Welcome

Texas State Transportation Innovation Council

TXSTIC.org

Innovation in Context

North Central Texas Council of Governments

TxSTIC Mission

Our mission is to facilitate the rapid implementation of innovative technology, tactics and techniques among transportation program delivery professionals at all levels of state government and throughout the private and non-profit sector to ensure smart, efficient investment in Texas highway and transportation infrastructure.

TxSTIC Vision

Our vision is to foster a collaborative culture for the rapid implementation of ready to deploy and beneficial innovations and technologies to efficiently deliver a safe and effective transportation system to the citizens of Texas.

TxSTIC Goals

TxSTIC's primary purpose is to provide a forum for transportation leadership to review and collaborate on specific initiatives that best align to the transportation goals of the State of Texas.

The TxSTIC will discuss and respond to key issues and challenges that impact the transportation system.

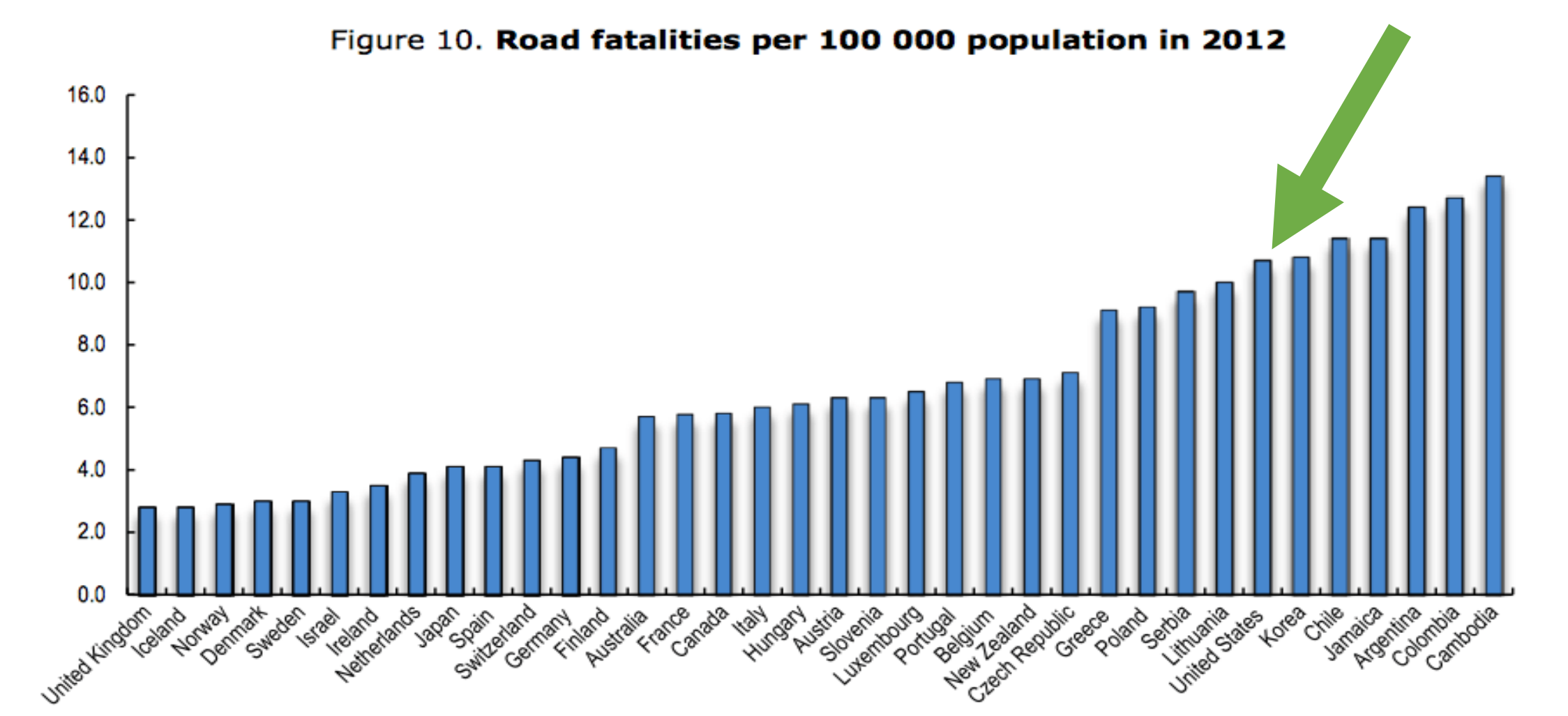
Innovation Context: Public Health

Heavy emphasis on motor vehicle travel; limited support for other options—mobility limits for many

Crashes leading cause of injury-related death for many age groups

Transportation accounts for one-third of U.S. CO2 emissions, other environmental burdens

Innovation Context Safety



Innovation Context: Performance

Hours in congestion up over past 20 years
ROI on new roads diminishing
No pricing = bottomless demand
Maintenance resources inadequate
Transportation cost burdensome for many—poverty cause

Innovation Context: Prospects--DFW

Public sector: $120+ billion investment

Vehicle Miles Traveled: Up 55%

Highway capacity: Up 18%

Vehicle hours in delay: Up 136%

Highway deaths: 15,000

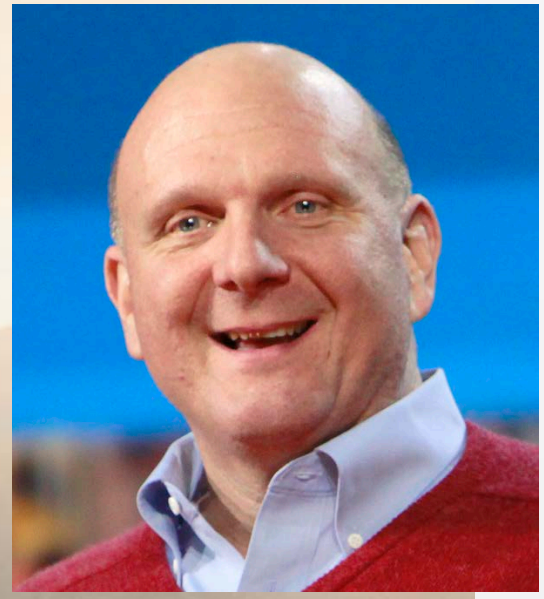
Highway injuries: 1,000,000

Prediction No. 1

"By 2030, 95% of U.S. passenger miles traveled will be served by on-demand autonomous electric vehicles owned by fleets, not individuals."

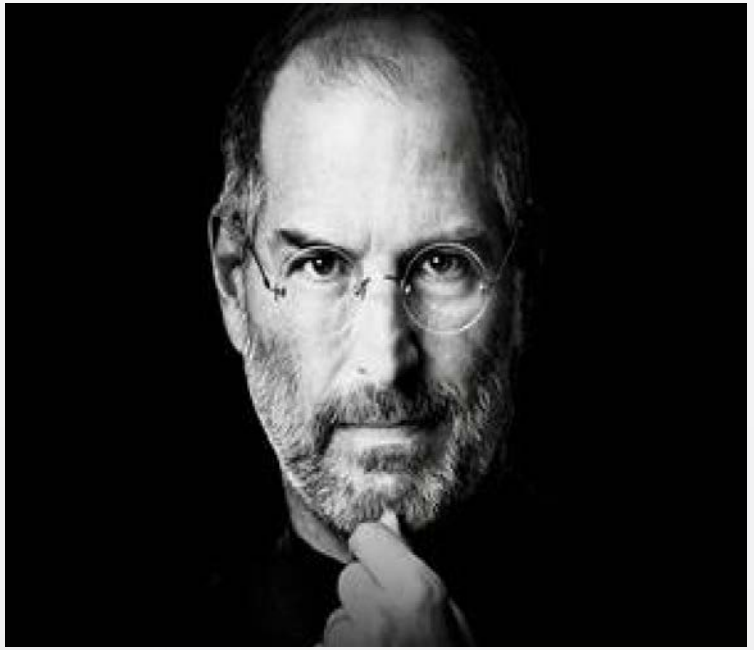
RethinkX
Disruption.
Implications.
Choices.

Prediction No. 2



Prediction No. 3

"It will be as big as the PC."



Q: Does Project Improve…

Public health, safety and welfare?

Long-term prospects of our transportation system?

Performance of current transportation system?

Culture of innovation in transportation sector?

Thomas J. Bamonte
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TXSTIC 17 Updates

Sonya Badgley, TXDOT

U.S. Department of Transportation
Federal Highway Administration

TxSTIC
TEXAS STATE TRANSPORTATION INNOVATION COUNCIL

Texas Department of Transportation

Addressing Safety of Freight Centers During Planned and Development Stages

Bill Frawley, TTI

b-frawley@tti.tamu.edu

Project Team

TXDOT Sponsors:

- Transportation Planning & Programming: Peter Smith
- Freight & International Trade: Caroline Mays

Project Manager: Sonya Badgley

Houston District: Bill Brudnick

Tyler District: Bryan Lutz

Traffic Operations: Charles Koonce III

Austin District: Joseph Muck

Freight & International Trade: Kale Driemeier

Traffic Operations: Marco Cameron

Road Weather Management – Weather Savvy Roads

Chandra Bhat, CTR

bhat@mail.utexas.edu

Project Team

TXDOT Sponsors:

- Maintenance Division Director: Michael Lee
- Brownwood District: Elias Rmeili

Project Manager: Joe Adams

Project Team:

- Emergency Management: Gilbert Jordan
- Operations Brownwood District: Carl Johnson
- Traffic Operations: Brian Fariello
- Traffic Operations: Jianming Ma
- Federal Highway: Toni Whitfield

Road Weather Management – Weather Savvy Roads

Brownwood District

Wildfires and flash floods have a significant impact on safety and mobility throughout Central Texas. TxDOT roadways play a critical role in enabling the evacuation of affected residents and effective inter-agency coordination.

Integrate and share data from multiple sources: to enhance safety during extreme weather events, reduce the impacts of such events on mobility, and support evacuation operations when needed. The Performing Agency will use integrated mobile observation (IMO) devices and explore the potential of social media to enhance data collection techniques and analysis capabilities and to support improved traffic management plans and evacuation strategies. Social media, such as Twitter, may be used to develop a better understanding of ongoing events, and to disseminate information in real time. It can also provide valuable information to analyze the outcomes of traffic management strategies in the aftermath of an event.

Implementation of cross agency data collection/sharing prototypes and test Intelligent Transportation System (ITS) strategies and other information dissemination techniques. The project data collection, sharing and analysis tools will factor in the importance of transferability and replicability to facilitate the use of products for weather-related conditions in other Texas locations, and to reduce the corresponding costs.

Road Weather Management – Weather Savvy Roads

Brownwood District

Objective 1 - Data collection, analysis and sharing:

Collect data for safety and continued mobility of people, products and services during wildfires, flash floods, and cold weather events that includes but is not limited to:

- the weather event characteristics,
- the roadway network, and
- related evacuation and traffic control plans

Objective 2 - Traveler information dissemination:

Integrate nation-wide best practices and feedback from stakeholders to provide information dissemination techniques and methodologies to determine the best use in leveraging new data and technologies.

Road Weather Management – Weather Savvy Roads

Workshops

2 Half Day workshops in two Districts

Training Material

Data-Driven Safety Analysis

Beaumont District

Many predictive and systemic analysis tools are now available that provide the means to quantify safety impacts in a similar way that roadway capacity and operations, environmental impacts, drainage, and pavement life can be quantified. TTI will develop a logical and practical framework for integrating these tools into practice within the Beaumont District.

3 Element Framework

- Identification of roadway segments and intersections with the greatest potential to reduce crashes and the development and evaluation of potential safety treatments.
- Correlation of prevalent crash types with specific roadway features to allow the development and evaluation of systemic safety improvements.
- Integration of safety assessment directly into the project development process.

Data-Driven Safety Analysis

Beaumont District

TTI will develop a process that integrates data driven and evidence-based safety analysis into the design and operations of state roadways within the Beaumont District. The framework is intended to be a model that could be adapted and utilized in other districts to assist decision makers as they determine viable roadway safety investments and enable incorporation of safety analyses directly into the design process.

User Guide and Workshops

How and when to apply the framework, what resources are required, and how the information can ultimately be used to continually improve roadway safety performance.

Practical assessment of when a basic safety assessment approach is suitable contrasted to the need to use an enhanced procedure. Includes, sample calculations for the various procedures included in the document.

Workshops for District Managers and Analysts/Designers

Data-Driven Safety Analysis

Robert Wunderlich, TTI

r-wunderlich@tti.tamu.edu

Project Team

Traffic Operations: Darran McDaniel

Project Manager: Wade Odell

Beaumont District: Tucker Ferguson

Beaumont District: Cory Taylor

Beaumont District: Cindy Dougherty

Federal Highway, TX Division: Steve Ratke

Design: Ken Mora

Automated Traffic Signal Performance Measures (ATSPM) for Improved Traffic Signal Operation and Maintenance in Texas

Srinivasa Sunkari, TTI

s-sunkari@tti.tamu.edu

Project Team

TXDOT Sponsors:

- Austin District: Terry McCoy
- Houston District: Quincy Allen
- Traffic Operations: Brian Fariello

Project Manager: Sonya Badgley

Project Team:

- Austin District: John Nevares, Imelda Barrett
- Department of Public Safety: MAJ David Palmer
- Federal Highway, TX Division: Toni Whitfield
- Traffic Operations: Henry Wickes
- Houston District: Ugonna Ughanze

Automated Traffic Signal Performance Measures (ATSPM) for Improved Traffic Signal Operation and Maintenance in Texas

Houston and Austin

The U.S. Department of Transportation (U.S. DOT) - Federal Highway Administration (FHWA), in conjunction with the American Association of State Highway and Transportation Officials (AASHTO), operate the Every Day Counts 4 program. The U.S. Department of Transportation (U.S. DOT) is promoting automated traffic signal performance measures (ATSPMs) under its Every Day Counts (EDC) program as a means to improve traffic signal performance. ATSPMs consist of high-resolution data-logging capability added to existing traffic signal infrastructure and data analysis techniques. This provides transportation operating agencies with the information needed to proactively identify and adjust operation of their traffic signal systems.

Specific objectives of using ATSPM:

Increased Safety. A shift to proactive operations and maintenance practices can improve safety by reducing the traffic congestion that results from poor and outdated signal timing.

Targeted Maintenance. ATSPMs provide the actionable information needed to deliver high-quality service to customers, with significant cost savings to agencies.

Improved Operations. Active monitoring of signalized intersection performance lets agencies address problems before they become complaints.

Automated Traffic Signal Performance Measures (ATSPM) for Improved Traffic Signal Operation and Maintenance in Texas

There are estimated to be over 25,000 signalized intersections in Texas, with over 2,700 of these traffic signals operated by the Receiving Agency. Receiving Agency staff has limited budget and time to monitor and maintain these intersections and corridors. For many of these signals, public feedback is the primary measure of performance.

ATSPM for Improved Traffic Signal Operation and Maintenance in Texas seeks to proactively provide increased safety, targeted maintenance, and improved operations.

Sonya Badgley, TXDOT
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TXSTIC.org

Implementing the Next Generation of Ultra-Thin Slurry Overlays

TxDOT Mike Arellano and Wade Odell

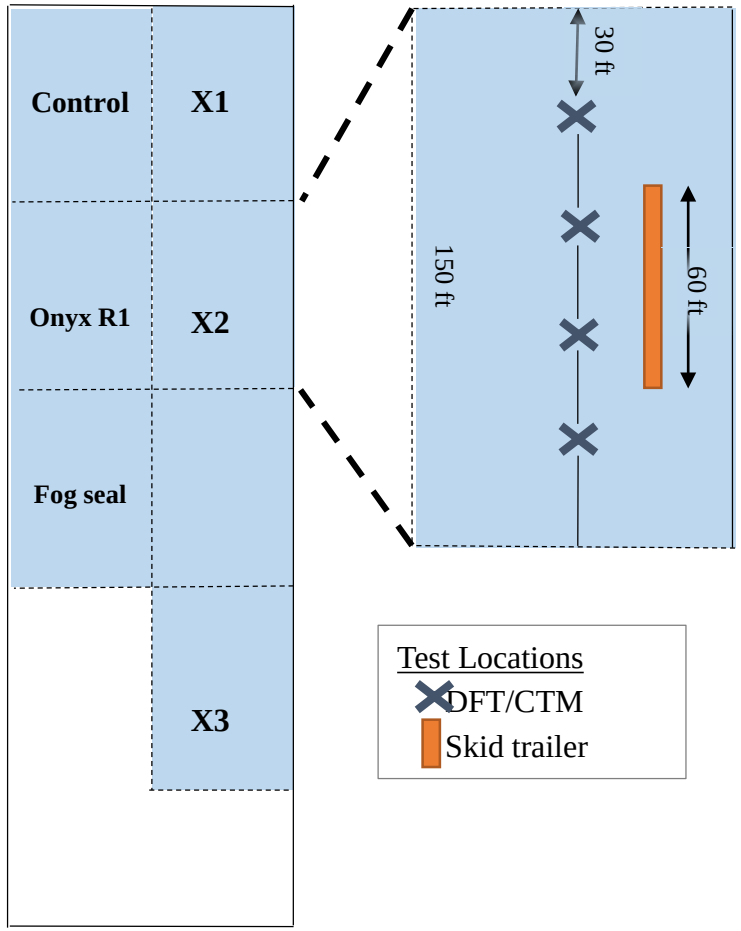
Texas A& M Transportation Institute

Tom Scullion, Cindy Estakhri and Tommy Blackmore

Ultra-Thin Slurry Overlays

- Spray applied maintenance treatment.
- Cross between slurry and fog seal.
- Cost $1:60 – $1:80 Sq. yard (turn key price)
  - Chip Seals $2:50
  - Overlays $6 - $8
- Properties:
  - Polymer-mod emulsion.
  - Embedded aggregate.
  - Rapid cure time.
  - Long-term black color.

Background
Test Section Construction 2014 at TTI



Placed on Riverside campus

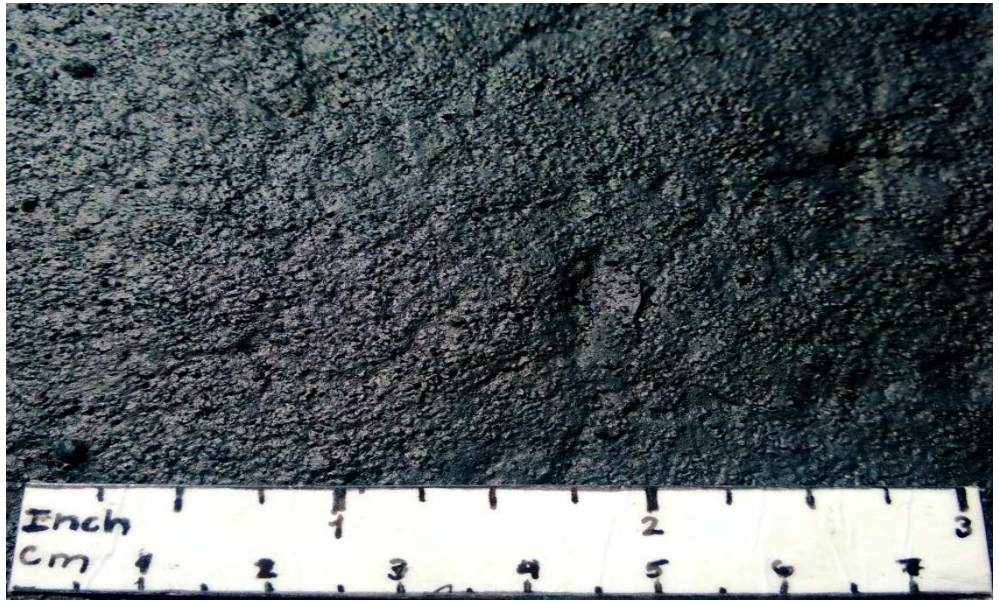
X1, X2, X3

Onyx R1

Fog seal squeegee applied

Original Performance Summary

- Higher skid performance over fog seal.
- Macrotexture, highly dependent on existing surface
- Unknown long-term durability.



Safety Applications

Under consideration by TxDOT Districts

Pavement Preservation Applications

Under consideration by TxDOT Districts

Work Plan

- Task 1 Plan Construction of Test Sections
  - Three Districts Austin, Fort Worth and Beaumont
    - 23, 212 and 18 lane miles respectively let in 2017
  - Document upfront condition
  - Identify objectives
- Task 2 Update Specifications
  - Existing SS 3028 (largely industry recommendations)
- Task 3 Construct and Monitor test Sections
  - Skid measurements for duration of study
  - Collect samples/Lab testing
  - Performance evaluation

Work Plan Continued

- Task 4 Prepare Workshop training materials
  - Guidelines to TxDOT Districts on where and how to use these
  - Findings of study
- Task 5 Present Training materials Workshop
  - Two training schools

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Accelerating Traffic Incident Management Data Collection

Tony Voight, TTI

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Jeff Kaufman, TTI

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Project Team

TXDOT Sponsors:

- Austin District: Terry McCoy
- Houston District: Quincy Allen

Project Manager: Sonya Badgley

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- Federal Highway, TX Division: Toni Whitfield
- Traffic Operations: Brian Fariello
- Houston District: Eliza Paul
- Houston District: Ugonna Ughanze

Research Involvement

North Central Texas Council of Governments

Introduction

Why is this Important?

- **Strategic Planning**
  - Explore new Ideas
- **Innovative Planning**
  - Different approach to solve issues
- **Limited Resources**
  - Funding, staff, etc.
- **Address Changing Landscape**
  - National Ambient Air Quality Standards, Safety
- **Knowledge Based**
  - Autonomous Vehicles

Research Involvement - National

Transportation Research Board (TRB)

- Air Quality Committee – Member
  - Analysis: Regional and Project-Level Air Quality Innovations Subcommittee – Chair
- Asset Management Committee – Member
- Plan Works – Member
- Roadmap for Transportation and Public Health – Member
- Value of Transportation Infrastructure Task Force – Member
- Standing Committee on Congestion Pricing – Member
- Standing Committee on Managed Lanes – Member
- Standing Committee on Military Transportation – Friend
- Standing Committee on Transportation Planning Applications – Friend

National Cooperative Highway Research Program (NCHRP)

- Project Panel on Case Studies for the Successful Completion of the National Environmental Policy Act (NEPA) Process for Multimodal Transportation Projects – Member

Research Involvement - State

Texas Department of Transportation (TxDOT)

- Planning and Environmental Functional Area Committee(FAC) – Member
- State Bicycle Advisory Committee – Member

Texas Air Quality Research Program (AQRP)

- Advisory Council – Member
- Texas State Transportation Innovation Council (STIC) – Member
- Transportation Programming and Investment Decision-Making Committee – Communications Coordinator

Sample of Current Research Project Involvement

TxDOT Project 0-6945

Ramp Metering Impact Study with Potential Regional Deployment Within the Dallas-Fort Worth Ozone Nonattainment Area

TxDOT Project 0-6927

Evaluation of Bicycle and Pedestrian Monitoring Equipment to Establish Collection Database and Methodologies for Estimating Non-Motorized Transportation

TxDOT Project 0-6636

Study conducted to find ability of photocatalytic NO_X/HRVOC/O_3 removal in transportation applications by applying coatings to existing concrete highway structures. Results found cost of applying coatings in the field to reduce air pollution is too large for the insubstantial NO_X reduction.

NCHRP Project 03-121

Incorporating Freight, Transit and Incident Response Stakeholders into Integrated Corridor Management (ICM): Process and Strategies for Implementation

Research Involvement - Local

University Partnership Program

Purpose: Support next generation of graduates and extend staff resources

University of Texas at Arlington

Driver Sensitivity to Dynamic Pricing of Managed Lanes in the North Central Texas Region

Public Health Performance Measures and Their Role in the Regional Metropolitan Transportation Planning Process

University of Texas at Austin

Travel Modeling in an Era of Connected and Automated Transportation Systems: An Investigation in the DFW Area

Long-Range Planning Implications of Managed Lane Facilities

Texas Southern University

Planning for Express Buses Operating in a Modern Network of Managed Lanes

Community Rail Viability (Social Parameters as a Component of the Transit Network Analysis)

Research Interests

Travel Behavior Associated with Application of New Technology

- Managed Lanes
- Autonomous Vehicles
- Automated Vehicles/Connected Vehicles

Benefits of Separating Freight Traffic

- Separate Lanes within Existing Corridors
- Truck Lane Restrictions
- Underground/Elevated Freight Shuttles

University Partnership Program

- Identify mobility gaps for low-income, elderly adults

Research Interests

High-Emitting Vehicles

Measurement of Exhaust from Vehicles Equipped with On-board Diagnostic Equipment

Heavy-Duty Diesel Trucks

Inter and Intra-regional Truck Inventory

Truck Idling Inventory (Non-truck Stop Locations)

Thank You

Chris Klaus
North Central Texas Council of Governments
Senior Program Manager
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e-Construction

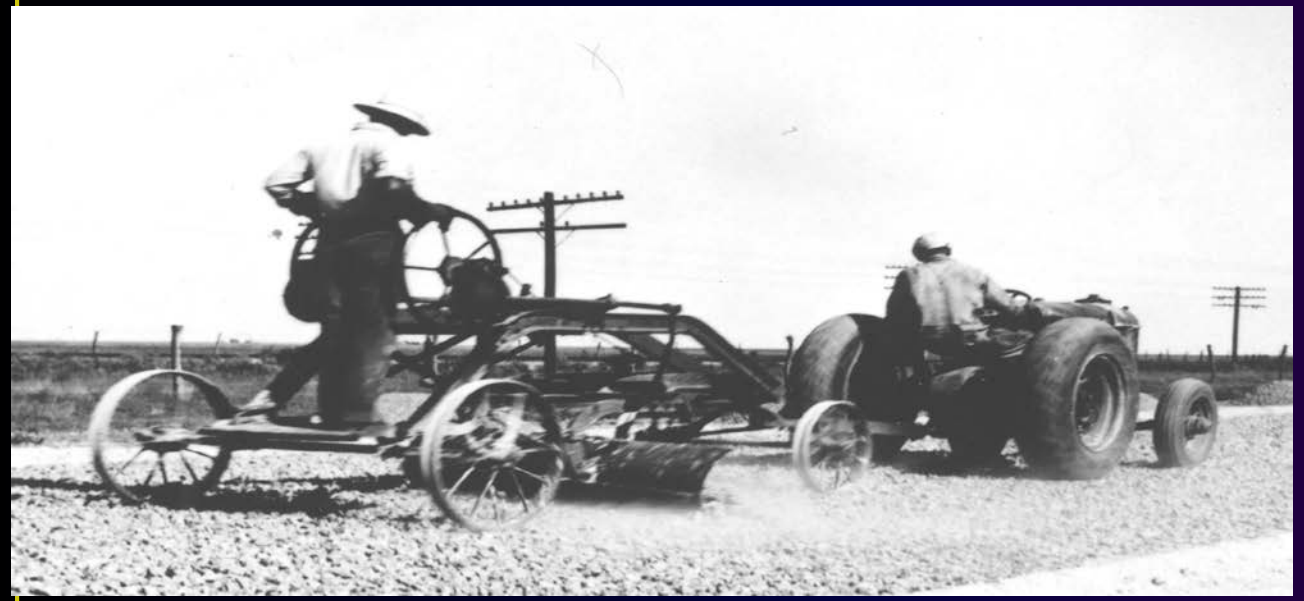
What is it?

Joe Graff, P.E., Director, Construction Section, Construction Division

Presentation Outline

- Definition of e-Construction
- Texas Interpretation of e-Construction
- Implementation to date.
- Short term future
- Long term
- Conclusion

LORAIN-250



What is e-Construction?

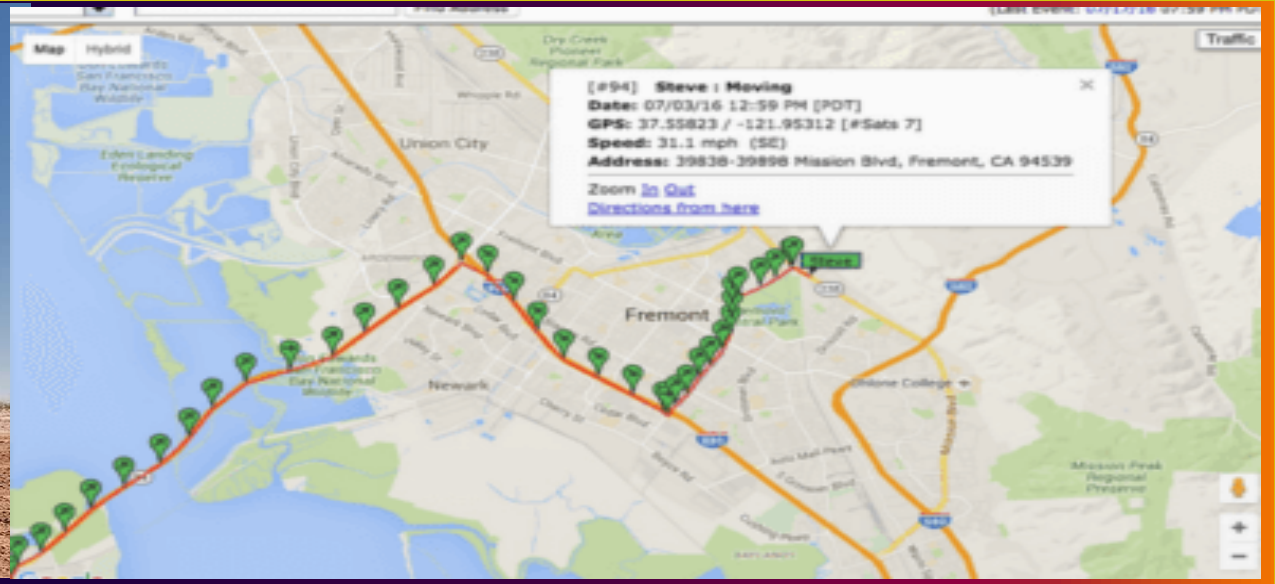
- FHWA defines e-Construction as:

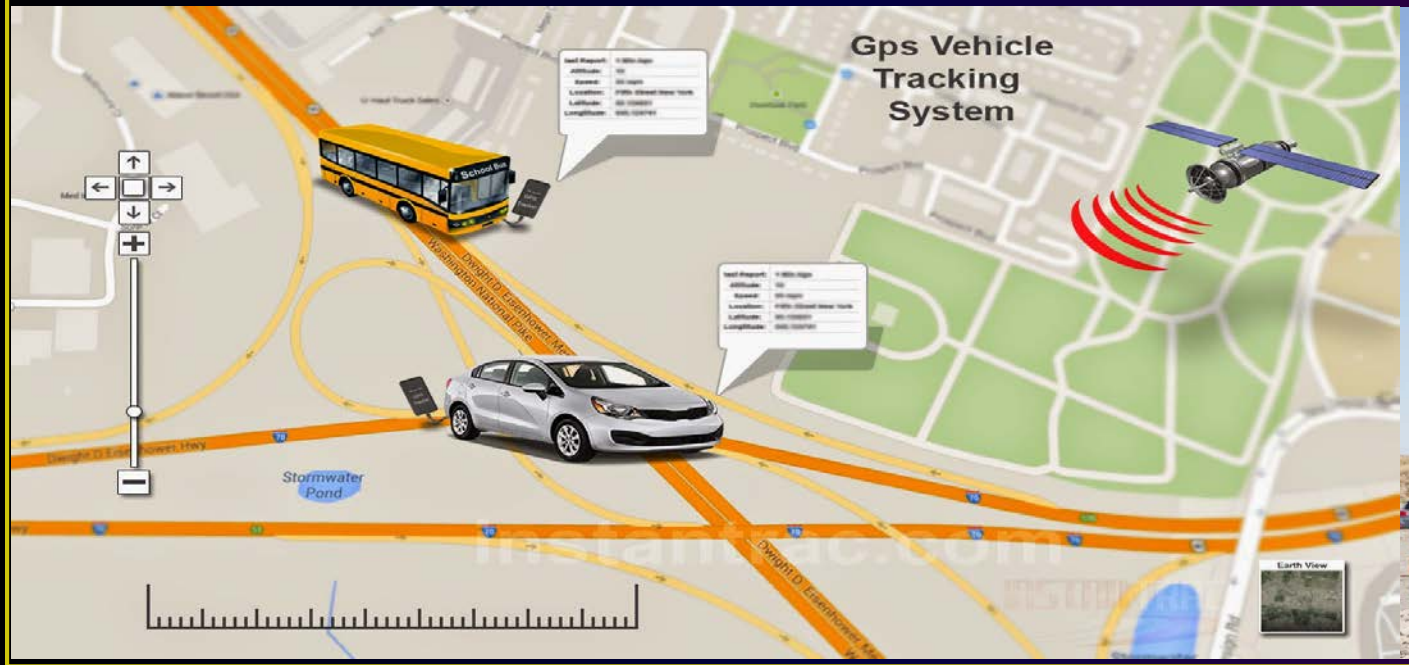
…a paperless construction administration delivery process including electronic submission of all construction documentation by all stakeholders, electronic document routing/approvals (e-signature), and digital management of all construction documentation in a secure environment allowing distribution to all project stakeholders through mobile devices.

TxDOT e-Construction

- Letting
  - Prequalification
  - Electronic Bidding - ICX
  - Electronic Contract Documents
    - Proposal - BPS
    - Plans – TxDOT Web Plans on Line
    - Standards – Web Site
    - MPL – Web Site
    - Contract, bonds, signature, etc. - Future
    - Insurance - Email
- Electronic Construction Records
  - DWR's - SiteManager
  - Test Results - SiteManager
  - Pay Quantities - SiteManager
  - Payrolls – EPRS/LCP Tracker
- Field Collection of Data by Handheld Devices
  - I-Phones – Hotspots
  - Use of I-Pads or Surface Pro's
    - Directly into SiteManager
    - Plans
    - Specifications
    - Photos
    - Checklists
    - Worksheets – Seal Coat Asphalt, Aggregate, ACP, Drill Shaft Log, Piling Reports, etc.
- Construction Surveying
  - 3-D Modeling –
  - Earthwork by GPS
  - Lidar
- Construction Communications – Letters, memos, test results, schedules, meeting minutes, etc. Scanned and sent by Email.
- Other Construction Records – Projectwise
- Tickets – ACP, Concrete, Flex Base, Mulch Sod, etc.
  - Scan Hardcopies
  - Electronic Tickets

DEERE


Map
Hybrid
Traffic
[#94] Steve : Moving
Date: 07/03/16 12:59 PM [PDT]
GPS: 37.55823 / -121.95312 [#Sats 7]
Speed: 31.1 mph (SE)
Address: 39838-39898 Mission Blvd, Fremont, CA 94539
Zoom In Out
Directions from here
Union City
Fremont
Newark


Gps Vehicle
Tracking
System
Stormwater
Pond
Earth View

Current Status

- Where are we now?
- Electronic Bidding –
  - June 2017 Letting –
    - Construction - 402 Bids received on 78 Projects
    - Maintenance – 72 Bids received on 21 Projects
    - June 6 – 242 Bids received on 48 Projects – 2 Paper Bids
    - June 7 – 232 Bids received on 51 Projects – 2 Paper Bids
    - Total – 474 Bids on 99 Projects – 4 paper bids.

99.16% Electronic Bids!!!!!!!

Current Status

- SiteManager – All Construction and Maintenance Projects are managed with SiteManager. Daily Work Requests, Test Results, Contractor Payments
- ProjectWise – Many districts are using ProjectWise for all of their construction records.
- 3D Modeling – Many projects are currently being designed in 3D and 3D information is available on some projects for contractors construction earthwork operations.
- Field Collection of Data – Some I-Pads are being used. Consultants performing CE&I are using I-Pads or other hardware and Proprietary Software such as ProCore, Newforma, Headlight, Submittal Exchange

A Look into the Future – Short Term

- Electronic Bidding – Require Use
- Investigate Electronic Contracts and Signatures for Payment and Performance Bonds and Contract Documents
- Site Manager – Migrate to newer version in about 1 year
- Purchase and distribute Surface Pro's to large number of inspectors.
- Use ProjectWise for all Construction Contract Document Management.
- Provide 3-D Models to Contractors.
- Investigate use of UAV's.
- Investigate use of LIDAR in Construction.

A Look into the Future – Long Term

- Site Manager – Migrate to web version
- Increase the use of Surface Pro's and collect data in the field – DWR's, Photos,
- Provide 3-D Models to Contractors.
- Use UAV's to inspect hard to access construction and document construction progress
- Use LIDAR to perform quality control on surveying

Questions?

Leading the Way in an Era of Rapid Change

Texas State Transportation Innovation Council Meeting

Austin, TX

June 20, 2017

FHWA Office of Innovative Program Delivery Mission

Improve transportation performance by driving innovation into action through partnerships, technology development, and capacity building

Foster a *Culture of Innovation*

OIPD Centers

Tony Furst
Chief Innovation Officer

Robert Ritter
Managing Director

Center for Accelerating Innovation
(CAI)

Center for Innovative Finance Support
(CIF$)

Center for Transportation Workforce Development
(CTWD)

Center for Local Aid Support
(CLAS)

CENTER FOR
ACCELERATING INNOVATION

***Tom Harman**, Director*

Shares the **success of innovation** at the national and local levels

Facilitates the rapid deployment of innovation into the transportation community based on the Every Day Counts initiative.

EDC

STIC State Transportation Innovation Councils

Fosters & supports the State Transportation Innovation Councils' national network

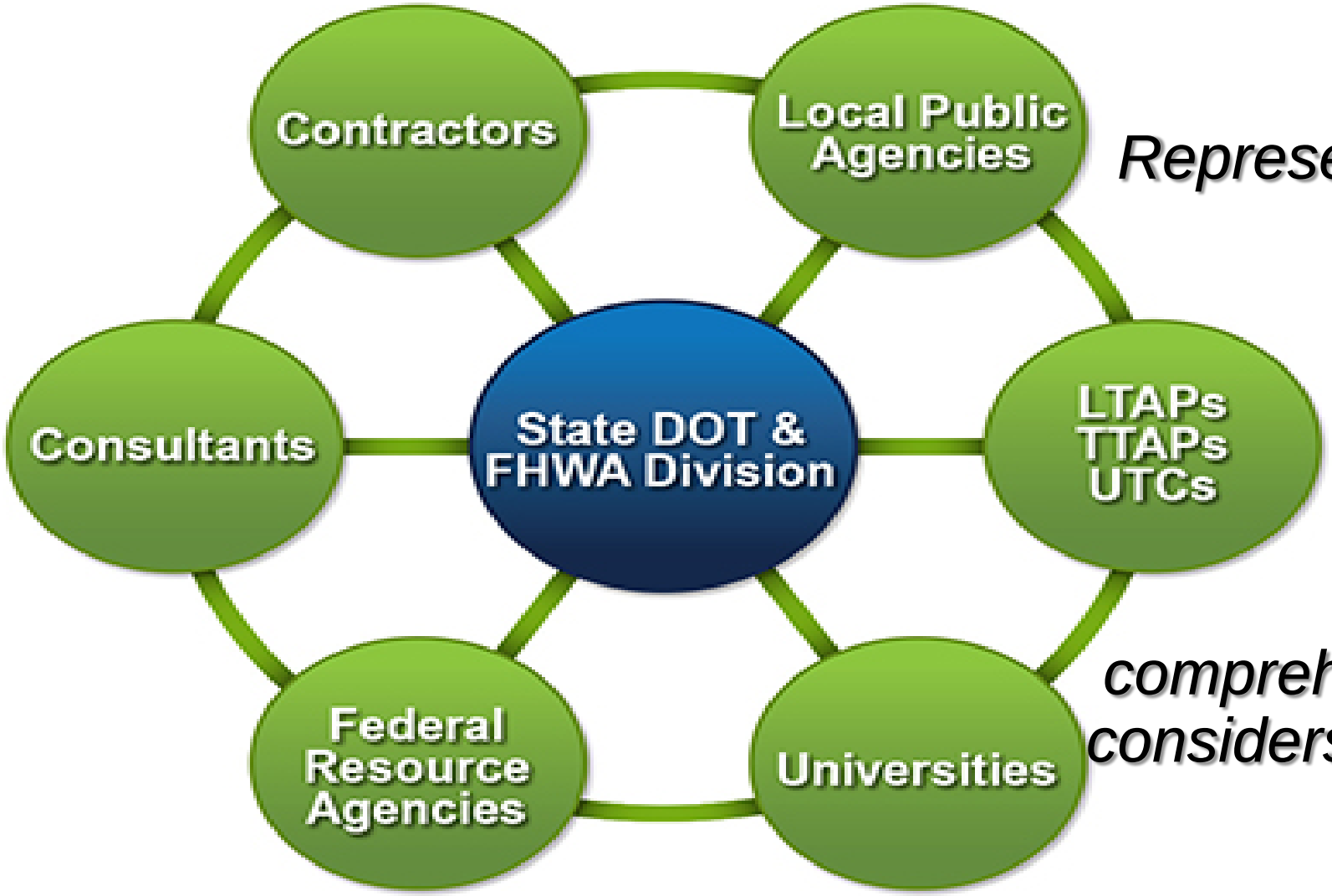
AIDDemo Accelerated Innovation Deployment

Supports innovation thru the Accelerated Innovation Deployment grant program

Transforming Transportation Through Innovation

Innovation & Collaboration

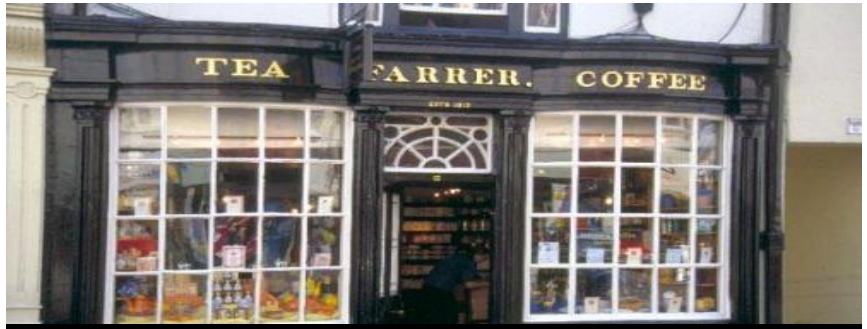
National STIC Network



Represents multiple stakeholders from the transportation community

comprehensively and strategically considers all sources of innovation

SUCCESS

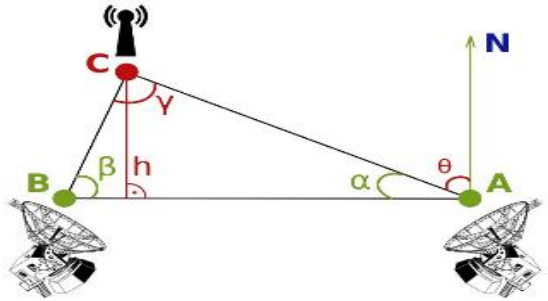


Idea Sharing –
Innovations are based on a Network of Ideas

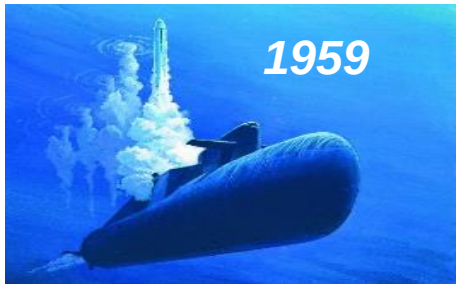
Yes and . . .

Yes and. . .

Yes and. . .

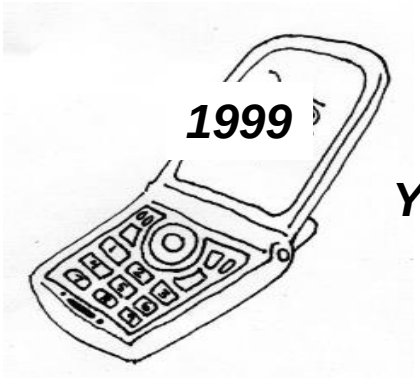


Yes and. . .



Yes and. . .

Yes and. . .



Yes and. . .

Yes and. . .

Source: https://www.ted.com/talks/steven_johnson_where_good_ideas_come_from and http://www.pcworld.com/article/2000276/a-brief-history-of-gps.html

Thank You!

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Program Coordinator

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Senior Advisor

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Lunch

Return @ 1PM CST

0-6920: Proactive Traffic Signal Timing and Coordination for Congestion Mitigation on Arterial Roads

PI: Xing Wu, PhD, PE
Co-PI: Hao Yang, PhD
Dept. of Civil & Environmental Engineering
Lamar University

Contents

1 Background

2 Research Objectives

3 Proactive Signal Control

4 Test based on Simulation

5 Field Experiment

6 Summary

7 Large-Scale Implementation

Background

Traffic Congestion

- National congestion
  - 5 million-hour delay of daily commutes;
  - $100 billion financial lost:
- State-wide congestion - Texas
  - 60 –hour delay annually for each commuter in Houston Area;
  - Increase to 100 hours in 2025;
  - $12 billion financial lost in 2025:

Reference: Lomax, T., Lasley, P., Ellis, D., and Stockton, B., *Mobility Investment Priorities Project*, Tech. Rep, Texas A&M Transportation Institute, Texas, USA, 2013

Background

Typical Signal Control Algorithms

- Fixed-time Plan
  - The phase sequence and the duration of each phase are predefined.
- Reactive/Actuated Control
  - The phase at each time interval is assigned to the one with the highest delay -- found by detectors.
- Proactive Control
  - The phase at each time interval is assigned to the one with this highest predicted delay based on the *short-term predicted* timing –varying traffic volume.

Research Objectives

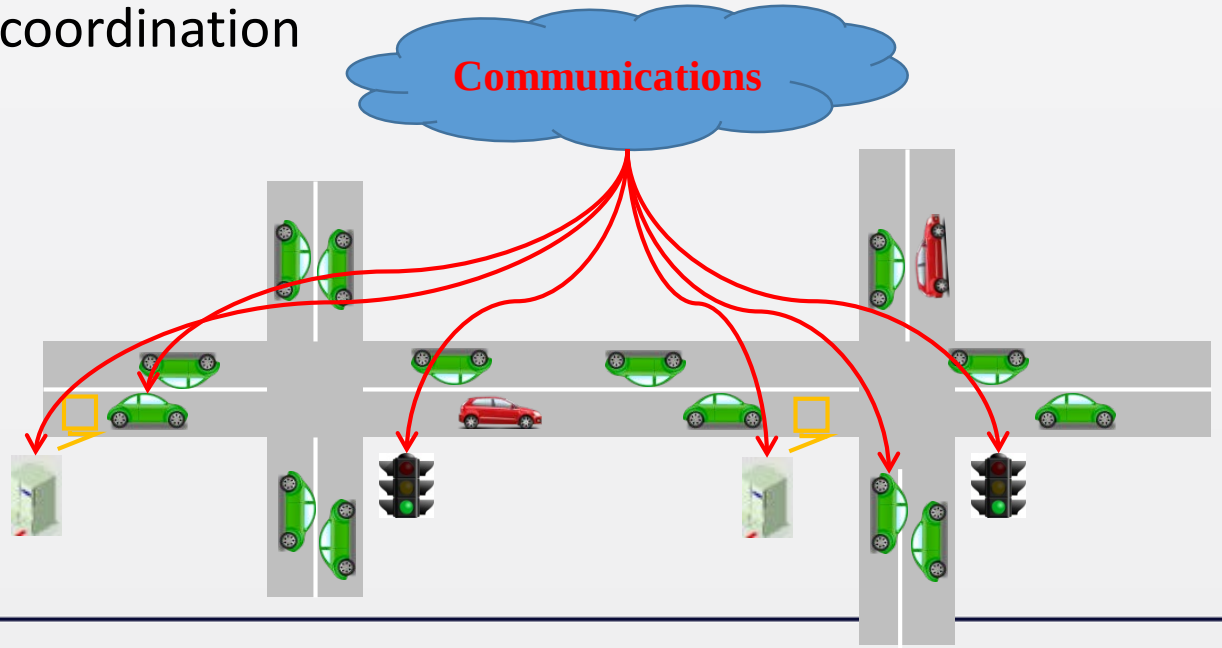
Proactive Signal Control System

- Develop a fully collaborative vehicle-signal control systems
  - Utilize communications among loop detectors, traffic signals and connected vehicles (if any);
  - Gather real-time traffic conditions and predict short-term conditions;
  - Update signal phasing and timing (SPaT) plan based on the short-time traffic prediction.
- Optimize the performance of signalized intersections
  - Mitigate traffic congestions, vehicle emissions, and fuel consumption;
  - Reduce travel time and stop delay in the vicinities of intersections

Proactive Signal Control

Collaborative Vehicle-signal Control Environment

- Connections among vehicles, loop detectors and signals
- Optimize phase assignments and duration without being restricted by cycle length
- Optimize Signal Phasing and Timing (SPaT) plans of multiple signals with coordination



Proactive Signal Control

Signal Control at Intersections

- Vehicle approaches (lane group)
- Phases
- Detectors
- Delay on each approach

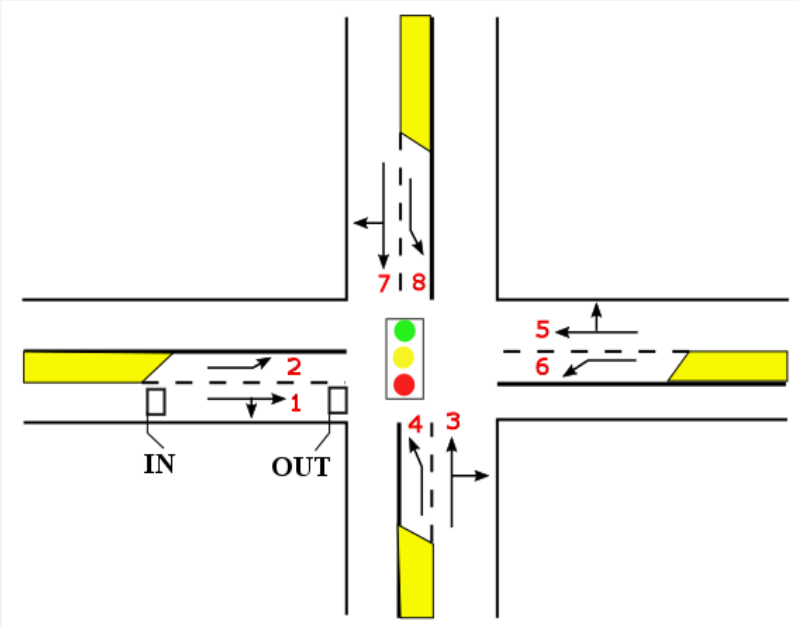
$$\boldsymbol{D_i(t)} = \sum_{\tau=0}^{t} \left(N_{I,i}(\tau) - N_{O,i}(\tau) - \frac{l_i}{v_i} \right)$$

$N_{I,i}(t)$: Cumulative inflow at the IN detector;

$N_{O,i}(t)$: Cumulative outflow at the OUT detector;

l_i : Distance between the IN and OUT detectors;

v_i : Road speed limit.



Proactive Signal Control

Signal Control at Intersections

Signal Optimization:

$$\min_{p_k(t),\forall k=1,2,\cdots,P} \sum_{i=1}^{N} D_i(T_0)$$

s.t.

$$N_{I,i}(t) = f_{I,i}(t);$$

$$N_{O,i}(t) = f_{O,i}(t);$$

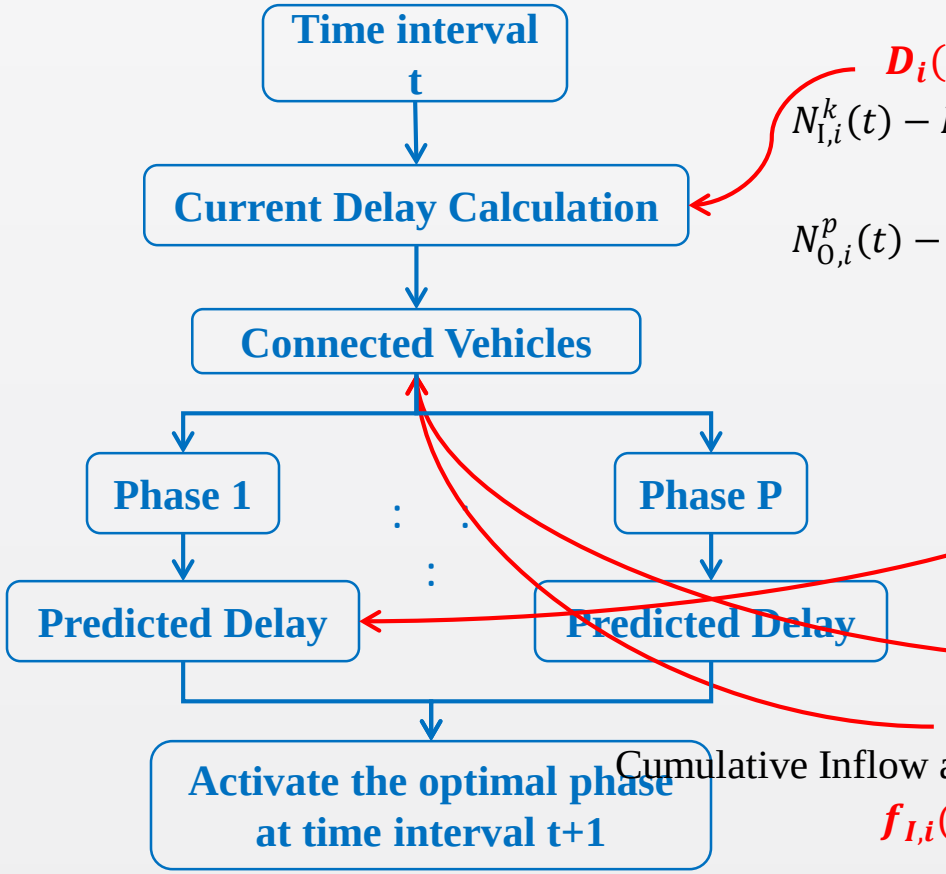
$$f_{O,i}(t) = \begin{cases} 0 & m_i(t) = 0 \\ Q_i & m_i(t) = 1 \end{cases};$$

$$m_i(t) = \begin{cases} 1 & i \in \mathcal{M}_k, p_k(t) = 1, \forall i = 1,2,\cdots,N \\ 0 & \text{otherwise} \end{cases}.$$

$f_{I,i}(t)$: Flow rate detected by the IN detector at time t;
$f_{O,i}(t)$: Flow rate detected by the OUT detector at time t;
Q_i : Road capacity for the approach i;
P : total number of phases;
N : total number of approaches;
$p_k(t)$: signal indicator for the phase k;
0: red; 1: green.
$m_i(t)$: Permissive indicator for the approach i;
0: prohibited; 1: permitted.
$\mathcal{M}_k$: set of approaches associated with the phase k.

Proactive Signal Control

System Development

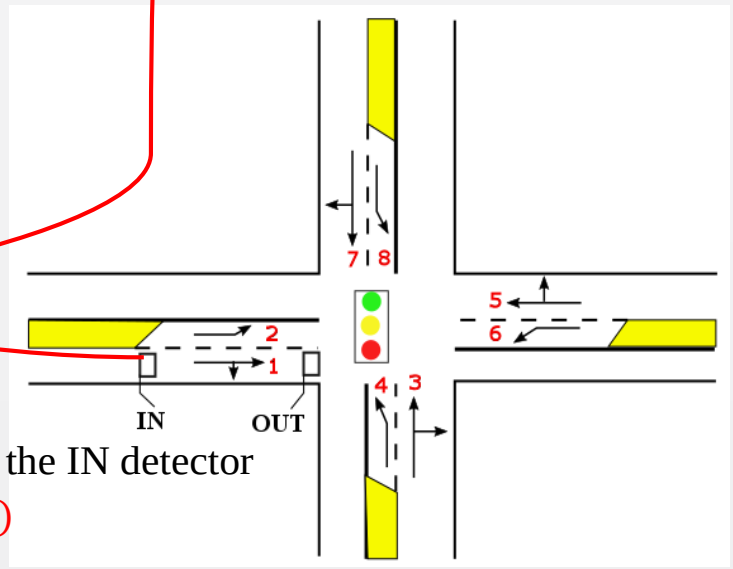


$$\boldsymbol{d_k(t_{n+1})} = \sum_{i=1}^{N}\left(D_i(t_n) + \sum_{t=t_n}^{t_{n+1}}\left(N_{\mathrm{I},i}^{k}(t) - N_{\mathrm{O},i}^{k}(t) - \frac{L_i}{v_i}\right)\right)$$

$$\boldsymbol{D_i(t)} = \sum_{\tau=1}^{t}\left(N_{I,i}(\tau) - N_{O,i}(\tau) - \frac{l_i}{v_i}\right)$$

$$N_{\mathrm{I},i}^{k}(t) - N_{\mathrm{I},i}^{k}(t-1) = f_{I,i}(t), i = 1,2,\cdots,N;$$

$$N_{\mathrm{O},i}^{p}(t) - N_{\mathrm{O},i}^{p}(t-1) = \begin{cases} Q_i & i \in \mathcal{M}_p \\ 0 & \text{otherwise} \end{cases}$$



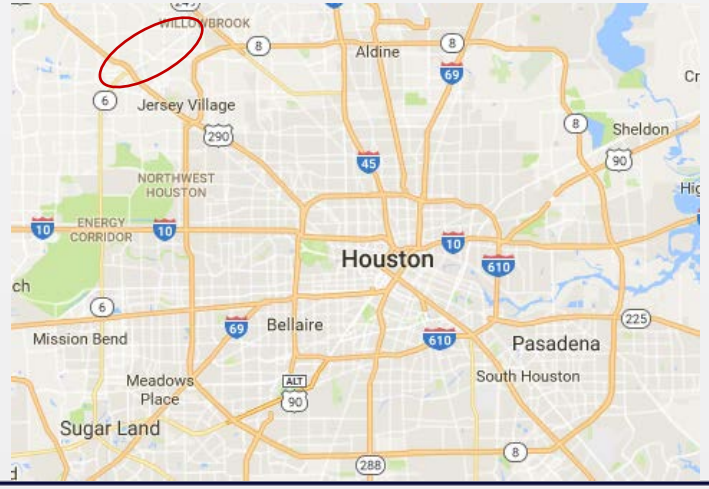
Cumulative Inflow at the IN detector

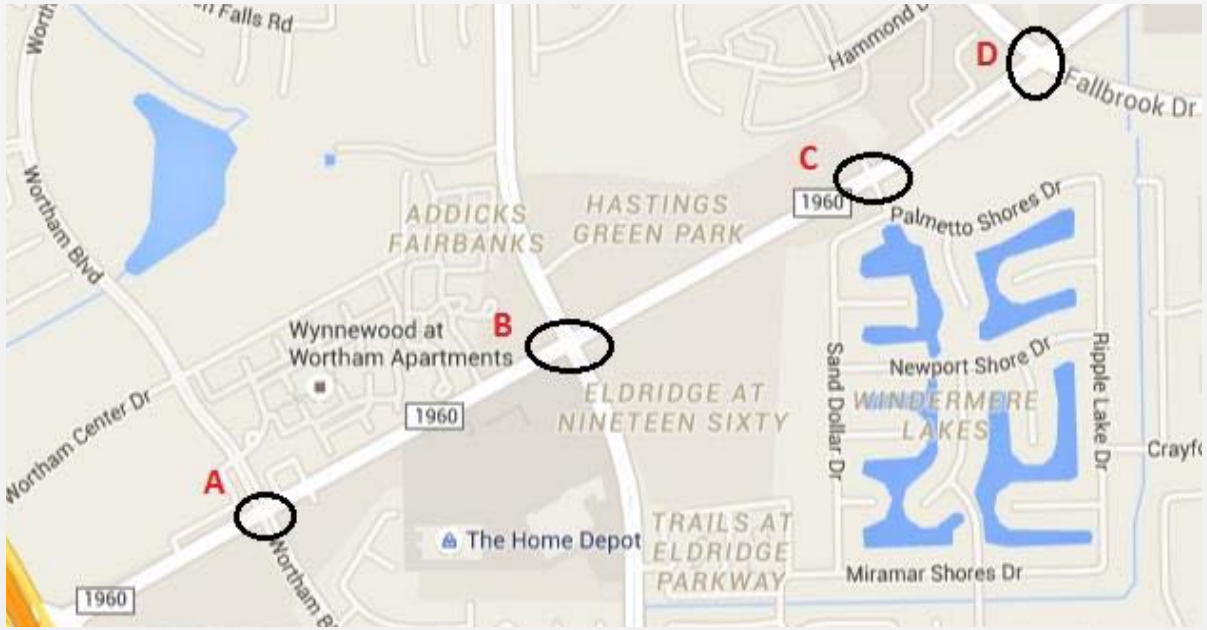
$\boldsymbol{f_{I,i}(t)}$

Test based on Simulation

Testbed – FM1960

- Four Intersections
  - Wortham Blvd.
  - N Eldridge Pkwy.
  - Windermere Lake Blvd.
  - Fallbrook Dr.





Test based on Simulation

Testbed – Major road (FM1960)

- Total Length
  - 2,315 meters
- Speed Limits on the major road
  - 40 mph
- Number of lanes of the major road
  - Three lanes, and additional one left-turn lane ahead of each intersection

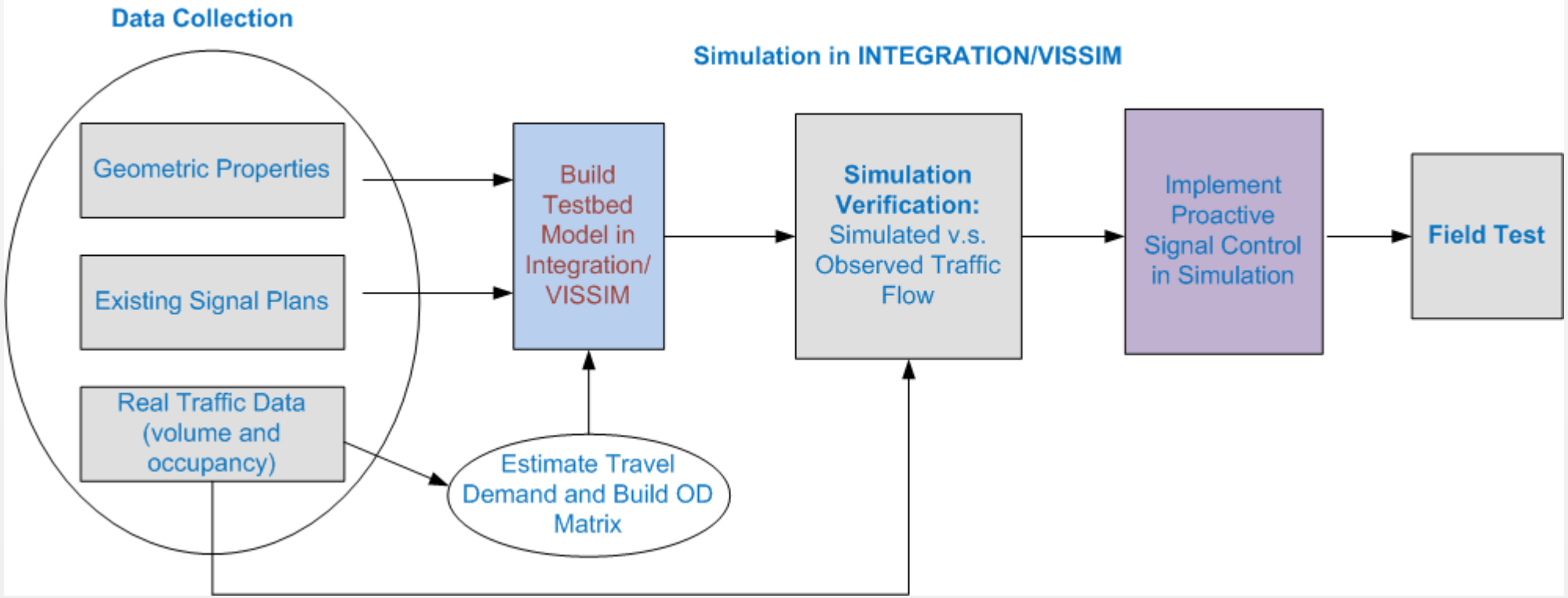
Test based on Simulation

Testbed – Minor roads

Direction	Intersection	Intersection Name	Speed Limit (mile/hour)	Center to Center Distance (meter)	Cumulative Distance from Start point (meter)
West to East	Start				0
	A	Wortham Blvd.	35 (N), 35(S)	300*	300
	B	N Eldridge Pkwy.	40 (N),40(S)	685	985
	C	Windermere Lake Blvd.	30(S)	675	1660
	D	Fallbrook Dr.	30 (N), 35 (S)	405	2065
	End			250	2315

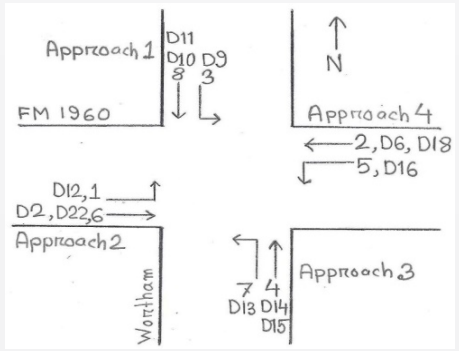
Test based on Simulation

Methodological Framework

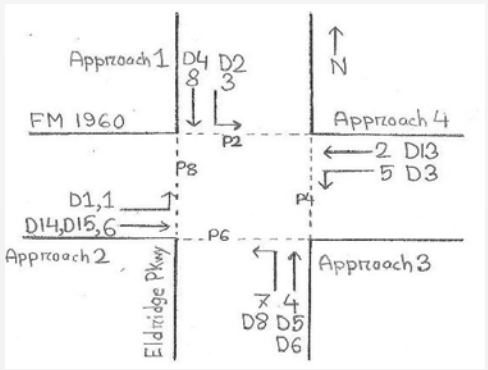


Test based on Simulation

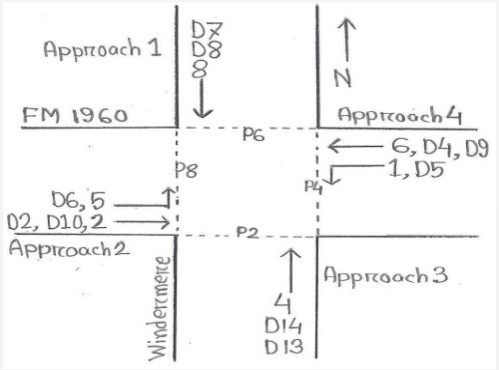
Signal Plans



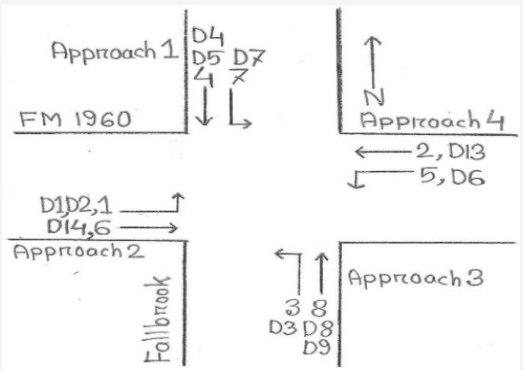
A



B



C



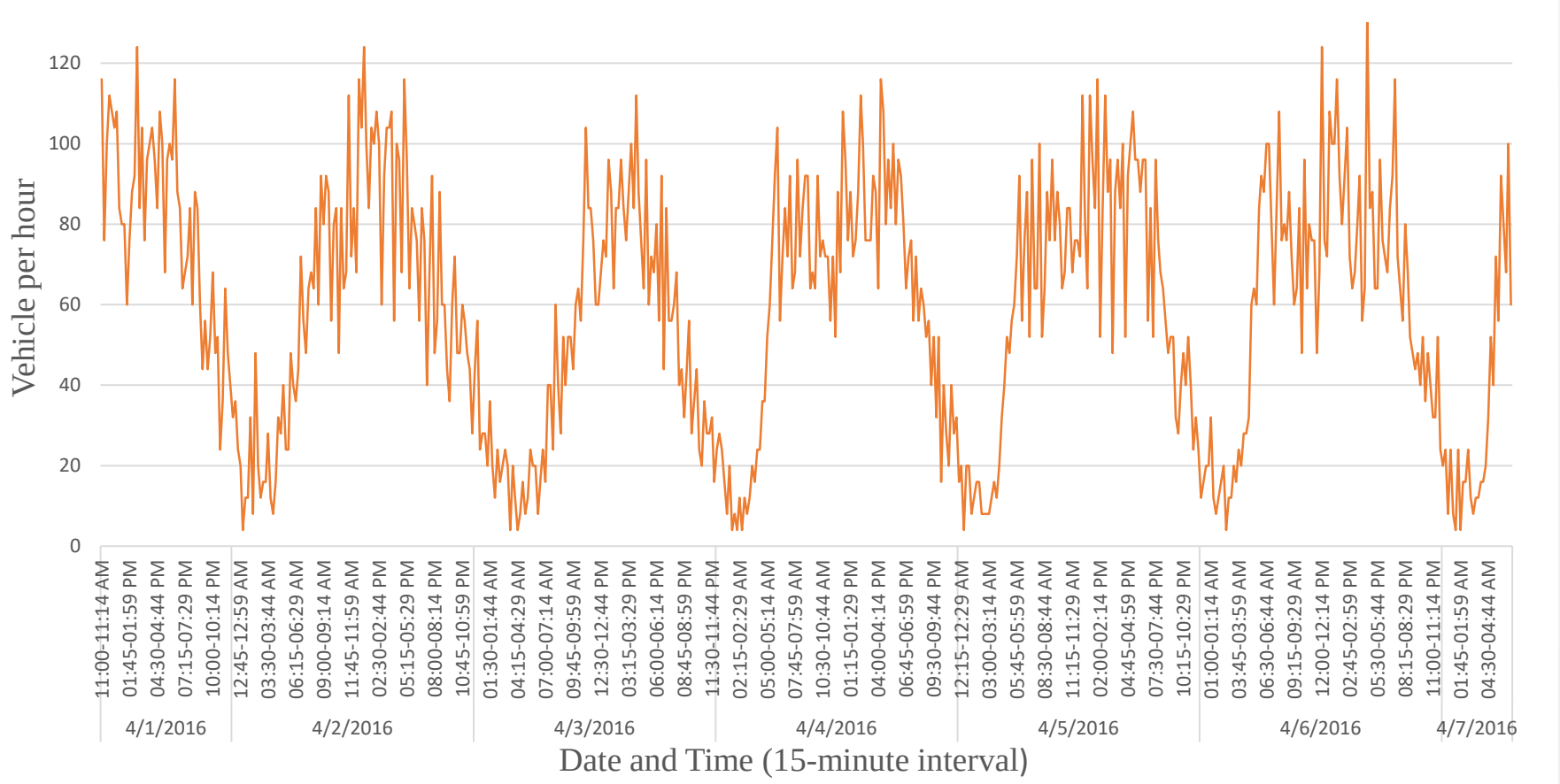
D

Data Collection

- The road traffic data was collected from 11 am, 04/01/16 to 7 pm, 04/07/16;
- The data was read from the loop detectors for every 1 minute;
- The data was summarized as every 15 minutes for each phase to measure the congestion level of the test bed.

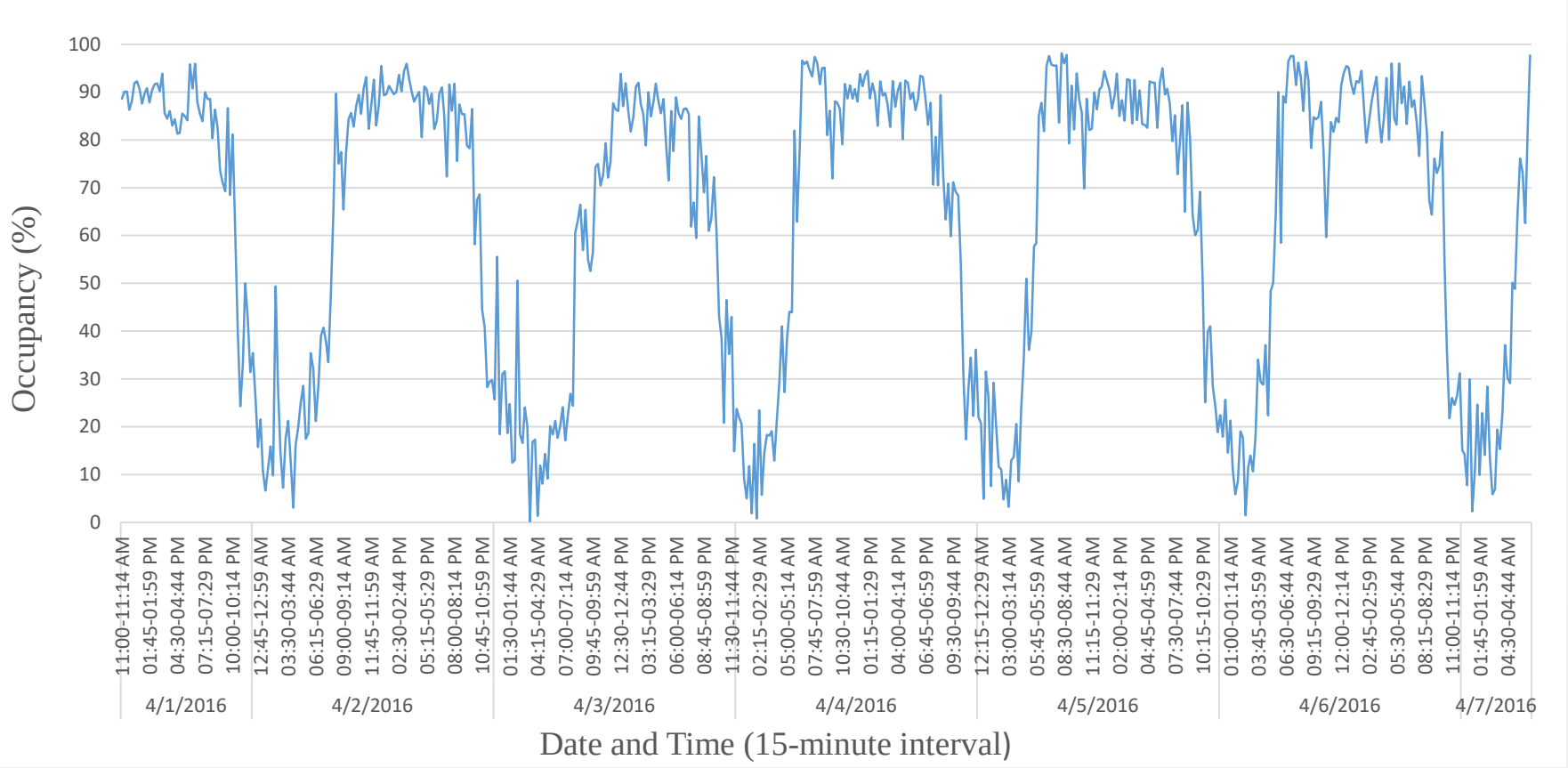
Test based on Simulation

Hourly Volume for Phase 5 (Left-turn traffic movements at major road FM 1960, Intersection B at N Eldridge Pkwy)



Test based on Simulation

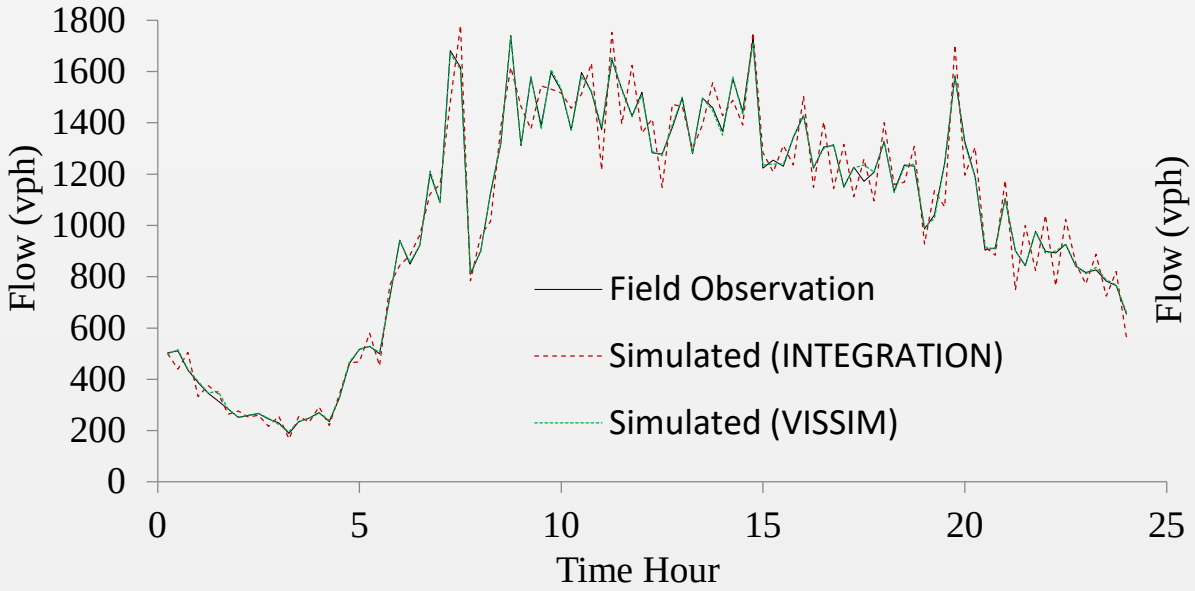
Occupancies for Phase 5 (Left-turn traffic movements at major road FM 1960, Intersection B at N Eldridge Pkwy)



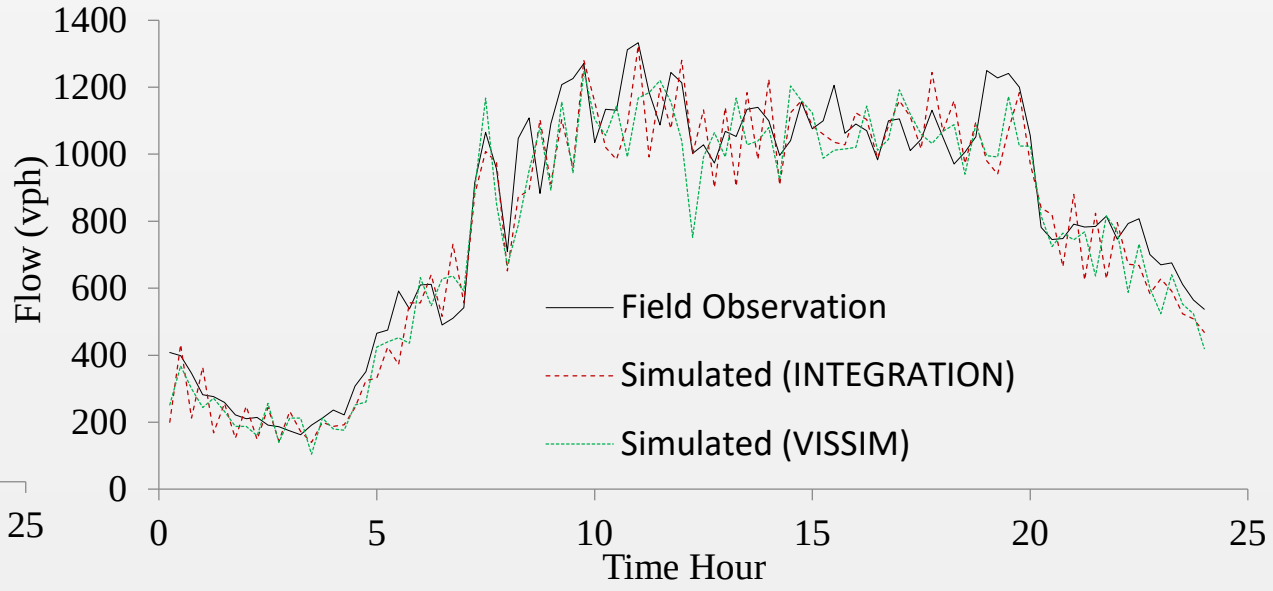
Test based on Simulation

Simulation Verification

- Based on the existing signal plan and the collected traffic data, two simulation packages, *INTEGRATION* and *VISSIM*, were used to simulate the traffic of the testbed.



Eastbound, in-flow at major road in a weekday

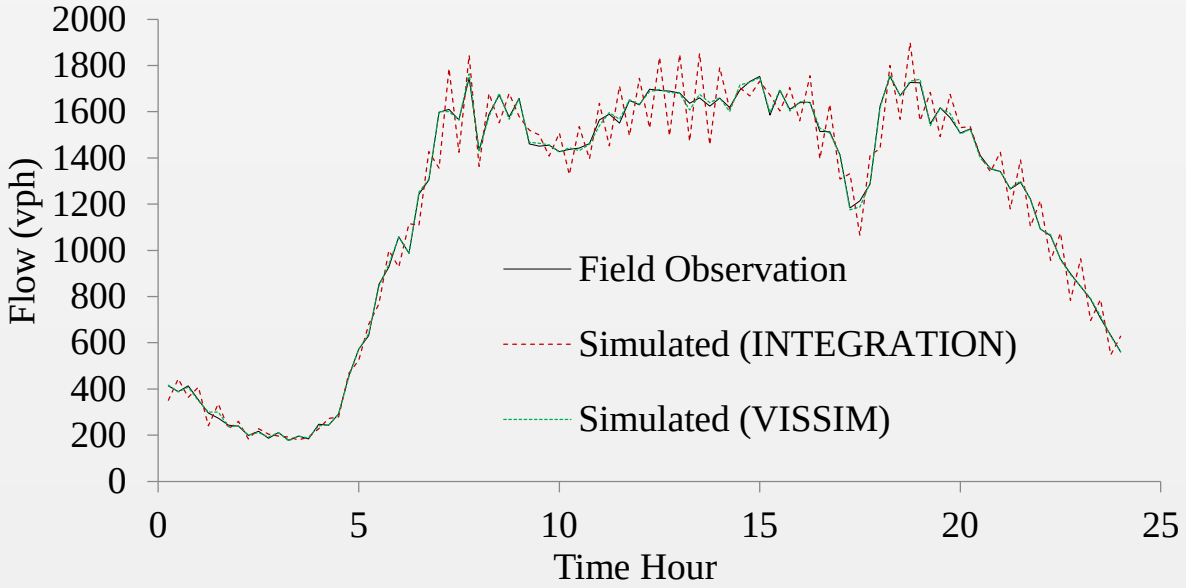


Eastbound, out-flow at major road in a weekday

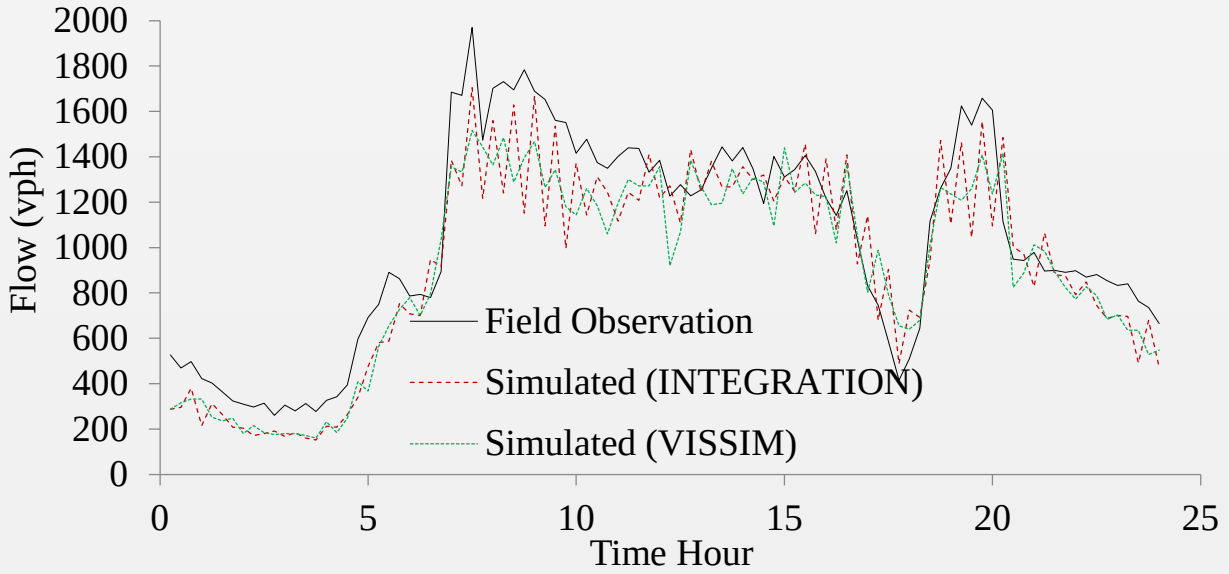
Test based on Simulation

Simulation Verification

- Based on the existing signal plan and the collected traffic data, two simulation packages, *INTEGRATION* and *VISSIM*, were used to simulate the traffic of the testbed.



Westbound, in-flow at major road in a weekday

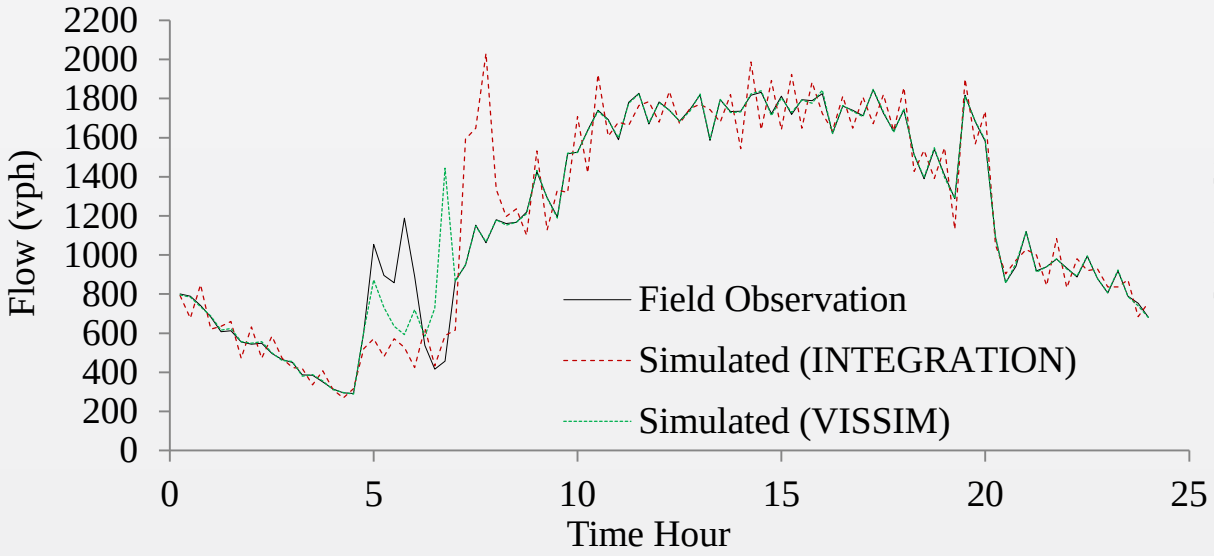


Westbound, out-flow at major road in a weekday

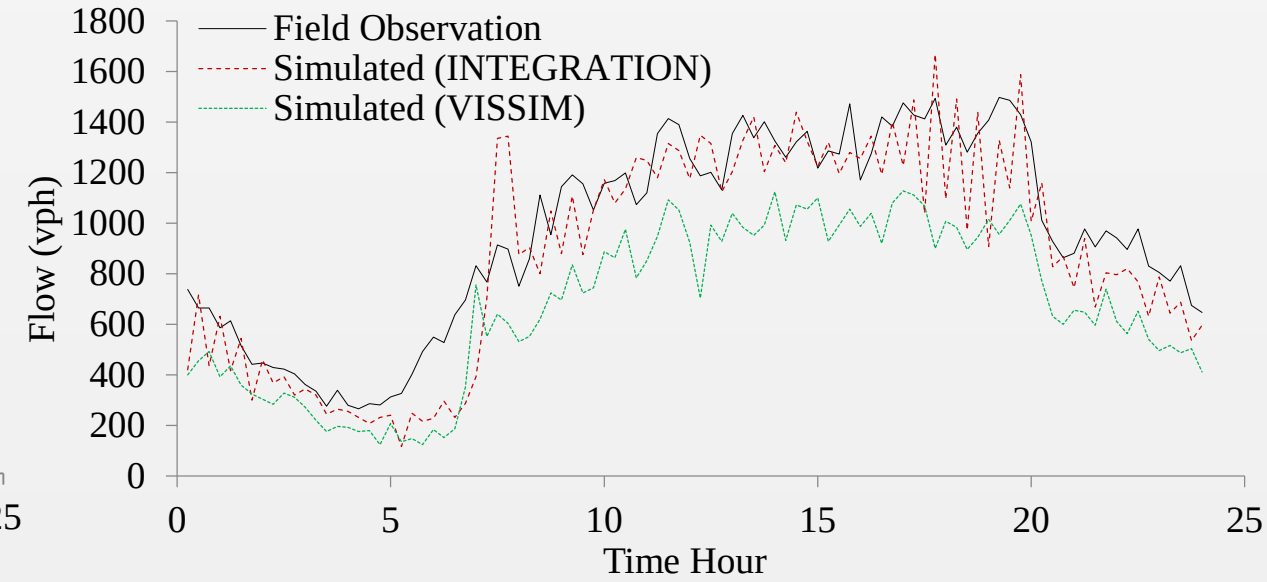
Test based on Simulation

Simulation Verification

- Based on the existing signal plan and the collected traffic data, two simulation packages, *INTEGRATION* and *VISSIM*, were used to simulate the traffic of the testbed.



Eastbound, in-flow at major road in a weekend

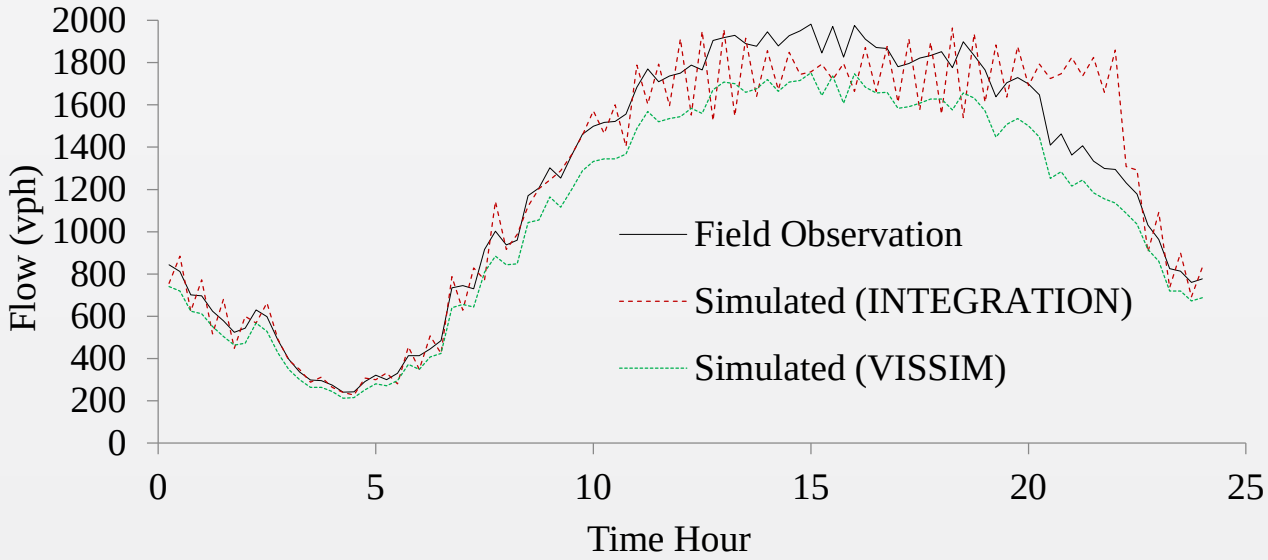


Eastbound, out-flow at major road in a weekend

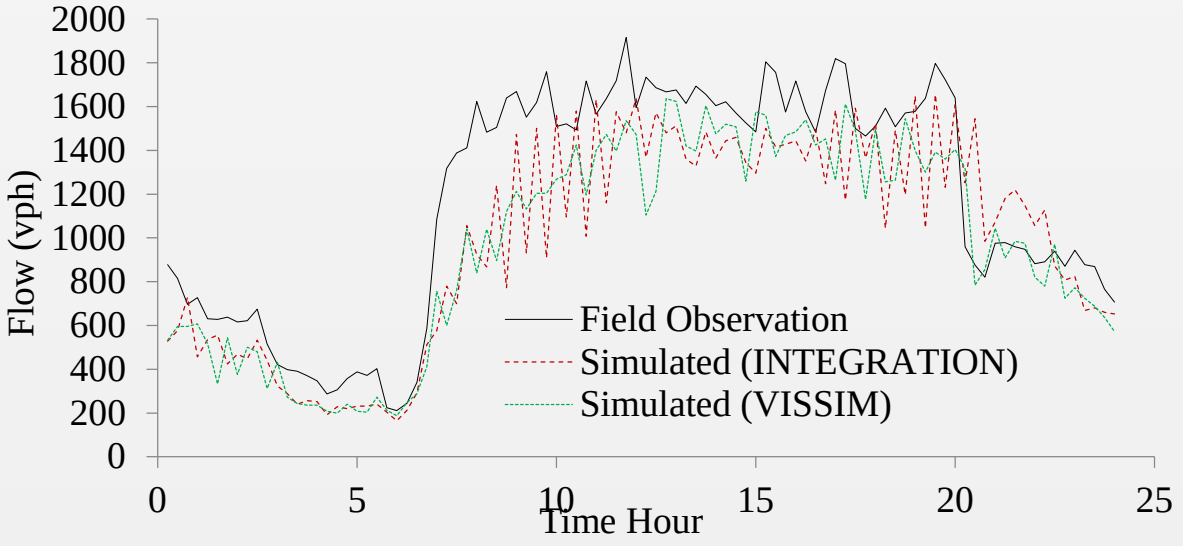
Test based on Simulation

Simulation Verification

- Based on the existing signal plan and the collected traffic data, two simulation packages, *INTEGRATION* and *VISSIM*, were used to simulate the traffic of the testbed.



Westbound, in-flow at major road in a weekend



Westbound, out-flow at major road in a weekend

Test based on Simulation

System Evaluation

- Performance on the major road, FM 1960 (Assume the existing of connected vehicles)

Overall network performance

Measurements (per trip)	Weekday			Weekend		
	Before	After	Diff	Before	After	Diff
Travel Distance (km)	1.64	1.64	0%	1.74	1.74	0%
Travel Time (second)	240.29	144.54	-40%	543.88	119.7	-78%
Delay (second)	166.92	41.67	-75%	207.98	42.52	-80%
Stop Delay (second)	107.34	14.68	-86%	131.31	14.44	-89%
Vehicle Stops	2.65	1.96	-26%	2.88	2	-31%
Fuel Usage (liter)	0.34	0.27	-21%	0.37	0.28	-24%
HC (gram)	1.78	2.05	15%	1.8	2.07	15%
CO (gram)	44.93	52.87	18%	45.11	53.47	19%
NOx (gram)	0.99	0.92	-7%	1.05	0.95	-10%
CO2 (gram)	713.91	566.31	-21%	786.46	589.04	-25%

Test based on Simulation

System Evaluation

- Performance on one minor road, N. Eldridge Pkwy. (Assume the existing of connected vehicles)

Overall network performance in a weekday

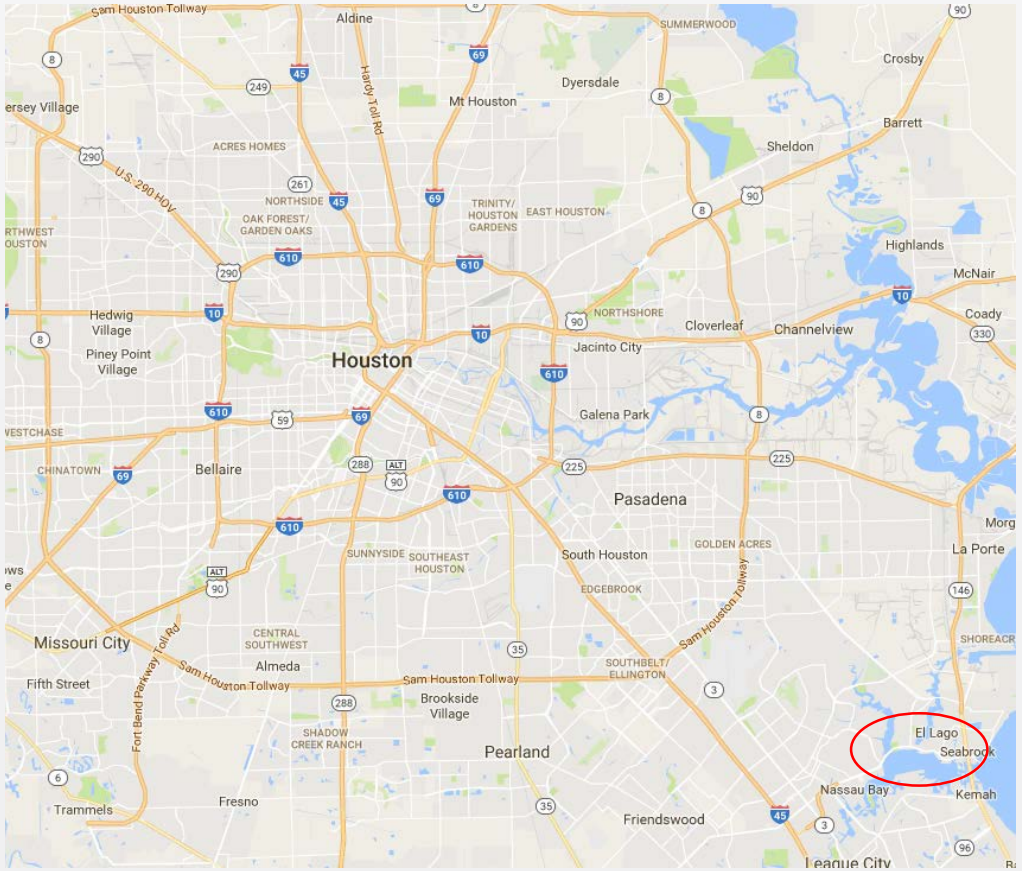
Approaches	Max Queue Length (veh)			Average Delay (second)		
	Before	After	Diff	Before	After	Diff
East Bound, FM1960	34.4	16.5	-52%	49.7	13.8	-72%
West Bound, FM1960	50.8	14.1	-72%	55.4	13.7	-75%
North Bound, Eldridge Pkwy	11.9	2.7	-77%	63.4	13.9	-78%
South Bound, Eldridge Pkwy	5.9	1.1	-81%	53.8	13.8	-74%

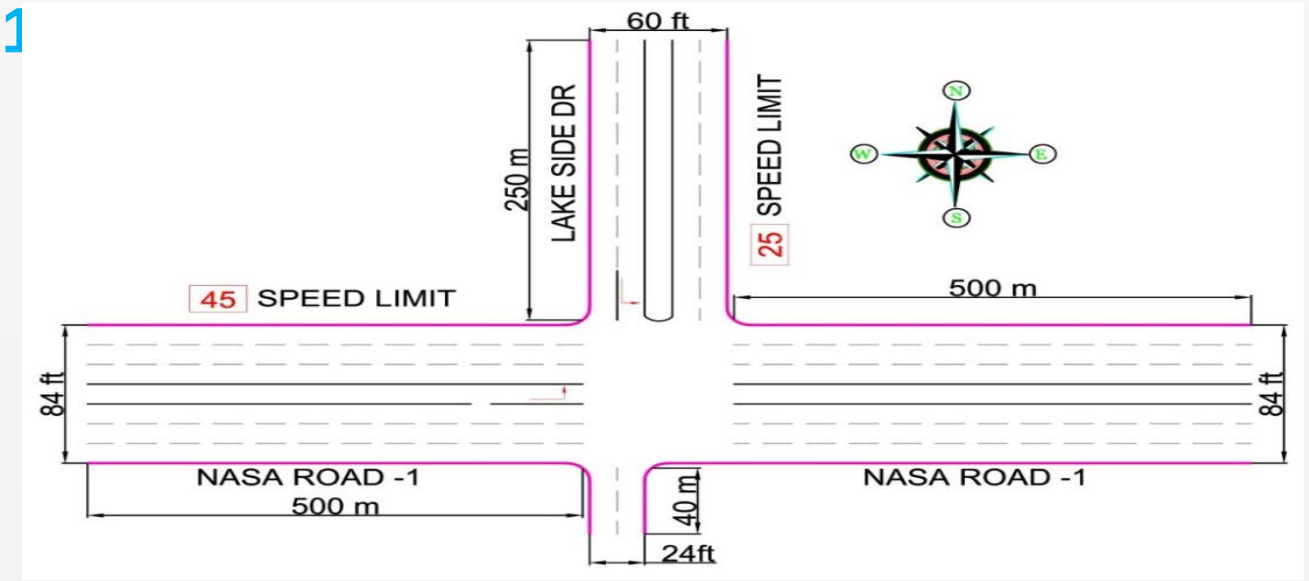
Overall network performance in a weekend

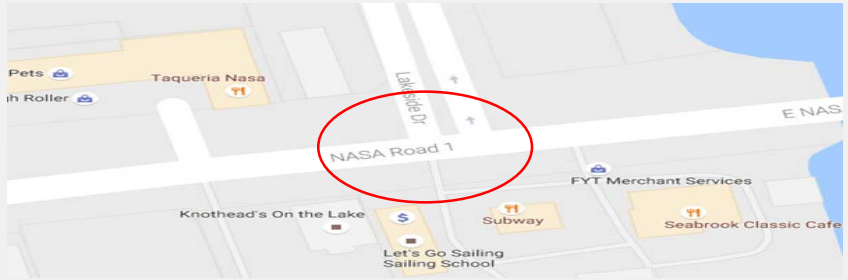
Max Queue Length (veh)			Average Delay (second)		
Before	After	Diff	Before	After	Diff
34.4	16.5	-52%	49.7	13.8	-72%
50.8	14.1	-72%	55.4	13.7	-75%
11.9	2.7	-77%	63.4	13.9	-78%
5.9	1.1	-81%	53.8	13.8	-74%

Field Experiment

Test Bed 2: NASA ROAD 1

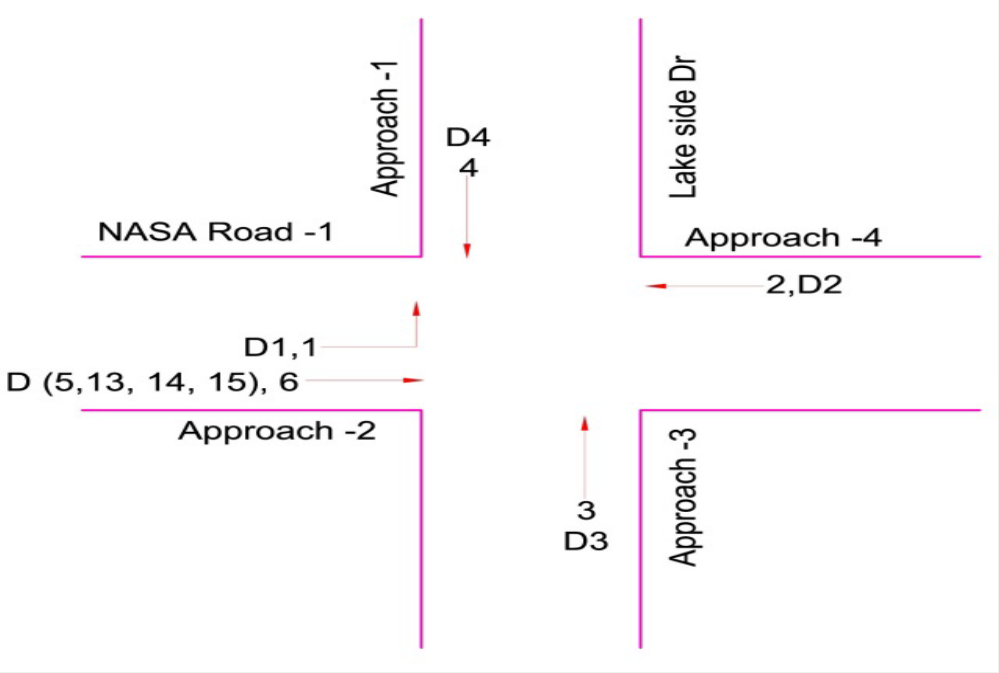






Field Experiment

Test Bed 2: NASA ROAD 1



Phase and detector information

Approach Number	Phase Number	Detector Number
1	4	4(SBD)
2	1	1(SBD)
	6	5, 13, 14, 15 (UD)
3	3	3(SBD)
4	2	2(UD)

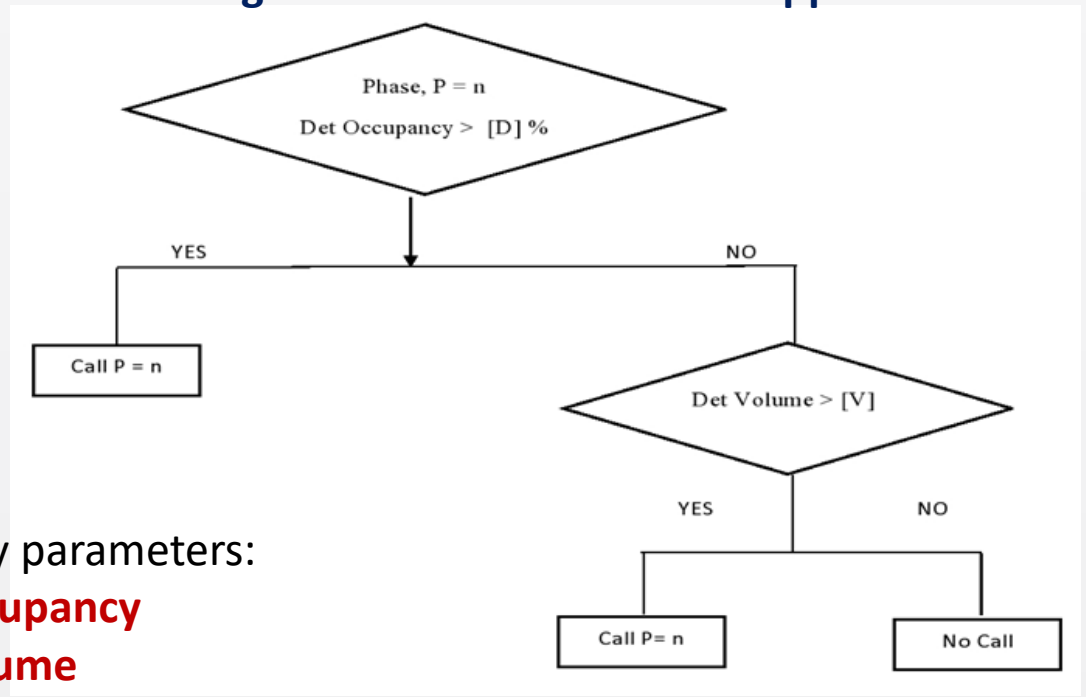
Existing signal control: actuated signal control

Field Experiment

Test Bed 2: NASA ROAD 1

ASC/3-2100 Controller

Logic Statement that can be applied



Two key parameters:

1. **Occupancy**
2. **Volume**

VISSIM has a package embedded to simulate this controller

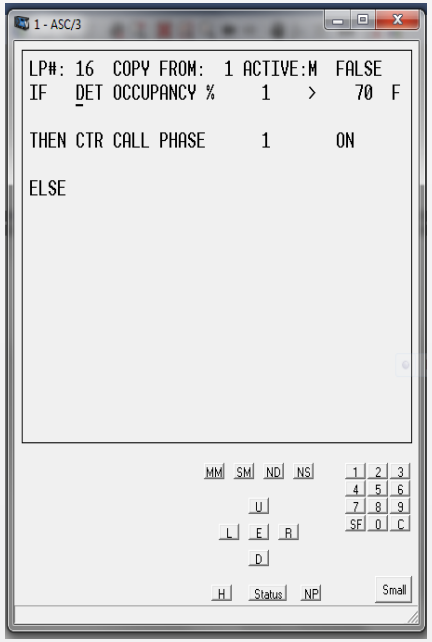
Field Experiment

Test Bed 2: NASA ROAD 1

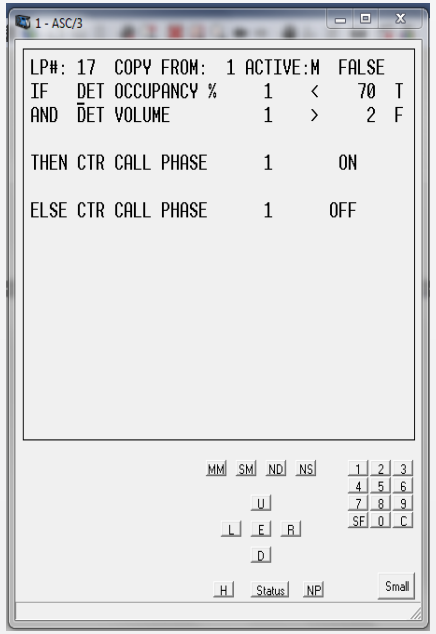
Critical values for volume and occupancy

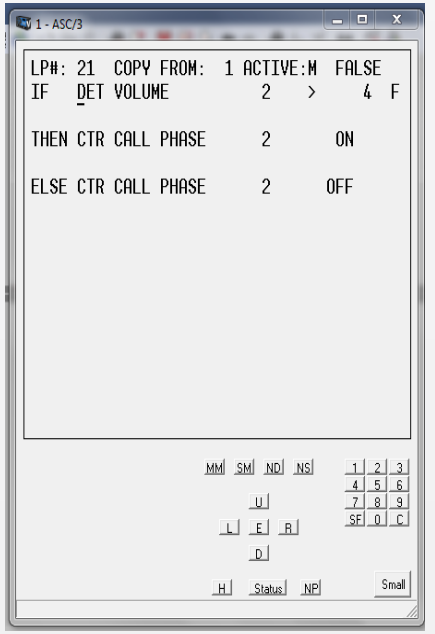
Phase Number	Detector	Volume	Occupancy (%)
1	1 (SBD)	2	70
2	2 (UD)	4	
3	3 (SBD)	2	70
4	4 (SBD)	2	70
6	5 (SBD) 13 (SBD) 14 (SBD) 15 (SBD)	6 2 2 2	

Logic Statement Setting in ASC/3-2100 Controller in VISSIM



Phase 1 (Stop bar Detector 1)

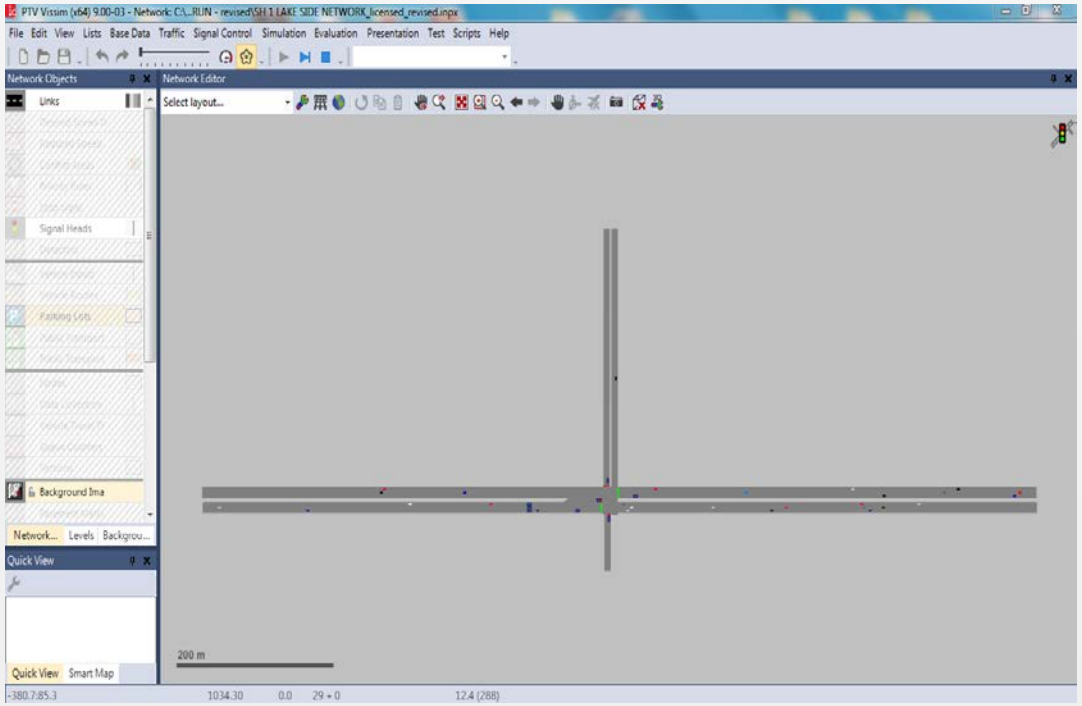




Phase 2 (Upstream Detector 2)

Field Experiment

Test Bed 2: NASA ROAD 1



Testbed simulated in VISSIM

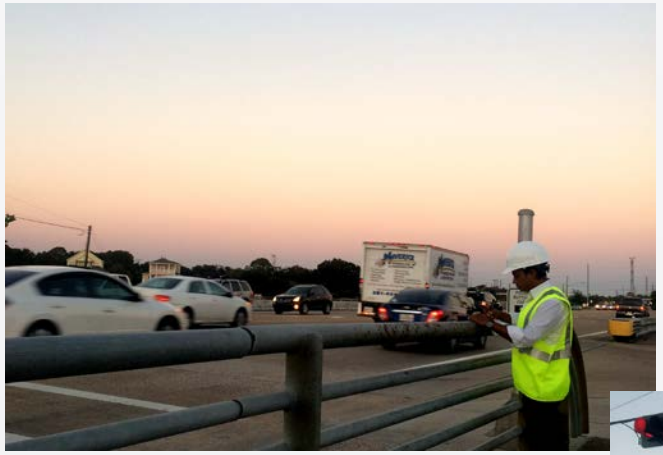
Change of parameter values

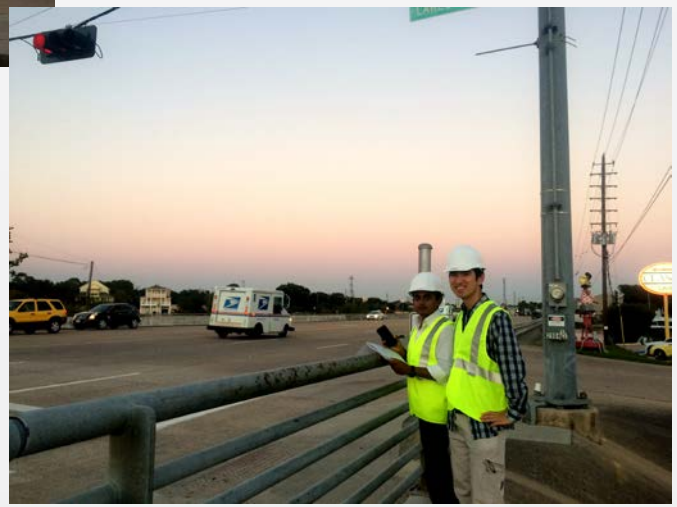
Phase	Minimum green time	Maximum green time	Vehicle Extension time
1 (actuated)	5	20	2.0
1* (proactive)	**0**	20	**3.0**
2 (actuated)	25	60	3.0
2* (proactive)	**5**	**70**	**5.0**
3 (actuated)	5	15	2.0
3* (proactive)	**0**	**20**	**3.0**
4 (actuated)	5	25	2.0
4* (proactive)	**0**	**30**	**3.0**
6 (actuated)	25	60	3.0
6* (proactive)	**10**	**90**	**5.0**

The highlighted values represent the corresponding changes

Field Experiment

Test Bed 2: NASA ROAD 1





Date of Field Observation

- Proactive Signal Control (November 22, 2016)
- Actuated Signal Control (December 9, 2016)

Weekday Peak Hour

- Morning Peak (Observation from 6:30am to 9:00am)
- Evening Peak (Observation from 3:00pm to 5:30pm)

Field Experiment

Test Bed 2: NASA ROAD 1

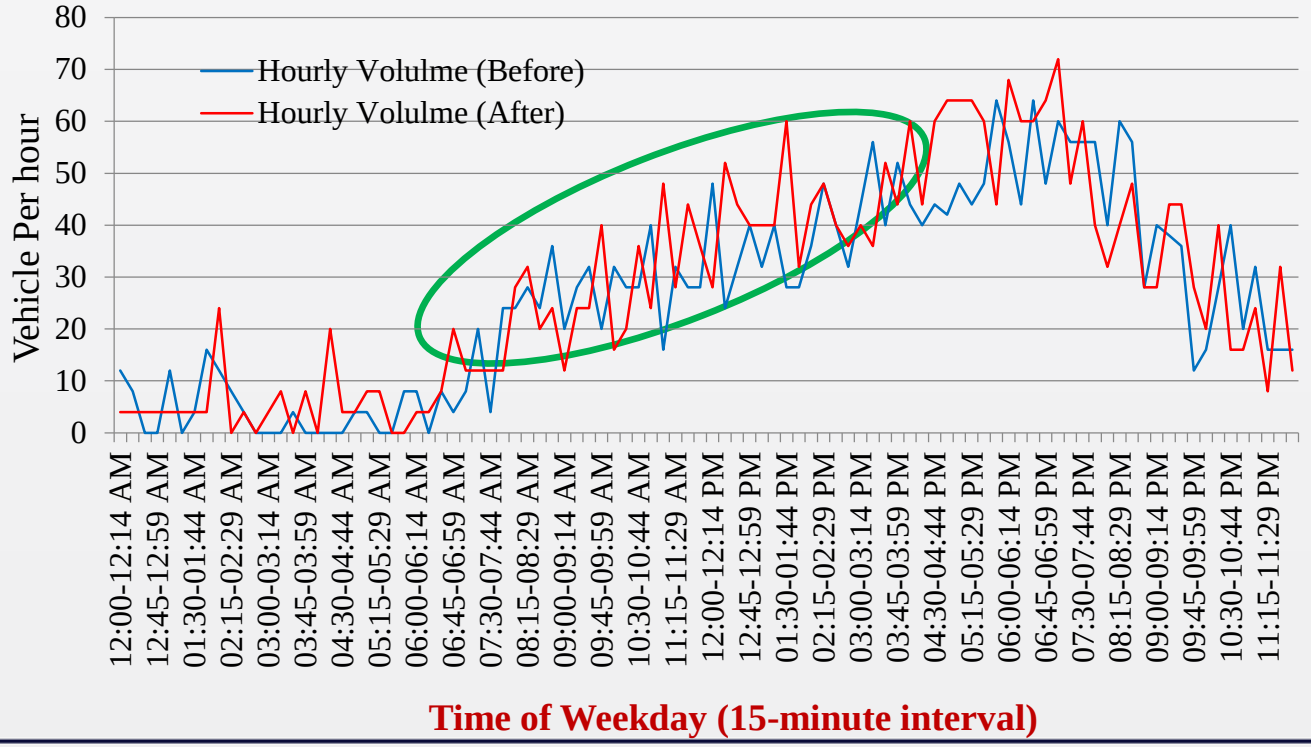
Evaluation of the proactive algorithm based VISSIM simulation

Parameters	Actuated Signal Control	Proactive Signal Control	Diff (%)
Average Delay (seconds)	6.71	6.00	**-11%**
Average Number of Stops	0.29	0.26	**-10%**
Average Stop delay (seconds)	3.28	2.54	**-29%**
Total Delay (seconds)	4878	4359	**-13%**
Speed Average (mile/hour)	60.84	61.59	**+1.2%**

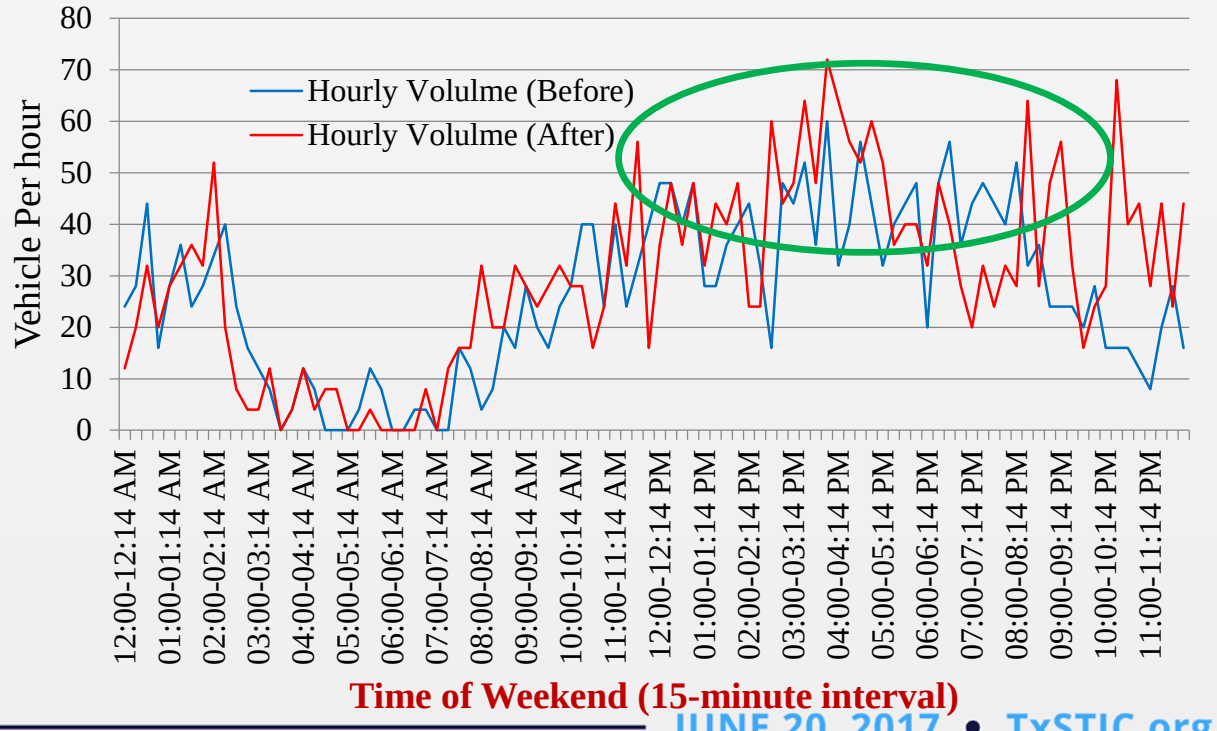
Field Experiment

Test Bed 2: NASA ROAD 1

Field data observations: Phase 1 (left-turn from the major road to the minor road, east-north)



Time of Weekday (15-minute interval)

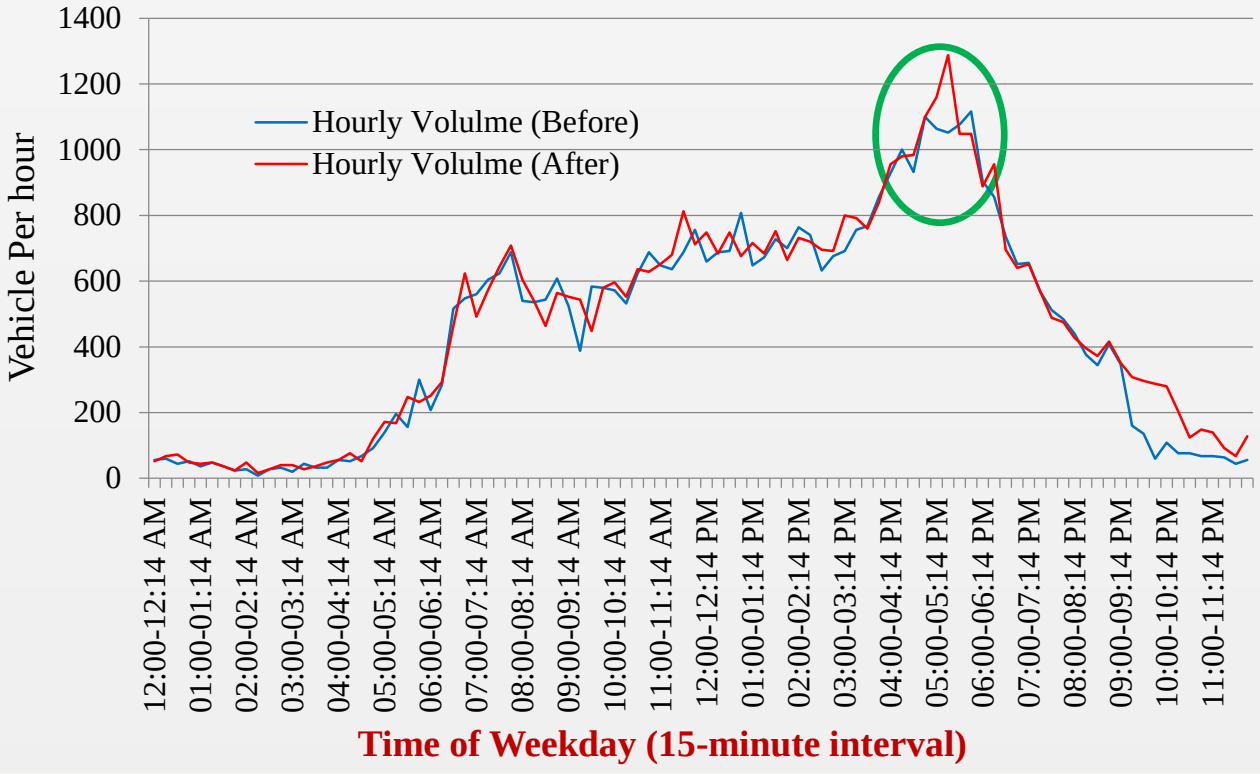


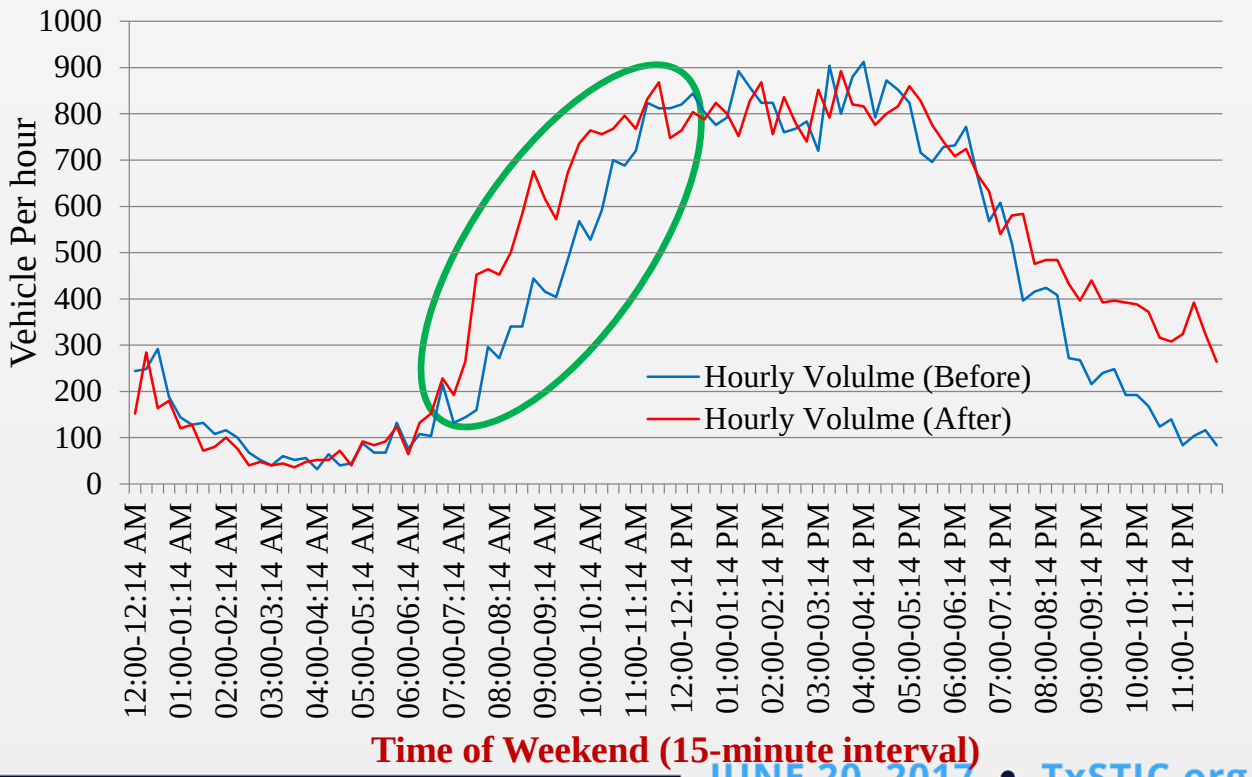
Time of Weekend (15-minute interval)

Field Experiment

Test Bed 2: NASA ROAD 1

Field data observations: Phase 6 (eastbound through traffic on the major road)

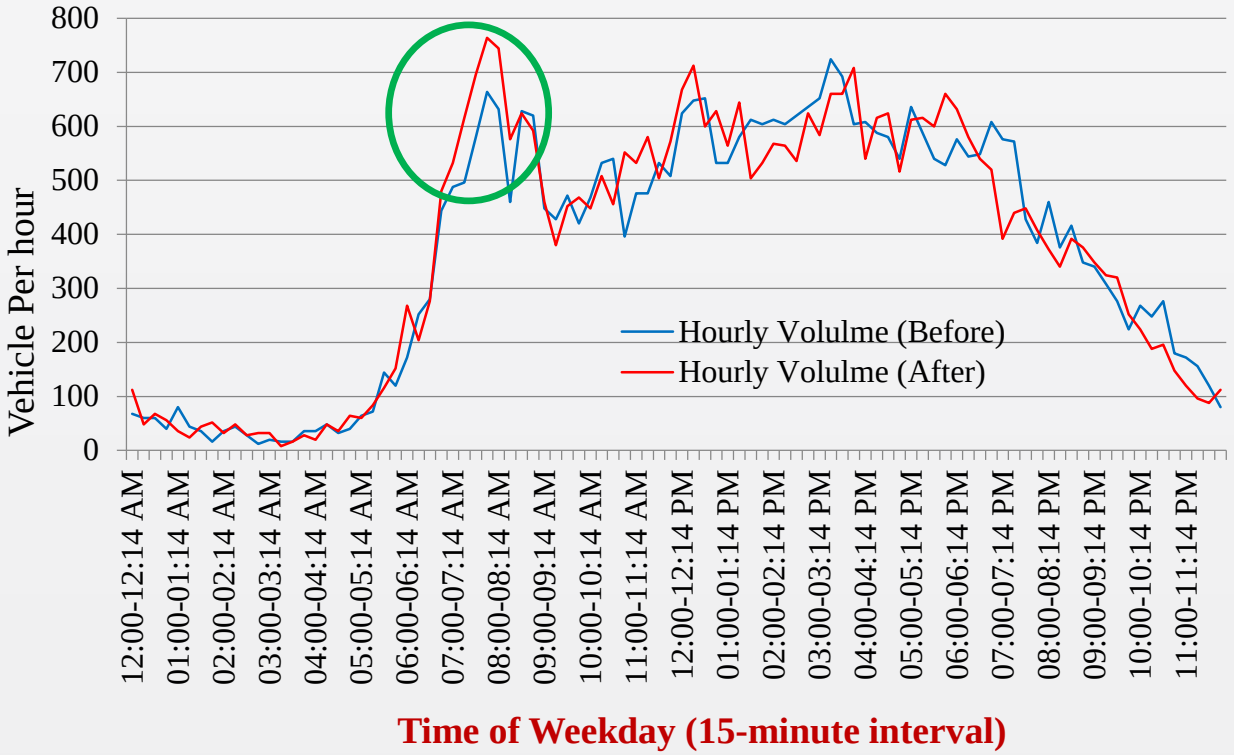


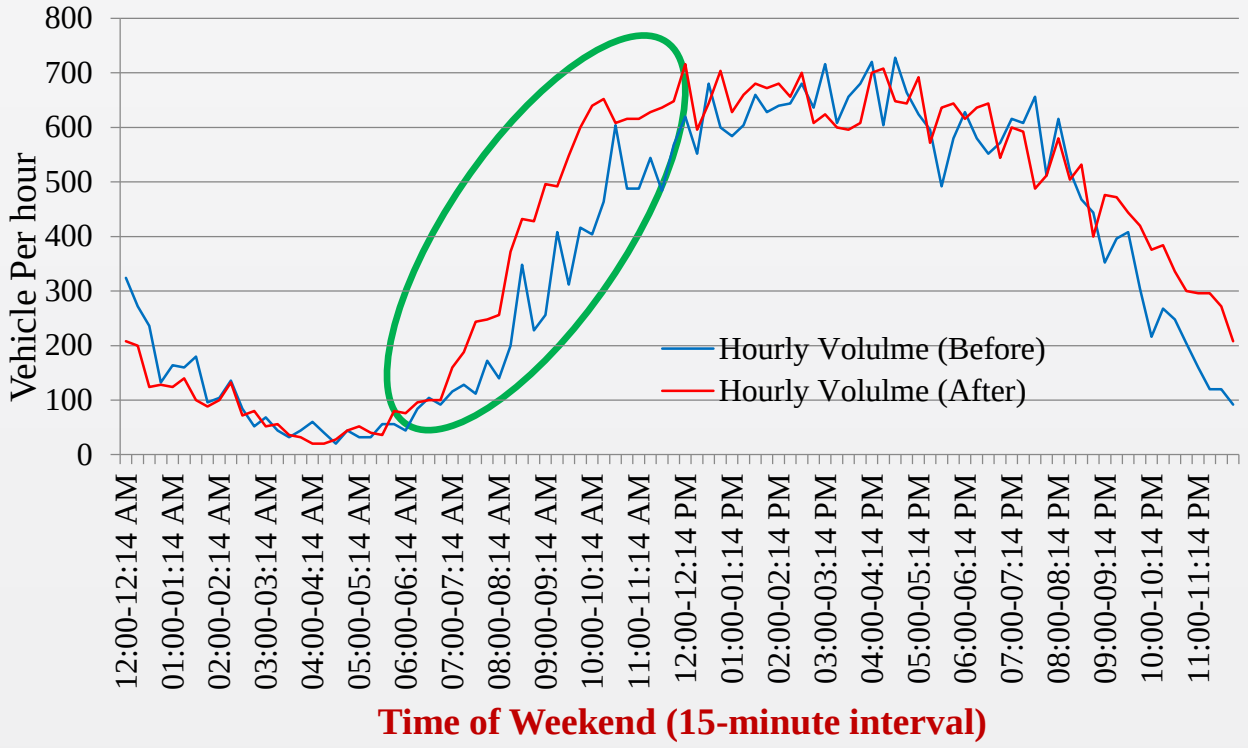


Field Experiment

Test Bed 2: NASA ROAD 1

Field data observations: Phase 2 (from the minor road to the major road)





Field Experiment

Test Bed 2: NASA ROAD 1

Evaluation of the proactive algorithm based field observation

Approach	Parameter	Actuated Control	Proactive Control	Diff (%)
Major Approach	Average Queue Length	24.80	10.00	60
	Maximum Queue Length	39.00	21.00	46
Minor Approach	Average Waiting Time	47.21	36.00	24
	Max Waiting Time	70.00	60.00	14

Summary

✓The proactive control system can significantly mitigate road congestion on the test bed, and also reduce emission and fuel consumption.

- From simulation (assuming connected vehicles existing in the network), it is seen that the vehicle delay reduced as high as 80%; the average number of stops of each vehicle reduced from 2.8 to 2; and the stop delay reduced up to 89%;
- On weekdays, the fuel consumption and CO2 is reduced about 21%, and 25% on weekends: this is equivalent to $2,400/day savings of gas on weekdays, and $3,270 on weekends (based on simulation, assuming connected vehicles existing in the network).

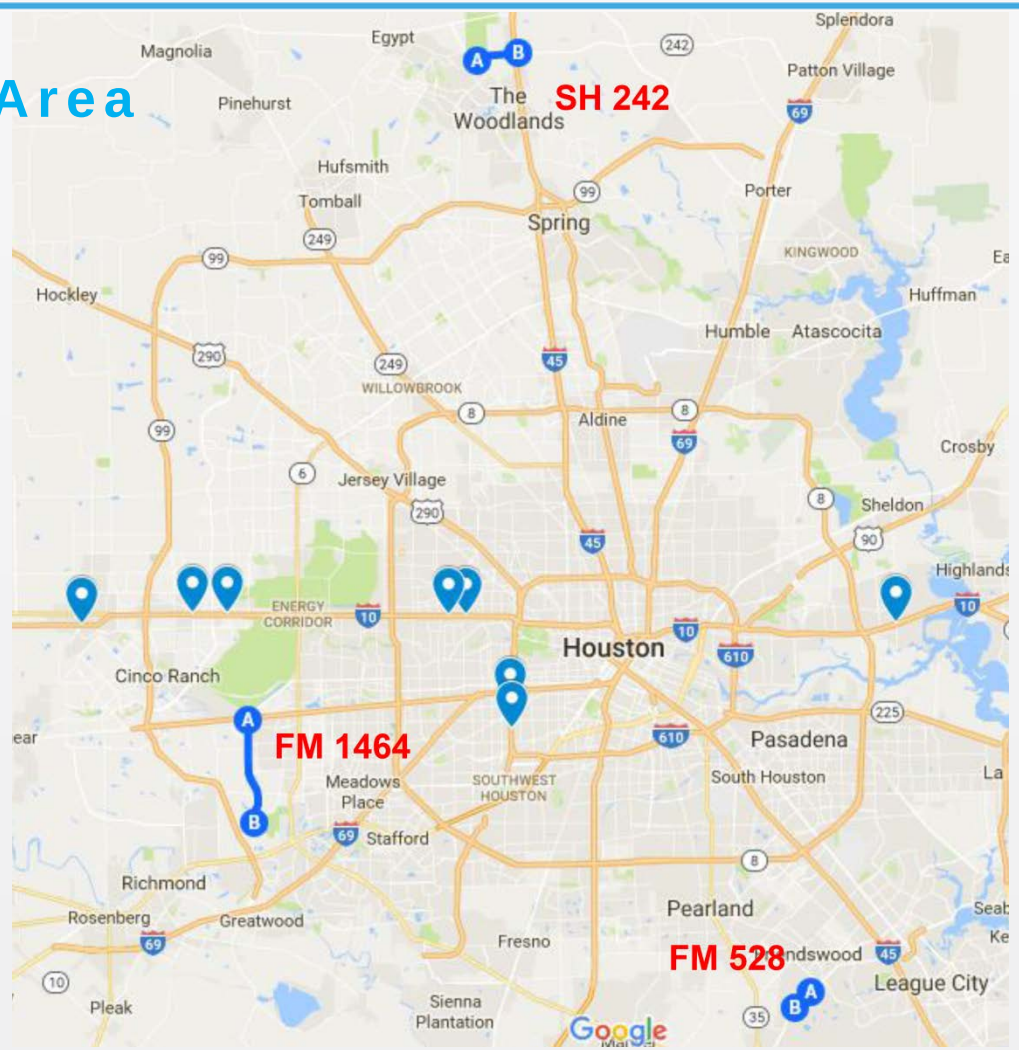
✓The field experiments also reports positive results:

- The proactive signal control system increases the average traffic volumes during peak hours.
- No complaint were received after the implementation
- The average queue length on the major road can be reduced up to 60%, and the average waiting time of vehicles on the minor road decreases up to 24%.

Large-Scale Implementation

30 Intersections at the Greater Houston Area

- Three testbeds (FM 528, SH 242 and FM 1464), which have consecutive intersections, and are installed with an Ethernet Programmable Automation Controller (**EPAC**)
- Other separate 8 intersections are using **the diamond controller mechanism**.



Questions?

Email: xing.wu@lamar.edu

TxDOT Research Project 0-6912

Innovative Tools and Techniques in Identifying Highway Safety Improvement Projects

Ioannis (Yianni) Tsapakis

Texas A&M Transportation Institute (TTI)

Highway Safety Improvement Program (HSIP)

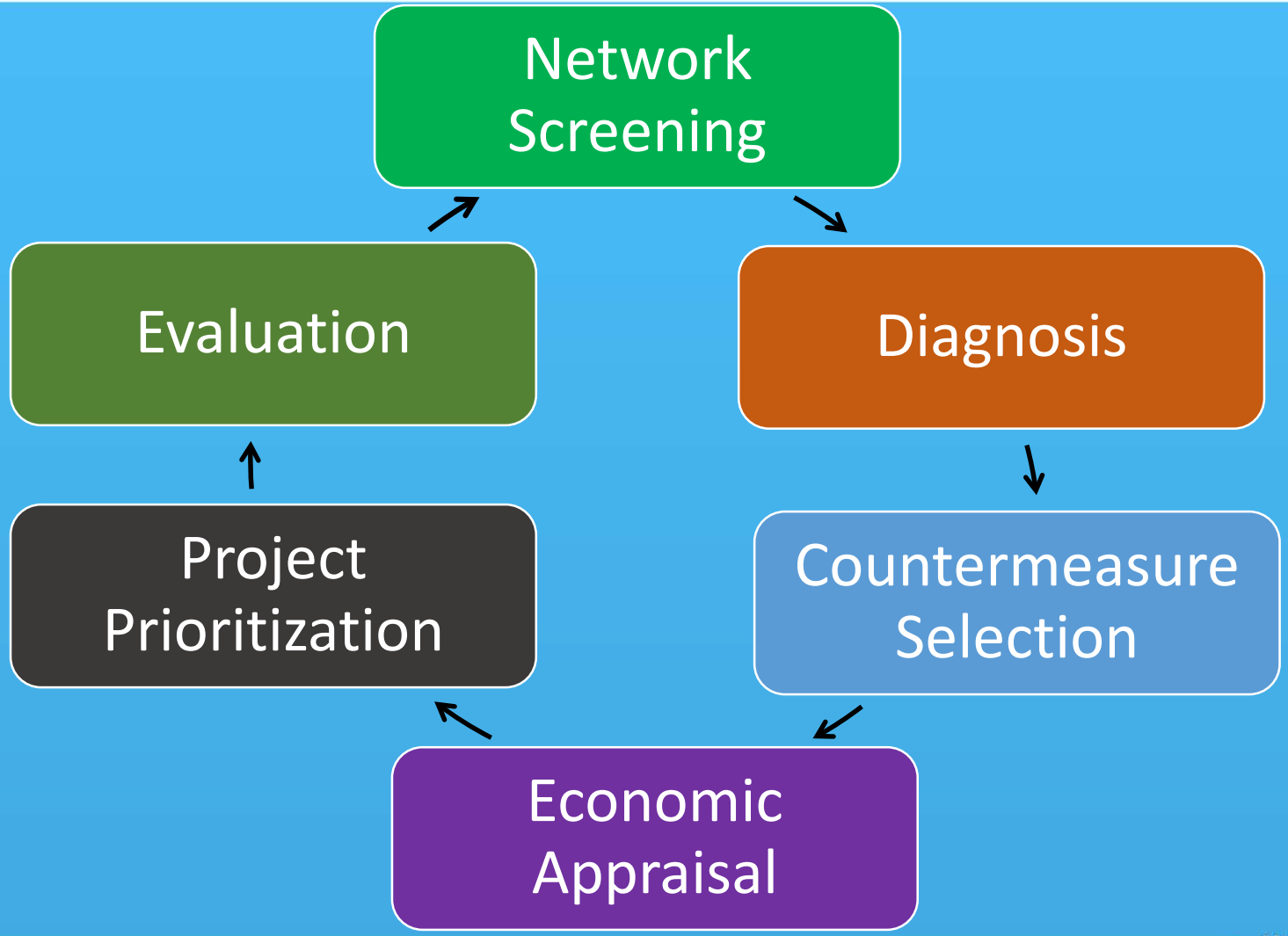
- **Federal-aid program (23 U.S.C. 148)**
- **Eligibility: Each state must develop a HSIP**
- **Goal: Reduce # and severity of fatalities and serious injury crashes on all public roads**
- **HSIP major components:**
  - Planning
  - Implementation
  - Evaluation

Research Questions

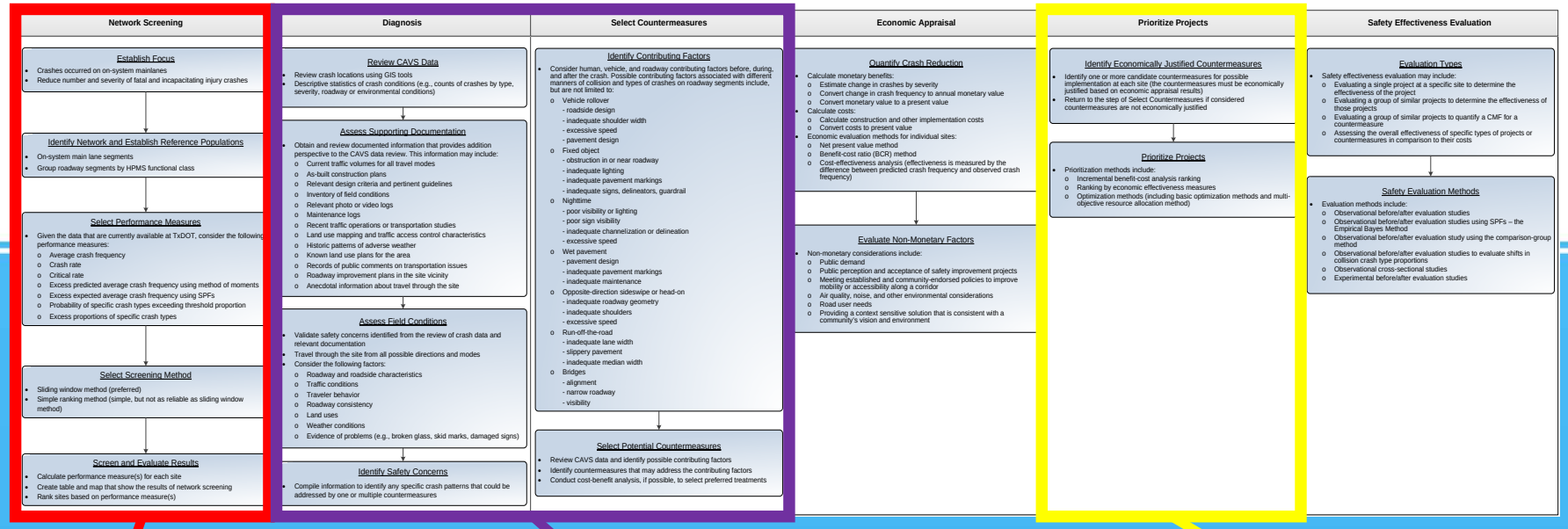
How can TxDOT:

- **Allocate funds in the most cost-effective manner?**
- **Create a level playing field for all TxDOT districts?**
- **Improve and streamline existing HSIP processes?**

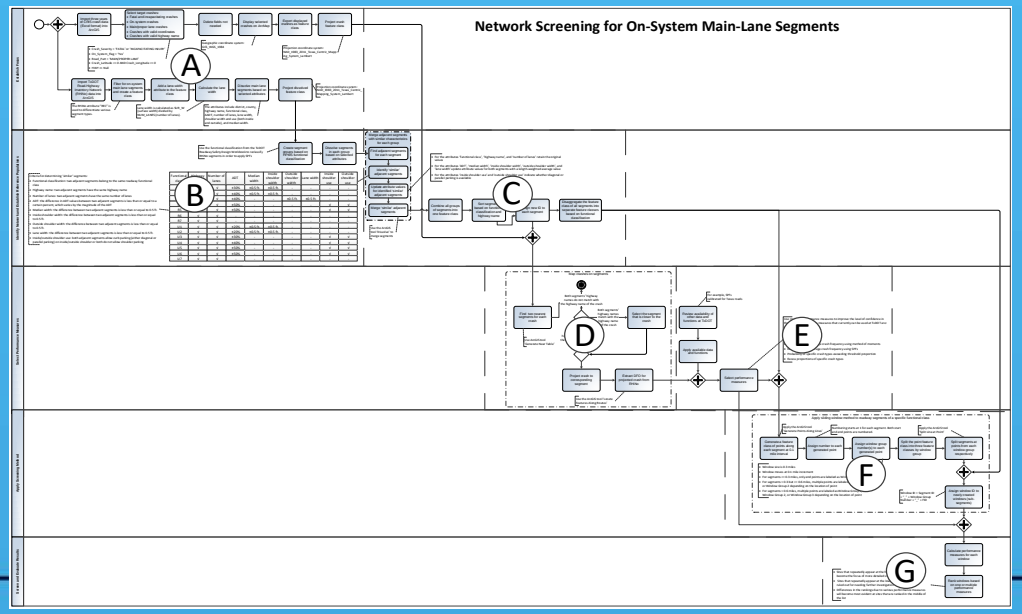
HSIP Process (Level 1 Diagram)



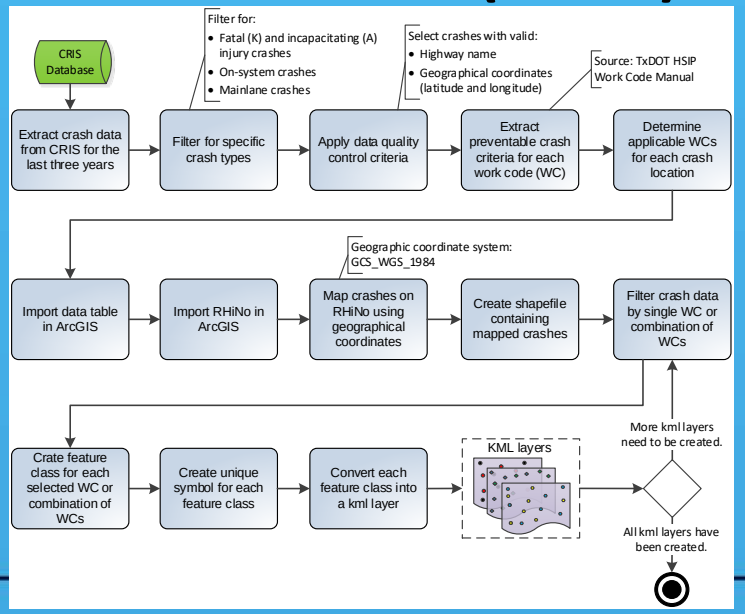
Level 2 Diagram



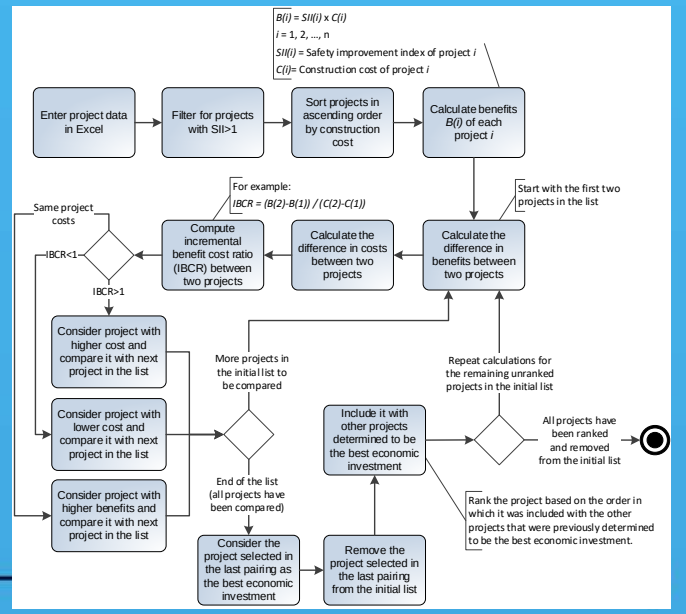
Network Screening



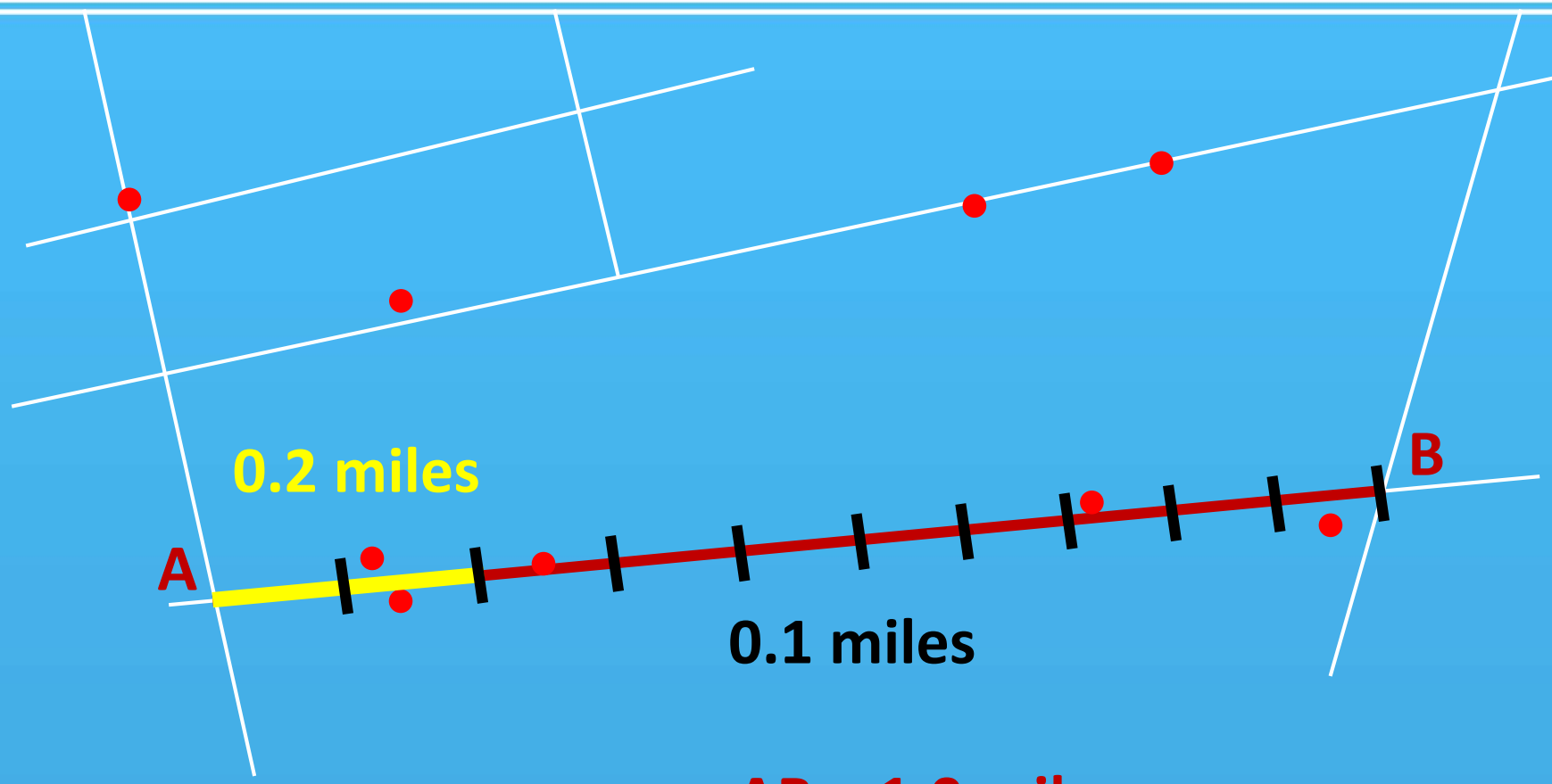
Crash Analysis and ViSualization (CAVS)



Project Prioritization



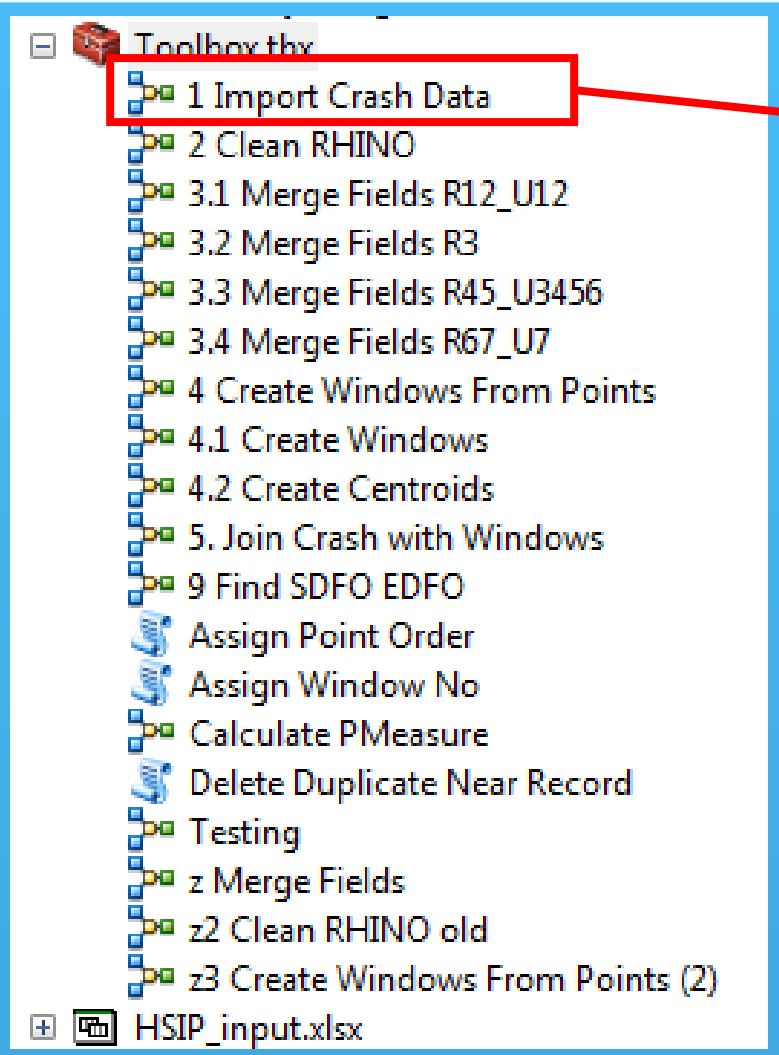
Network Screening for Segments

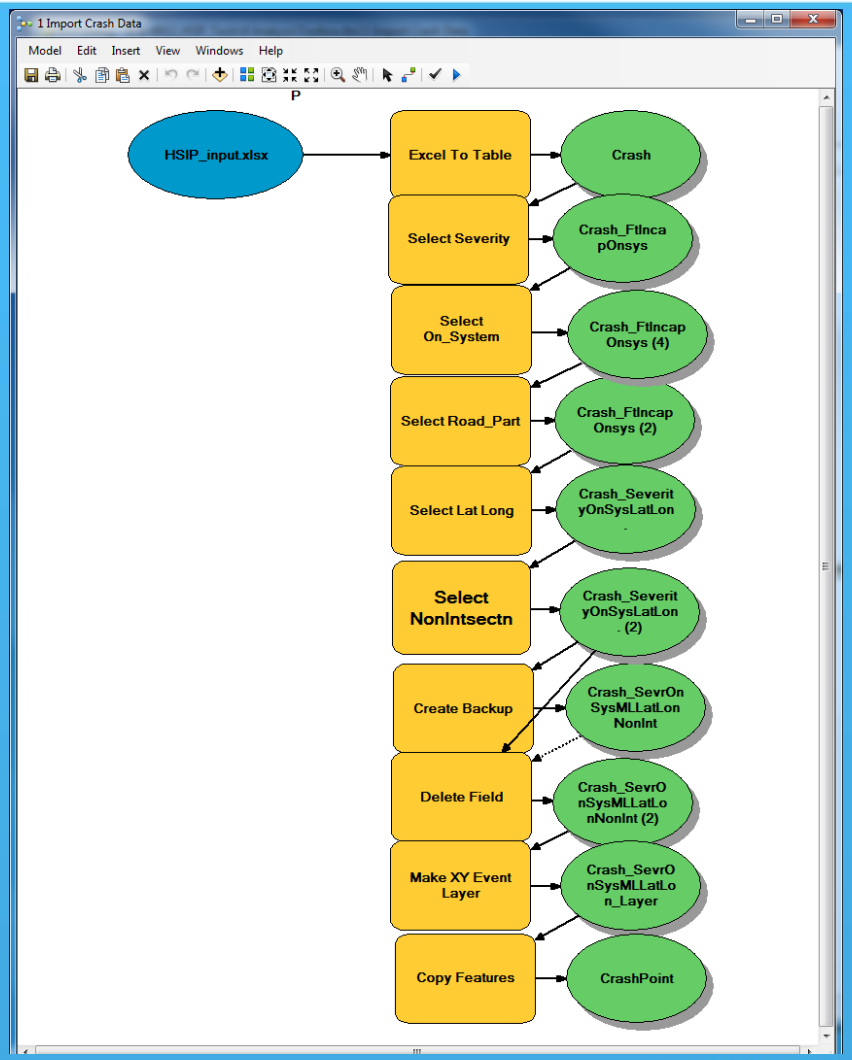


Performance Measures

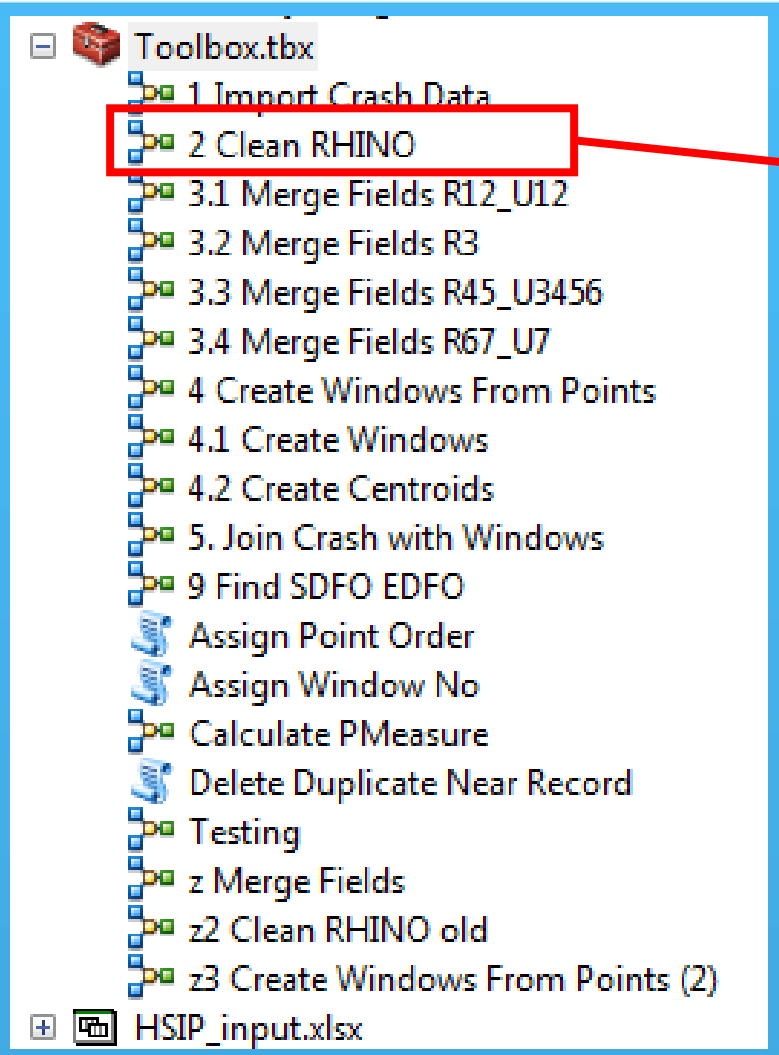
→	1. Crash Frequency
→	2. Crash Rate
	3. Equivalent Property Damage Only (EPDO) Average Crash Frequency
	4. Relative Severity Index (RSI)
→	5. Critical Rate
→	6. Excess Predicted Average Crash Frequency Using Method of Moments
	7. Level of Service of Safety (LOSS)
→	8. Excess Predicted Average Crash Frequency Using Safety Performance Functions (SPFs)
→	9. Probability of Specific Crash Types Exceeding Threshold Proportion
→	10. Excess Proportion of Specific Crash Types
	11. Expected Average Crash Frequency with Empirical Bayes (EB) Adjustment
	12. EPDO Average Crash Frequency with EB Adjustment
	13. Excess Expected Average Crash Frequency with EB Adjustment

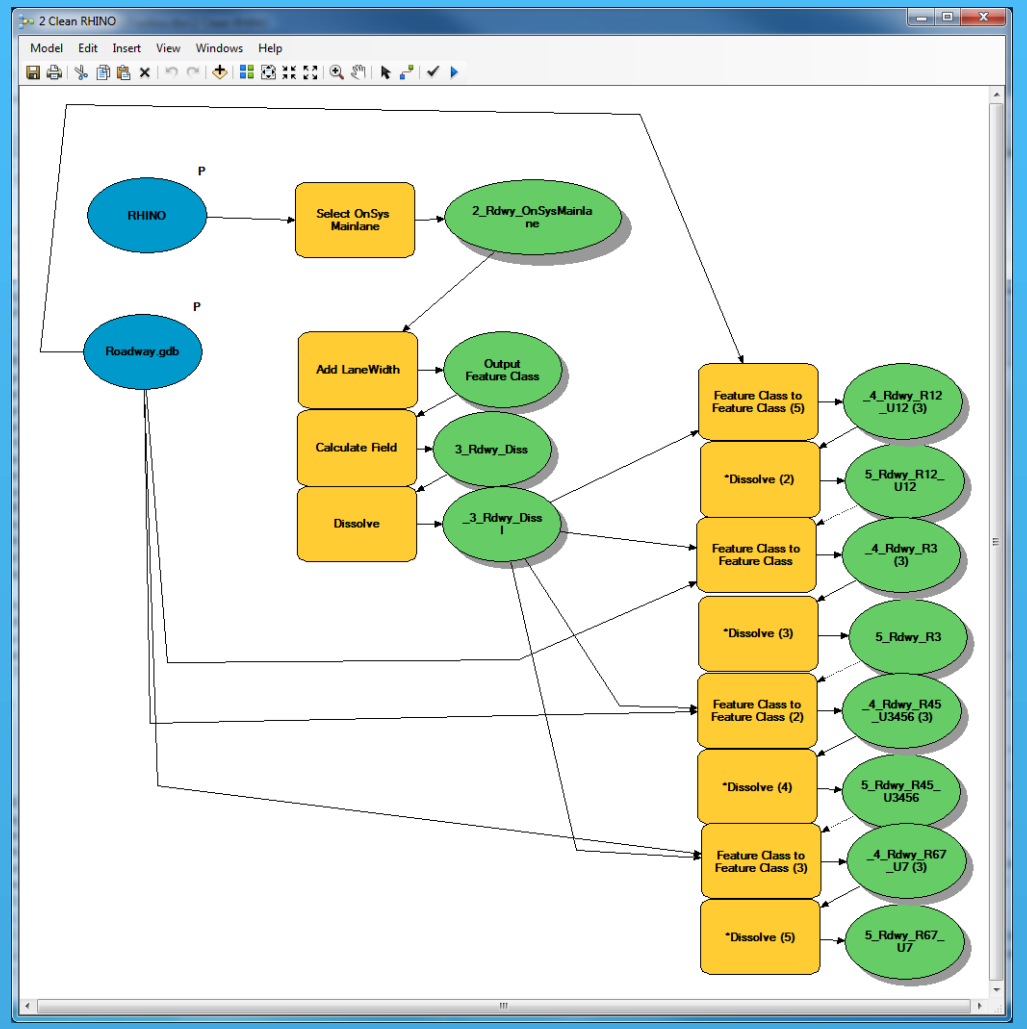
Network Screening ArcMap Toolbox



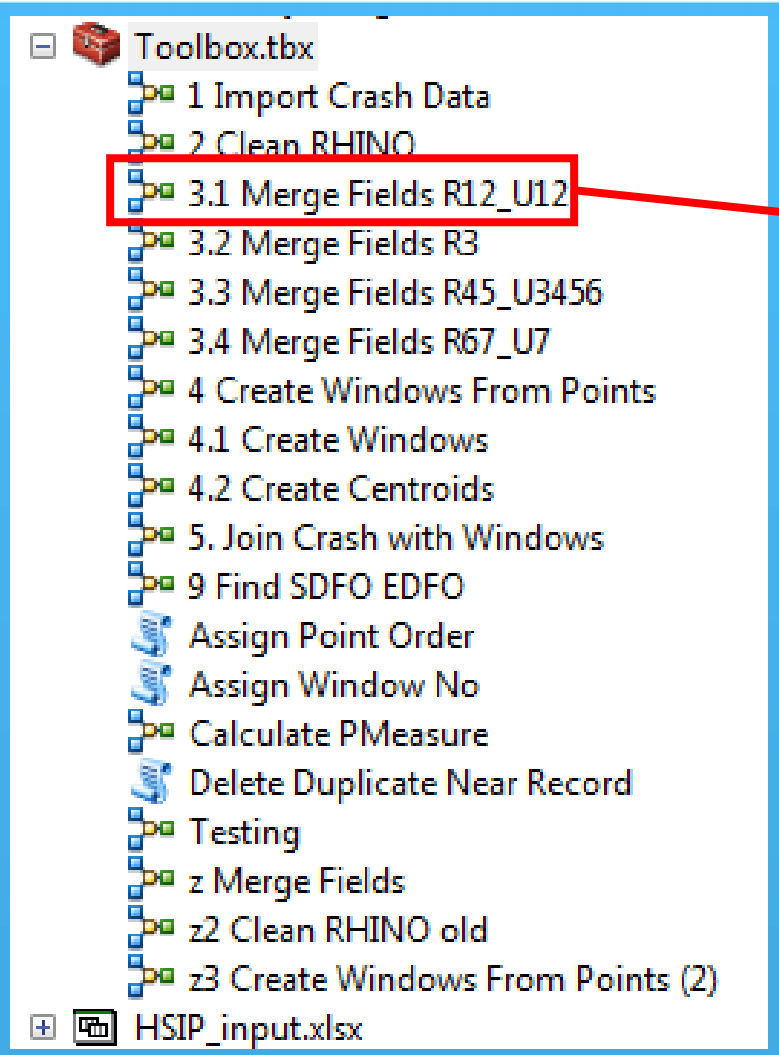


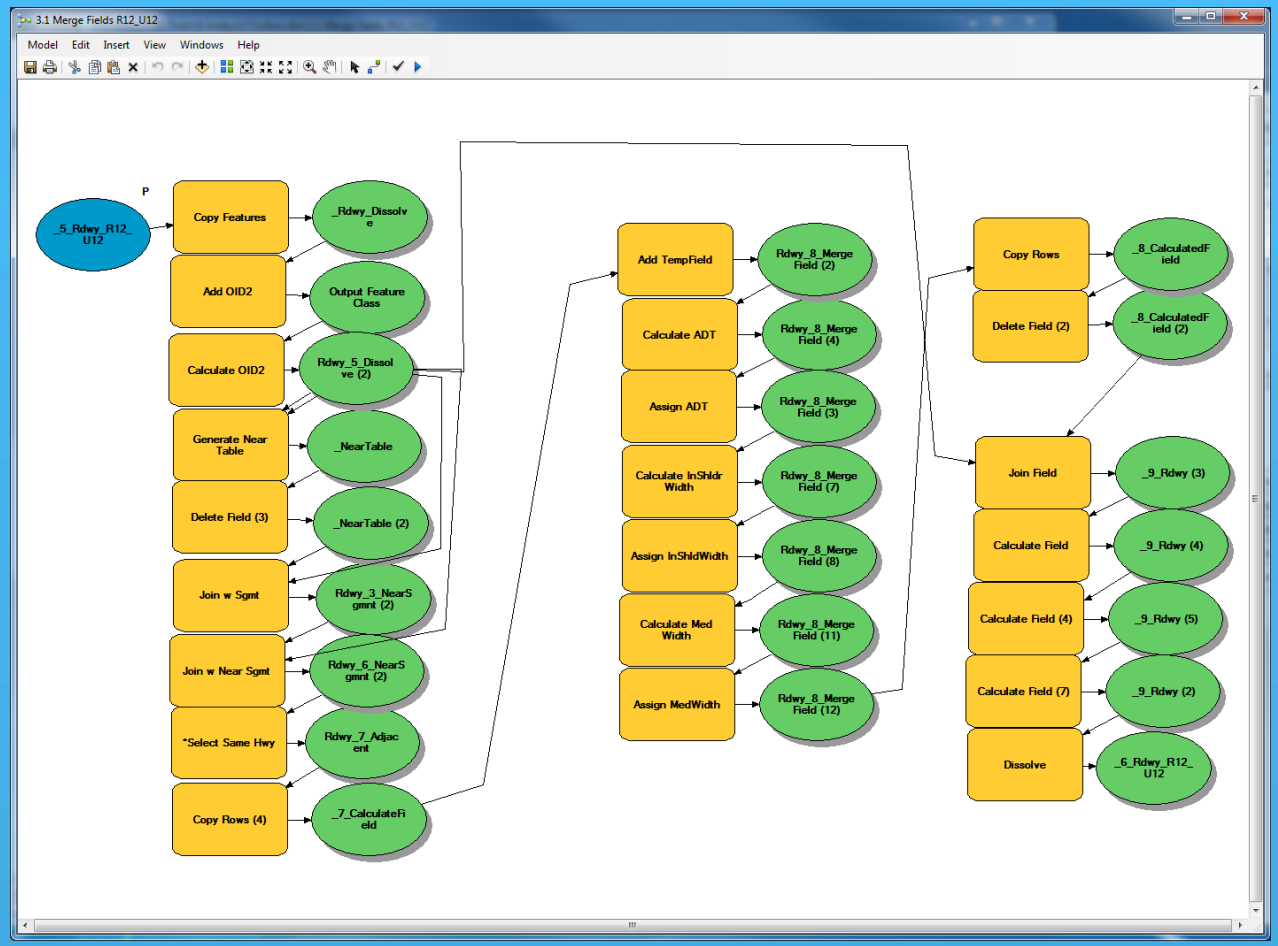
Network Screening ArcMap Toolbox



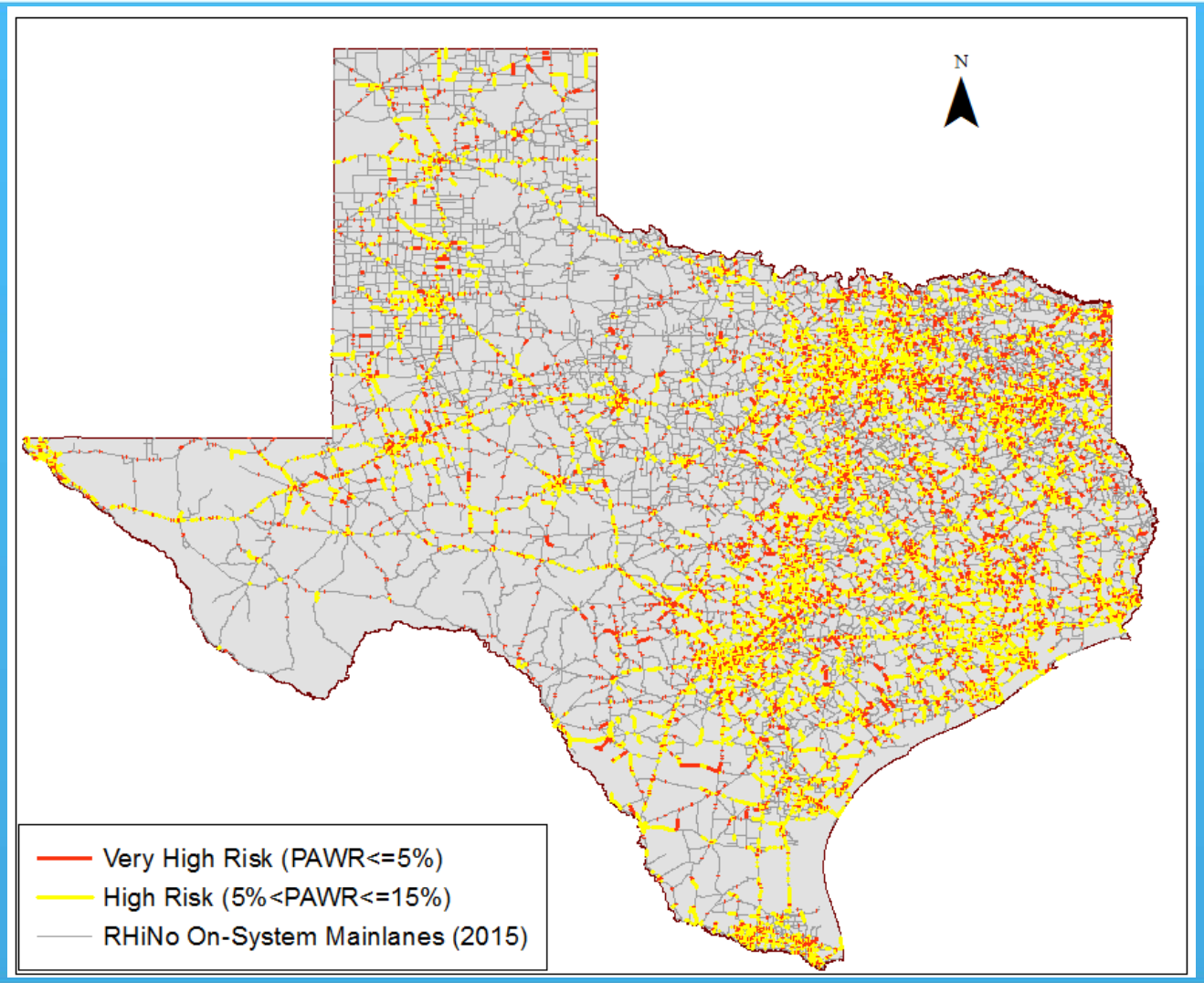


Network Screening ArcMap Toolbox

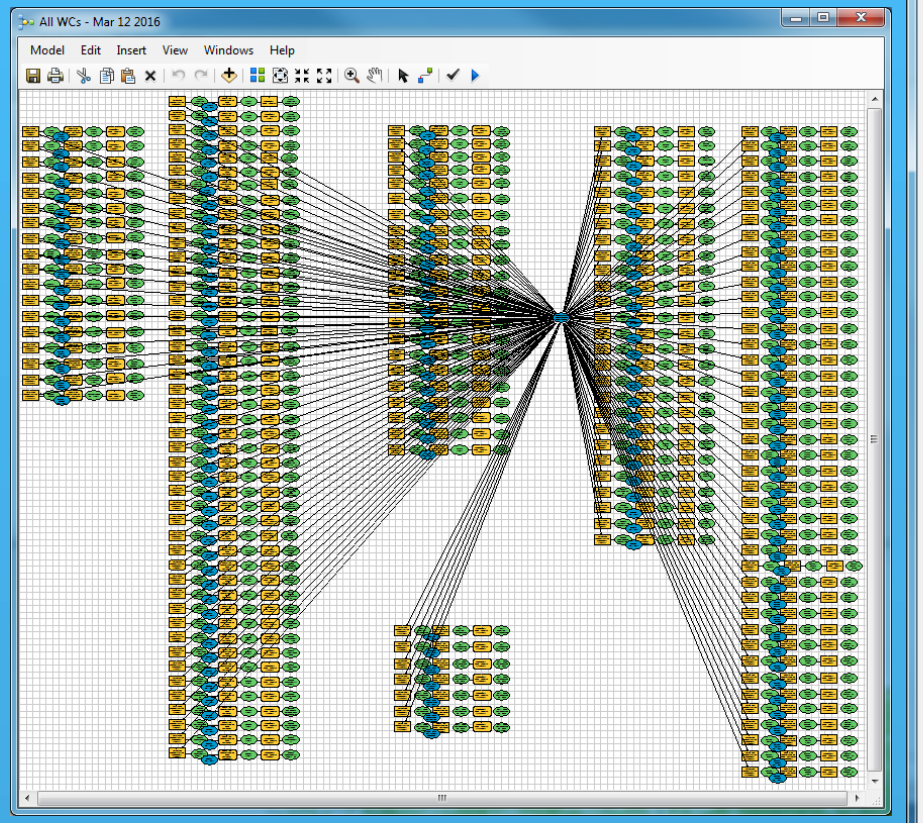




Network Screening Results



CAVS



HSIPLayers

Crashes | Master Plans

Import Data:
Select Excel File
Browse

Save Layers As...:
Select Output Location
Browse

Select Work Codes:
All
- 101 Install Warning-Guide Signs
- 102 Install STOP Signs
- 105 Install Intersection Flashing Beacon
- 106 Modernie Intersection Flashing Beacon
- 107 Install Traffic Signal
- 108 Improve Traffic Signals
- 110 Install Pedestrian Signal
- 111 Interconnect Signals
- 112 Overheight Warning System
- 113 Install Delineators
- 114 Install School ones
- 118 Replace Flashing Beacon with a Traffic Signal
- 119 Install Overhead Guide Signs
- 121 Convert Two-Way STOP Signs to Four-Way STOP Signs
- 122 Install Advance Intersection Warning Signals - Existing Warning Signs
- 123 Install Advance Curve Warning Signals - Existing Warning Signs
- 124 Install Advance Intersection Warning Signals and Signs
- 125 Install Advance Curve Warning Signals and Signs
- 128 Install Advance Intersection Warning Signs
- 130 Install Advance Curve Warning Signs
- 131 Improve Pedestrian Signals
- 133 Improve School one
- 136 Install LED Flashing Chevrons on Curve
- 137 Install Chevrons on Curve
- 138 Install Flashing Yellow Arrow
- 139 Install Surface Mounted Delineators on Centerline
- 143 Pedestrian Hybrid Beacon
- 201 Install Median Barrier
- 202 Convert Median Barrier
- 203 Install Raised Median
- 204 Flatten Side Slope

Select Districts:
All
- Abilene
- Amarillo
- Atlanta
- Austin
- Beaumont
- Brownwood
- Bryan
- Childress
- Corpus Christi
- Dallas
- El Paso
- Fort Worth
- Houston
- Laredo
- Lubbock
- Lufkin
- Odessa
- Paris
- Pharr
- San Angelo
- San Antonio
- Tyler
- Waco
- Wichita Falls
- Yoakum

Select Road Parts:
All
- Main Lane
- Frontage Road
- Entrance Ramp
- Exit Ramp
- Connection
- Detour
- Other
- Transitway
- Transitway Ramp
- Not Reported
- Undetermined
- Reported Invalid

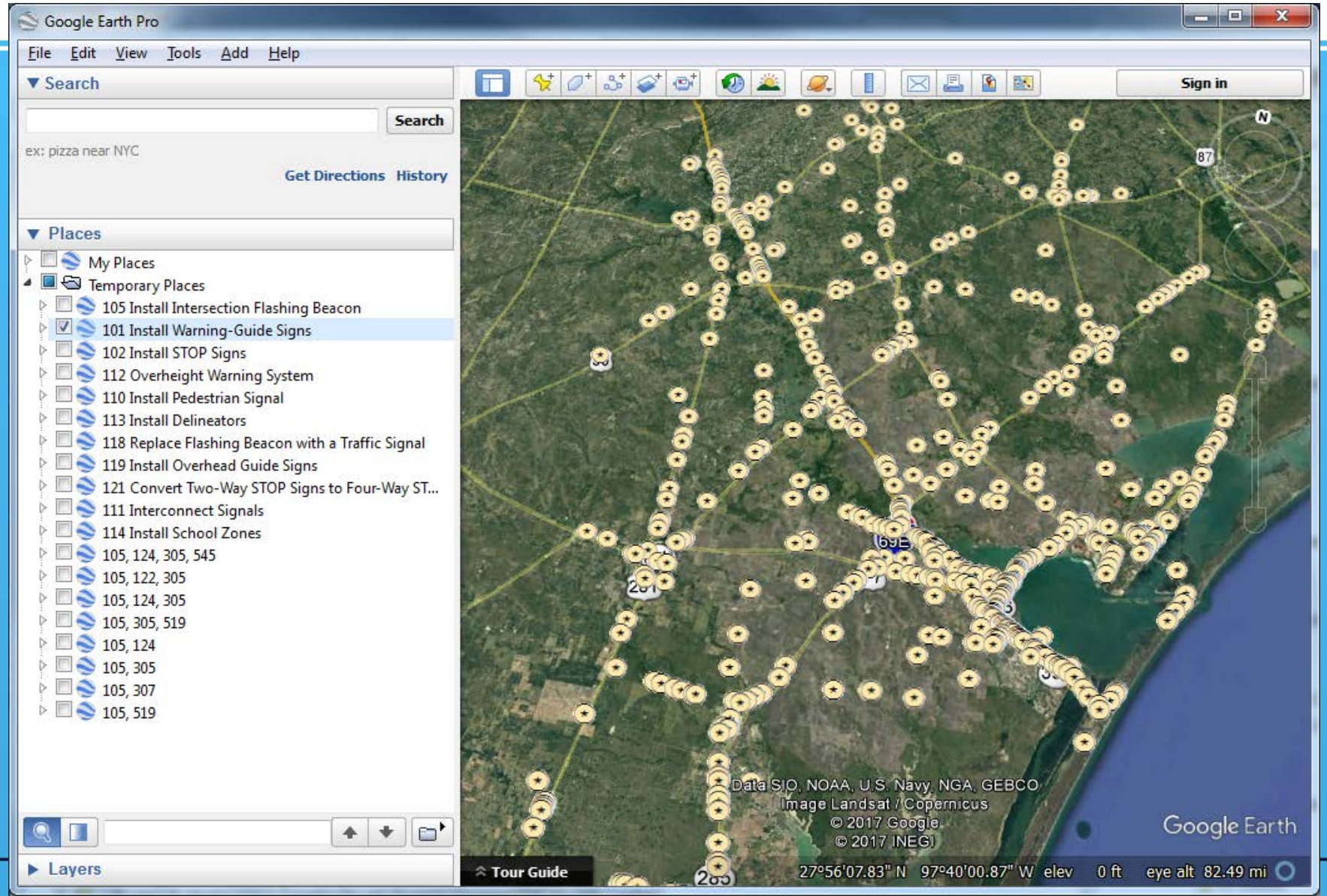
Select Functional Classes:
All
- Rural Interstate
- Rural Prin Aterial
- Rural Minor Arterial
- Rural Major Coll
- Rural Minor Coll
- Rural Local
- Urban Prin Arterial (IH)
- Urban Prin Arterial (Other Freeway)
- Urban Prin Arterial (Other)
- Urban Minor Arterial
- Urban Collector
- Urban Local

Select Severity:
All
- Killed (K)
- Incapacitating Injury (A)
- Non-Incapacitating Injury (B)
- Possible Injury (C)
- Not Injured (O)
- Unknown
- Reported Invalid
- Not Reported

Select System Crashes:
All
- On
- Off

Run

CAVS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Search
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ex: pizza near NYC
Get Directions History
Places
My Places
Temporary Places
105 Install Intersection Flashing Beacon
101 Install Warning-Guide Signs
102 Install STOP Signs
112 Overheight Warning System
110 Install Pedestrian Signal
113 Install Delineators
118 Replace Flashing Beacon with a Traffic Signal
119 Install Overhead Guide Signs
121 Convert Two-Way STOP Signs to Four-Way ST...
111 Interconnect Signals
114 Install School Zones
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105, 519
Layers
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
© 2017 Google
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Google Earth
Tour Guide
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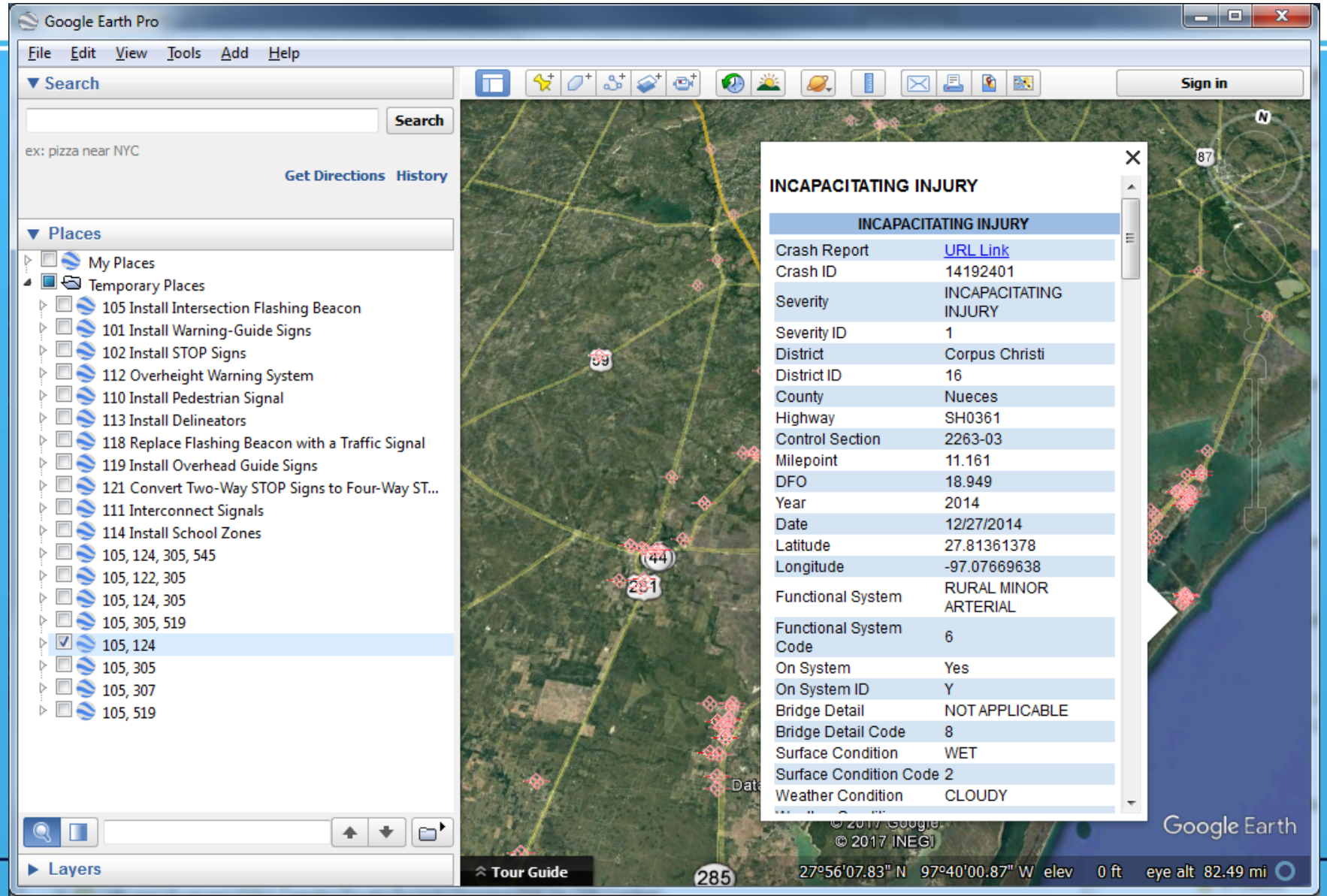
CAVS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105, 519
Layers
Sign in
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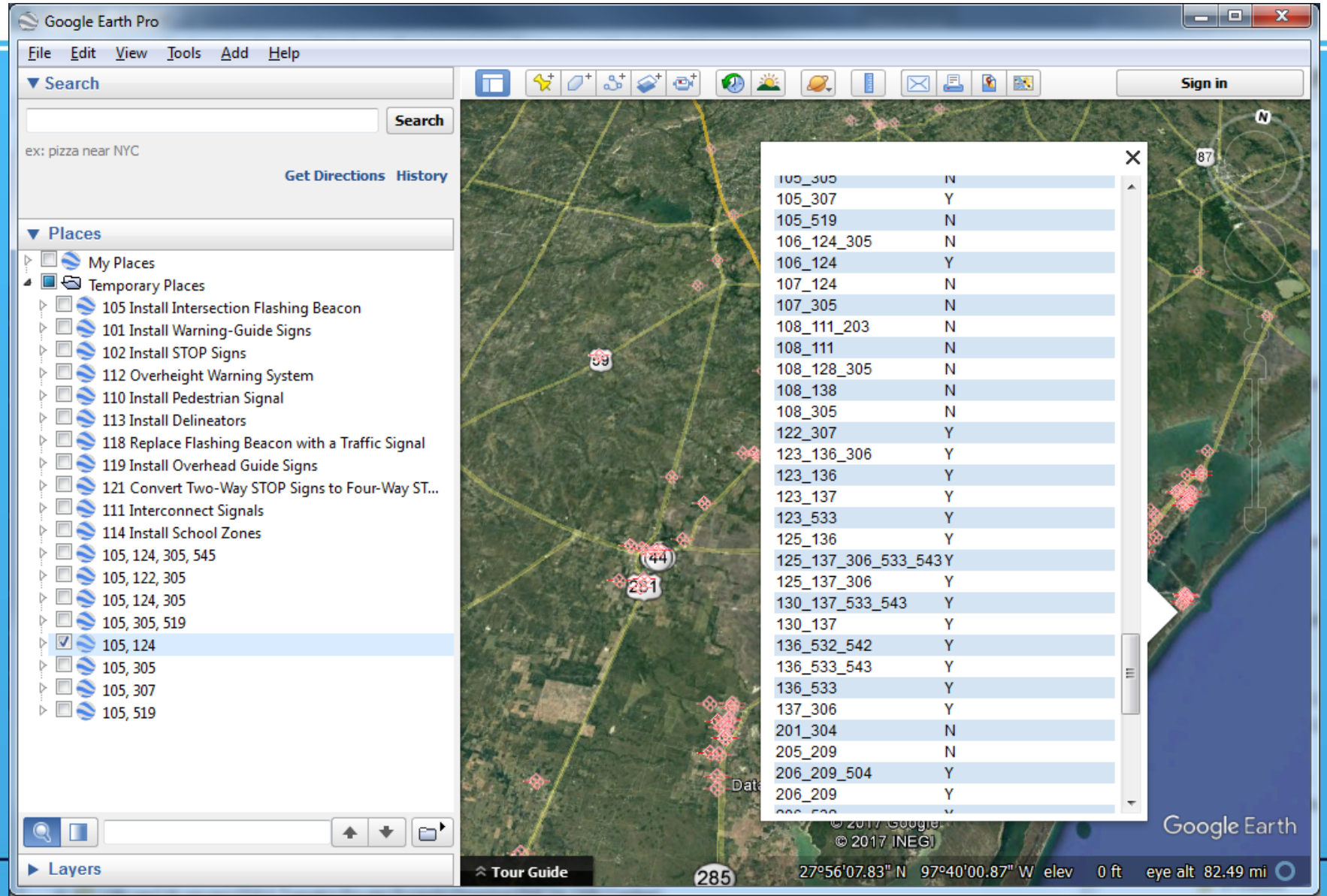
INCAPACITATING INJURY
Crash Report URL Link
Crash ID 14192401
Severity INCAPACITATING INJURY
Severity ID 1
District Corpus Christi
District ID 16
County Nueces
Highway SH0361
Control Section 2263-03
Milepoint 11.161
DFO 18.949
Year 2014
Date 12/27/2014
Latitude 27.81361378
Longitude -97.07669638
Functional System RURAL MINOR ARTERIAL
Functional System Code 6
On System Yes
On System ID Y
Bridge Detail NOT APPLICABLE
Bridge Detail Code 8
Surface Condition WET
Surface Condition Code 2
Weather Condition CLOUDY
© 2017 INEGI
Google Earth
Tour Guide
27°56'07.83" N 97°40'00.87" W elev 0 ft eye alt 82.49 mi

CAVS


Google Earth Pro
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ex: pizza near NYC
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My Places
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105, 124
105, 305
105, 307
105, 519
Layers
Sign in
105_307 Y
105_519 N
106_124_305 N
106_124 Y
107_124 N
107_305 N
108_111_203 N
108_111 N
108_128_305 N
108_138 N
108_305 N
122_307 Y
123_136_306 Y
123_136 Y
123_137 Y
123_533 Y
125_136 Y
125_137_306_533_543 Y
125_137_306 Y
130_137_533_543 Y
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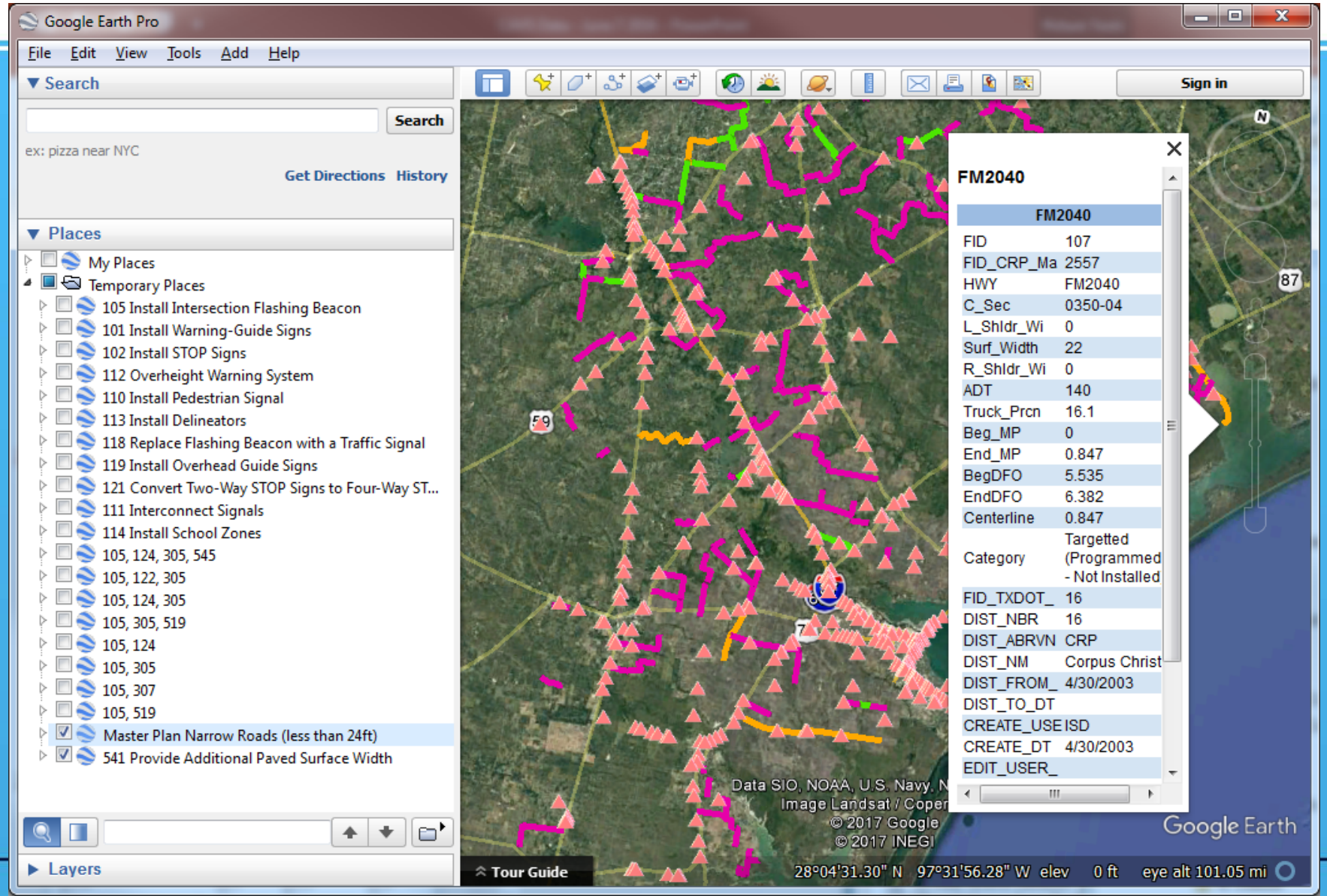
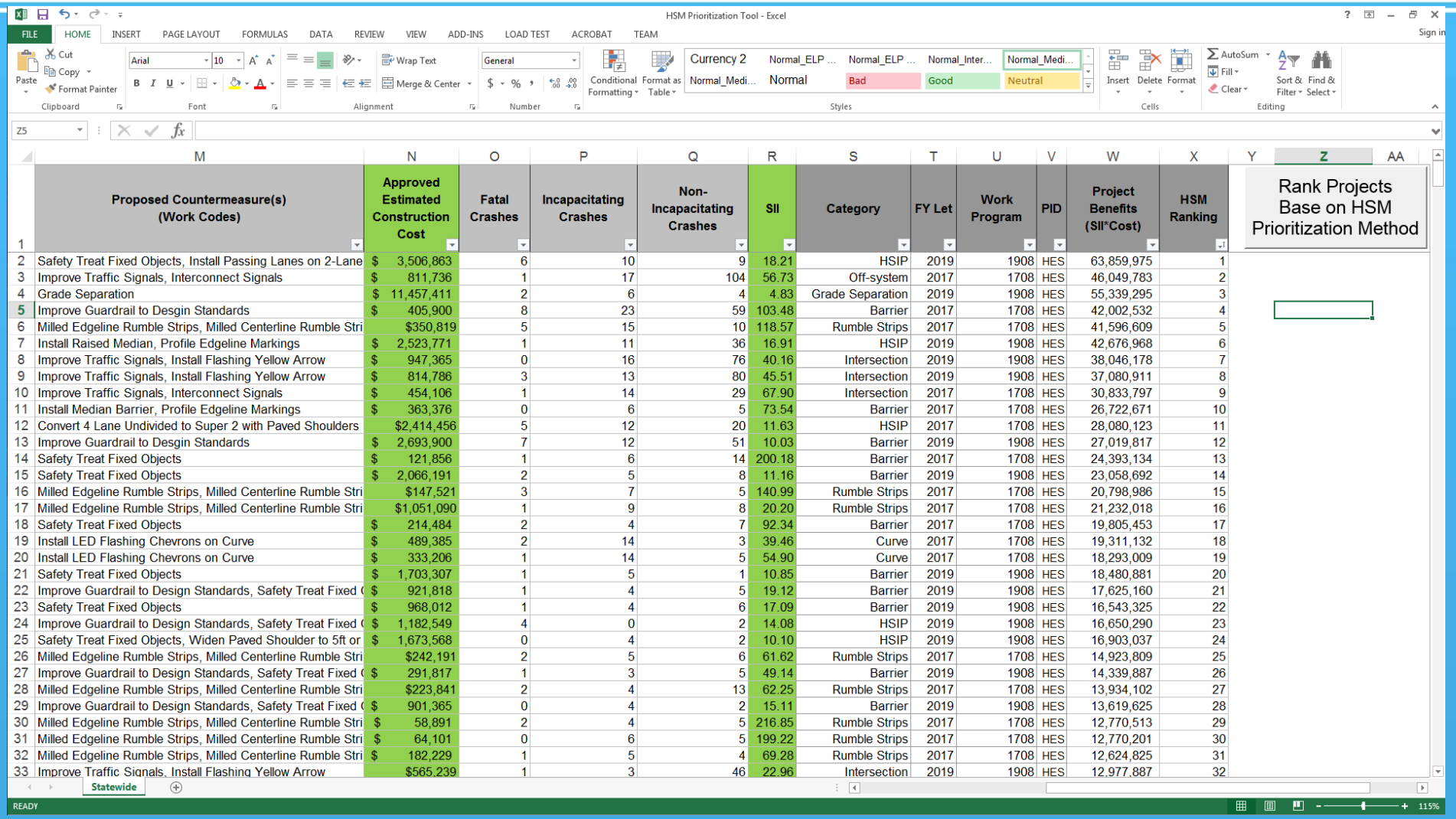
205_209 N
206_209_504 Y
206_209 Y
© 2017 INEGI
Google Earth
Tour Guide
27°56'07.83" N 97°40'00.87" W elev 0 ft eye alt 82.49 mi

CAVS and Master Plans



Project Prioritization



HSM Prioritization Tool - Excel

	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1	Proposed Countermeasure(s) (Work Codes)	Approved Estimated Construction Cost	Fatal Crashes	Incapacitating Crashes	Non-Incapacitating Crashes	SII	Category	FY Let	Work Program	PID	Project Benefits (SII*Cost)	HSM Ranking		Rank Projects Base on HSM Prioritization Method	
2	Safety Treat Fixed Objects, Install Passing Lanes on 2-Lane	$ 3,506,863	6	10	9	18.21	HSIP	2019	1908	HES	63,859,975	1			
3	Improve Traffic Signals, Interconnect Signals	$ 811,736	1	17	104	56.73	Off-system	2017	1708	HES	46,049,783	2			
4	Grade Separation	$ 11,457,411	2	6	4	4.83	Grade Separation	2019	1908	HES	55,339,295	3			
5	Improve Guardrail to Desgin Standards	$ 405,900	8	23	59	103.48	Barrier	2017	1708	HES	42,002,532	4			
6	Milled Edgeline Rumble Strips, Milled Centerline Rumble Stri	$350,819	5	15	10	118.57	Rumble Strips	2017	1708	HES	41,596,609	5			
7	Install Raised Median, Profile Edgeline Markings	$ 2,523,771	1	11	36	16.91	HSIP	2019	1908	HES	42,676,968	6			
8	Improve Traffic Signals, Install Flashing Yellow Arrow	$ 947,365	0	16	76	40.16	Intersection	2019	1908	HES	38,046,178	7			
9	Improve Traffic Signals, Install Flashing Yellow Arrow	$ 814,786	3	13	80	45.51	Intersection	2019	1908	HES	37,080,911	8			
10	Improve Traffic Signals, Interconnect Signals	$ 454,106	1	14	29	67.90	Intersection	2017	1708	HES	30,833,797	9			
11	Install Median Barrier, Profile Edgeline Markings	$ 363,376	0	6	5	73.54	Barrier	2017	1708	HES	26,722,671	10			
12	Convert 4 Lane Undivided to Super 2 with Paved Shoulders	$2,414,456	5	12	20	11.63	HSIP	2017	1708	HES	28,080,123	11			
13	Improve Guardrail to Desgin Standards	$ 2,693,900	7	12	51	10.03	Barrier	2019	1908	HES	27,019,817	12			
14	Safety Treat Fixed Objects	$ 121,856	1	6	14	200.18	Barrier	2017	1708	HES	24,393,134	13			
15	Safety Treat Fixed Objects	$ 2,066,191	2	5	8	11.16	Barrier	2019	1908	HES	23,058,692	14			
16	Milled Edgeline Rumble Strips, Milled Centerline Rumble Stri	$147,521	3	7	5	140.99	Rumble Strips	2017	1708	HES	20,798,986	15			
17	Milled Edgeline Rumble Strips, Milled Centerline Rumble Stri	$1,051,090	1	9	8	20.20	Rumble Strips	2017	1708	HES	21,232,018	16			
18	Safety Treat Fixed Objects	$ 214,484	2	4	7	92.34	Barrier	2017	1708	HES	19,805,453	17			
19	Install LED Flashing Chevrons on Curve	$ 489,385	2	14	3	39.46	Curve	2017	1708	HES	19,311,132	18			
20	Install LED Flashing Chevrons on Curve	$ 333,206	1	14	5	54.90	Curve	2017	1708	HES	18,293,009	19			
21	Safety Treat Fixed Objects	$ 1,703,307	1	5	1	10.85	Barrier	2019	1908	HES	18,480,881	20			
22	Improve Guardrail to Design Standards, Safety Treat Fixed (	$ 921,818	1	4	5	19.12	Barrier	2019	1908	HES	17,625,160	21			
23	Safety Treat Fixed Objects	$ 968,012	1	4	6	17.09	Barrier	2019	1908	HES	16,543,325	22			
24	Improve Guardrail to Design Standards, Safety Treat Fixed (	$ 1,182,549	4	0	2	14.08	HSIP	2019	1908	HES	16,650,290	23			
25	Safety Treat Fixed Objects, Widen Paved Shoulder to 5ft or	$ 1,673,568	0	4	2	10.10	HSIP	2019	1908	HES	16,903,037	24			
26	Milled Edgeline Rumble Strips, Milled Centerline Rumble Stri	$242,191	2	5	6	61.62	Rumble Strips	2017	1708	HES	14,923,809	25			
27	Improve Guardrail to Design Standards, Safety Treat Fixed (	$ 291,817	1	3	5	49.14	Barrier	2019	1908	HES	14,339,887	26			
28	Milled Edgeline Rumble Strips, Milled Centerline Rumble Stri	$223,841	2	4	13	62.25	Rumble Strips	2017	1708	HES	13,934,102	27			
29	Improve Guardrail to Design Standards, Safety Treat Fixed (	$ 901,365	0	4	2	15.11	Barrier	2019	1908	HES	13,619,625	28			
30	Milled Edgeline Rumble Strips, Milled Centerline Rumble Stri	$ 58,891	2	4	5	216.85	Rumble Strips	2017	1708	HES	12,770,513	29			
31	Milled Edgeline Rumble Strips, Milled Centerline Rumble Stri	$ 64,101	0	6	5	199.22	Rumble Strips	2017	1708	HES	12,770,201	30			
32	Milled Edgeline Rumble Strips, Milled Centerline Rumble Stri	$ 182,229	1	5	4	69.28	Rumble Strips	2017	1708	HES	12,624,825	31			
33	Improve Traffic Signals, Install Flashing Yellow Arrow	$565,239	1	3	46	22.96	Intersection	2019	1908	HES	12,977,887	32			

Statewide Implementation

- Conduct peer exchange & update CAVS process
- Refine network screening process
- Produce CAVS data for 2018 & 2019 HSIPs
- Perform network screening for 2018 & 2019 HSIPs
- Implement CAVS and network screening products

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Texas A&M Transportation Institute
(210) 321-1217
i-tsapakis@tti.tamu.edu

TxDOT Project 0-6861
Improving Safety and Efficiency of Signalized Intersections during Inclement Weather

Nadeem A. Chaudhary, Ph.D., PE.

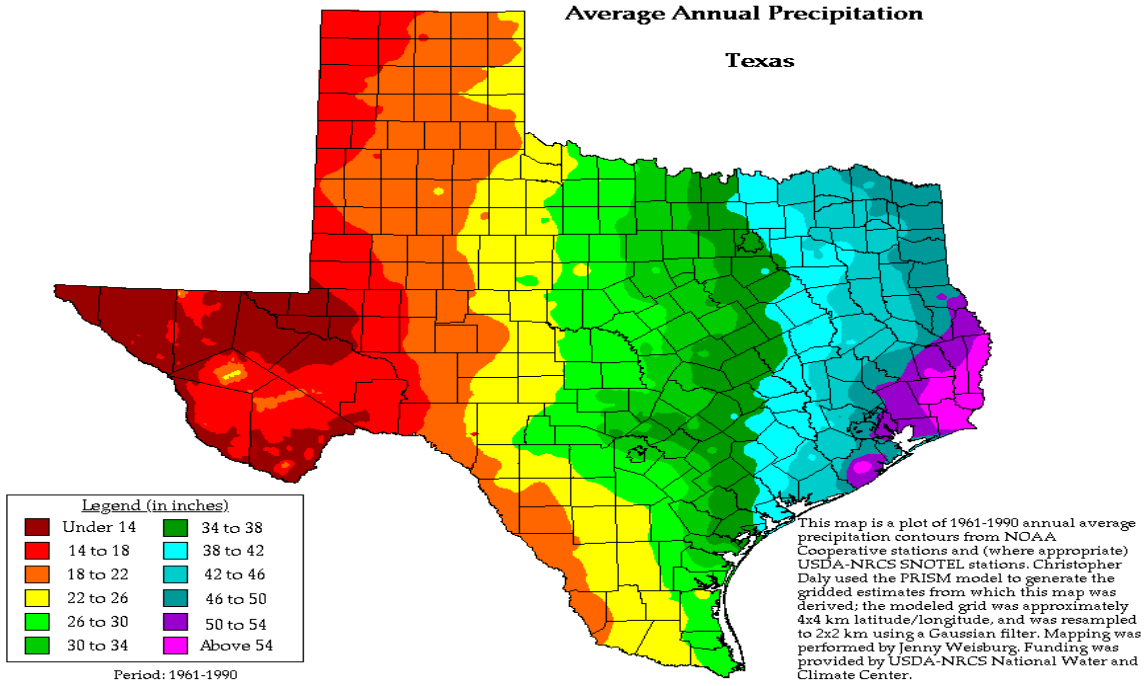
Tuesday, June 20, 2017

Project Goals and Objectives

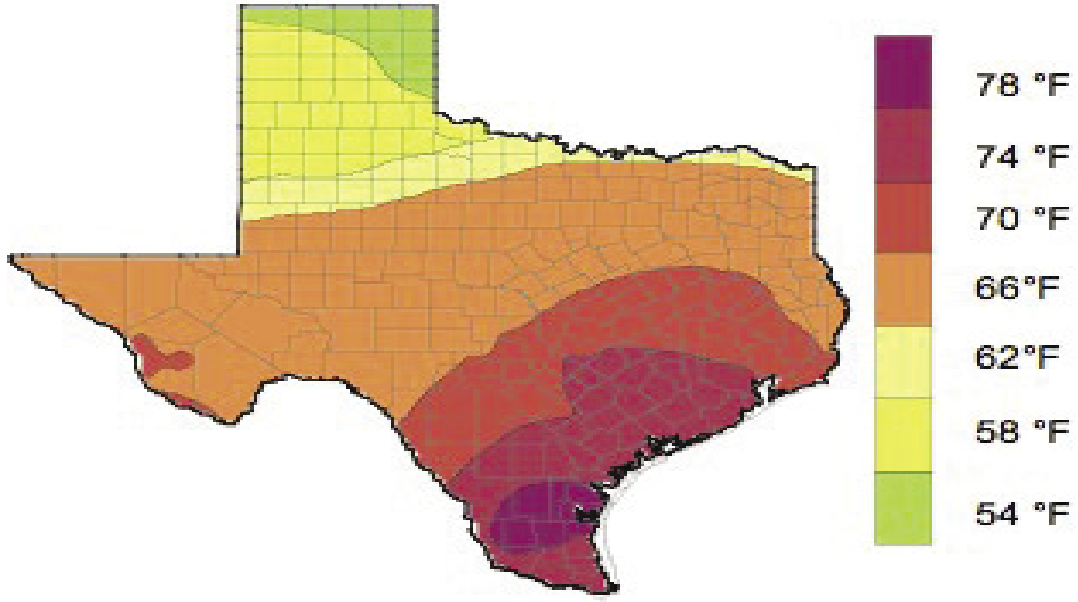
- Identify impacts of weather on traffic signal operations
- Identify appropriate weather responsive traffic management (WRTM) strategies for signals
- Establish criteria and architecture for deploying WRTM
- Conduct field tests

Weather Events Region-Dependent

Average Annual Precipitation



Mean Annual Temperature



Potential Impacts of on Signal Operations

Weather Event/ Factors Affected	Snow	Ice/ Sleet	Heavy Rain	Wind	Fog/ Dust	Signal Timing Parameters/ Hardware Impacted
Sight/Decision Distance (Visibility)	✓	✓	✓		✓	Clearance Intervals, Video Detection Failure
Vehicle Acceleration/Braking		✓	✓			Clearance Intervals, Gap Settings, Phase Times
Reduced Prevalent Speed	✓	✓	✓	✓	✓	Clearance Intervals, Phase Times
Increased Gaps in Vehicle Stream		✓	✓	✓	✓	Phase times, Gap Settings

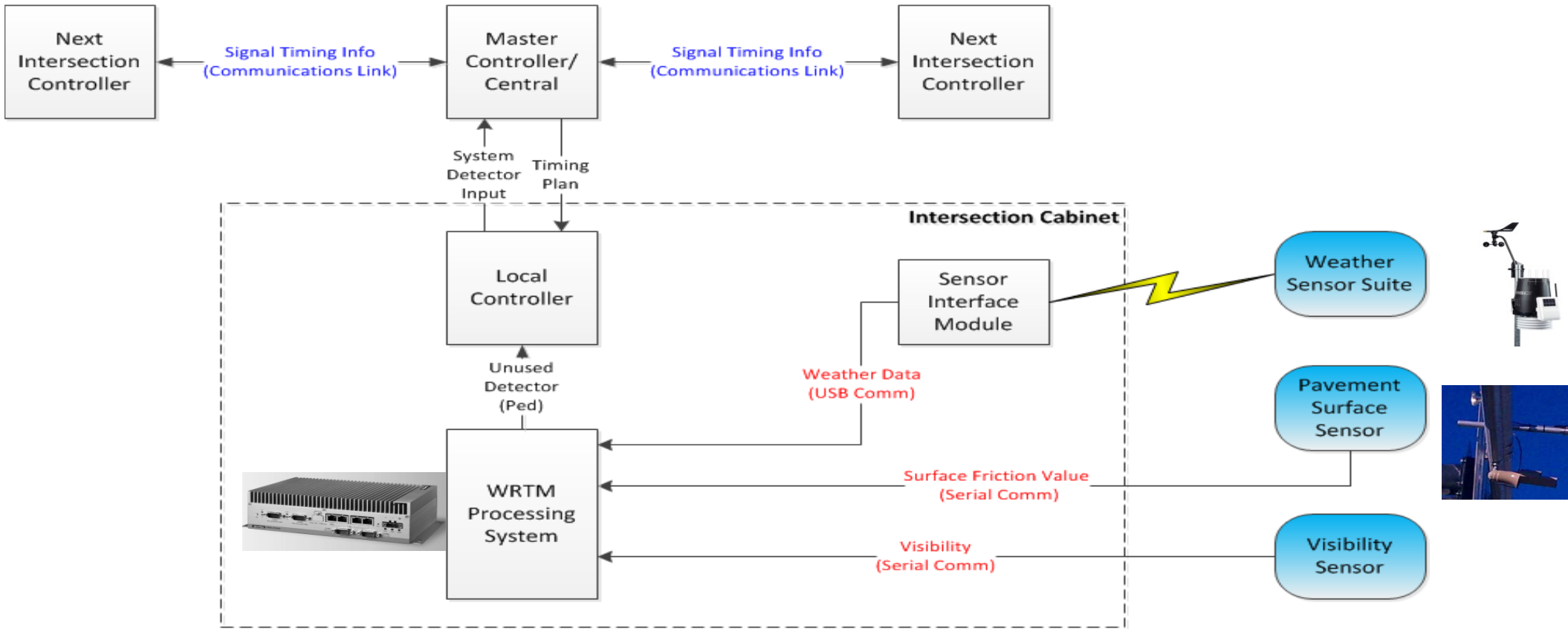
Detection Needs

- Visibility
  - Decreased to a user defined threshold.
  - Due to fog, dust, rain, snow, or haze.
- Pavement Conditions
  - Detect water, ice, or snow accumulations on the pavement.
  - Snow and ice could be detected by infrared sensors.
  - Wet pavement could be a detected by resistivity.
- Precipitation Intensity
  - Detect the intensity of rain

Weather Station Interface with the Traffic Signal System Requirements

- An isolated signalized intersection.
- A system of signals connected to a field master or with peer-to-peer communication
- A system of signal connected to a hardware (i.e., field) or central software master located at the traffic management center.

General Physical Architecture



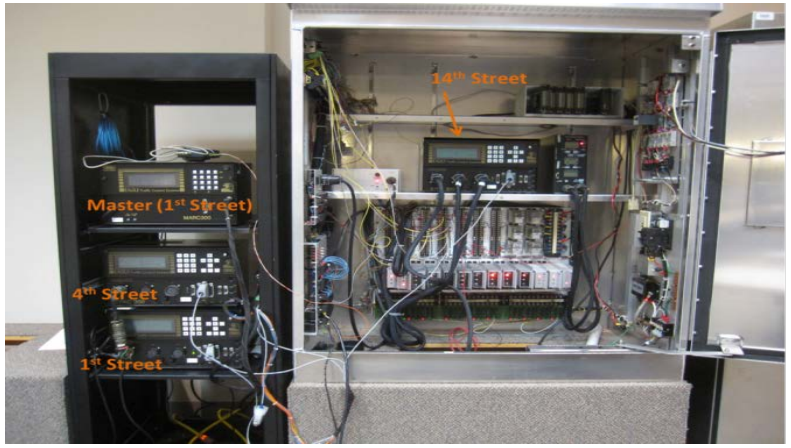
Timing Plan Selection Scheme

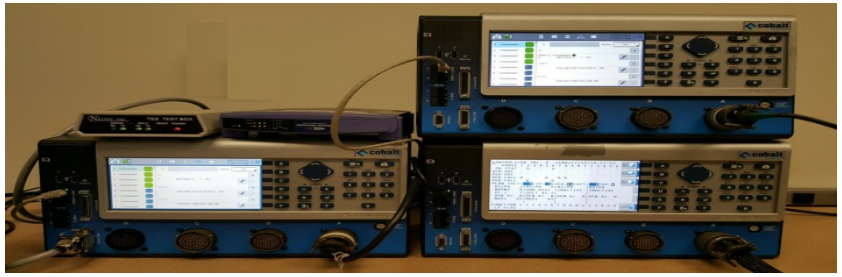
Time	Normal TOD Plan	Weather-Responsive Plan	Detector to Activate
7:00	1	5	Ped 1
15:30	2	6	Ped 3
20:00	3	7	Ped 5

- Special weather responsive plan corresponds to time-of-Day plan
- Computer processes information and places call to a selected detector
- Detector activates weather responsive plan

Three Field Sites Selected

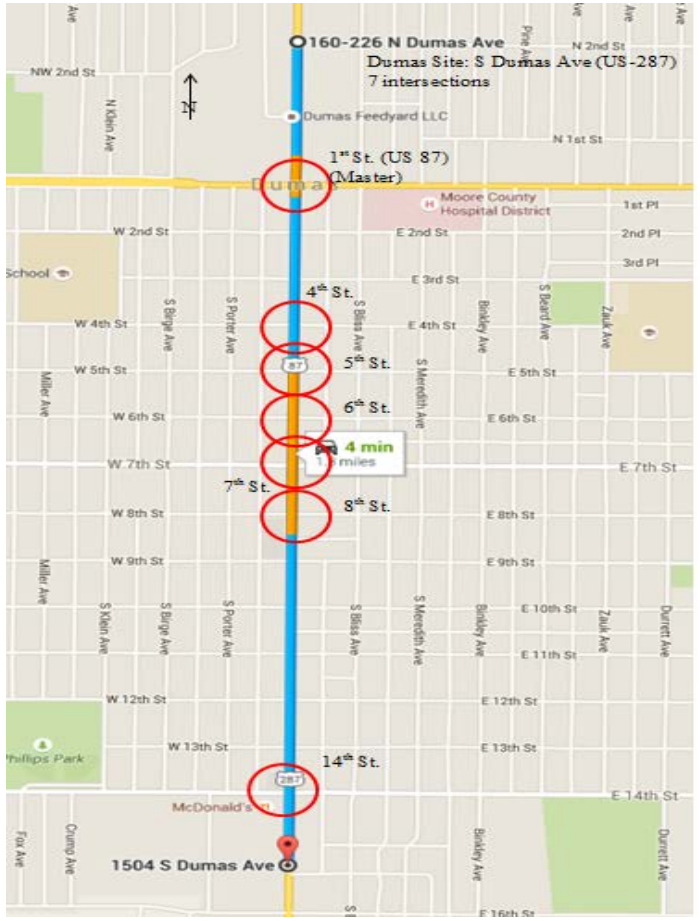
- In-lab tests conducted
- Timing plans developed and evaluated using computer simulation
  - Assumed impacts of weather
- Timing plans implemented in field
- Hardware installed in field



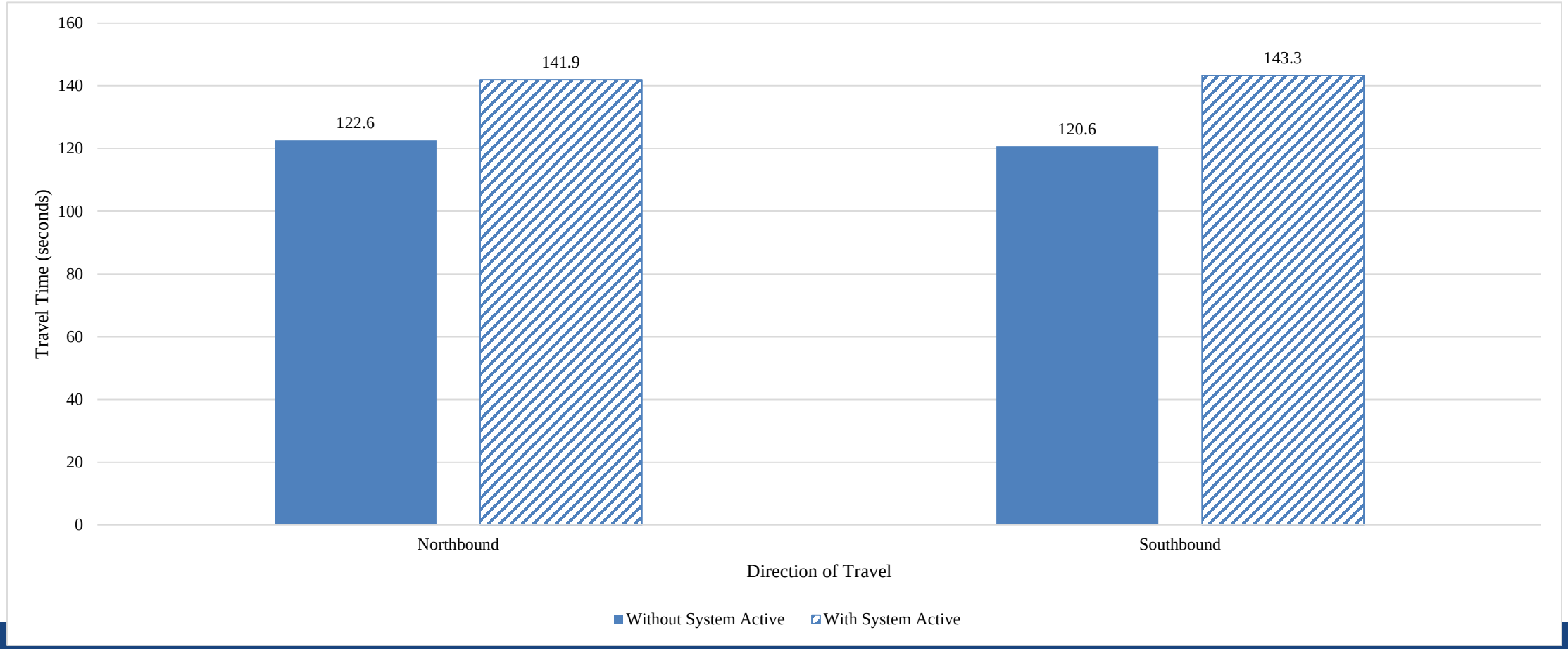


US 287, Dumas, TX

- 7 intersection, TS-1 corridor
  - Master controller @ 1st St.
  - Coordinated through 8th St.
  - 14th St. operates isolated
  - Communications to master vis wireless
- Significant trucks volumes
- Snow/ice
- Weather Sensors
  - Pavement condition
  - Weather monitoring

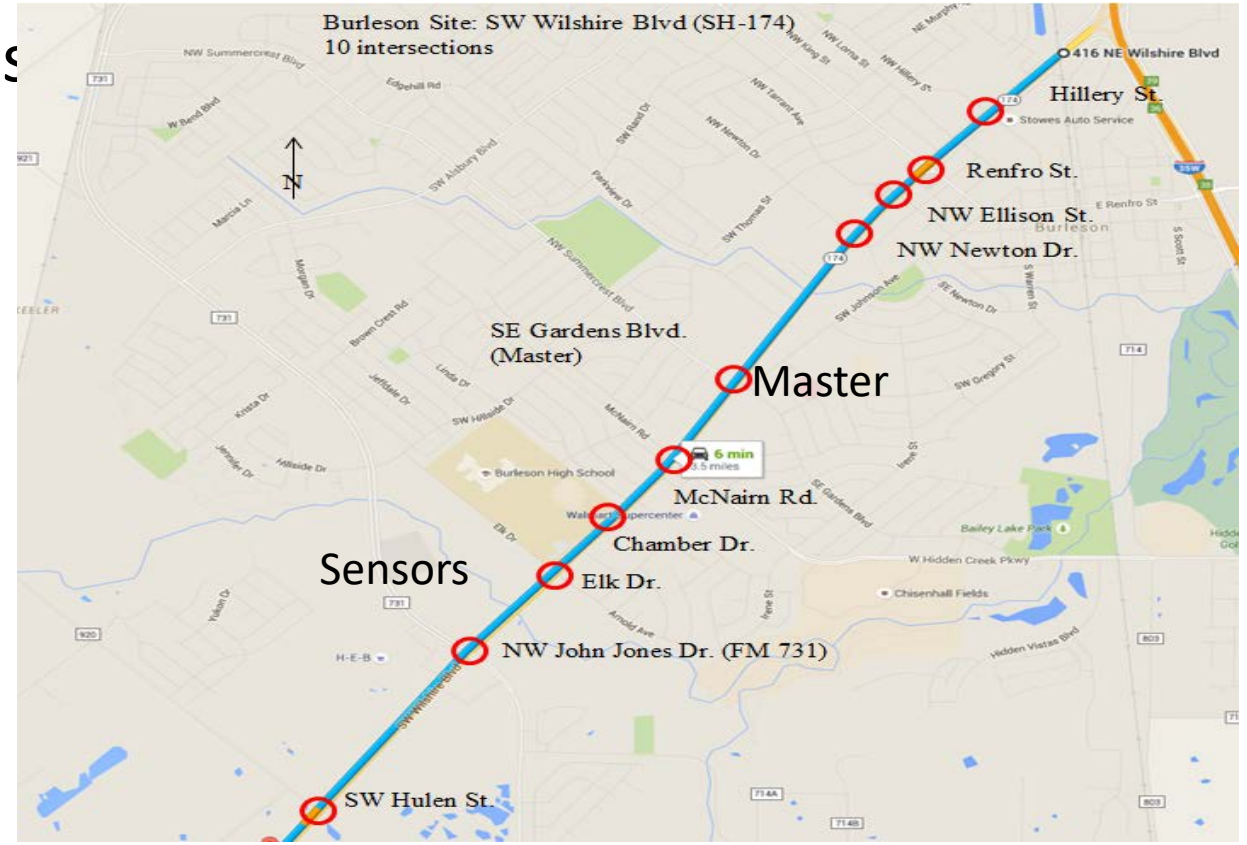


Evaluation Results - Dumas



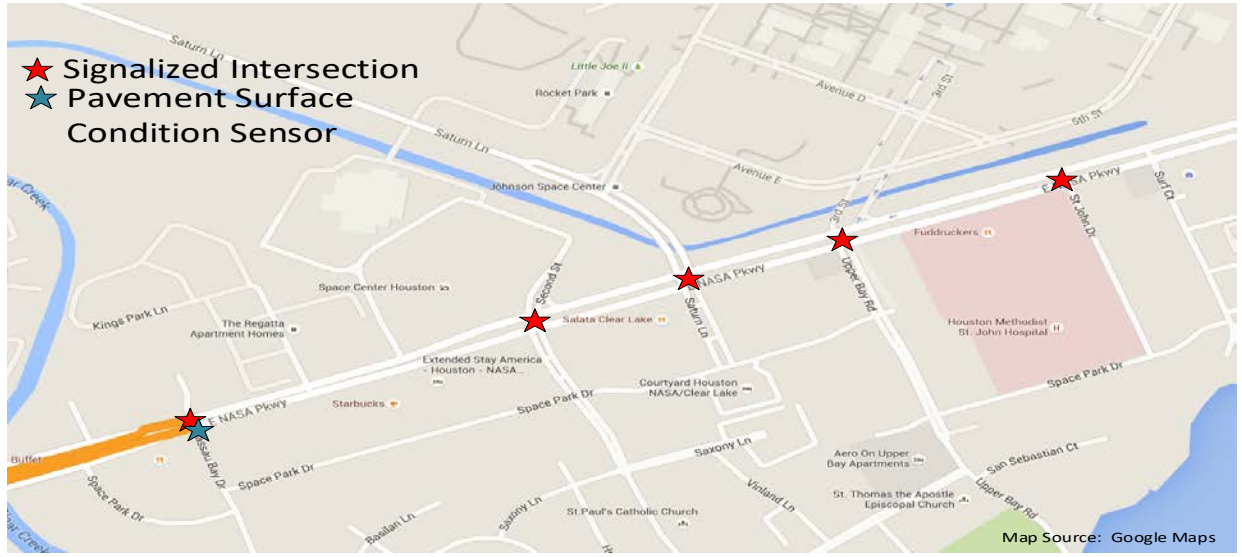
US 287, Burleson

- 10 intersections -- Eagle/Siemens M50 controllers in TS-2 cabinets
- Four coordinated TOD timing plans plus free operation
- WRTM system components
  - Pavement and weather sensors



NASA Road 1, Nassau Bay

- Four TOD timing plans plus "Free" operations
- Peer-to-peer communications
- Weather sensors
  - Pavement
  - Weather
  - Visibility



Findings/Lessons Leaned

- WRTM systems can be deployed using existing controller features
- Sensors require significant effort to calibrate
- Difficult to assess the degree to which modifying signal operations provides a benefit during weather conditions
- Further field-study based research is needed to determine:
  - Justification of when and where to deploy
  - Correlation between traffic operations, signal performance, and weather conditions
  - Guidelines for system calibration and fine-tuning

Questions

Use of Geocells in Pavement Design

The University of Texas at El Paso

Organization

- Problem Statement
- Research Objective
- Laboratory Evaluation Plan
- Finite Element Modeling
- Proposed Design Approach
- Life Cycle Cost Analysis
- Conclusions
- Implementation Phase
- Questions

Problem Statement

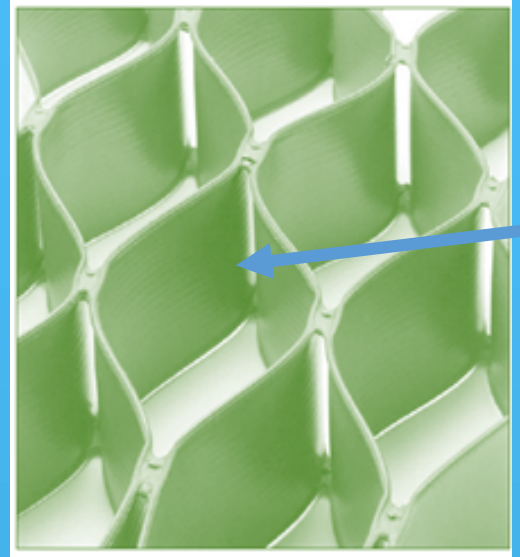
- Shortage of Good Quality Material
- Pavement Thickness Limitations
- Reduced Financial Resources

Research Objective

- Reduced Pavement Thickness
- Design with Lower Quality Base and Subgrade Materials and Still Reduce Thickness of Pavement
- Cost Efficient Pavement Design with Geocell

Laboratory Evaluation Plan -Geocell

Property	Unit	Value
Cell Height	mm	150
Cell Wall Thickness	mm	1.27
Material Composition	Polymer-Polyethylene	
Density of Material	Lbs/ft^3	58.4-60.2
Short term Seam Peel Strength	N (lbf)	2130 (480)
Long Term seam Peel Strength	lb	160 (for a period of 168 hours at 54° C



Property	Unit	Value
Cell Height	mm	100
Material	Polymer	Polyethylene
Cell Wall Thickness	mm	1.0
Peak Tensile Strength	kN/Strip	1.2
Peak Tensile Elongation	%	15.0
Joint Tensile Shear Strength	kN/Junction	0.80
Junction Tensile Peel Strength	kN/Junction	0.35

Laboratory Evaluation Plan -Soil

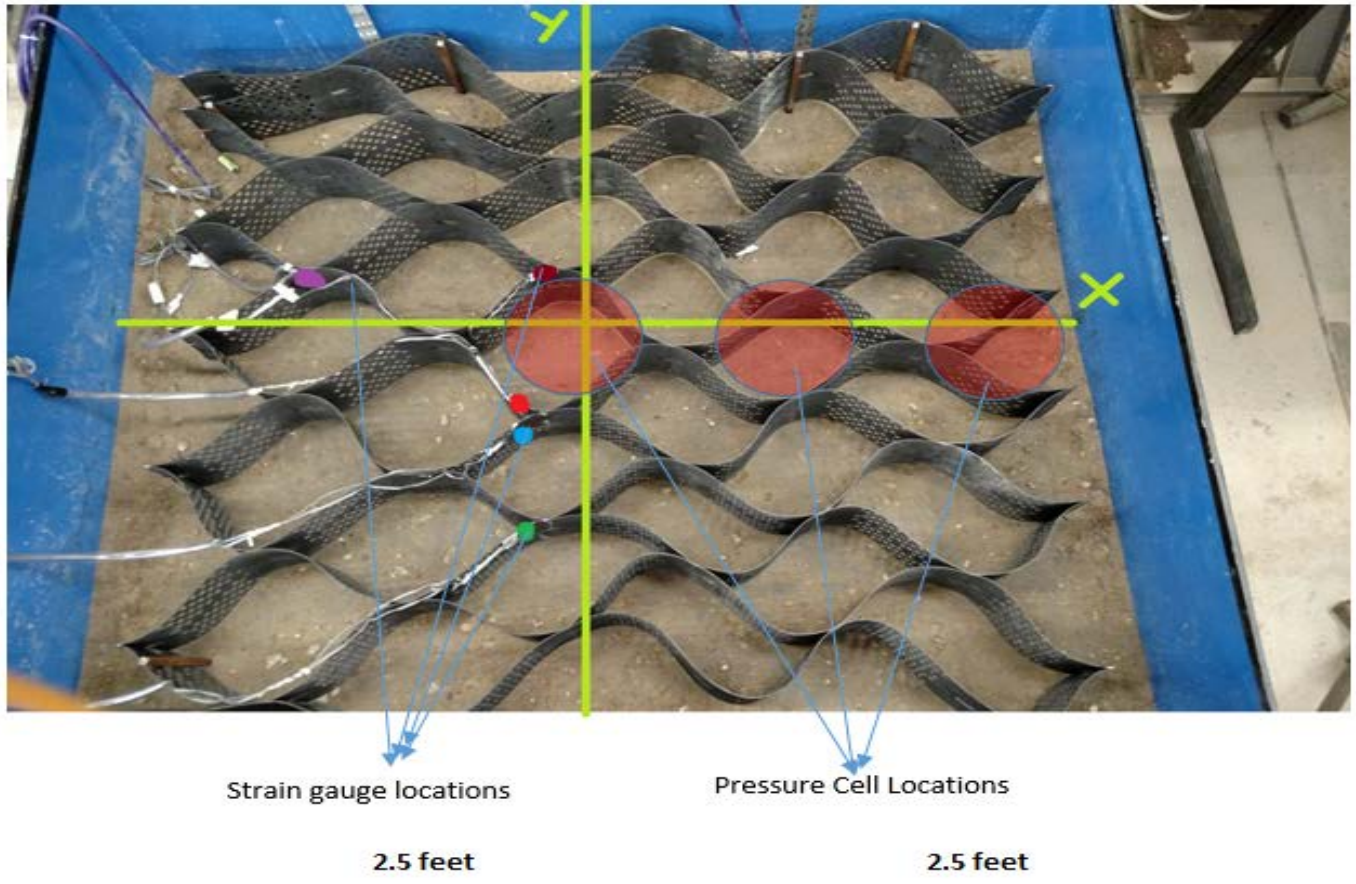
- **Two Subgrade Types**
  - Good (4.5 ksi)
  - Poor (2.5 ksi)

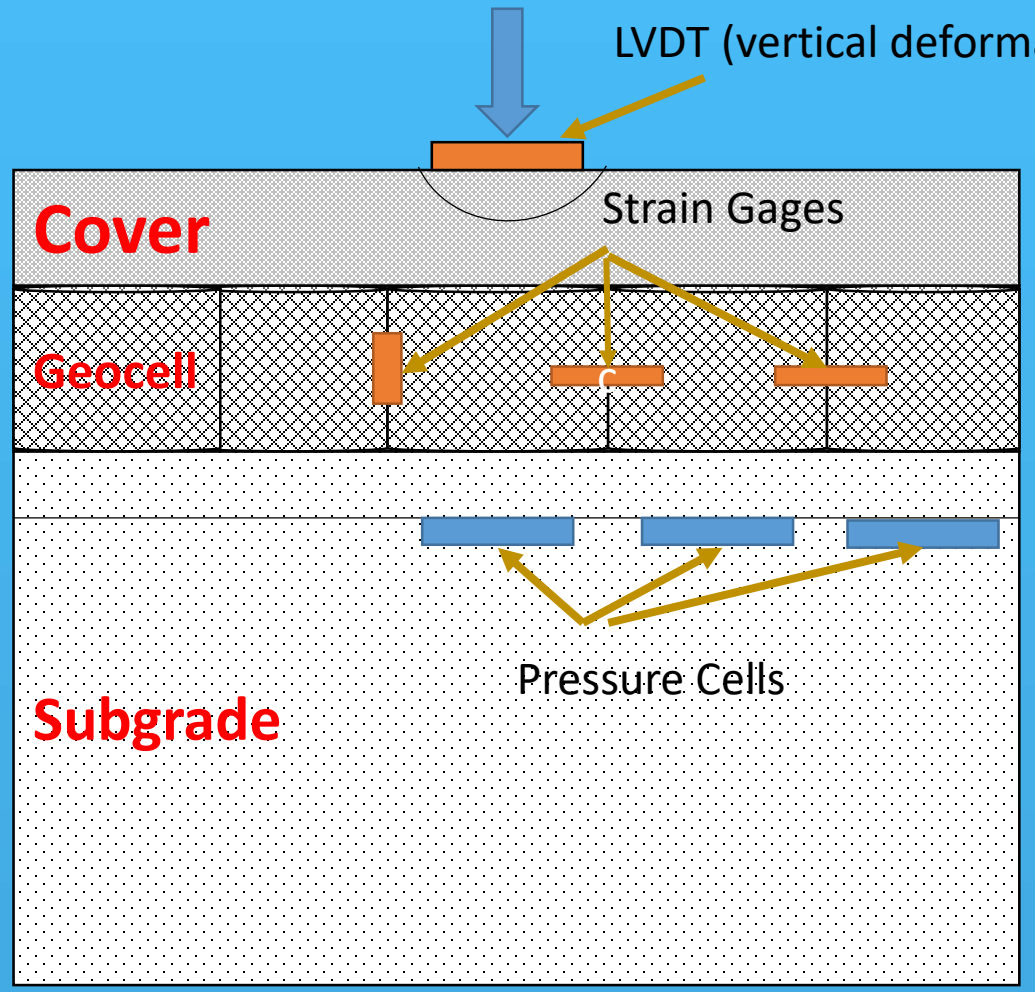
- **Three Base Types**
  - Good (15 ksi)
  - Marginal (12 ksi)
  - Poor (5 ksi)

Laboratory Evaluation Plan -Thickness

- Subgrade Thickness 24 in.
- Base Thickness 10 in.
- Geocell Height 3, 4, and 6 in.
- Cover Thickness (7, 6 and 4 in.)
- Two Loading Plate Types (10 and 12 in.)

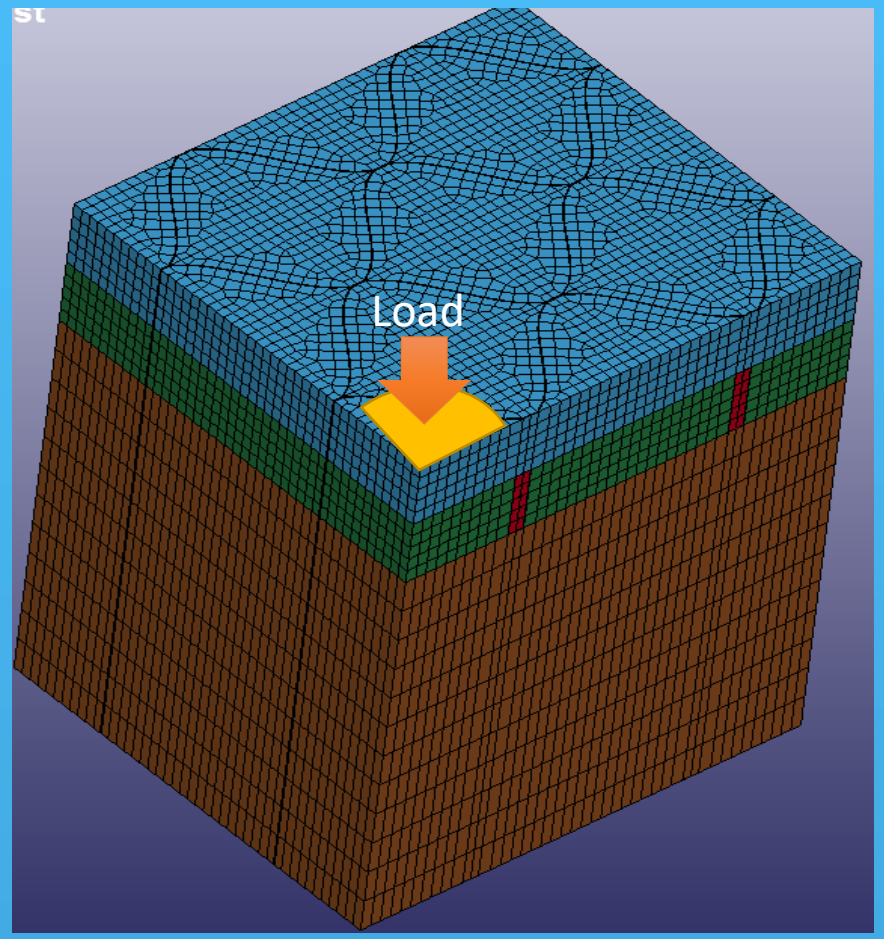
Laboratory Evaluation Plan
-Box Dimension and Instrumentation



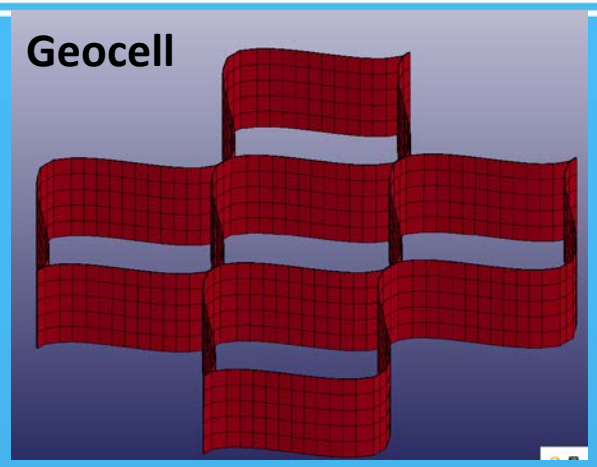


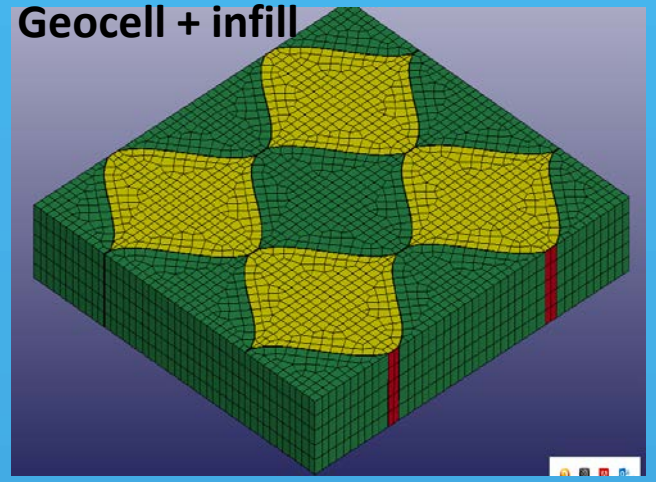
Box Size 3’ by 4’ by 5’

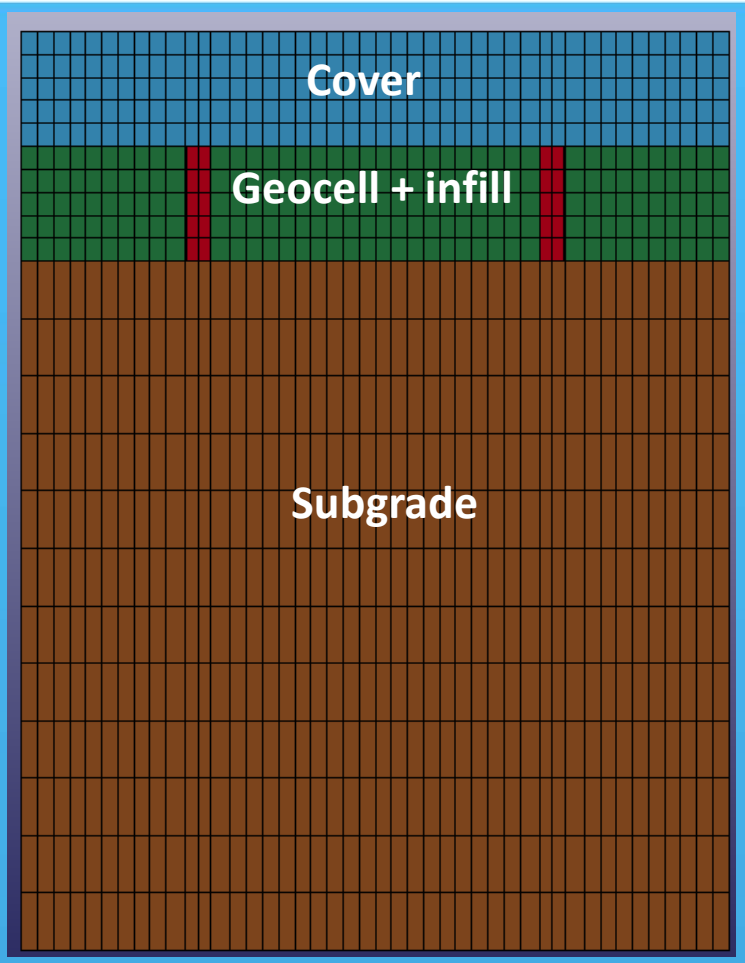
Finite Element Modeling



Quarter Model

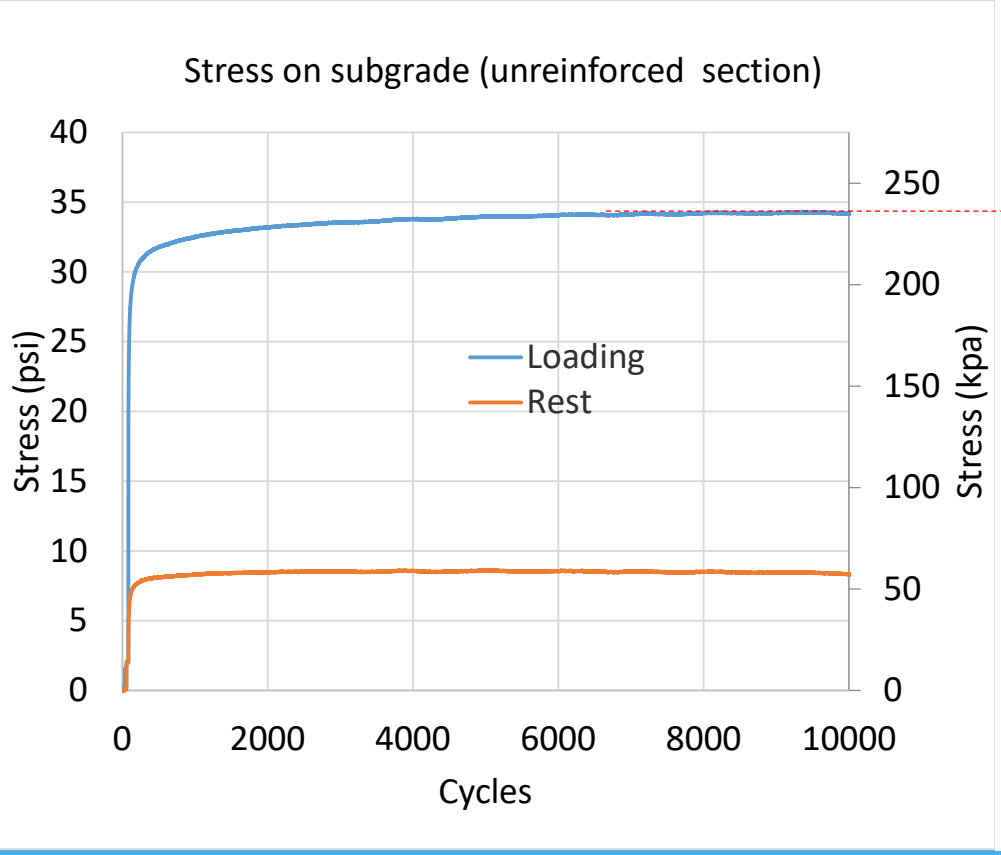




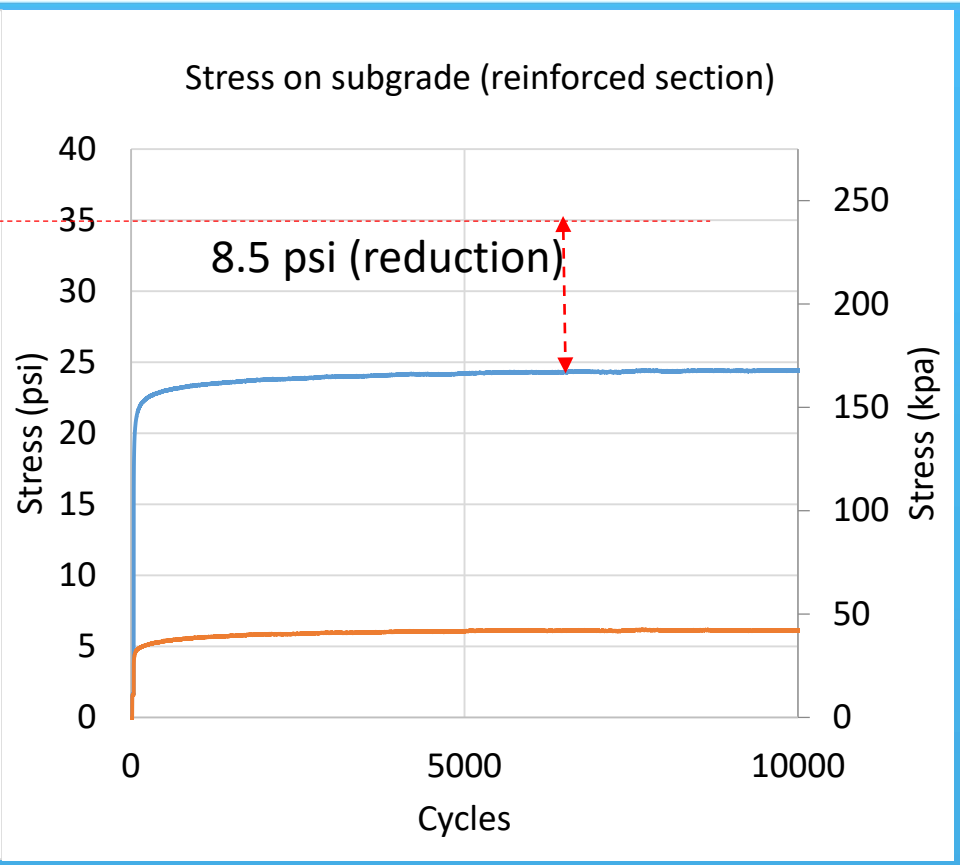


Section view

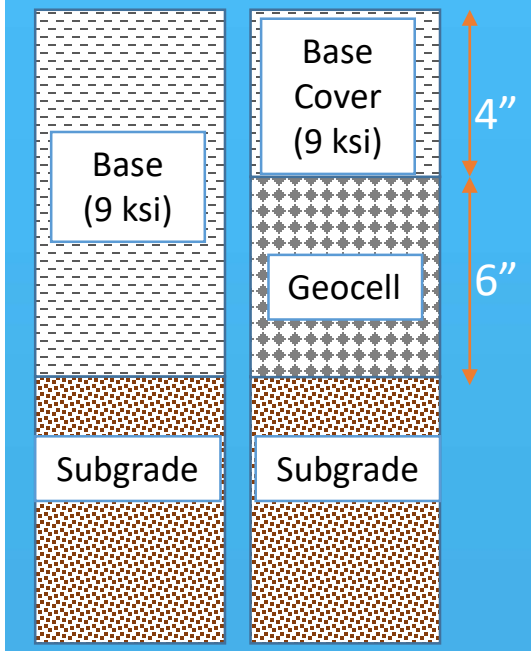
Typical Laboratory Test Results



No Geocell



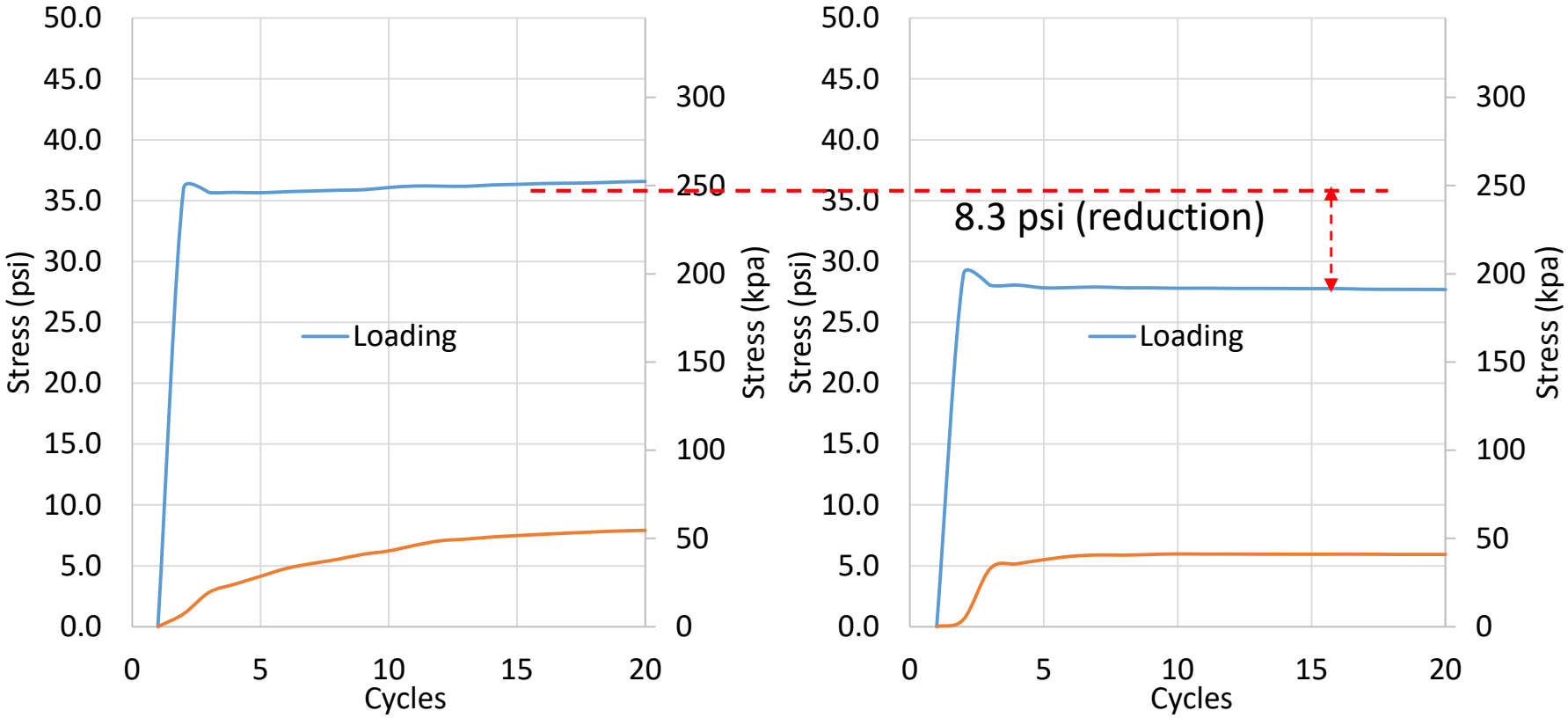
Geocell



10” Unreinforced compared with 6” Geocell and 4” Cover

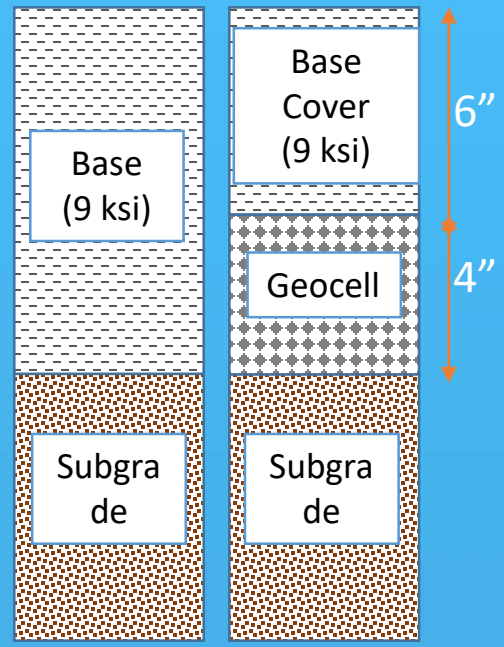
The stress on subgrade due to unreinforced section is 35% more than reinforced section

Comparison Between Laboratory and Finite Element Results



No Geocell

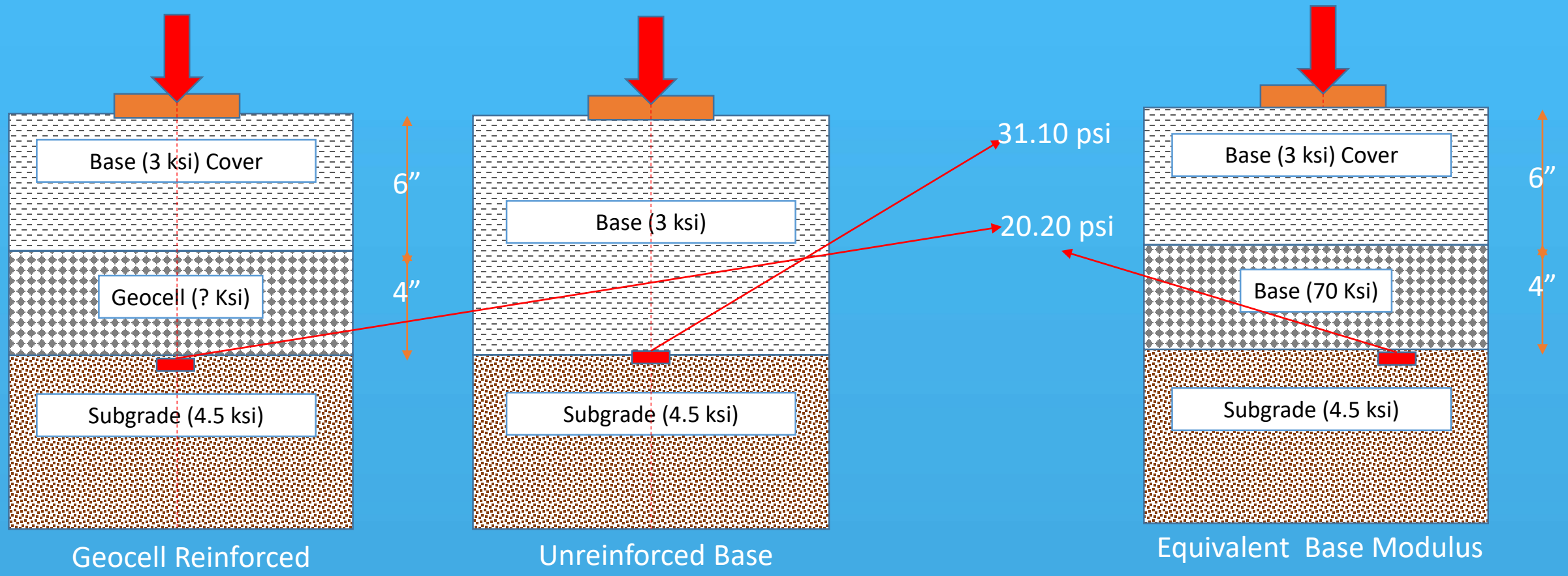
Geocell



10” Unreinforced compared with 4” Geocell and 6” Cover

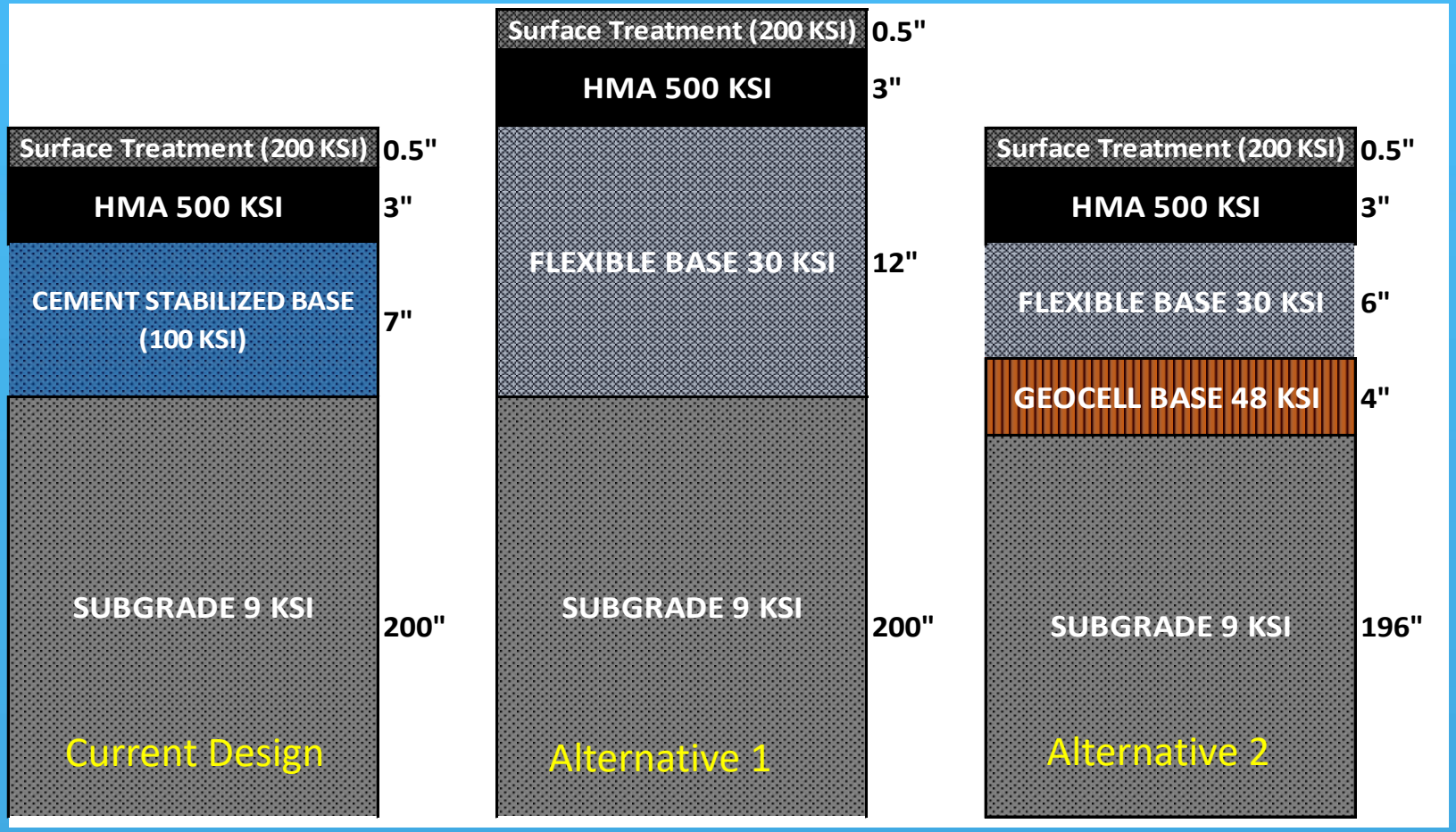
Design Approach

- Back-calculation of Geocell Reinforced Layer using Stress Analysis Tool of FPS-21.



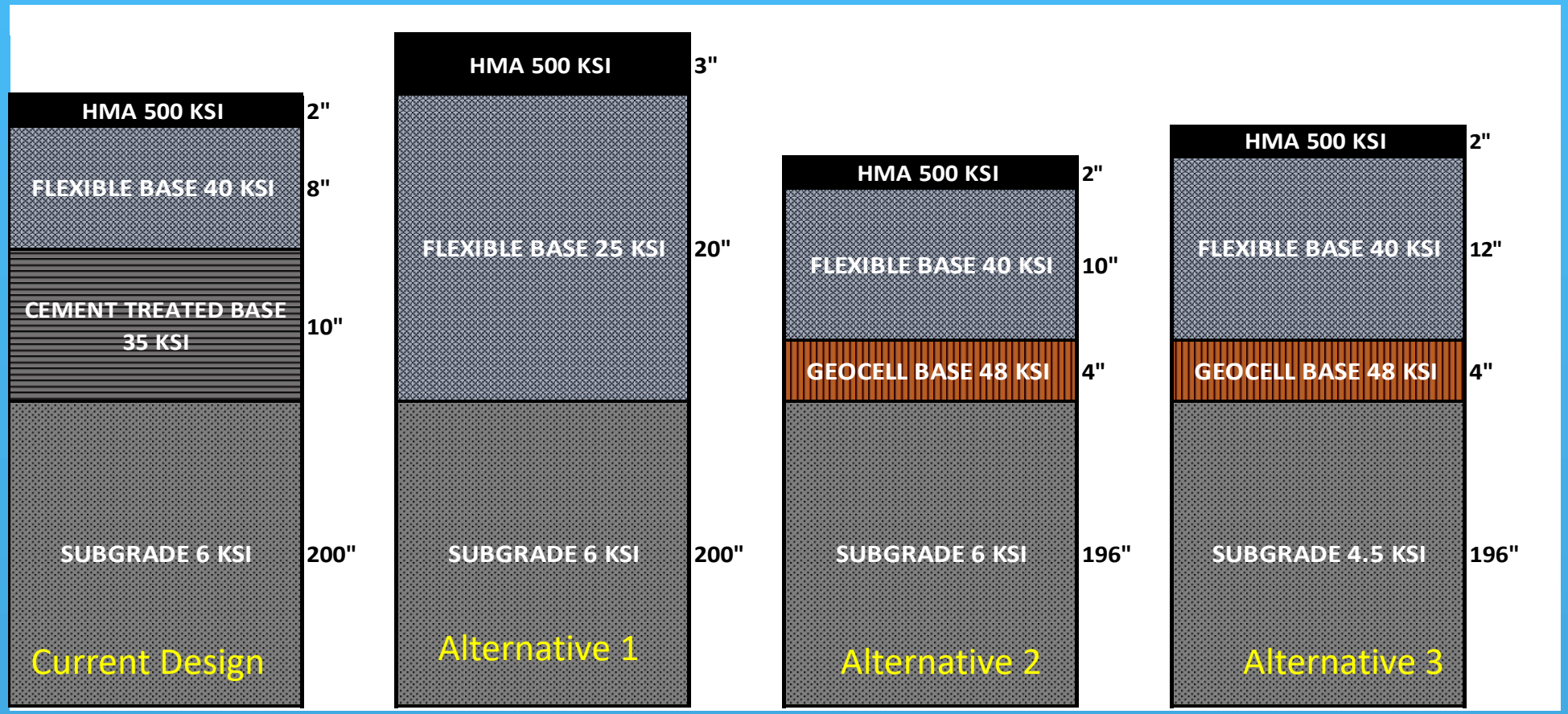
Design Using Equivalent Modulus - Paris District

Lamar County, Paris District (2015 ADT 1450, 2037 ADT 2030)



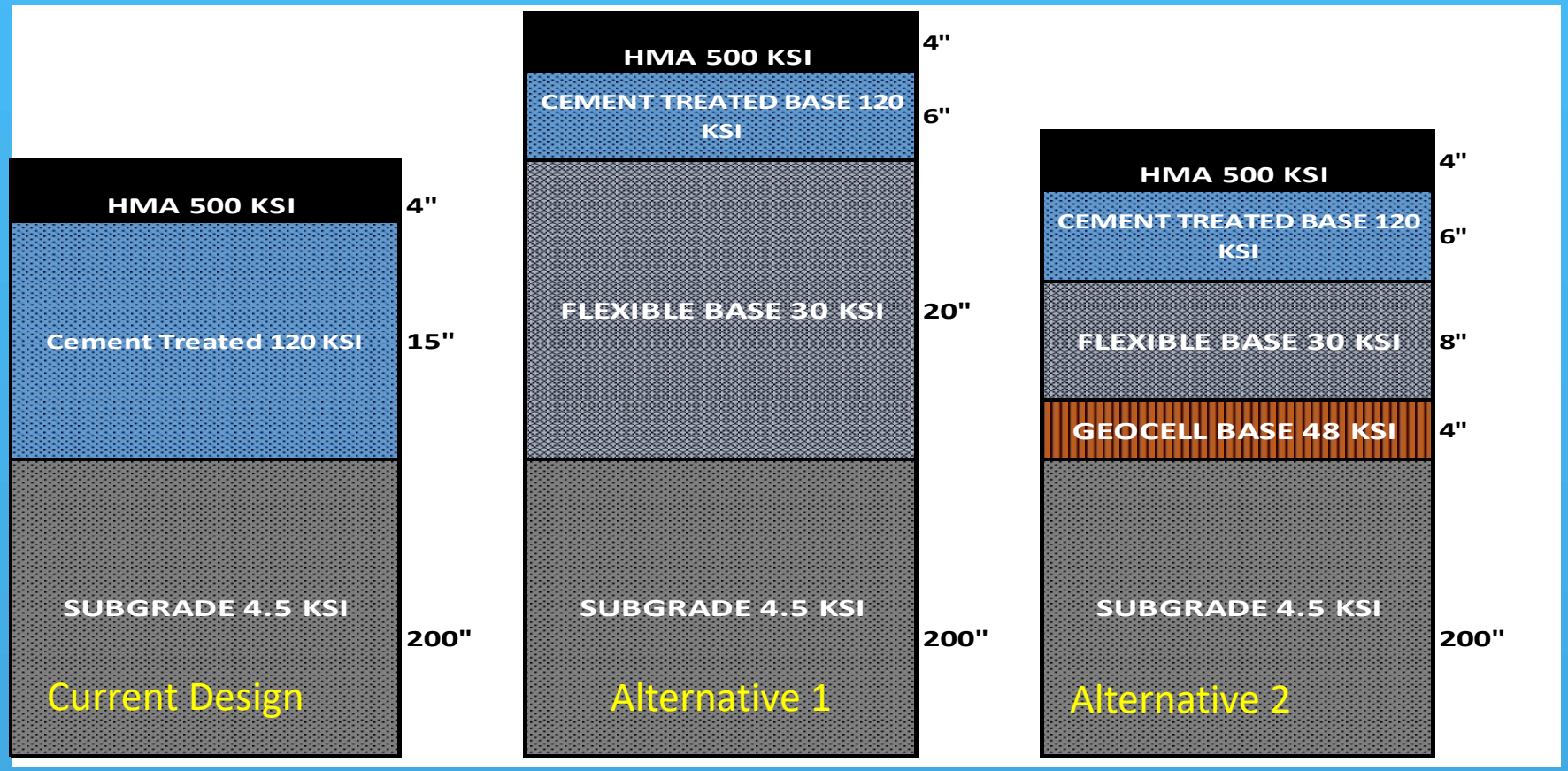
Design Using Equivalent Modulus -Dallas District

Ellis County , Dallas District (2017 ADT 1700, 2037 ADT 2400)



Design Using Equivalent Modulus -Fort Worth District

Tarrant County, Fort Worth District (2010 ADT 22990, 2030 ADT 33220)



Life Cycle Cost Analysis (Paris)

Current Design								
Description	Units	Unit Price	No of Lanes	Thickness (in)	Width (feet)	Length (miles)	Quantity (Yd^{-3})	Total Cost
Surface Treatment (200 ksi)	CY	115	2	0.5	12	1	196	$22,489
Hot Mix Asphalt (500 ksi)	CY	115	2	3	12	1	1173	$134,933
Cement treated Base (100 ksi)	CY	75	2	7	12	1	2738	$205,333
Subgrade (9 ksi)	CY	2	2	200	12	1	78222	$156,444
							Cost	$519,199

Design With Geocell								
Description	Units	Unit Price	No of Lanes	Thickness (in)	Width (feet)	Length (miles)	Quantity (Yd^{-3})	Total Cost
Surface Treatment (200 ksi)	CY	115	2	0.5	12	1	196	$22,489
Hot Mix Asphalt (500 ksi)	CY	115	2	3	12	1	1173	$134,934
Flexible Base (30 ksi)	CY	52	2	6	12	1	2347	$122,027
Geocell Base	CY	?	2	4	12	1	1564	?
Subgrade (9 ksi)	CY	2	2	196	12	1	76658	$153,316
						Alternative Cost		$410,276
					Difference Compared with Current Design			$108,923
						Geocell Cost Per Square Yard		$8

Life Cycle Cost Analysis (Dallas)

Current Design								
Description	Units	Unit Price	No of Lanes	Thickness (in)	Width (feet)	Length (miles)	Quantity (Yd^{-3})	Total Cost
Hot Mix Asphalt (500 ksi)	CY	115	2	2	11	1	717	$82,459
Flexible Base (40 ksi)	CY	56	2	8	11	1	2868	$160,616
Cement treated Base (35 ksi)	CY	60	2	10	11	1	3585	$215,111
Subgrade (6 ksi)	CY	2	2	200	11	1	71704	$143,407
							Cost	$601,593

Design With Geocell								
Description	Units	Unit Price	No of Lanes	Thickness (in)	Width (feet)	Length (miles)	Quantity (Yd^{-3})	Total Cost
Hot Mix Asphalt (500 ksi)	CY	115	2	2	11	1	717	$82,459
Flexible Base (30 ksi)	CY	52	2	10	11	1	3585	$200,771
Geocell Base	CY	?	2	4	11	1	1434	?
Subgrade (4.5 ksi)	CY	2	2	196	11	1	70270	$140,359
						Alternative Cost		$423,769
					Difference Compared with Current Design			$177,824
						Geocell Cost Per Square Yard		$14

Conclusions

- Use of Geocell Reduced Stress on Top of Subgrade Layer
- Pavement Can be Designed with Lower Quality Base and Subgrade Material and Still Reduce Overall Thickness of Pavement System
- Life Cycle Cost Analysis (LCCA) Suggests Lower Overall Cost of Construction
- Sustainable Solution to Material Problem

Implementation Phase

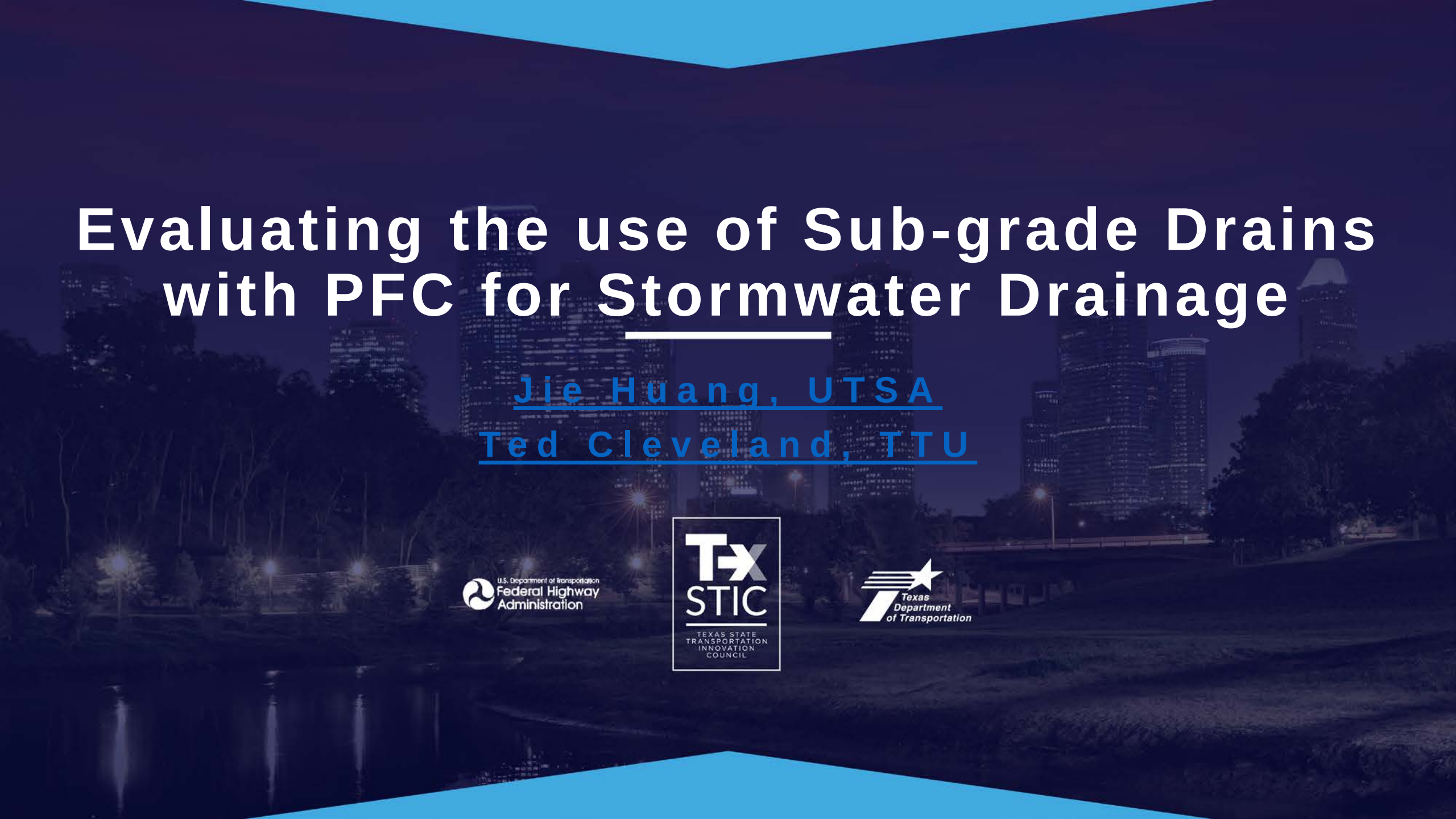
- Working with some Districts and Looking for Districts Interested in Placing Geocell in their Pavements Especially in Low-Volume Roads

Thank You for Support

Vivek Tandon
vivek@utep.edu
Ph.: 915-747-6924

Evaluating the use of Sub-grade Drains with PFC for Stormwater Drainage

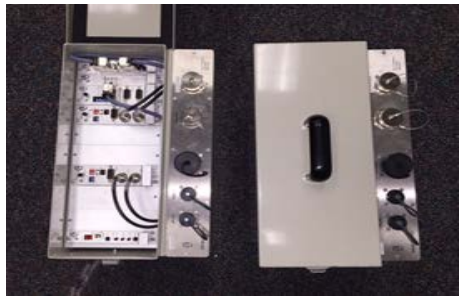
Jie Huang, UTSA
Ted Cleveland, TTU

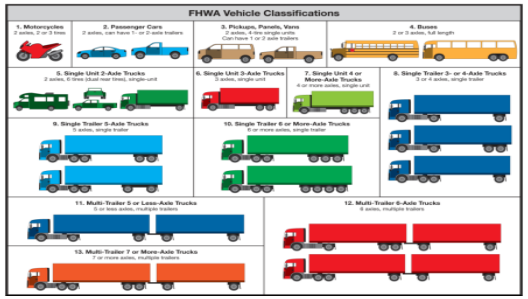


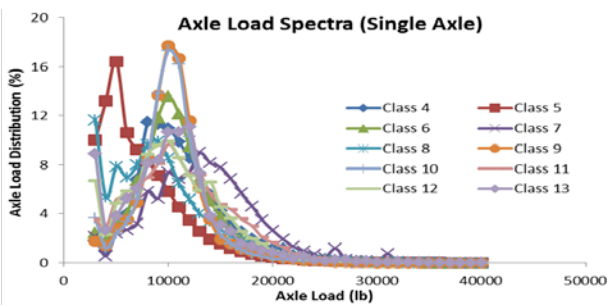
Project 0-6940

Develop System to Render Mechanistic-Empirical Traffic Data for Pavement Design

TxSTIC Meeting June 20th , 2017







by

Lubinda, Abu, & Sang

Agenda

- **Introduction**
- Task by Task Review
- Work Done to Date
- Assistance or Involvement by TxDOT
- Discussions & Comments

Introduction

- Project details
- Problem statement
- Technical objectives
- Work plans & research tasks
- Product deliverables
- Tentative meeting & workshop schedule

Project Details

- 2-year Deliverable-Based Research Project
- Sep. 2016
  ~ Aug. 2018

TxDOT PMC

- **Sonya Badgley (PM)**
- Hua Chen
- Gisel Carrasco
- Enad Mahmoud
- DarHao Chen
- Brett Haggerty
- Daniel Garcia
- James Robbins
- Terry Sepulveda
- Miles Garrison
- Robert Moya
- Lacy Peters

TTI Research Team

- **Lubinda F. Walubita (PI)**
- Sang Ick Lee
- Wenting Liu
- Sheng Hu
- Andrew Wimsatt
- Jerry Le
- Edgar Kraus
- Dung Nguyen

Abstract (Problem Statement)

- Axle Load Spectra is primary traffic data input for Mechanistic-Empirical (ME) pavement design

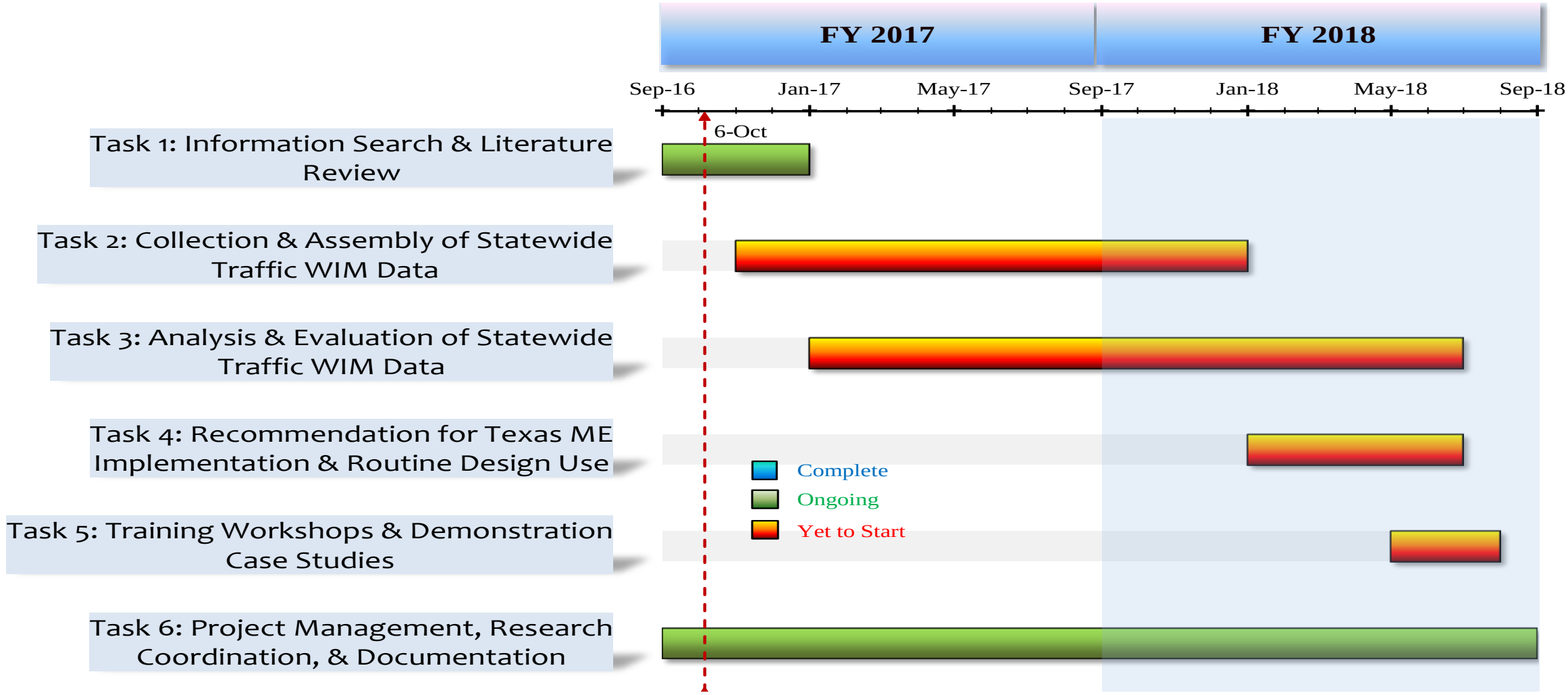
- Limited number of permanent roadside weigh-in-motion (WIM) stations that can produce ME-compatible traffic data on only a few major highways in Texas
  - Volume data (ADT, ADTT, % Truck)
  - FHWA vehicle classification
  - Axle load data (axle load spectra)
  - Seasonal variation (monthly & hourly adjustment factors)

- No easy/practical means of obtaining ME-compatible traffic data for locations where nearby permanent WIM stations are not available

Technical Objectives

- To review the practice methodologies of other state agencies, and recommend best practices for generating ME design-ready traffic data
- To develop a ‘cluster analysis’ methodology for reliably predicting project-specific ME-compatible traffic loading data
- To explore the feasibility of applying portable WIM systems for generating the ME-compatible traffic data
- To identify and recommend mechanisms for delivering the ME-compatible traffic data to pavement designers

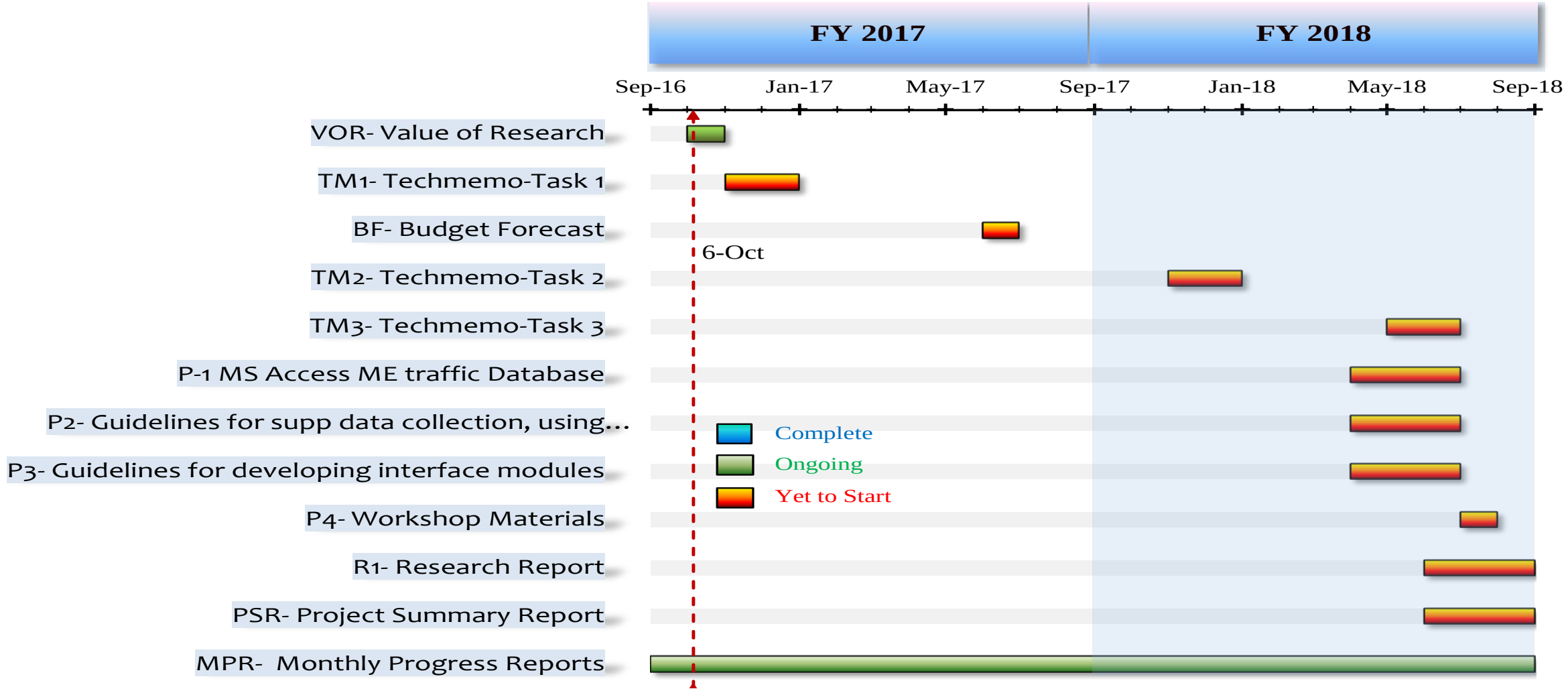
Research Tasks & Timeline



Texas Department of Transportation

Texas A&M Transportation Institute

Product Deliverables



Texas Department of Transportation

Texas A&M Transportation Institute

Agenda

- Introduction
- **Task by Task Review**
- Work Done to Date
- Assistance & Involvement by TxDOT
- Discussions & Comments

Task by Task Review

Task 6
Project Management, Research Coordination, and Documentation

Task 1
Information Search & Literature Review

Task 2
Collection & Assembly of Statewide Traffic WIM Data

Task 3
Analysis and Evaluation of Statewide Traffic WIM Data

Task 4
Recommendation for Texas ME Implementation and Routine Design Use

Task 5
Training Workshop & Demonstration Case Studies

Task 1: Information Search & Literature Review

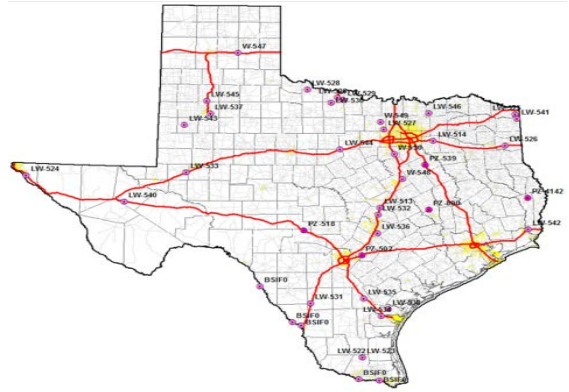
- Desktop literature search
  - Prediction of project-specific ME-compatible traffic data
  - Cluster analysis techniques in practice
  - Other alternative methodologies (e.g. Portable WIM)

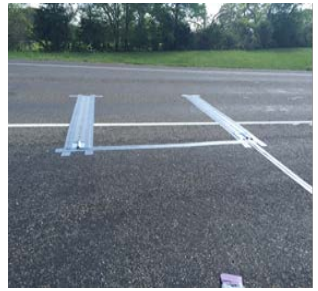
- Survey of other agencies
  - Survey questionnaire & email communication
  - Information on DOTs that have adopted the ME design

- Comparative evaluate & recommend best methodologies
  - Summarize findings from literature search & survey
  - Best methods for generating ME traffic data for Texas

Task 2: Collection & Assembly of Statewide Traffic WIM Data

- Collect traffic data from the existing permanent WIM Stations
  - State & federal (e.g., TPP, LTPP)
  - Collect at least 3 previous years' worth of traffic data
- Deploy portable WIM systems on selected highways
  - Supplement permanent WIM data
  - Project-specific ME-compatible traffic data
- Deploy pneumatic tube traffic counters on selected highways
  - Collect site-specific volume & classification data to supplement WIM data
  - Input for cluster analysis





TxDOT Help ⇒ Permanent WIM Data | Portable WIM Site Location |Traffic Control
⇒ More portable WIM Unit Purchase ≥ 3 More

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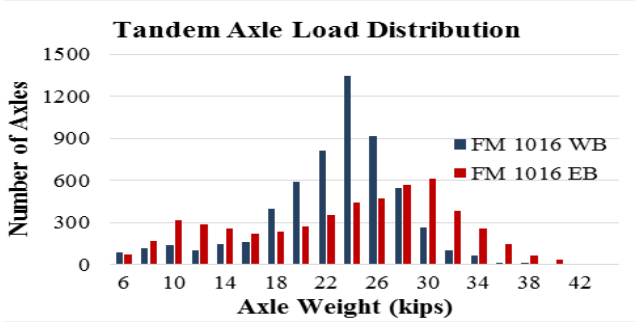
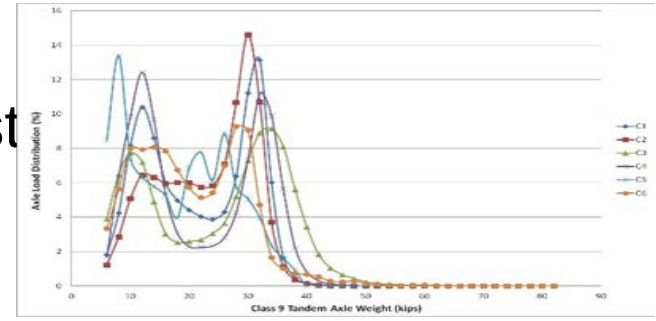
Task 3: Analysis & Evaluation of Statewide Traffic WIM Data

- Analysis of collected WIM traffic data
  - Data quality check
  - WIM data analysis ⇒ ME-compatible traffic data
  - Pneumatic tube data analysis to generate volume
- Develop cluster analysis methodology
  - Identify/develop clustering method
  - Analyze WIM data to generate traffic data clusters
  - Analyze pneumatic tube data for cluster analysis input
- Generate ME compatible traffic data from portable WIM syst
  - Portable WIM systems ⇒ ME compatible traffic data
  - Compare with the data from cluster analysis





TxDOT Help ⇒ Desired/Required ME Traffic Data Format

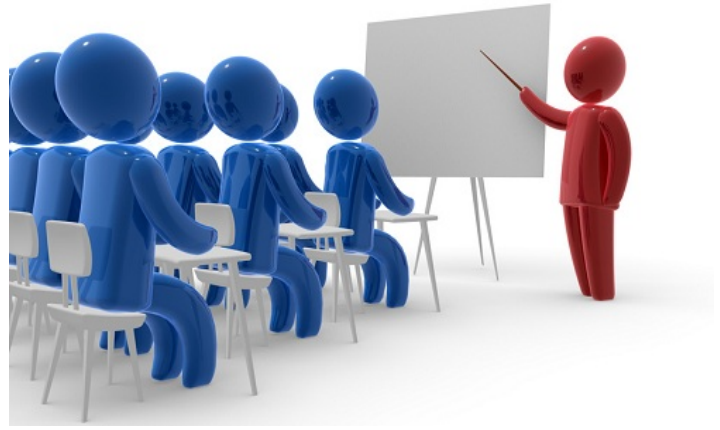
Task 4: Recommendation for Texas ME Implementation

- Develop a ME-compatible traffic database
  - MS Access database for data storage/access
  - Directly measured (WIM & tubes) data
  - “Cluster analysis” generated data
  - Reference for PVMNT designers& traffic data analysts
- Develop guidelines for database management
  - Traffic database development
  - Managing & populating the database
  - Database implementation for PVMNT design
- Guidelines for Developing Interface Modules
  - Future development of interfacial modules to directly import traffic data into ME design software

Task 5: Training Workshop & Demonstration Case Studies

- Training workshops (in liaison with TxDOT)
  - Half-day WebEx workshops
    (End of Yr.1 → Mid of Yr.2 → End of Yr.2)
  - Methodologies for generating site-specific ME-compatible traffic data
  - Methodologies and benefit of utilizing ME traffic data for pavement design
  - Relevant key lessons learned

- Demonstration case studies
  - Example case studies with TxME
  - Traditional ESAL based design vs. axle load spectra based design (ME)



TxDOT Help ⇒ Assist/Participate in Workshops
⇒ ME Design Workshop

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Task 6: Project Management

- Value of Research
  - Increased service life by accurate traffic prediction
  - Efficient use of PVMNT materials
  - Engineering design improvement

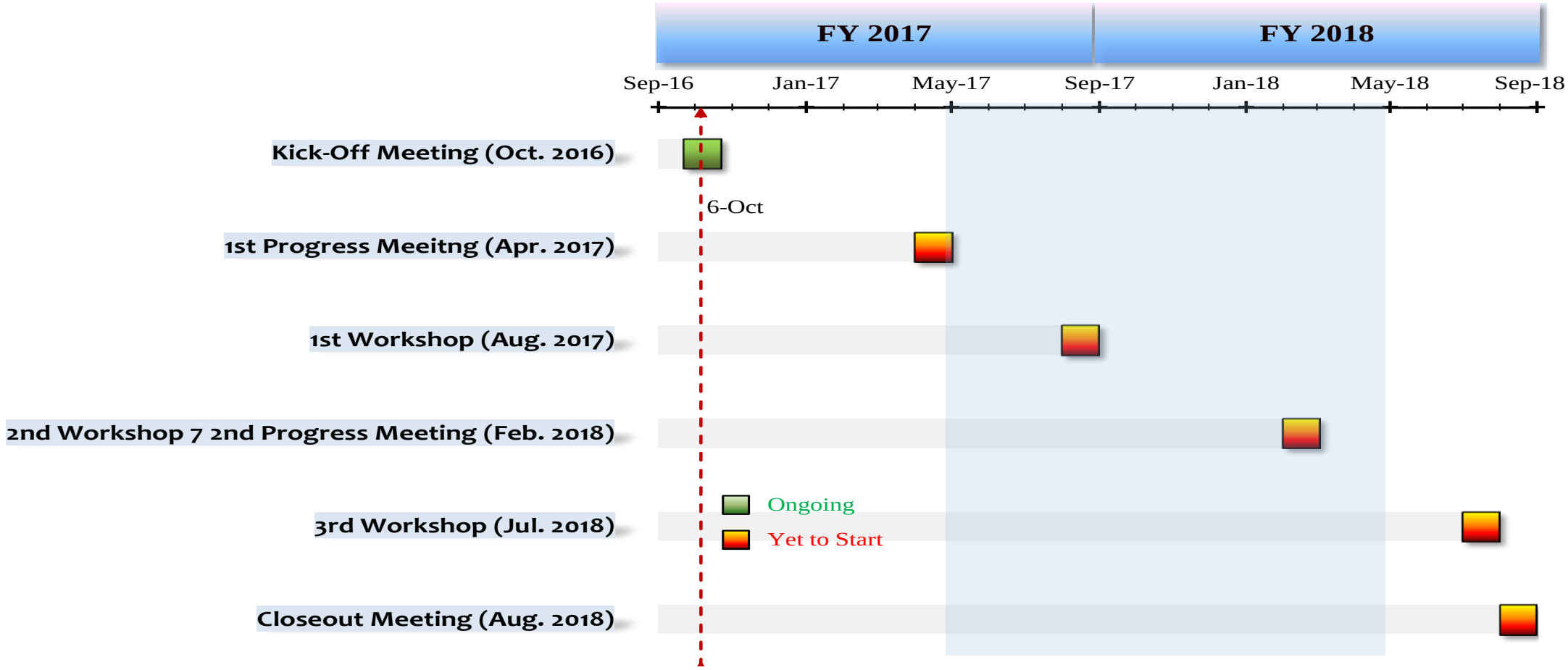
Functional Area	Qualitative	Economic	Both	TxDOT	State	Both
Increased Service Life		✓		✓		
Materials and Pavements		✓			✓	
Engineering Design Improvement			✓			✓

- Synthesize & report all findings & recommendations
  - Monthly progress reports
  - Tech memos
  - Technical report & summary reports

- Attend progress meetings & presentations
  - Kick-off meeting
  - Progress update meetings & workshops

Task 6. Project Management

- Tentative Progress meeting & workshop schedule



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Agenda

- ❑ Introduction
- ❑ Task by Task Review
- ❑ **Work Done to Date**
- ❑ Assistance & Involvement by TxDOT
- ❑ Discussions & Comments

Task 1: Literature Review

Task 2: Traffic Data Collection
- SH 7 (Bryan)
- US 83 (LRD)

Task 4: Texas ME Implementation

Task 6: Project Management

Task 1 (Survey Questionnaire)

Research Project: 0-6940
Develop System to Render Mechanistic-Empirical Traffic Data for Pavement Design
Texas A&M Transportation Institute (TTI)

Survey about the state-of-practice regarding provision for ME design-ready traffic data

Name of agency: _____

Part I: Mechanistic-Empirical (ME) method for Pavement Design

I-1. Is the Mechanistic-Empirical (ME) method used for designing pavements by your agency?

- ○ Yes
- ◉ No

If the answer to Question I-1 is Yes, then answer Questions I-2 to I-4 and Part II, otherwise go to Part II.

I-2. What type of pavement is designed using the ME method?

- ◉ Flexible Pavement
- ○ Rigid Pavement
- ○ Both

I-3. What pavement design software is used for ME pavement design?

- ◉ AASHTOWare Pavement ME Design software
- ○ DARWin-ME
- ○ M-E design software developed by the agency
- ○ Other (Please Specify)

I-4. What level of traffic data is typically used for ME design?

- ◉ Level 1 (Site Specific)
- ○ Level 2 (State Default)
- ○ Level 3 (National Default)

Part II: Traffic Data Collection

II-1. How does your agency collect traffic data for pavement design purposes?

- ○ Parmanent Weight-In-Motion (WIM) Stations
- ○ Portable Weight-In-Motion (WIM) Systems
- ○ Traffic counters (i.e. Traffic tube)
- ◉ Both WIM and
- ○ Other (Please Specify)

II-2. How does your agency generate ME traffic data for roadways where nearby traffic data collectors are not available?

- ○ Using Portable WIM traffic counters
- ○ Assume from comparable roadways
- ○ Using default traffic data set by the agency
- ◉ Cluster analysis
- ○ Other (Please Specify)

II-3. What method is being or will be used for generating Level 1 traffic data?

- ◉ Permanent WIM Stations
- ○ Portable WIM Systems
- ○ Cluster Analysis
- ○ Other (Please Specify)

II-4. What cluster analysis technique is used (if any)?

- ◉ K-Means Clustering
- ○ Hierarchical Clustering
- ○ Other (Please Specify)

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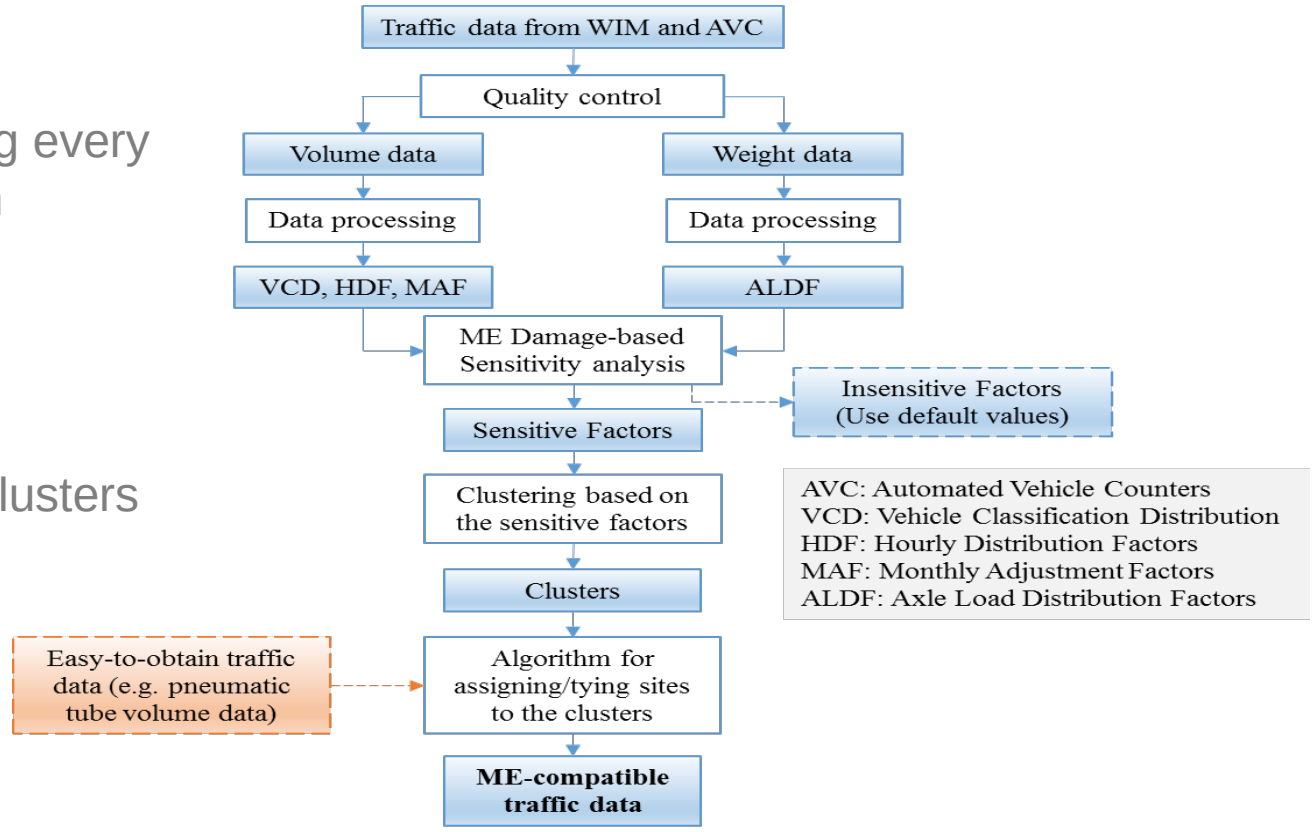
Task 1 (Literature Review)

- Literature review on cluster analysis techniques
  - K-Means Clustering
    - Predefine number of clusters
    - Clusters are created by associating every observation with the nearest mean
  - Hierarchical Clustering
    - Start with n-clusters (n = number of WIM stations)
    - Compare & merge similar pair of clusters



Task 2 (Traffic Data Collection)

- Conducted work in five Districts
  - Laredo District – IH 35, US 83, SH 7, FM 468
  - Corpus Christi District – US 281
  - Atlanta District – US 59, FM 3129
  - Pharr District – US 281
  - Bryan District – SH 7

Task 2 (Traffic Data Collection)

- September 2016
  - Collected traffic data on US 83 and SH 7 in the Laredo District using portable WIM.
- October 2016
  - Collected traffic data on US 83 in the Laredo District using portable WIM

Task 2 (Traffic Data Collection)

- November 2016
  - Collected permanent WIM data from TxDOT TPP, namely W531 (IH 35, Laredo District), W523 (US 281, Pharr District), & W541 (FM 3129, Atlanta District).
  - Collected traffic data on US 83 in the Laredo District & US 59 in the Atlanta District using portable WIM
  - Analyzed the collected portable WIM data to generate ME compatible traffic data for US 83 in the Laredo District
- December 2016
  - Analyzed the three year (2013-2015) WIM data for W531 (IH 35, Laredo District) supplied by the TPP.
  - Analyzed the portable WIM data collected from US 83 in the Laredo District

Task 2 (Traffic Data Collection)

- January 2017
  - Surveyed highway US 281 in Corpus Christ District for portable WIM site location
  - Analyzed the 2015 Station W531 (IH 35, Laredo District) permanent WIM data
  - Completed analyzing the US 83 (Laredo District) portable WIM data
  - Continued with portable WIM data analysis for US 59 (Atlanta District)
  - Prepared & submitted (in PPT format) the 2015 Station W531 (IH 35, Laredo District) permanent WIM data
  - Prepared & submitted (in PPT format along with TxME input files) the US 83 (Laredo District) portable WIM data to the District.

Task 2 (Traffic Data Collection)

- February 2017
  - Prepared tools/accessories for portable WIM installation on US 281 in the Corpus Christ District
  - Completed analysis of 2015 Station W531 (IH 35 Laredo District) WIM data including FPS & TxME input data
  - Preliminarily analyzed the Stations W523 & W 541 WIM data including volume, classification, & weights
  - Prepared & submitted (in PPT format) the 2015 Station W531 (IH 35 Laredo District) WIM updated data analysis

Task 2 (Traffic Data Collection)

- March 2017
  - Installed portable WIM unit (TRS-2) on US 281 in Corpus Christ District for traffic data collection.
  - Liaised with TPP for permanent WIM traffic data request for Stations W513, W524, W534, W542, & W547 namely volume, classification, weights, & vehicle speed data as well as Stations W531, W523, & W541 (speed data)
  - Completed analysis of SH 7 (Bryan District) portable WIM data including FPS & TxME input data
  - Analyzed Stations W523 & W 541 WIM data including volume, classification, distribution, ATHWLDs, & weights
  - Developed a prototype MS Access M-E traffic database (The T-DSS)
  - Prepared PPT slides for SH 7 (Bryan District) portable WIM data

Task 2 (Traffic Data Collection)

- April 2017
  - Measured & collected 7-days portable WIM data on US 281 in Corpus Christ District
  - Liaised with TPP for permanent WIM traffic data request for Stations W513, W524, W534, W542, & W547 namely volume, classification, weights, & vehicle speed data as well as Stations W531, W523, & W541 (speed data)
  - Completed analysis of FM 468 (Laredo District) portable WIM data including FPS & M-E inputs
  - Completed analysis of Stations W523 & W 541 permanent WIM data including FPS & TxME inputs
  - Continued enhancing & populating the prototype MS Access M-E traffic database (The T-DSS)
  - Prepared PPT slides for FM 468 (portable WIM) & Stations W523 & W 541 (permanent WIM) data.

Task 2 (Traffic Data Collection)

- May 2017
  - Continued measuring & collecting portable WIM data on US 281 in Corpus Christ District
  - Liaised with TPP for permanent WIM traffic data request for Stations W513, W524, W527, W534, W542, & W547
  - Updated & enhanced the Excel analysis templates & macros for both permanent & portable WIM data analysis
  - Completed analysis of US 281 (Corpus Christi District) 7-days portable WIM data including FPS & M-E inputs
  - Updated Station W531 data analysis to include M-E PDG & AASHTOWare inputs
  - Finalized analysis of Stations W523 & W 541 permanent WIM data including FPS , TxME, & AASHTOWare inputs
  - Continued enhancing & populating the prototype MS Access M-E traffic database (The T-DSS)

Task 2 (Traffic Data Collection)

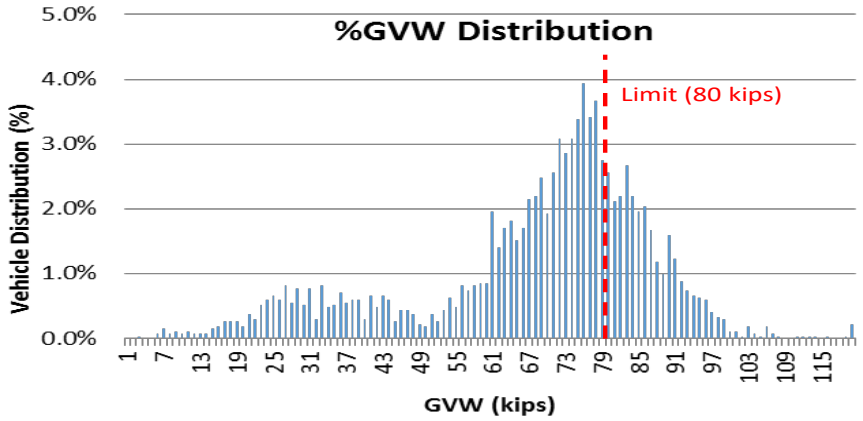
- June 2017
  - Continue liaison with TPP on permanent WIM related data (volume, classification, weights, & vehicle speed)
  - Continue measuring & collecting portable WIM data on Hwy US 281 in Corpus Christi District
  - Continue enhancing the Excel analysis templates & macros to make them more user-friendly
  - Analyze the traffic data (both permanent & portable WIM) to M-E format for the database
  - Continue developing, updating & populating the prototype MS Access M-E traffic database

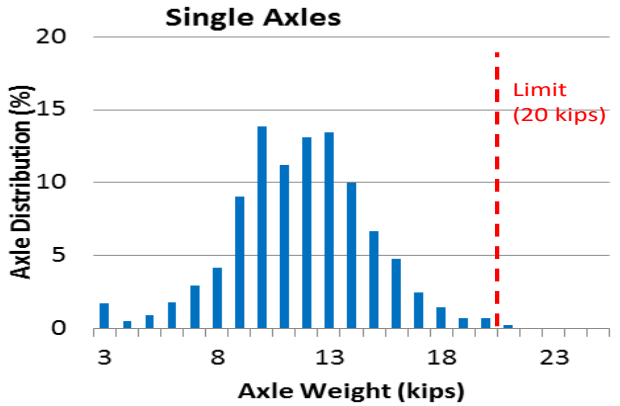
Task 2 (Traffic Data Collection – US 83).

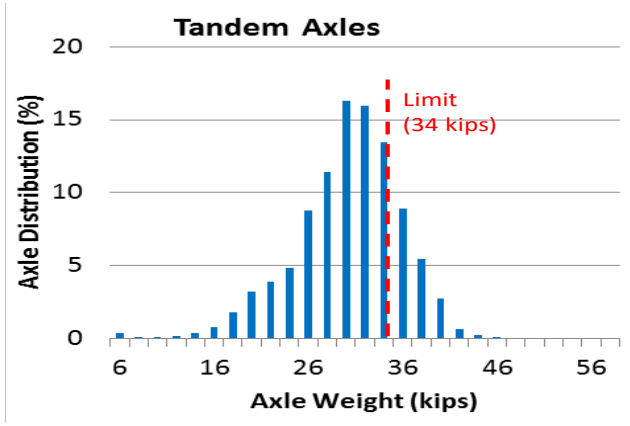
- ME traffic data collected using portable WIM (LRD) ⇒ RM 698-696 on US 83 NB

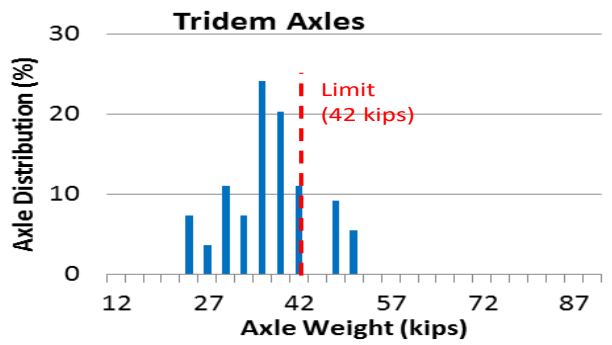
Volume	
ADT	1714
ADTT	495
Truck %	28.8%
20-Yr 18-kip ESALs	8.44 million

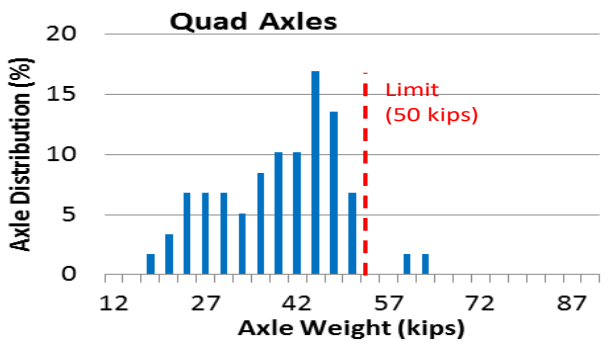
Parameter	FPS Input
ADT-Beginning	3429
ADT-END 20 Year	6,193
18 kip ESALs 20 Years (million)	8.44
Avg. vehicle speed (mph)	59.7
%Trucks in ADT	28.8%





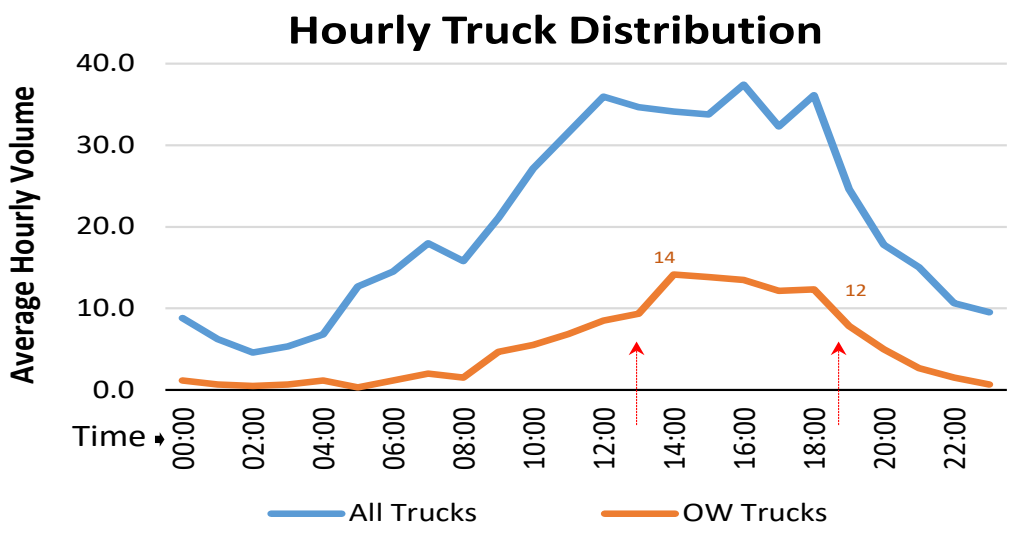


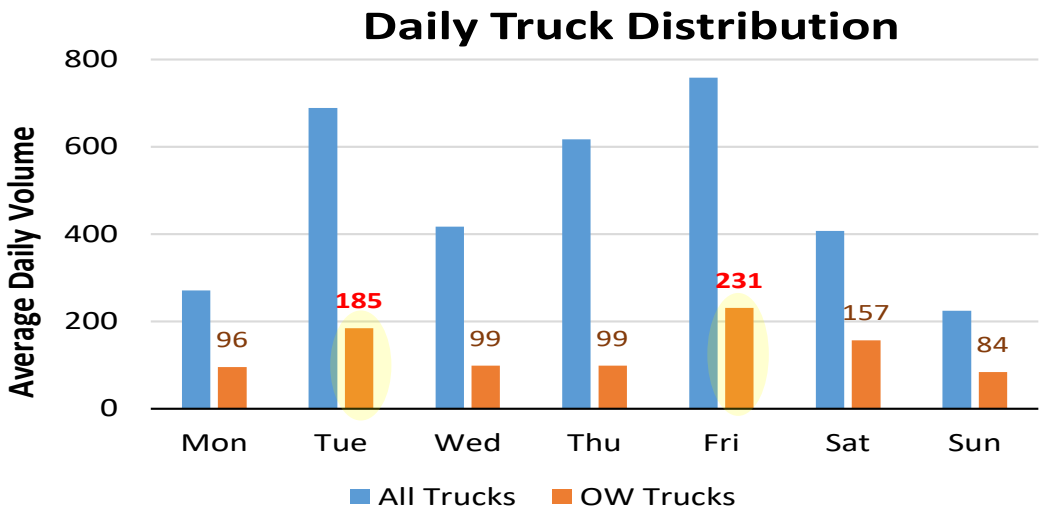




Task 2 (Traffic Data Collection – US 83)..

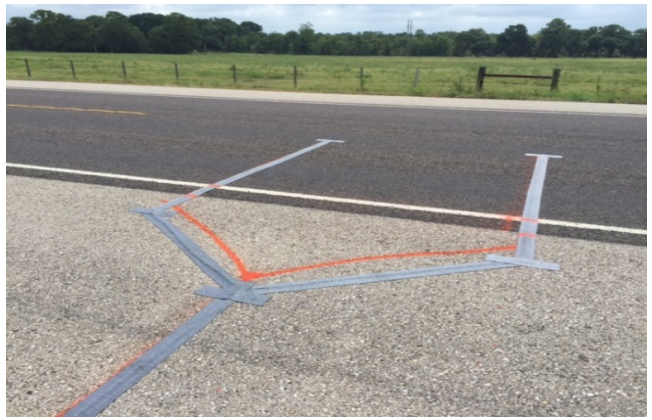
- ME traffic data collected using portable WIM (LRD) ⇒ RM 698-696 on US 83 NB



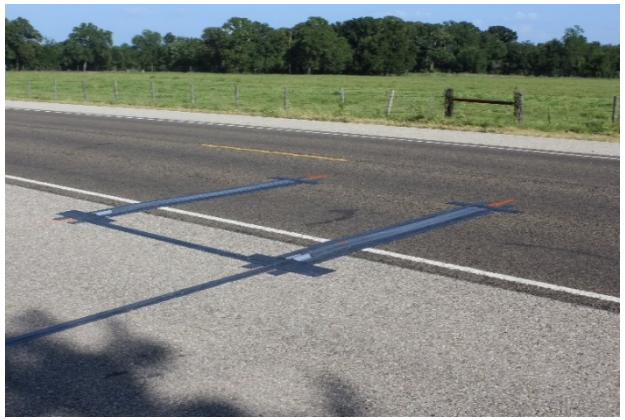


Task 2 (Traffic Data Collection – SH 7).

- Deployed portable WIM system on SH 7 (EB & WB) in Bryan District
  - To assess the applicability of portable WIM systems for ME traffic data
  - To compare sensor installation techniques
  - To identify most suitable technique for deploying portable WIM system for traffic data collection



(1) Pocket Tape



(2) Metal Loading Plates

(3) Embedded Sensors & Loops

Portable WIM sensor installation in SH 7 (Bryan District)

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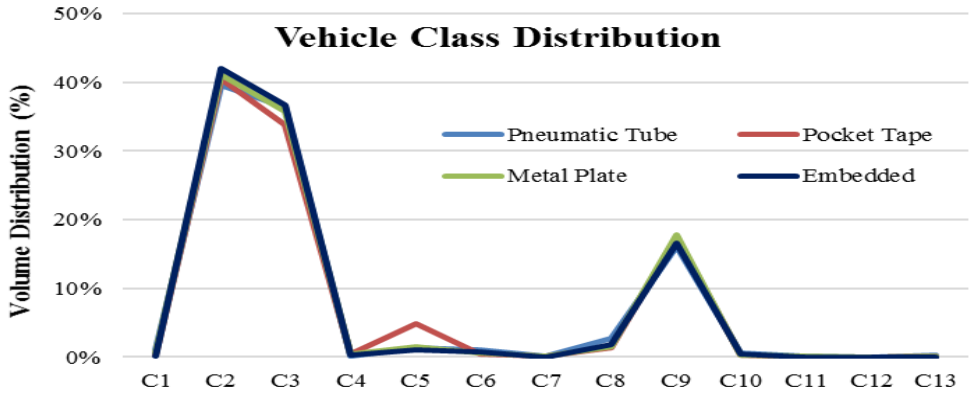
Task 2 (Traffic Data Collection – SH 7)..

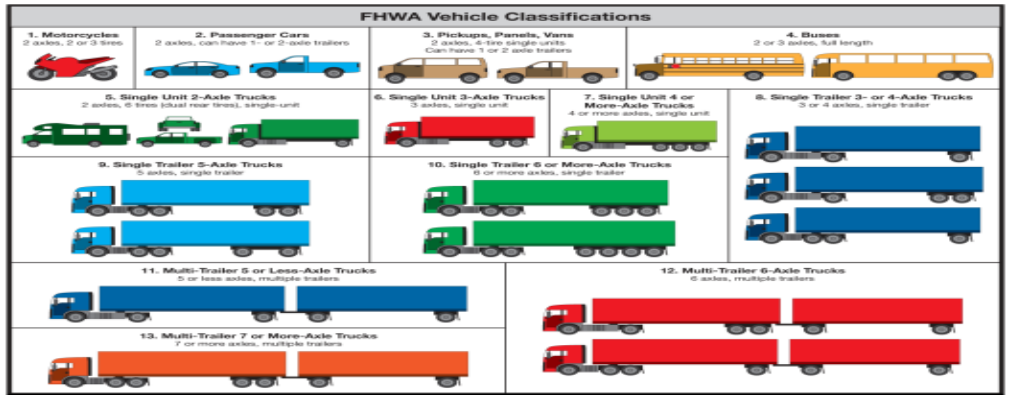
- Volume, Classification & Speed

Volume	Pneumatic Tube	Pocket Tape	Metal Plate	Embedded
ADT	1059	1046	1025	951
ADTT	243	268	231	201
Truck %	22.9%	25.6%	22.5%	21.1%
20-Yr 18-kip ESALs	3.461 Million	3.165 Million	3.298 Million	3.870 Million

Speed	Pneumatic Tube	Pocket Tape	Metal Plate	Embedded
Max (All)	123.1	135	133	121
Max (Truck)	98.7	102	108	111
Avg (All)	65.8	69	66	69.5
Avg (Truck)	62	67.2	64.3	67.8
Speed limit	70	70	70	70

Daily 18-kip ESAL	Pneumatic Tube	Pocket Tape	Metal Plate	Embedded
Single Axles	-	96	90	122
Tandem Axles	-	233	232	247
Tridem Axles	-	0	0	7
Quad Axles	-	0	0	2
Total Daily ESAL		330	322	378





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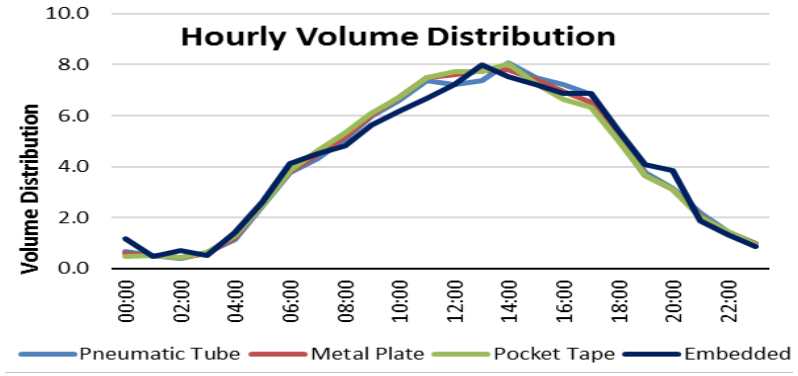
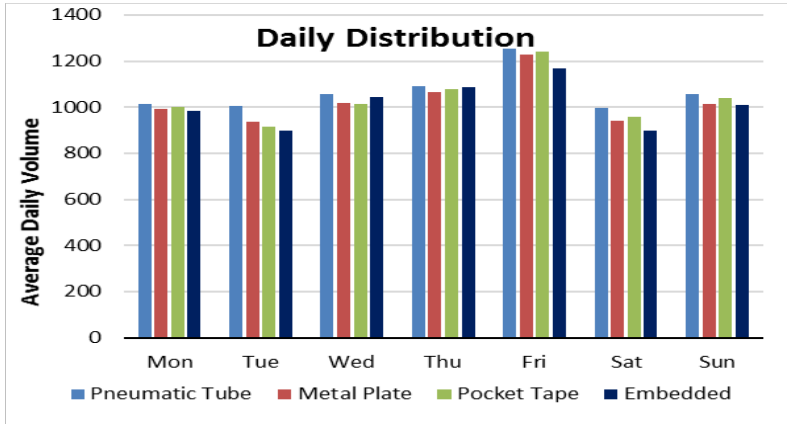
Task 2 (Traffic Data Collection – SH 7)..

- Hourly, Daily, & FPS Input

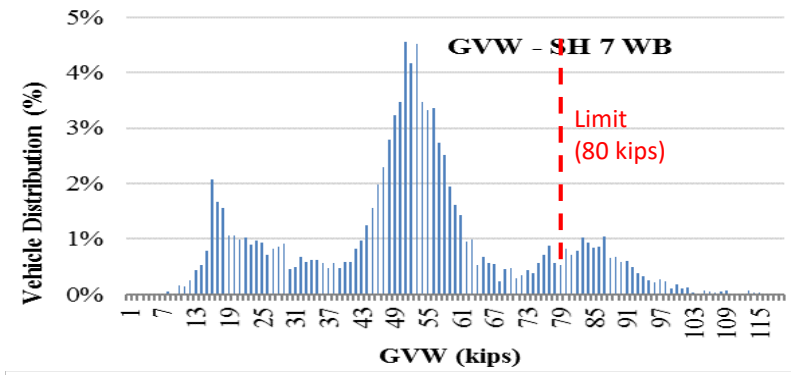


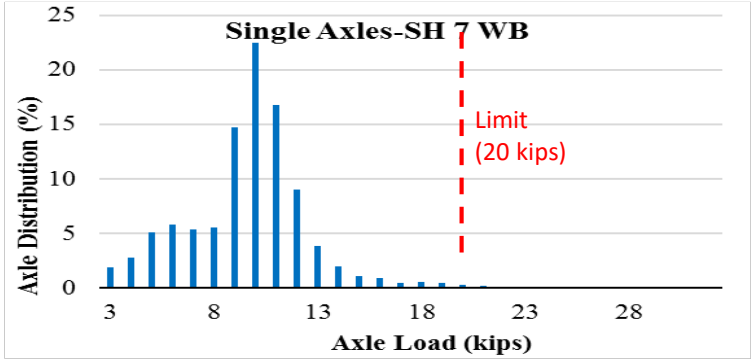


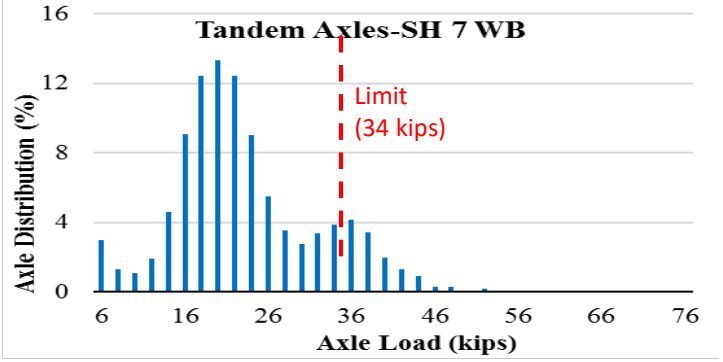
Parameter	Pneumatic Tube	Pocket Tape	Metal Plate	Embedded Sensor
ADT-Beginning	2118	2090	2050	1902
ADT-END 20 Year	3,825	3,775	3,703	3,435
18 kip ESALs 20 Years (million)	3.461	3.165	3.298	3.870
Avg. vehicle speed (mph)	65.8	69	66	69.8
% Trucks in ADT	22.9%	25.6%	22.5%	21%

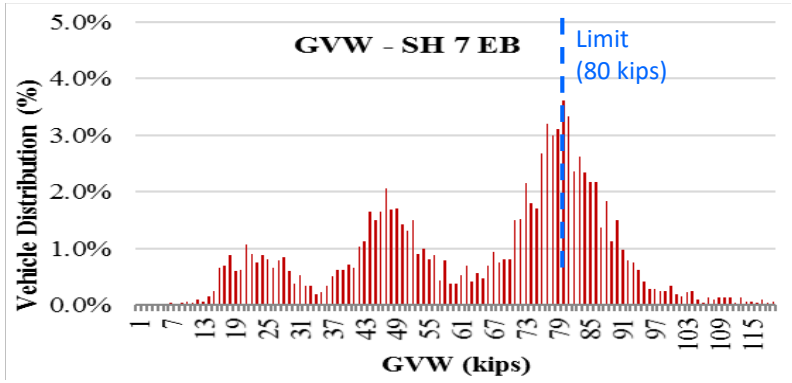
Task 2 (Traffic Data Collection – SH 7)…

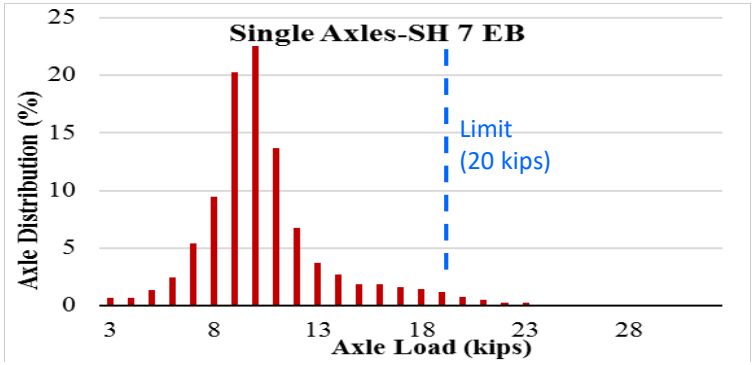
- GVW distribution

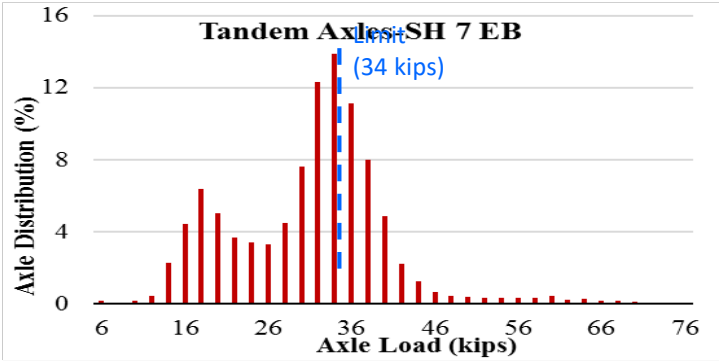












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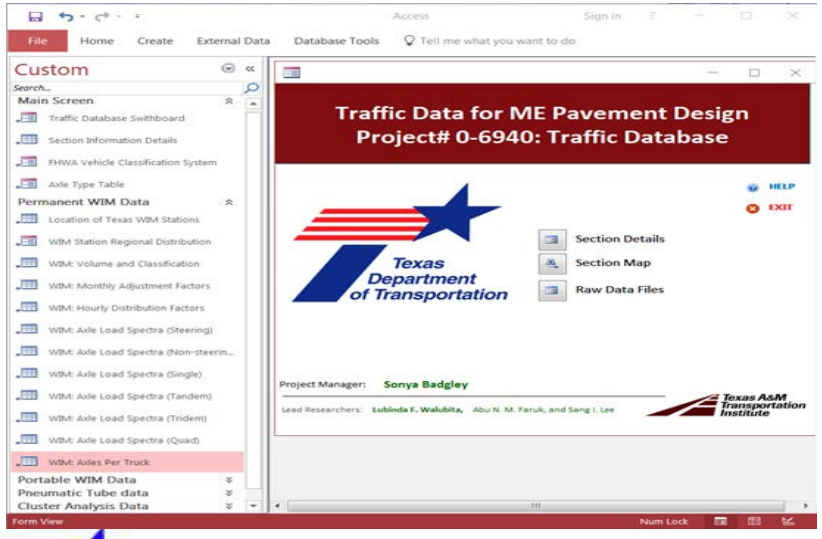
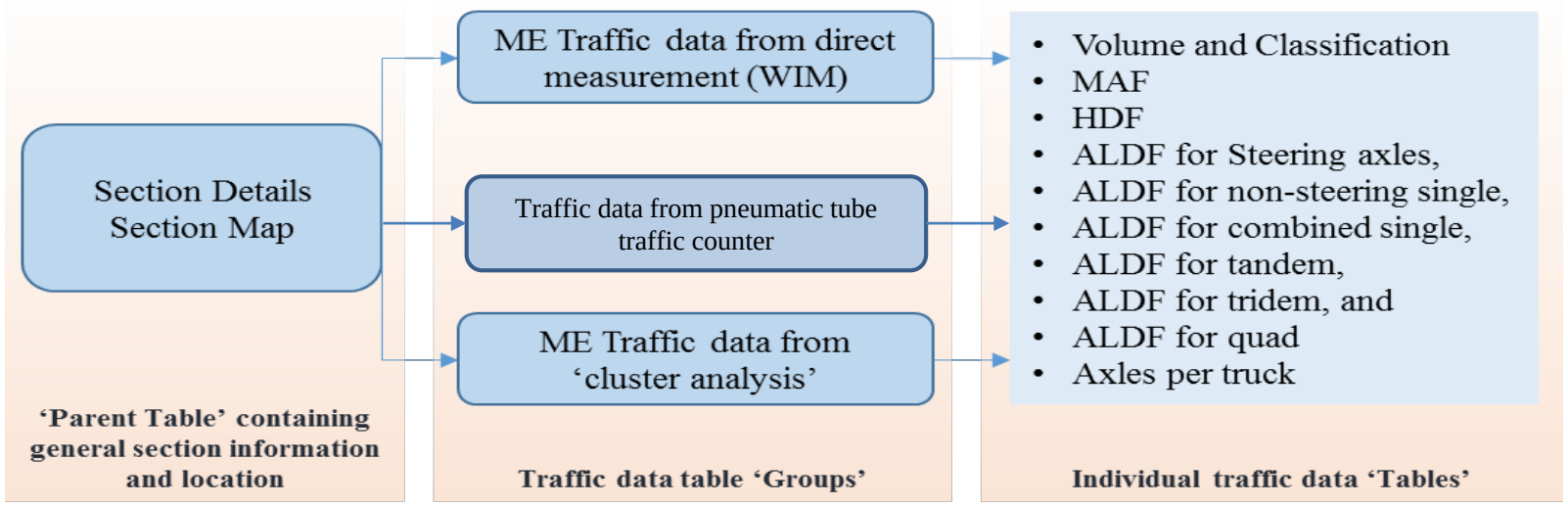
Task 4 (MS Access Database)

- A traffic database outlines is developed in MS Access for storing and accessing traffic data as:
  - Traffic data from permanent WIM stations
  - Portable WIM traffic data
  - Pneumatic tube traffic data
  - ME traffic data from cluster analysis





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Agenda

- Introduction
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- Work Done to Date
- **Assistance & Involvement by TxDOT**
- Comment & Discussions

Assistance & Involvement by TxDOT

- Participate & assist in survey questionnaires
- Facilitate access to permanent WIM data from TPP
- Assist with field traffic data collection including identifying the highways & traffic control provision (where needed)
- Assist in identifying ME pavement design packages requiring interface modules for importing ME traffic data
- Participate & assist in organizing the demo workshops

Comments & Discussions

Development of TxDOT UAS Flight Operations Manual, Policy Recommendations and Initial Application Evaluations

Joe Adams, RTI

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Texas State Transportation Innovation Council

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October 2017

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