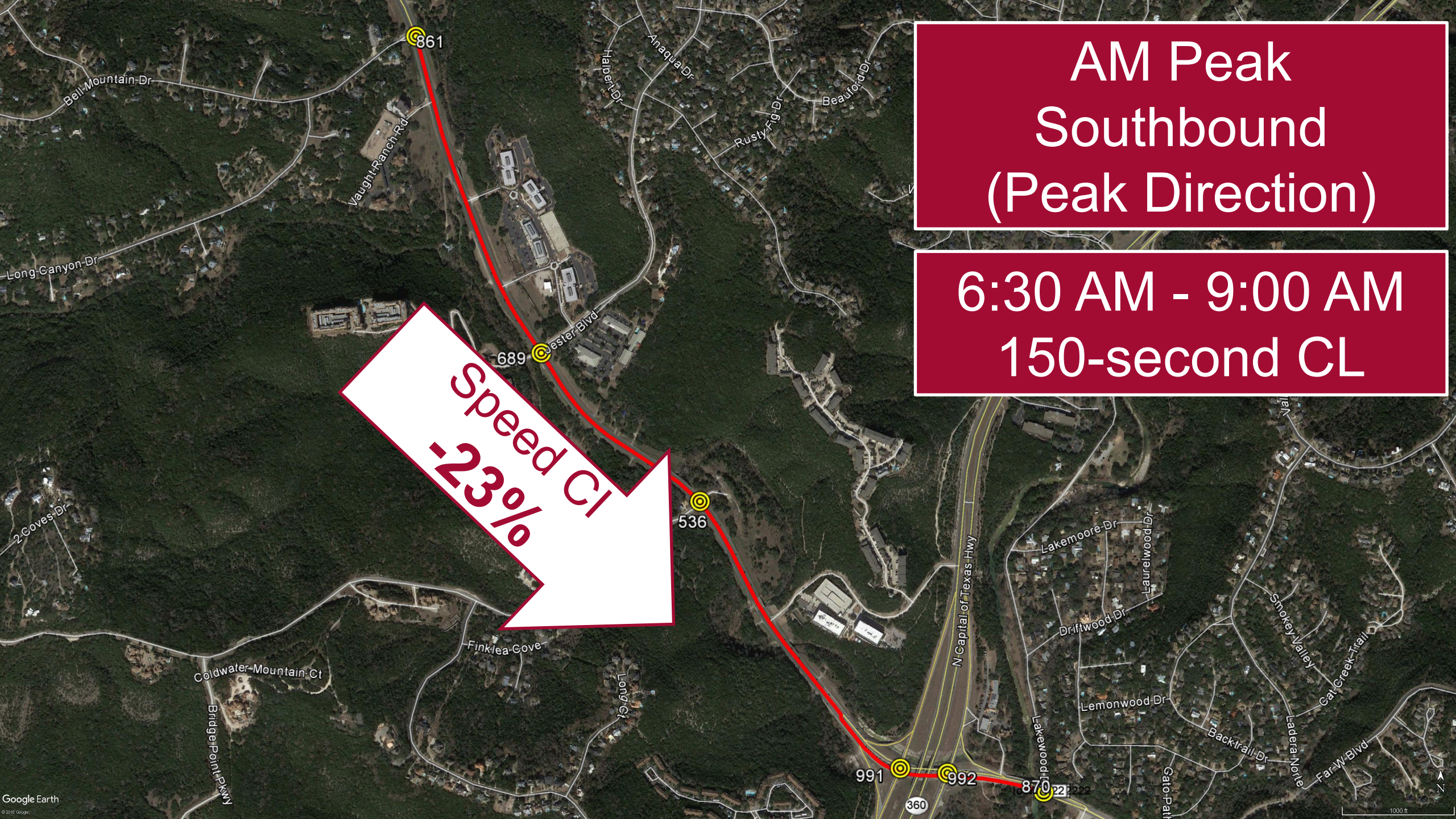


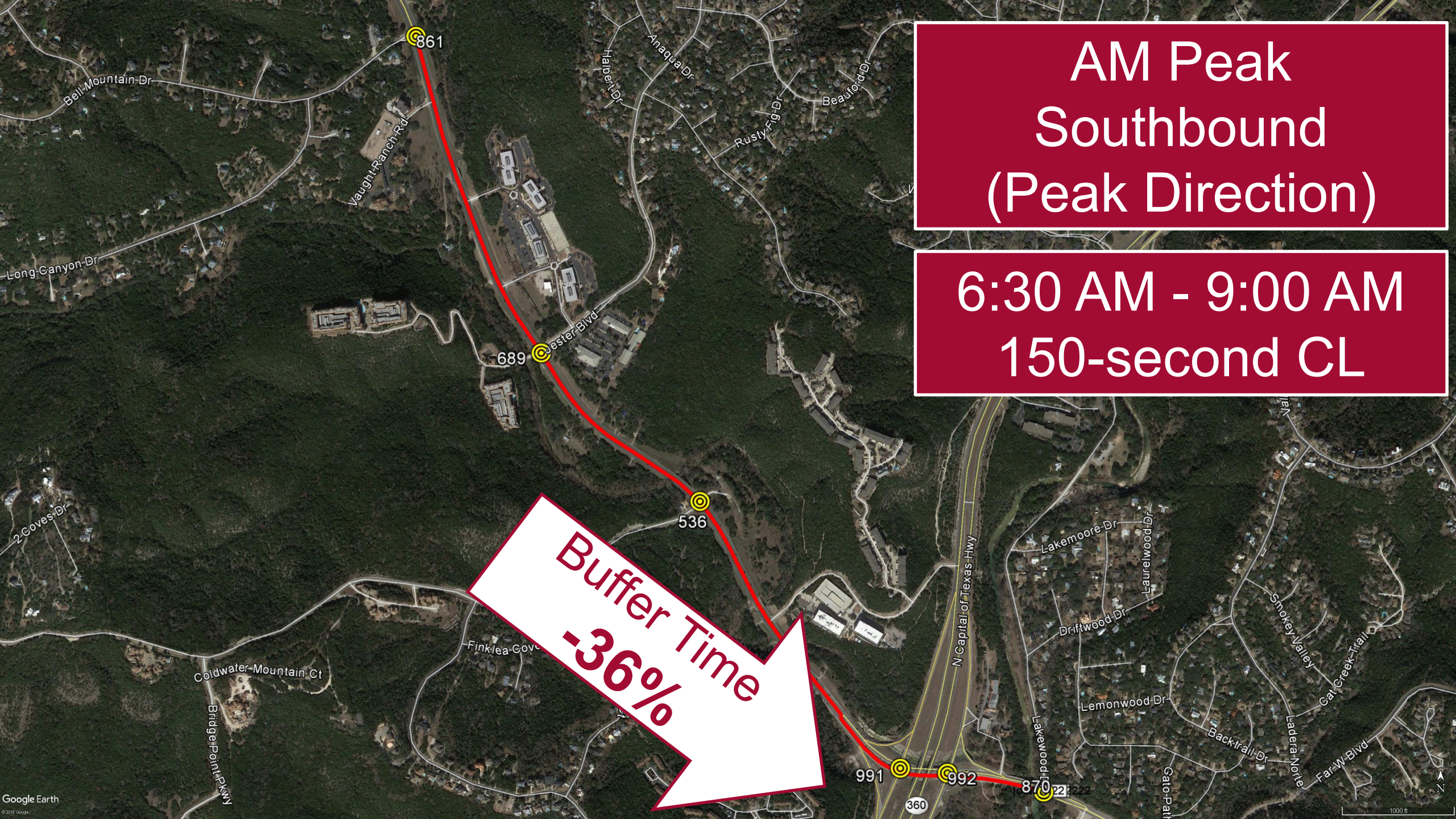
$$Planning\ Time\ Index = \frac{95\%\ Travel\ Time}{Free - Flow\ Travel\ Time}$$

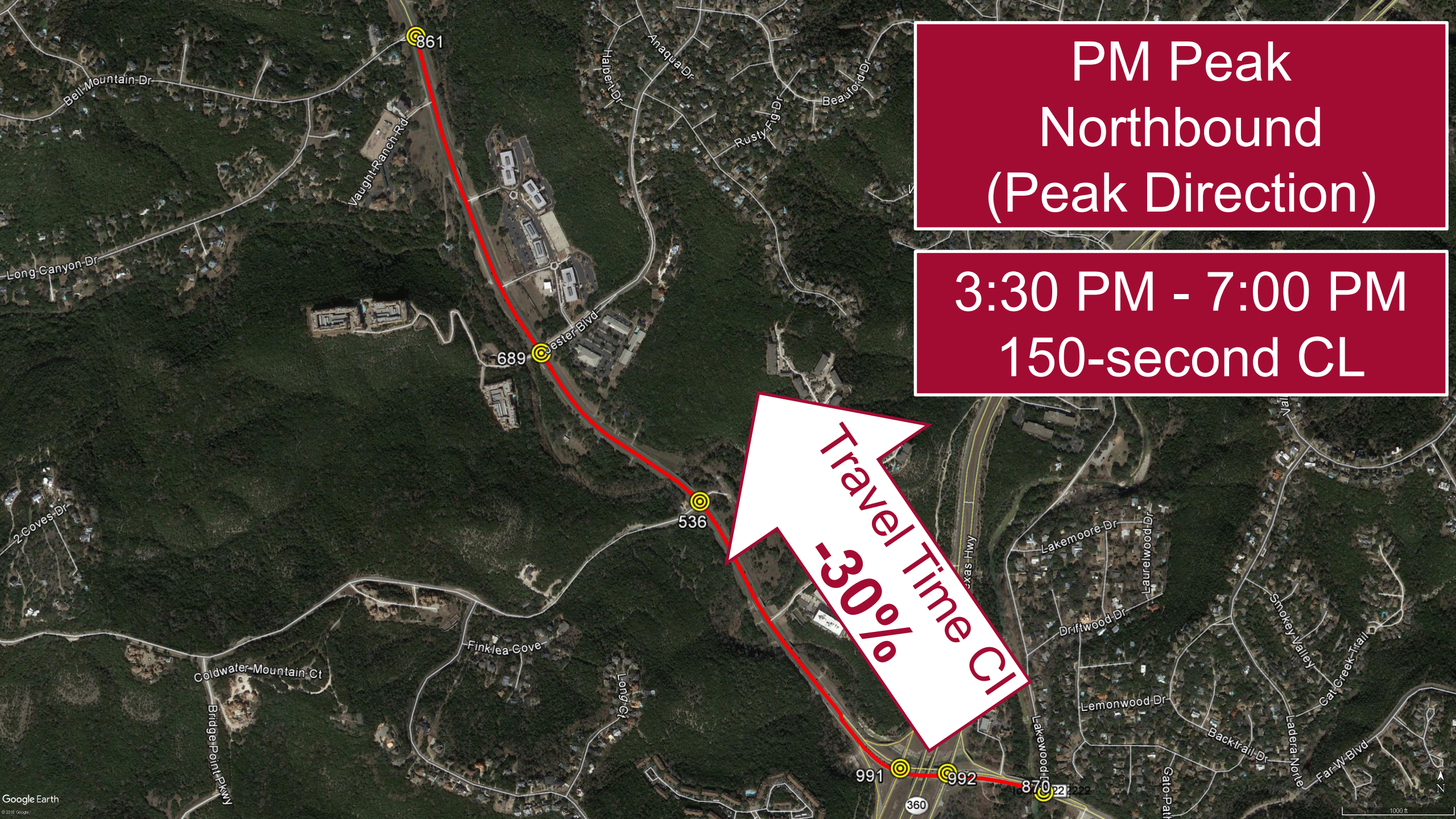
Buffer Time

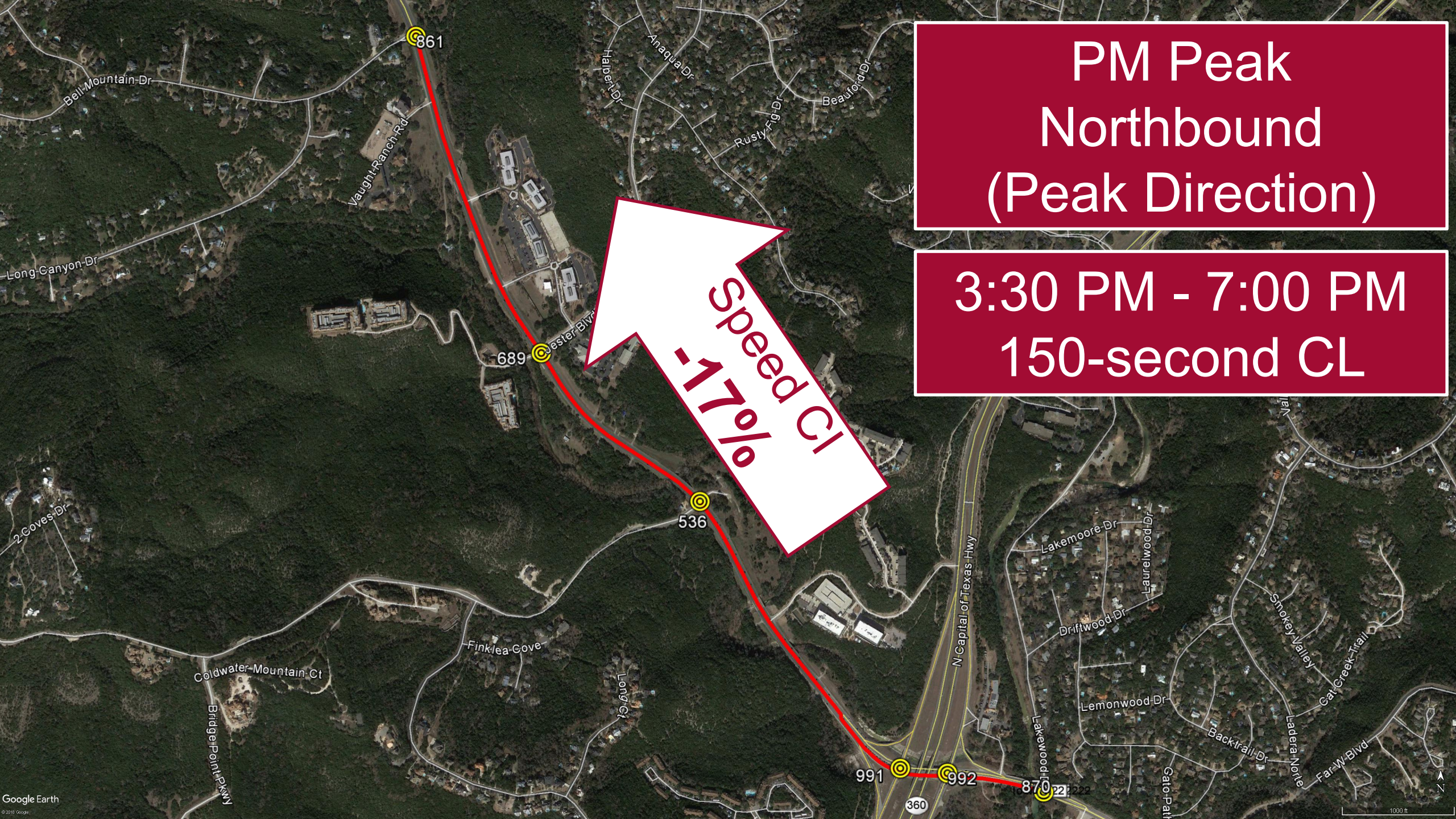

SB RM 2222
$Buffer\ Time = 95\%\ Travel\ Time\ - Average\ Travel\ Time$
Buffer Time (mins)
1.5
1.25
1
0.75
0.5
0.25
0
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Time of Day
2017-10-16 - 2017-11-17 (Mo,Tu,We,Th,Fr)
2018-01-22 - 2018-02-23 (Mo,Tu,We,Th,Fr)

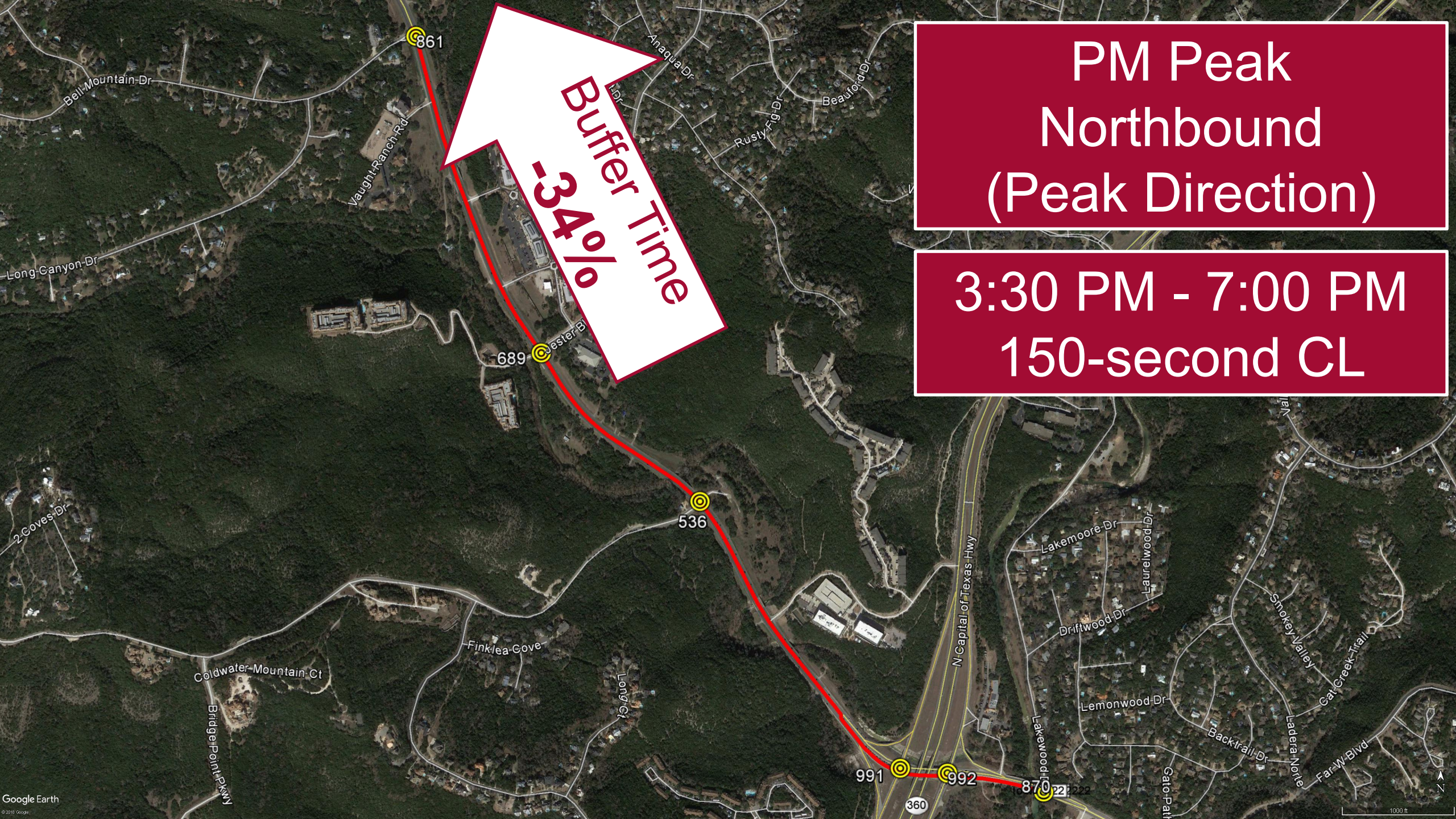

AM Peak
Southbound
(Peak Direction)
6:30 AM - 9:00 AM
150-second CL
Travel Time CI
-41%
861
689
536
991
992
870
Bell Mountain Dr
Long Canyon Dr
2 Coves Dr
Coldwater Mountain Ct
Bridge Point Pkwy
Finklea Cove
Long Ct
Halbert Dr
Anaqua Dr
Rusty Fig Dr
Beauford Dr
Lester Blvd
N Capital of Texas Hwy
Lakemoore Dr
Laurelwood Dr
Driftwood Dr
Lemonwood Dr
Lakewood Dr
Smokey Valley
Cat Creek Trail
Backtrail Dr
Ladera Norte
Far W Blvd
Gato Pati
360
Google Earth


AM Peak
Southbound
(Peak Direction)
6:30 AM - 9:00 AM
150-second CL
Speed CI
-23%
861
689
536
991
992
870
Bell Mountain Dr
Vaught Ranch Rd
Long Canyon Dr
Halbert Dr
Anaqua Dr
Rusty Fig Dr
Beauford Dr
Chester Blvd
2 Coves Dr
Finklea Cove
Coldwater Mountain Ct
Bridge Point Pkwy
Long Ct
N Capital of Texas Hwy
Lakemoore Dr
Laurelwood Dr
Driftwood Dr
Lemonwood Dr
Lakewood Dr
Smokey Valley
Cat Creek Trail
Backtrail Dr
Ladera Norte
Far W Blvd
Gato Pati
360
Google Earth


AM Peak
Southbound
(Peak Direction)
6:30 AM - 9:00 AM
150-second CL
Buffer Time
-36%
861
689
536
991
992
870
Bell Mountain Dr
Vaught Ranch Rd
Long Canyon Dr
Halbert Dr
Anaqua Dr
Rusty Fig Dr
Beauford Dr
Chester Blvd
2 Coves Dr
Coldwater Mountain Ct
Bridge Point Pkwy
Finklea Cove
N Capital of Texas Hwy
Lakemoore Dr
Laurelwood Dr
Driftwood Dr
Lemonwood Dr
Lakewood Dr
Smokey Valley
Cat Creek Trail
Backtrail Dr
Ladera Norte
Far W Blvd
Gato Pati
360
Google Earth


PM Peak
Northbound
(Peak Direction)
3:30 PM - 7:00 PM
150-second CL
Travel Time CI
-30%
861
689
536
991
992
870
Bell Mountain Dr
Vaught Ranch Rd
Halbert Dr
Anaqua Dr
Rusty Fig Dr
Beauford Dr
Long Canyon Dr
Chester Blvd
2 Coves Dr
Finklea Cove
Coldwater Mountain Ct
Bridge Point Pkwy
Long Ct
Texas Hwy
Lakemoore Dr
Laurelwood Dr
Driftwood Dr
Lemonwood Dr
Lakewood Dr
Smokey Valley
Cat Creek Trail
Backtrail Dr
Ladera Norte
Far W Blvd
Gato Pati
360
Google Earth


PM Peak
Northbound
(Peak Direction)
3:30 PM - 7:00 PM
150-second CL
Speed CI
-17%
861
689
536
991
992
870
Bell Mountain Dr
Vaught Ranch Rd
Long Canyon Dr
Halbert Dr
Anaqua Dr
Rusty Fig Dr
Beauford Dr
2 Coves Dr
Coldwater Mountain Ct
Bridge Point Pkwy
Finklea Cove
Long Ct
N Capital of Texas Hwy
Lakemoore Dr
Laurelwood Dr
Driftwood Dr
Lemonwood Dr
Lakewood Dr
Smokey Valley
Cat Creek Trail
Backtrail Dr
Ladera Norte
Far W Blvd
Gato Pati
360
Google Earth


PM Peak
Northbound
(Peak Direction)
3:30 PM - 7:00 PM
150-second CL
Buffer Time
34%
861
689
536
991
992
870
Bell Mountain Dr
Vaught Ranch Rd
Anaqua Dr
Beauford Dr
Rusty Fig Dr
Long Canyon Dr
2 Coves Dr
Coldwater Mountain Ct
Bridge Point Pkwy
Finklea Cove
Long Ct
N Capital of Texas Hwy
Lakemoore Dr
Laurelwood Dr
Driftwood Dr
Lemonwood Dr
Lakewood Dr
Smokey Valley
Cat Creek Trail
Backtrail Dr
Ladera Norte
Far W Blvd
Gato Pati
360
Google Earth

Analysis and Results – User Delay Costs

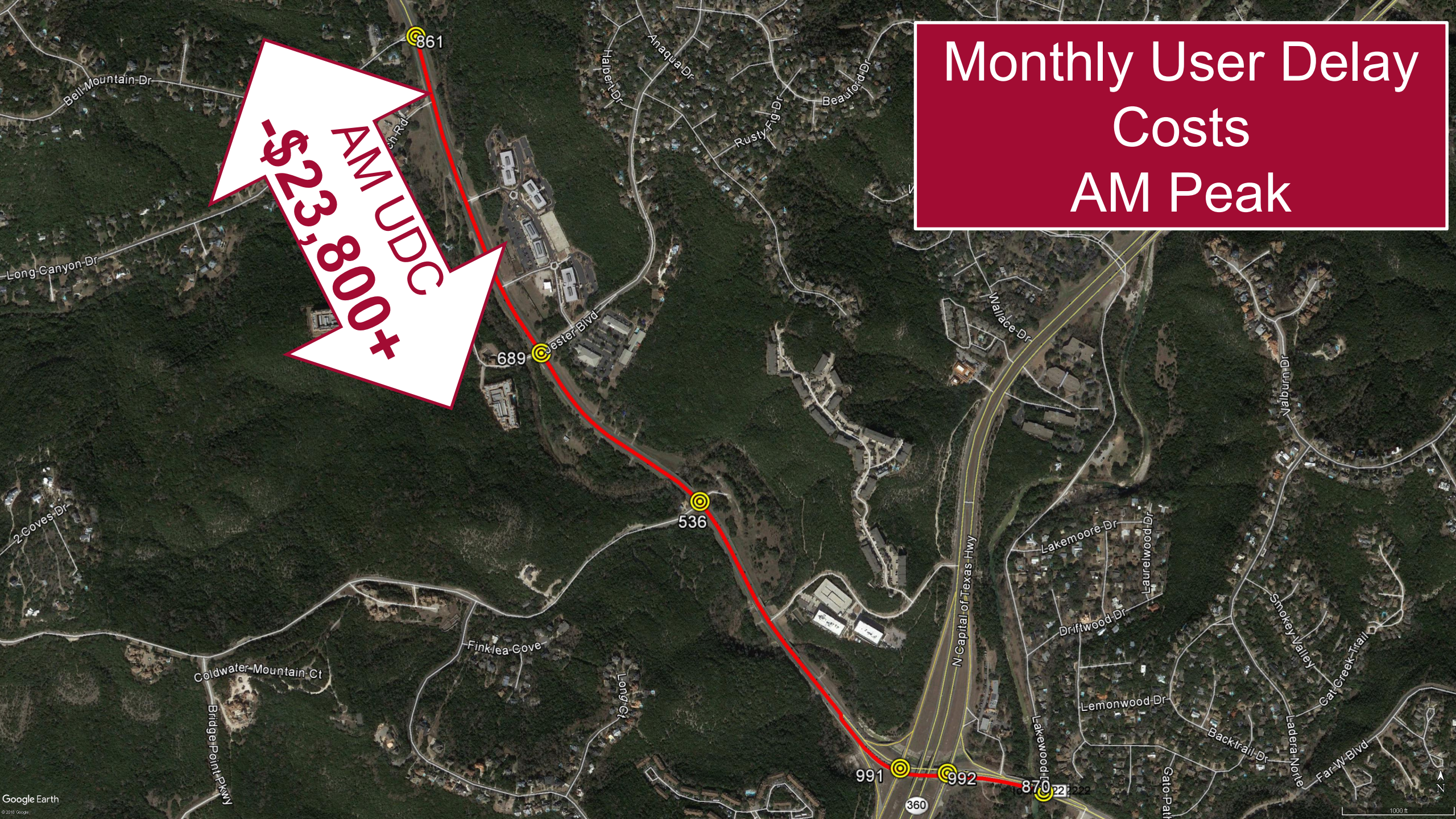
- Combines probe speed data with volume data provided by the Texas Transportation Institute to estimate the cost of delay experienced by drivers as a result of congestion.

User Delay Cost

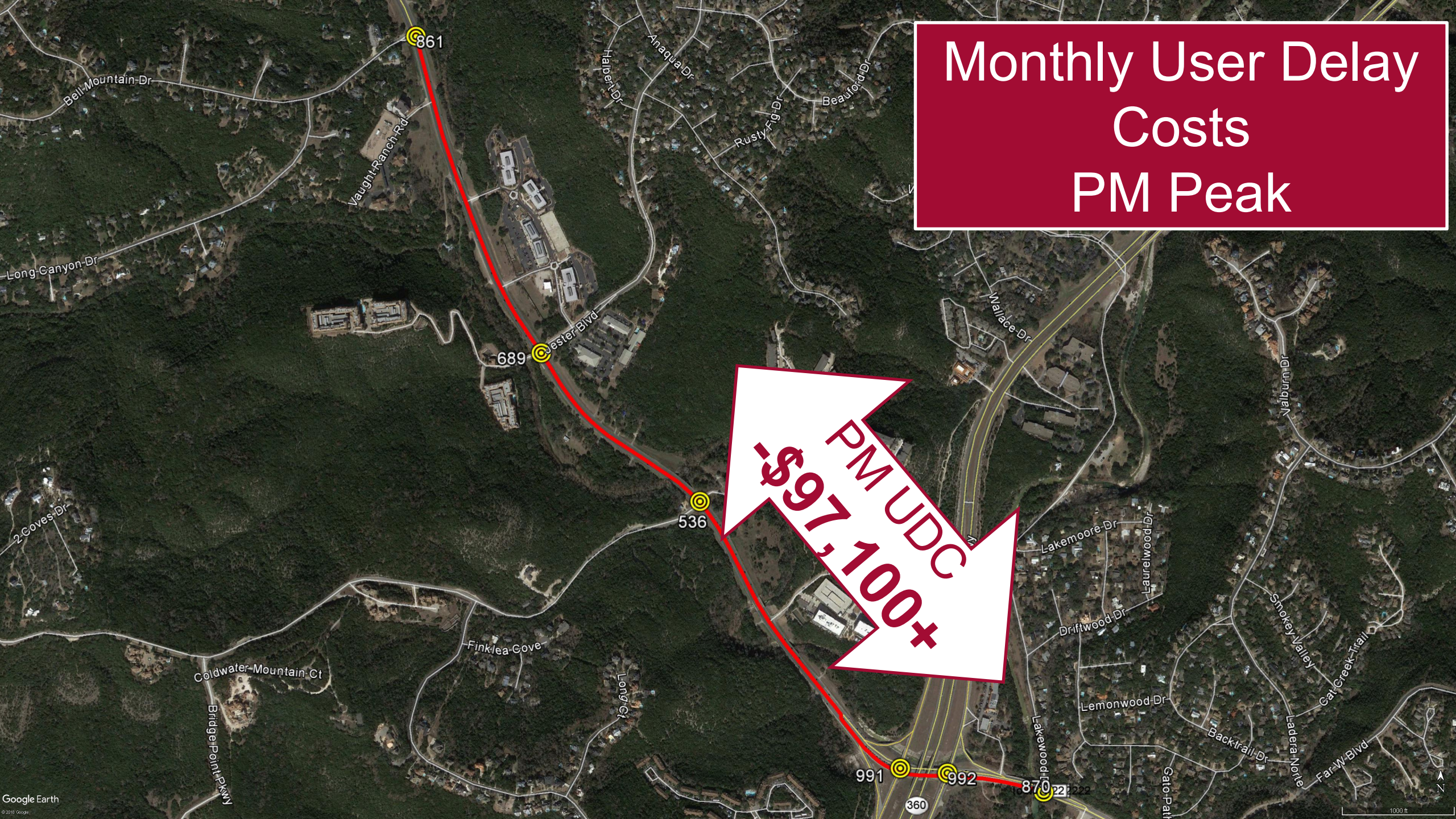
Monday, October 16, 2017 1:00 AM
Delay cost:
Total: $4.16
Per VMT: $0.01
Hours of delay:
Person-hours: 10m 6s
Vehicle-hours: 8m 15s
Vehicle miles traveled (VMT):
Total: 508 miles
Passenger: 458 miles
Commercial: 51 miles
Delay per VMT: 0.0162 mins / mile
Data validity: 100%
Click the table cell to see links to congestion scans

	12 AM	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	Daily Totals
10/16/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.2K	$0.4K	$0.4K	$0.3K	$0.3K	$0.2K	$0.2K	$0.4K	$0.5K	$0.4K	$3.5K	$6.3K	$1.4K	$0.3K	$0.1K	$0.1K	$0K	$0K	$15.1K
10/17/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.2K	$0.8K	$0.5K	$1.3K	$0.1K	$0.5K	$0.3K	$0.2K	$0.7K	$0.5K	$4.7K	$6K	$2.1K	$0.4K	$0.2K	$0.1K	$0K	$0K	$18.8K
10/18/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.8K	$0.3K	$1K	$0.4K	$0.1K	$0.1K	$0.2K	$0.2K	$0.9K	$0.9K	$5K	$7.6K	$1.9K	$0.2K	$0K	$0K	$0K	$0.1K	$20K
10/19/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.1K	$0.5K	$0.5K	$0.6K	$0.1K	$0.1K	$0.3K	$0.3K	$0.4K	$0.9K	$4.9K	$5.3K	$1.9K	$0.4K	$0.1K	$0.1K	$0K	$0K	$16.6K
10/20/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.1K	$0.4K	$1K	$0.5K	$0.4K	$0.4K	$0.3K	$0.1K	$1K	$0.9K	$4.6K	$2.9K	$0.4K	$0.2K	$0.2K	$0K	$0K	$0K	$13.7K
10/21/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0K	$0.1K	$0.2K	$0K	$0.1K	$0.2K	$0.2K	$0.9K	$0.2K	$0.4K	$0.4K	$0.3K	$0.2K	$0.3K	$0K	$0K	$0K	$0.1K	$3.8K
10/22/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0K	$0.1K	$0.1K	$0.4K	$0.3K	$0.1K	$0.3K	$0.2K	$0.4K	$0.1K	$0.2K	$0K	$0.1K	$0K	$0K	$0K	$0K	$0K	$2.3K
10/23/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.8K	$1.1K	$0.6K	$0.1K	$0.1K	$0.5K	$0.1K	$0.2K	$0.4K	$2.8K	$5.4K	$1.2K	$0.1K	$0.1K	$0K	$0K	$0K	$13.6K
10/24/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.5K	$0.4K	$0.9K	$1K	$0.2K	$0.5K	$0.3K	$0.2K	$0.6K	$0.3K	$4.4K	$5K	$1.3K	$0.4K	$0.1K	$0K	$0K	$0K	$16.3K
10/25/17	$0K	$0K	$0K	$0K	$0K	$0.2K	$0.2K	$0.3K	$0.8K	$0.2K	$0K	$0.1K	$0.1K	$0.2K	$0.7K	$0.8K	$5.1K	$5.6K	$2.1K	$0.3K	$0.1K	$0.2K	$0.1K	$0K	$17.3K
10/26/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.1K	$0.7K	$1.1K	$0.8K	$0.3K	$0.2K	$0.7K	$0.3K	$0.7K	$0.6K	$6.1K	$4.9K	$1.9K	$0.5K	$0.3K	$0.1K	$0K	$0K	$19.5K
10/27/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.2K	$0.7K	$1.2K	$0.6K	$0K	$0.1K	$0.3K	$0.6K	$1.2K	$1.4K	$5.9K	$5.2K	$0.8K	$0.1K	$0K	$0.1K	$0K	$0K	$18.5K
10/28/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0K	$0K	$0K	$0.1K	$0.1K	$0.3K	$0.2K	$0.2K	$0.3K	$0.3K	$0.3K	$1.4K	$0.4K	$0.2K	$0.1K	$0K	$0.1K	$0K	$4.2K
10/29/17	$0K	$0K	$0.1K	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.2K	$0.1K	$0.2K	$0.1K	$0.1K	$0.2K	$0.3K	$0.2K	$0.4K	$0K	$0K	$0.1K	$0K	$0.1K	$2.4K
10/30/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.2K	$0.6K	$0.2K	$0.1K	$0.3K	$0K	$0.2K	$0.7K	$0.5K	$0.4K	$3.1K	$5.2K	$2.4K	$0.7K	$0.1K	$0K	$0K	$0K	$14.8K
10/31/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.1K	$0.6K	$0.8K	$0.5K	$0.4K	$0.6K	$0.4K	$0.6K	$1K	$0.7K	$14K	$24.3K	$9.1K	$2.5K	$0.4K	$0.1K	$0K	$0K	$56.2K
11/01/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.6K	$1.3K	$0.9K	$0.2K	$0.3K	$0.7K	$0.7K	$0.6K	$1K	$4.2K	$5.1K	$2.3K	$0.4K	$0.1K	$0.1K	$0K	$0K	$18.6K
11/02/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.3K	$1.3K	$0.7K	$0.3K	$0.6K	$0.4K	$0.3K	$0.4K	$0.5K	$3.1K	$2.9K	$0.9K	$0.4K	$0.2K	$0.1K	$0K	$0K	$12.6K
11/03/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.4K	$0.8K	$1.4K	$0.7K	$0.1K	$0.2K	$0.6K	$1K	$1.1K	$1.7K	$4.5K	$2.7K	$0.7K	$0.3K	$0.1K	$0.1K	$0K	$0K	$16.6K
11/04/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.1K	$0.1K	$0.1K	$0.2K	$0.2K	$0.2K	$0.3K	$0.1K	$0.4K	$0.2K	$0.5K	$0.3K	$0.2K	$0K	$0.1K	$0K	$0K	$3.1K
11/05/17	$0K	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.1K	$0.3K	$0.2K	$0.3K	$1K	$0.4K	$0.2K	$0.4K	$0.1K	$0K	$0.1K	$0K	$0K	$0.1K	$0K	$0K	$3.4K
11/06/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.8K	$1K	$0.8K	$0.3K	$0.3K	$0.2K	$0.5K	$0.6K	$0.5K	$2.8K	$6.8K	$3.2K	$0.3K	$0.1K	$0K	$0K	$0K	$18.5K
11/07/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.2K	$0.5K	$1.3K	$0.8K	$0.1K	$0.5K	$0.3K	$0.5K	$1K	$0.9K	$4.3K	$8K	$3.6K	$0.6K	$0.1K	$0.1K	$0K	$0K	$22.7K
11/08/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.2K	$0.9K	$1.2K	$0.7K	$0.4K	$0.5K	$0.6K	$0.5K	$0.6K	$0.7K	$6.3K	$11.6K	$5K	$0.6K	$0.1K	$0.3K	$0K	$0K	$30.2K
11/09/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.3K	$0.9K	$1.2K	$0.7K	$0.2K	$0.2K	$0.2K	$0.5K	$0.3K	$0.7K	$4.6K	$7.3K	$4.9K	$0.3K	$0.1K	$0.1K	$0K	$0K	$22.7K
11/10/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.3K	$0.6K	$0.8K	$0.7K	$0.2K	$0.3K	$0.5K	$0.5K	$1.7K	$1K	$4.4K	$3.9K	$0.9K	$0.3K	$0.1K	$0.1K	$0.3K	$0.1K	$16.9K
11/11/17	$0K	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.1K	$0.2K	$0.2K	$0.4K	$0.6K	$0.9K	$0.4K	$0.5K	$0.4K	$0.4K	$0.2K	$0.3K	$0.3K	$0.2K	$0.1K	$0K	$5.3K
11/12/17	$0.1K	$0K	$0K	$0K	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.8K	$0.6K	$0.8K	$0.1K	$0K	$0.5K	$0.5K	$0.1K	$0.1K	$0K	$0.1K	$0K	$0K	$3.9K
11/13/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.2K	$0.5K	$0.7K	$0.6K	$0.5K	$0.1K	$0.4K	$0.2K	$0.6K	$0.5K	$4.2K	$7.9K	$1.8K	$0.7K	$0.1K	$0K	$0K	$0K	$19.3K
11/14/17	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.1K	$0.5K	$1K	$0.7K	$0.2K	$0.4K	$0.3K	$0.3K	$0.9K	$0.4K	$5.3K	$8.2K	$2.6K	$0.2K	$0.2K	$0.1K	$0K	$0K	$21.5K
11/15/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.2K	$0.5K	$1.1K	$0.8K	$0.1K	$0.1K	$0.3K	$0.4K	$0.5K	$0.4K	$5K	$7.1K	$2.4K	$0.5K	$0.3K	$0K	$0K	$0K	$19.9K
11/16/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.1K	$0.6K	$0.8K	$0.6K	$0.2K	$0.3K	$0.4K	$0.4K	$1K	$0.4K	$4.1K	$5.8K	$2.2K	$0.2K	$0.1K	$0.1K	$0K	$0.1K	$17.4K
11/17/17	$0K	$0K	$0K	$0K	$0K	$0K	$0.4K	$0.4K	$0.9K	$0.9K	$0.1K	$0.2K	$0.1K	$1K	$1K	$1.8K	$3.6K	$2.1K	$0.9K	$0.2K	$0K	$0.1K	$0.1K	$0K	$13.9K
Hourly Totals	$0.3K	$0.1K	$0.2K	$0.1K	$0.1K	$2.1K	$5.7K	$14.9K	$24.4K	$17.8K	$6.6K	$9.4K	$12.1K	$14.5K	$20.4K	$21.2K	$123K	$166.5K	$59.7K	$12.1K	$4.1K	$2.5K	$1.1K	$0.7K	Grand Total $519,505.71

Monthly User Delay Costs AM Peak



Monthly User Delay Costs
PM Peak



Monthly User Delay Costs PM Peak

Analysis Conclusions

- Overall, the RM 2222 retiming effort was a success.
- Travel time was reduced 5% in peak direction AM & PM
- Operations made more reliable/less variable overall
- Significant UDC savings for the City of Austin
- Explosive population growth in Central Texas

Lessons Learned

Before & After Studies

Crowd-Sourced vs. Floating Car

Crowd-Sourced Data

- Massive data set
  - Up to years of data
  - 24 hours of data
- Flexible
- Historical
- Continuous
- Collection of links
- Normal day?

Floating Car TTR

- Limited data set
  - 5 runs per direction per peak
- Stops
- Context
  - Weather
  - Construction
- Full corridor
- Labor intensive

Benefits of Probe-Based Data

- As accurate as Bluetooth
- No infrastructure investment
- Historical data available
- Large data set
- 24-hr continuous data set
- No additional labor for collection
- No local storage
- Advanced metrics

Challenges of Probe-Based Data

- No stop information
- Lack of context
  - Weather
  - Special events
  - Incidents
  - Temporary lane closures
  - Operational issues
- Combination of links

Kimley»Horn

Questions

Tom Hartmann, P.E., PTOE, IMSA TS II
tom.hartmann@kimley-horn.com