“Integration of ITS into Rural Work Zones”

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Project Objectives

- Develop ITS architecture for rural WZs
- Develop guidelines for use of WZ ITS
- Develop and test proof-of-concept WZ ITS
  - Dynamic queue warning
  - Travel time/delay

DEVELOP ITS STRATEGIES AND ARCHITECTURE

Description of work	TMUTCD TA-No.	Duration L: Long, I:Intermed. S: Short	Schedule 24-hr, D: Day, N: Night	WZ Boundary S : Stationary, M: Mobile	Potential Impacts D : Delays Q : Queues RE: Rear-End Collision SC: Side-swipe Collision FC: Frontal Collision	Potential ITS Solutions

RURAL ROAD WORK GROUPS BY LOCATION

- Work within the Traveled Way of Two-Lane Highways
- Work Within the Traveled Way of Multilane Undivided Highways
- Work Within the Traveled Way of Multilane Divided Highways
- Work Within the Traveled Way of Expressways and Freeways
- Work on the Shoulder
- Work in the Vicinity of Highway-Rail Grade Crossings

POTENTIAL ITS STRATEGIES/APPLICATIONS

- Dynamic Congestion Advisory
- Dynamic Merge (at work zones with lane closures)
- Dynamic Queue Warning Systems
- Excessive Speed Warning
- Haul Road Warning
- Optimized Restriction/Closure
- Travel Time/Delay Information
- Variable Speed Limit (VSL) / Var Speed Advisory
- Work Space Intrusion Warning
- Other

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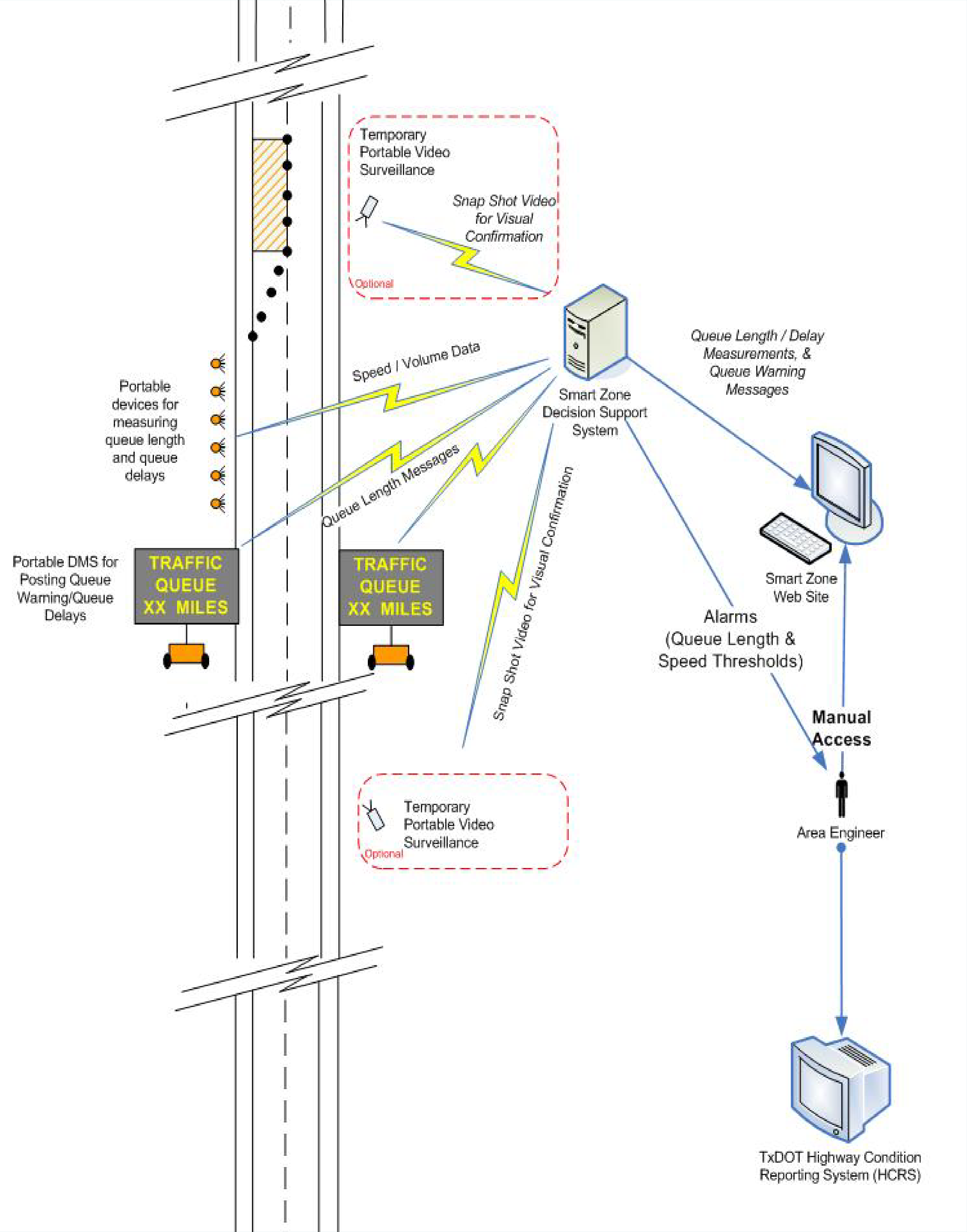
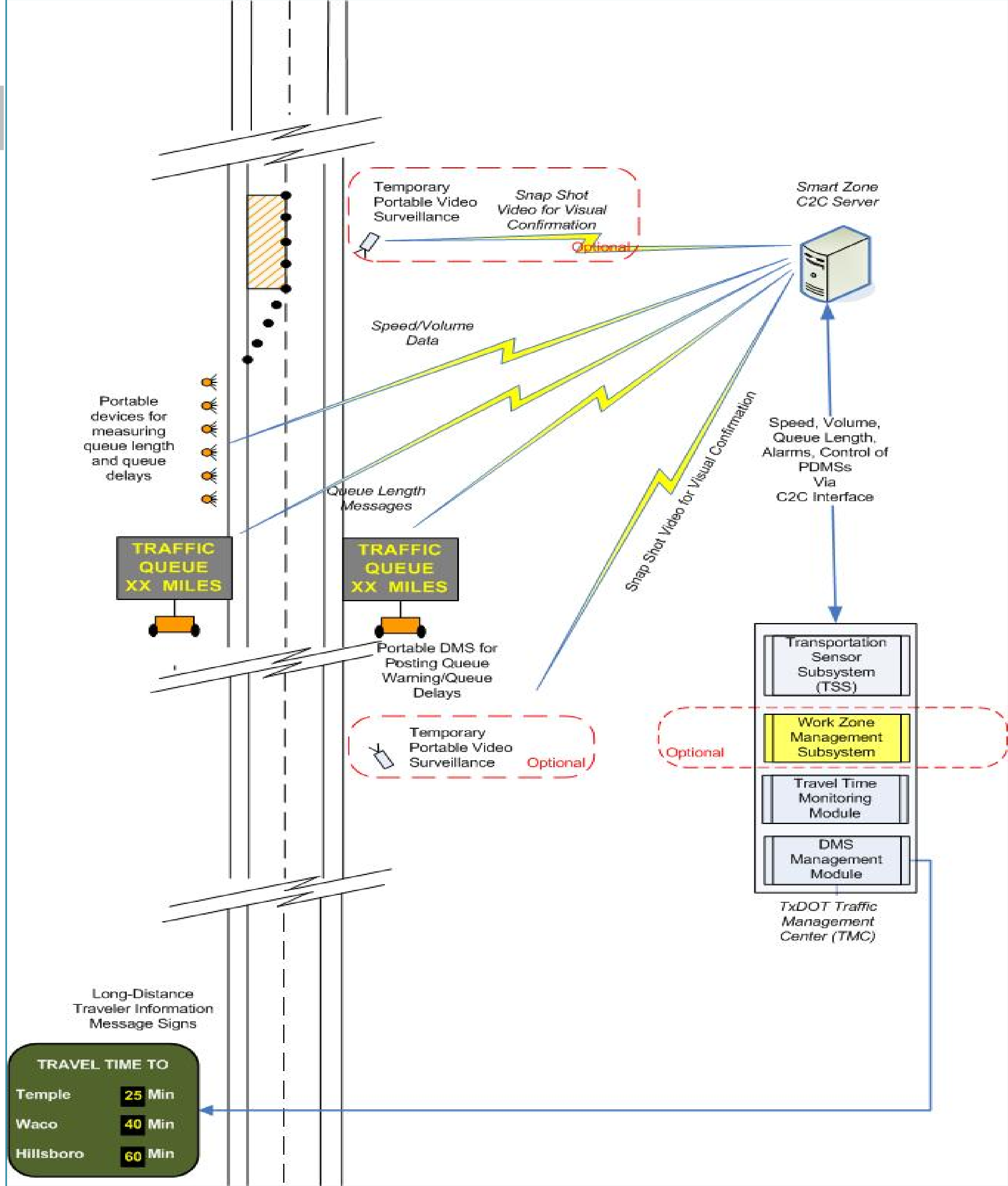
Stand-Alone



TxDOT Source:
Center-to-Center Communications
Command/Control Interface Control Document
C2C-CICD – 4.3.0
July 7, 2008

Integrated



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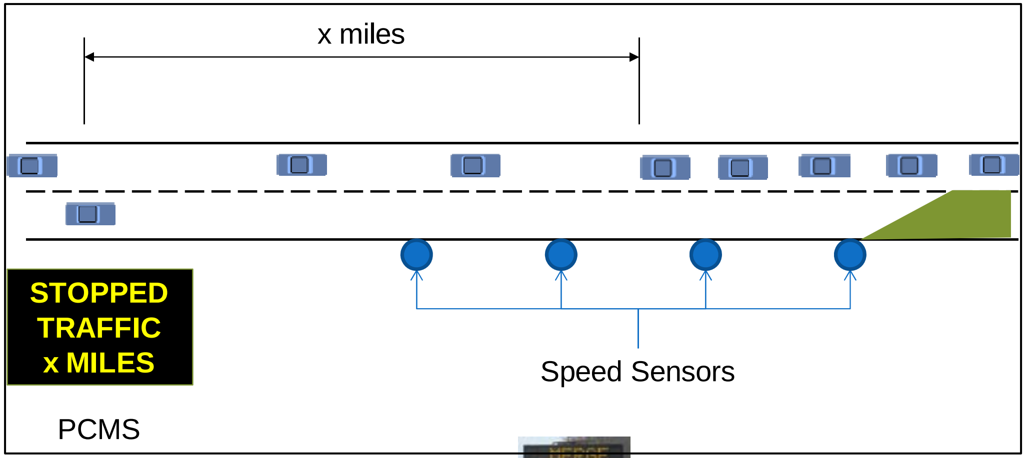
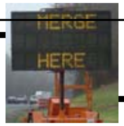
Develop Guidelines for Use of ITS

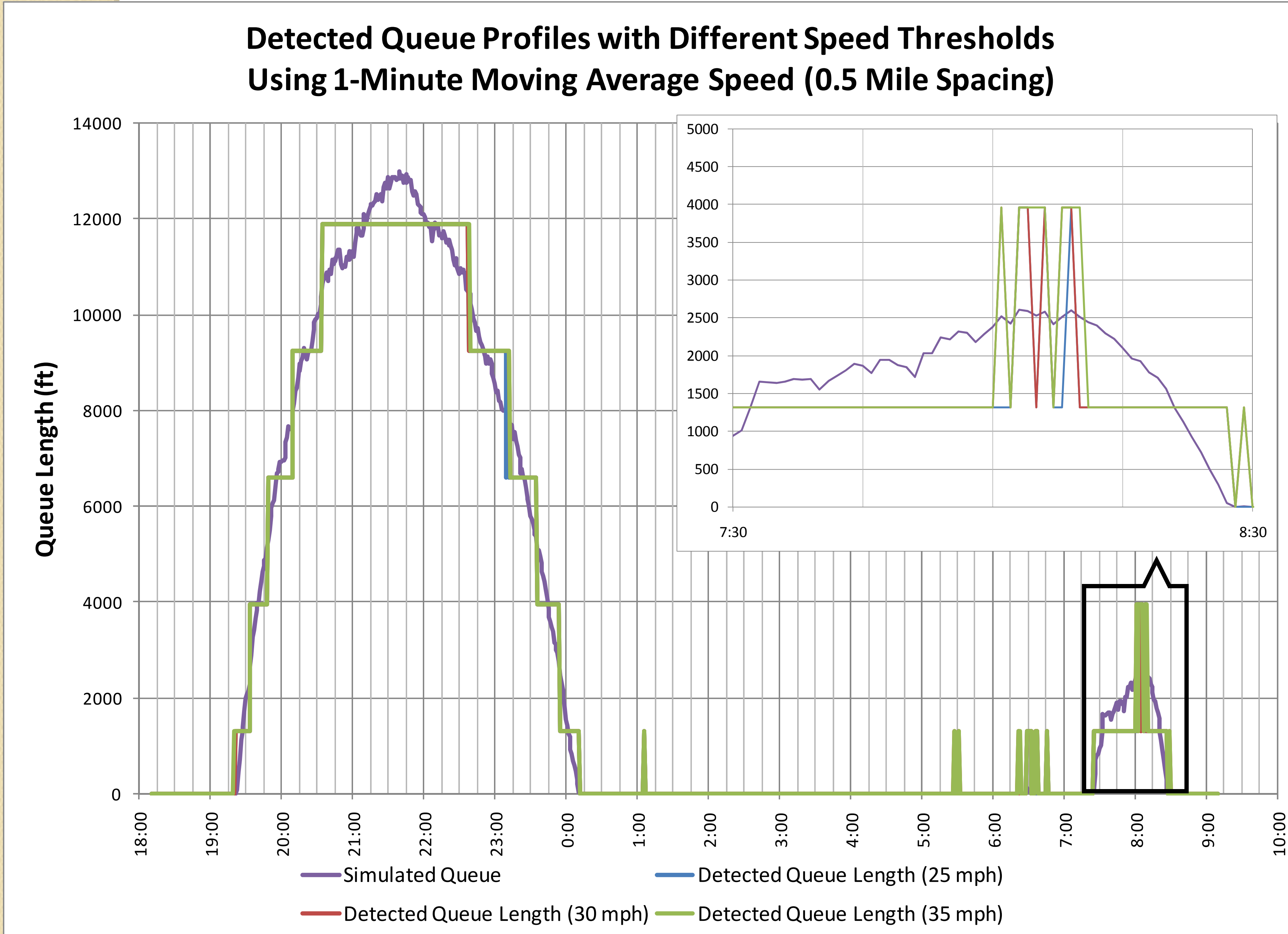
- Benefit/Cost Analysis
  - Benefits
    - Delay reduction
    - Crash reduction
  - Costs
    - ITS cost from private provider

Smart Work Zones

- SWZ Queue Warning
  - Speed sensors
  - Portable changeable message sign (PCMS)
  - CPU to process sensor data
  - Communication between CPU & PCMS

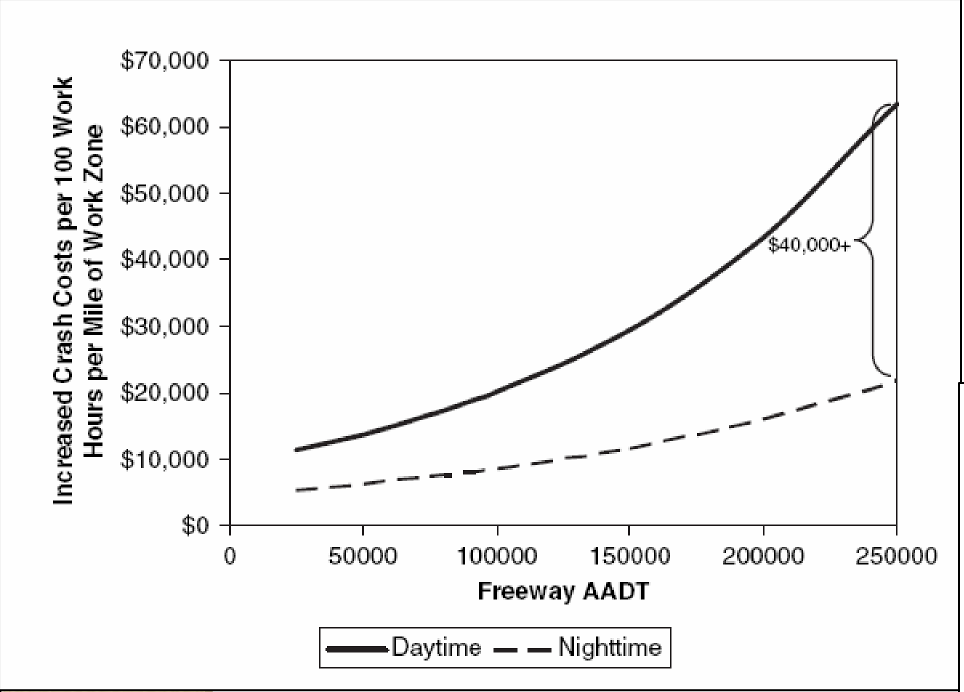




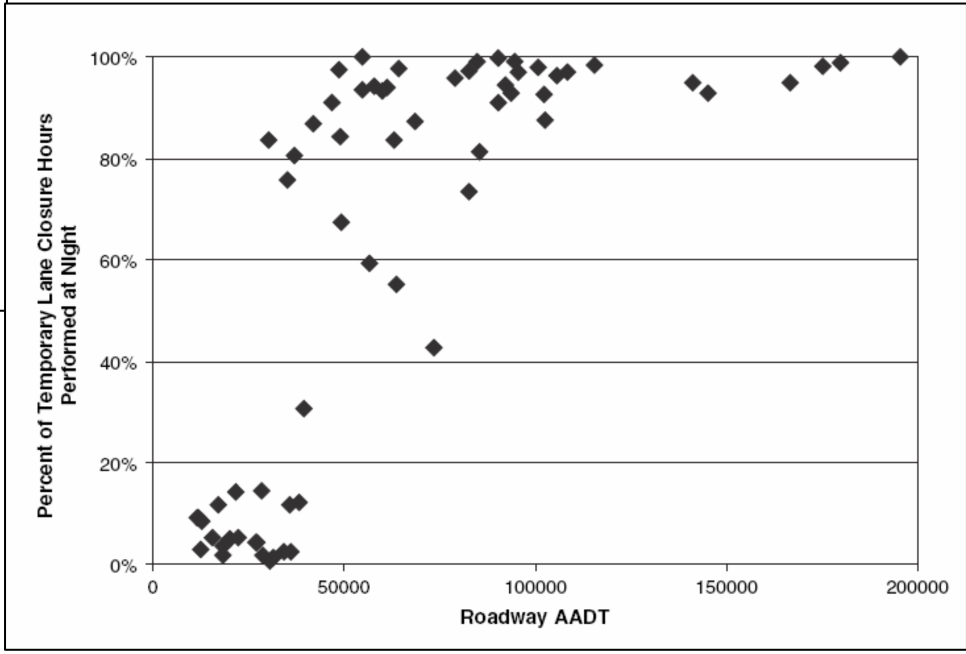


Detected Queue Profiles with Different Speed Thresholds
Using 1-Minute Moving Average Speed (0.5 Mile Spacing)
Queue Length (ft)
14000
12000
10000
8000
6000
4000
2000
0
18:00
19:00
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
7:30
8:30
Simulated Queue
Detected Queue Length (25 mph)
Detected Queue Length (30 mph)
Detected Queue Length (35 mph)

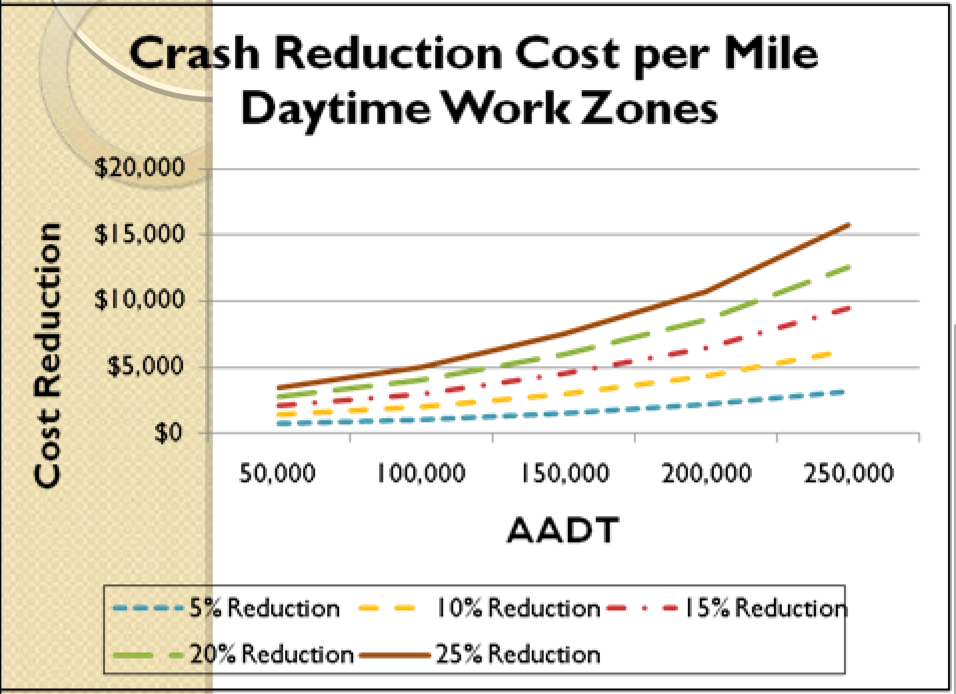
Daytime vs nighttime work zones

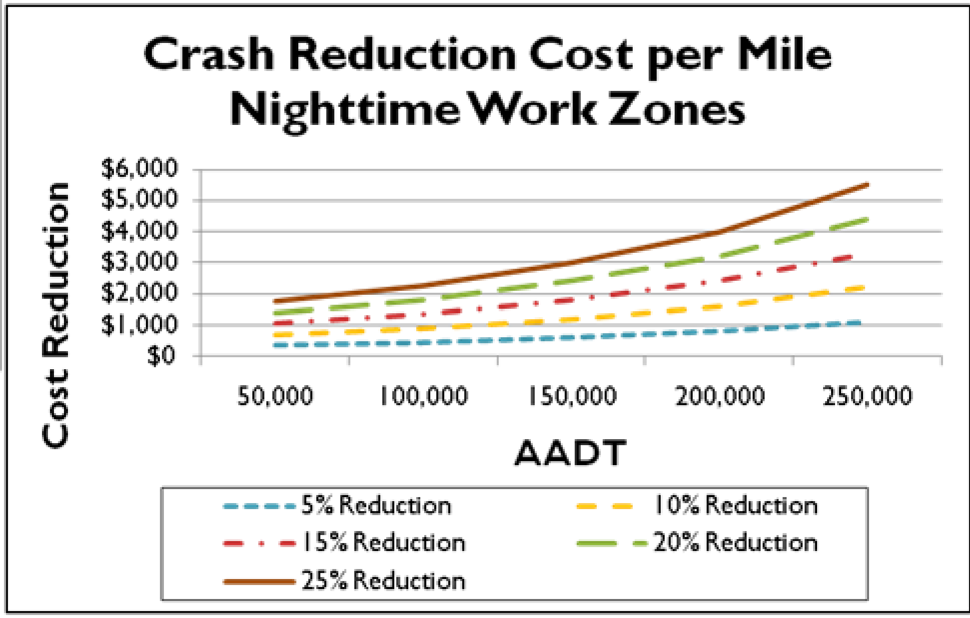


Source: NCHRP 627



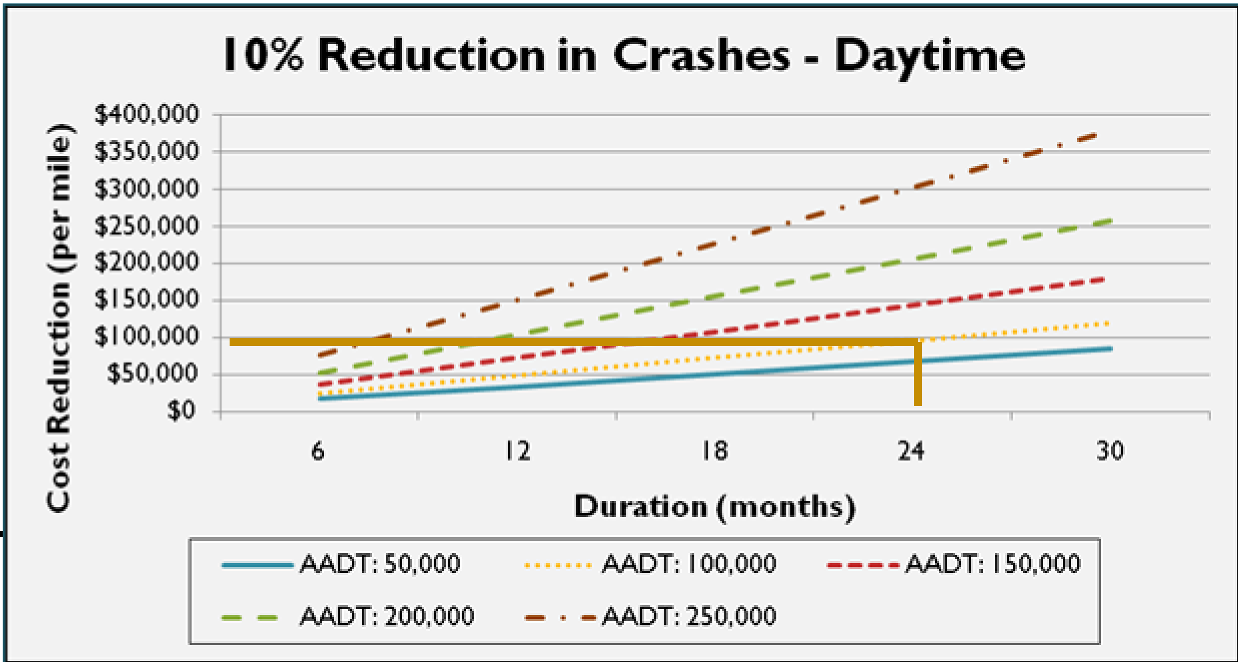
Crash costs in WZ vs AADT





Example

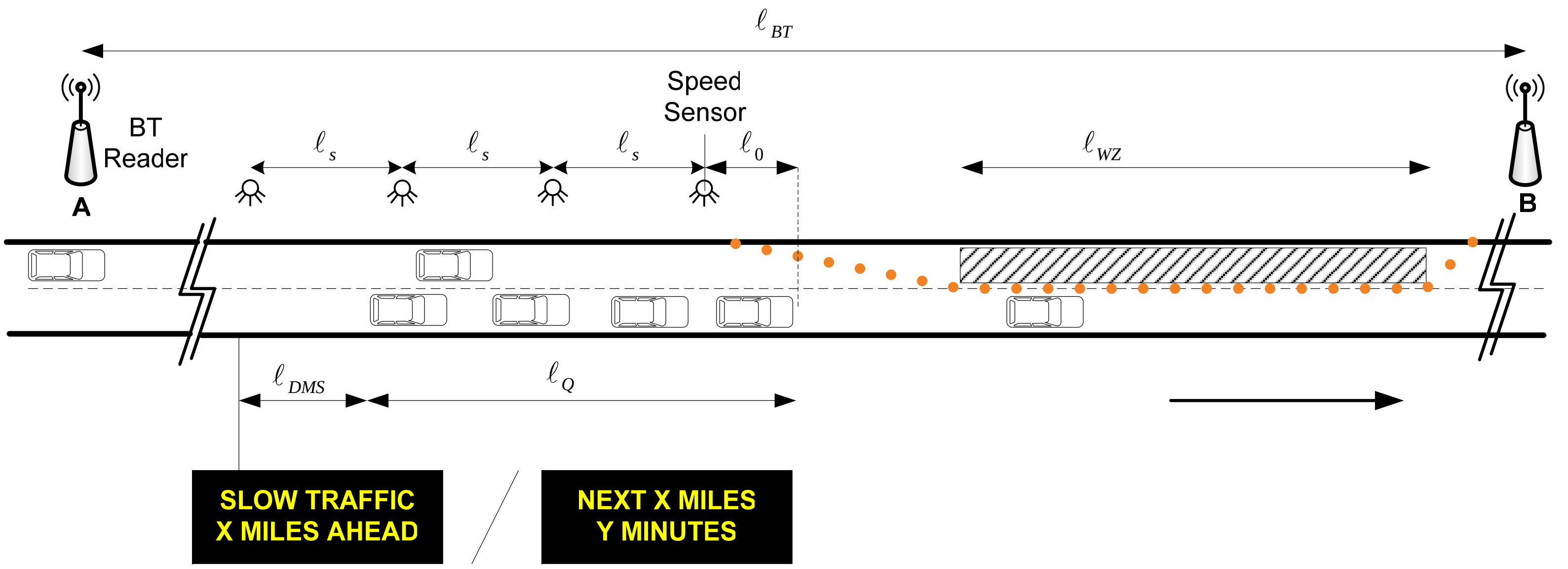
- Cost of SWZ with 4 sensors & 2 PCMSs $71,000
- Length of influence zone: 3.0 mi
- Assumed crash reduction due to SWZ 10%
- AADT 100,000 vpd
- Duration 24 mo, daytime work only



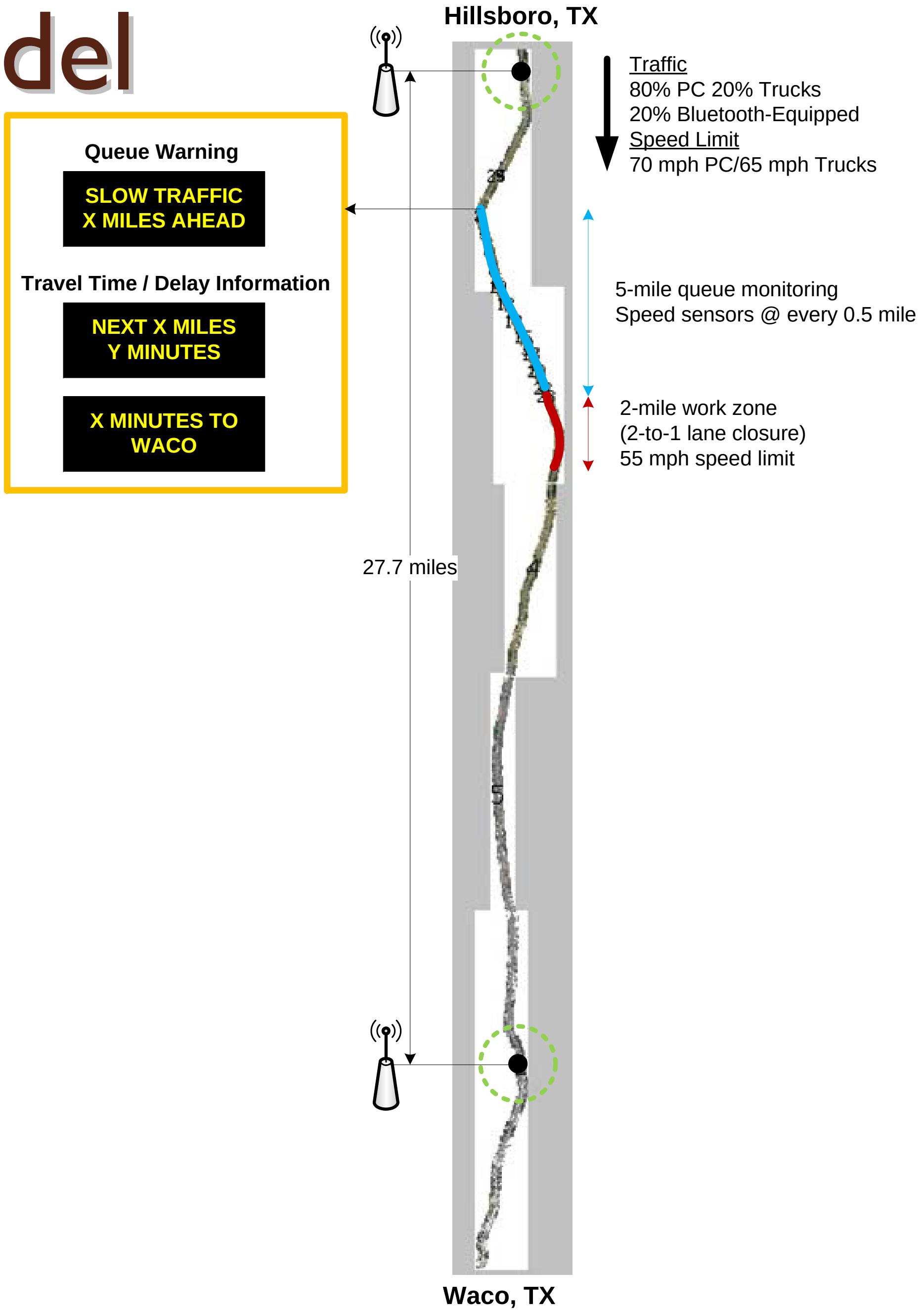
Proof-of-concept testing

- Design Objectives
  - Provide dynamic queue warning
  - Provide reliable estimate of travel time/delay

Smart Work Zone Concept



Simulation Model



Work Zone Capacity = 1650 vph

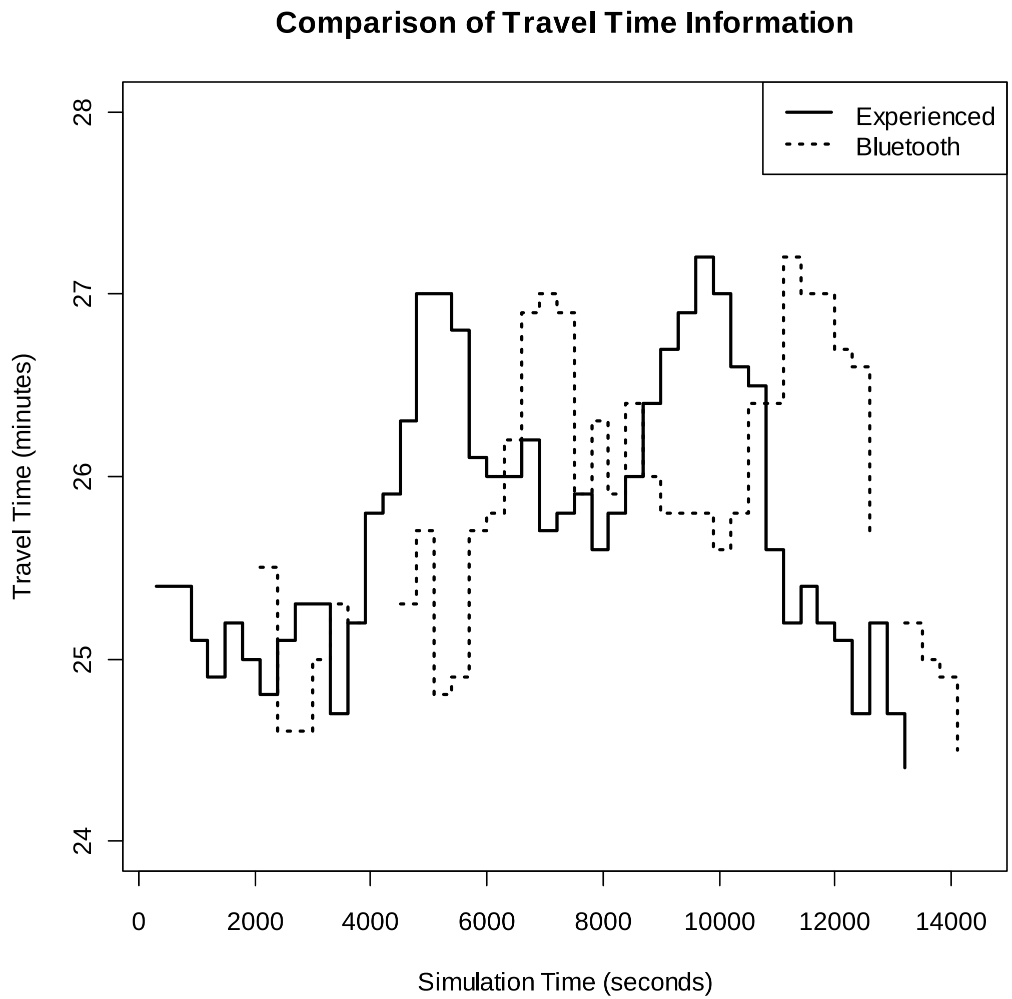
Simulation Design

- Queue monitoring
  - Speed-based algorithm
- Travel time monitoring
  - Bluetooth-based system

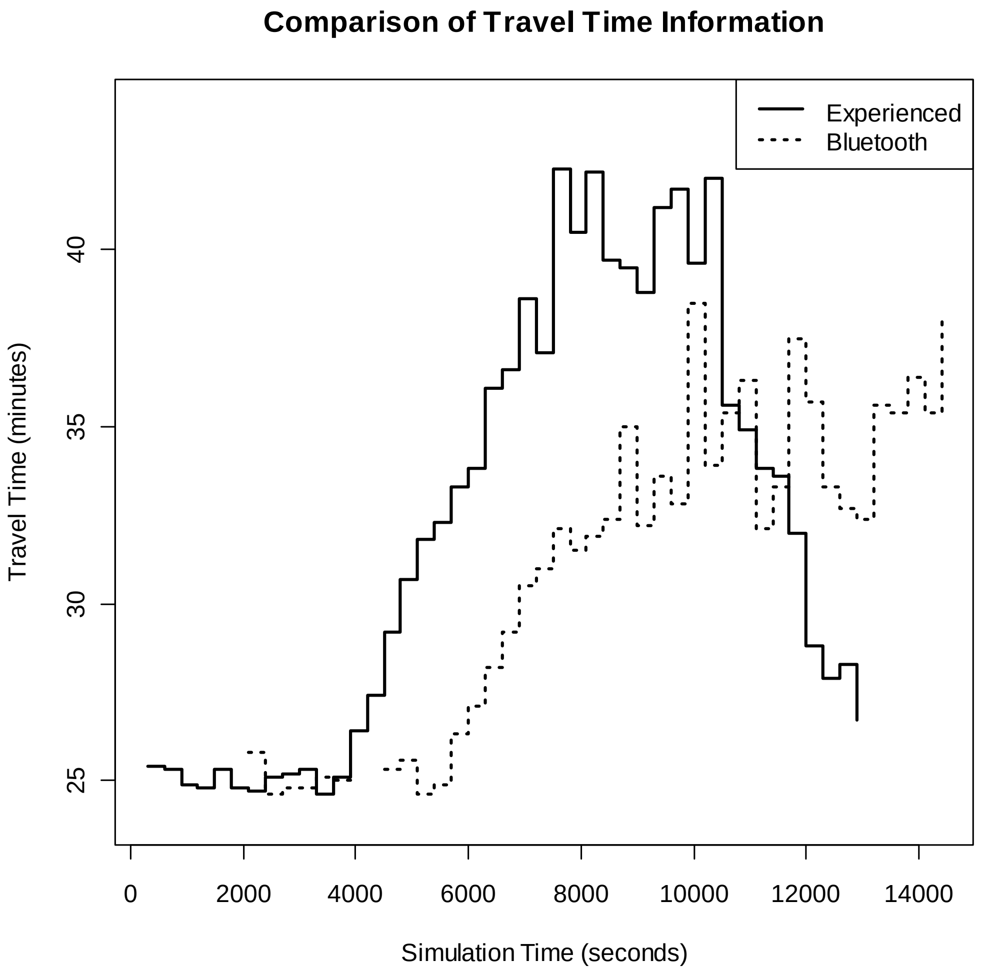
Design Parameters

- Queue monitoring
  - 35-mph speed threshold
  - 0.5-mile spacing
  - 5-minute aggregation interval
- Bluetooth parameters
  - 1-sec reading frequency
  - 100-m effective range (class 1 device)

Travel Time Comparison: v/c < 1



Travel Time Comparison: v/c > 1



Proposed Algorithm

$$d_{total} = d_Q + d_{WZ} + d_U$$

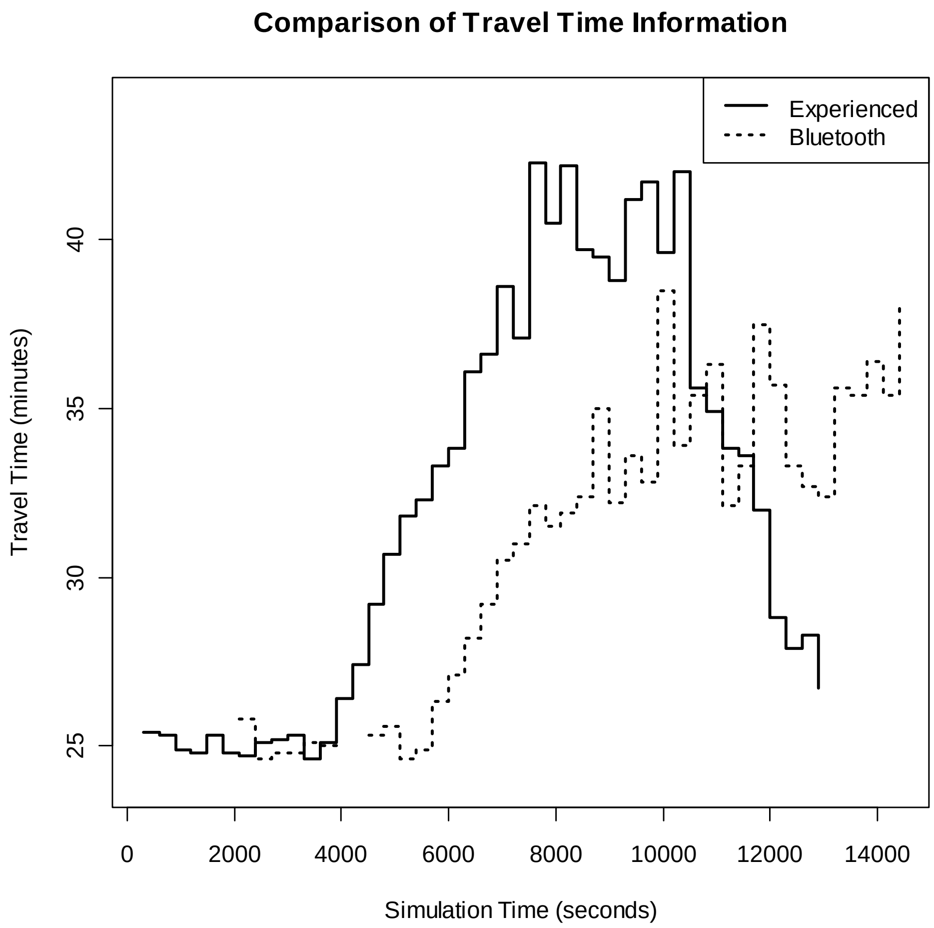
d_{total} = Total delay (minutes/veh)
d_Q = Delay in queue
d_{WZ} = Delay in traveling through the work zone
d_U = Unaccounted delay

Estimating Travel Time Using Proposed Algorithm

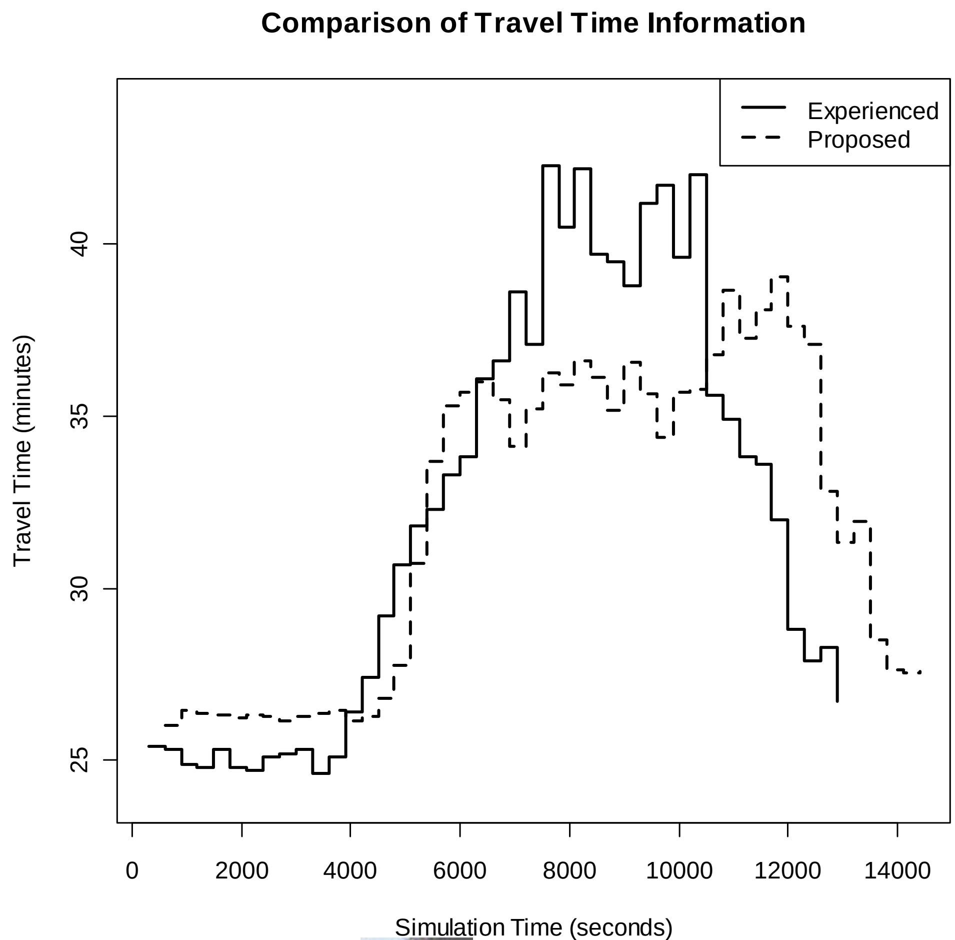
$$tt_t = tt_f + d_{Q,t} + d_{WZ,t} + d_{U,t}$$

- tt_t = Estimated travel time at time t
- tt_f = Free-flow travel time (minutes)

Algorithm Performance Bluetooth Travel Time



Algorithm Performance Proposed Algorithm



Evaluation Results

ID	Peak Volume (vph)	v/c	Ramp Interruption	Volume Profile	RMSE (min)		
					BT	Proposed	%
1	1600	0.97	Yes	Dual Peak	1.27	0.73	43%
2	1800	1.09	Yes	Dual Peak	2.45	1.32	46%
3	2000	1.21	Yes	Dual Peak	5.1	2.37	54%
4	1600	0.97	Yes	Single Peak	1.08	0.74	31%
5	1800	1.09	Yes	Single Peak	3.33	1.60	52%
6	2000	1.21	Yes	Single Peak	5.66	3.72	34%
7	1600	0.97	No	Dual Peak	1.09	0.77	29%
8	1800	1.09	No	Dual Peak	2.47	1.42	43%
9	2000	1.21	No	Dual Peak	4.96	2.27	54%
10	1600	0.97	No	Single Peak	0.82	0.77	6%
11	1800	1.09	No	Single Peak	3.24	1.61	50%
12	2000	1.21	No	Single Peak	5.87	4.25	28%

Summary of Findings

- ITS architecture
  - Stand Alone
  - Integrated
- Justifying SWZ in rural areas
  - High AADT
  - v/c > 1.0
  - Extended duration
- Bluetooth travel time
  - Improvement 6% to 54%
- Dynamic queue warning
  - Maximum queue length
  - Speed sensor spacing < 1.0 mi

Contact information

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