UNIVERSITY OF TEXAS ARLINGTON

Evaluating Lost Capacity Due to Technology Related Behavior

Meeting on January 8, 2020

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Project Overview

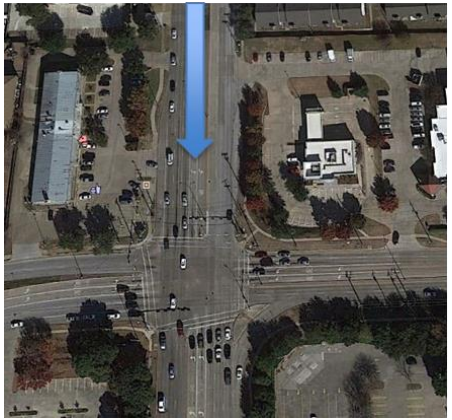
- Use historic data to assume the delay at the intersection
- With new technology, driver distraction and delay at traffic signals may have increased
- Aims to evaluating lost capacity : if the current assumptions used for operations need to be adjusted to more accurately reflect actual delay associated with new technology or other in-vehicle distractions.

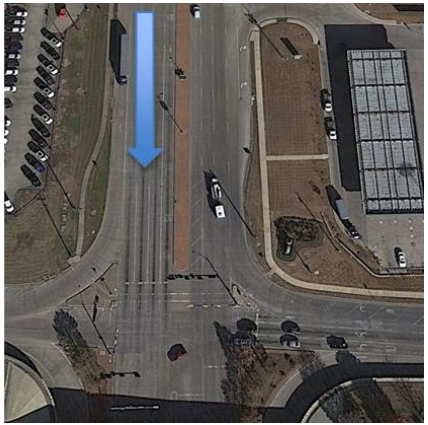
Project Progress

- Developed data collection and analysis framework
- Completed data collection for three sites
- Completed quantitative assessments on start-up delay and the associated distraction behaviors for two sites.

Data collection set-up

Video and field observation

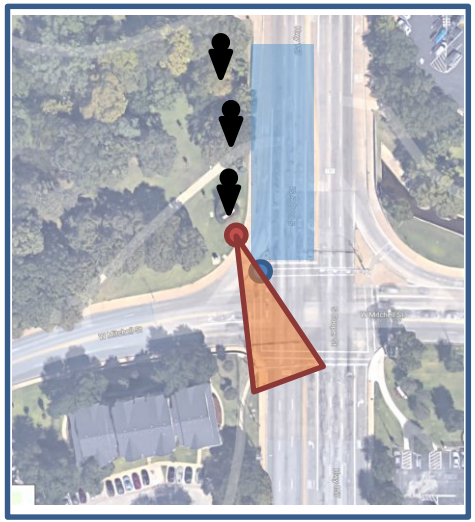




	Site 1	Site 2	Site 3
Location	Matlock	Pioneer	South Belt Line Rd
Date and time	June 04-06, July 21-23 4:00pm to 6:00pm	July 02-05 4:00pm to 6:00pm	November 01,08,15,22 4:30 pm to 6:00pm
Total Cycle	131	98	130
Total Vehicle	2,985	1,876	

Data Collection

At the field..



- Two cameras capture vehicle queue and signal cycle
- Three observers record vehicle distraction behavior

Six types of distraction

Distraction on Green?

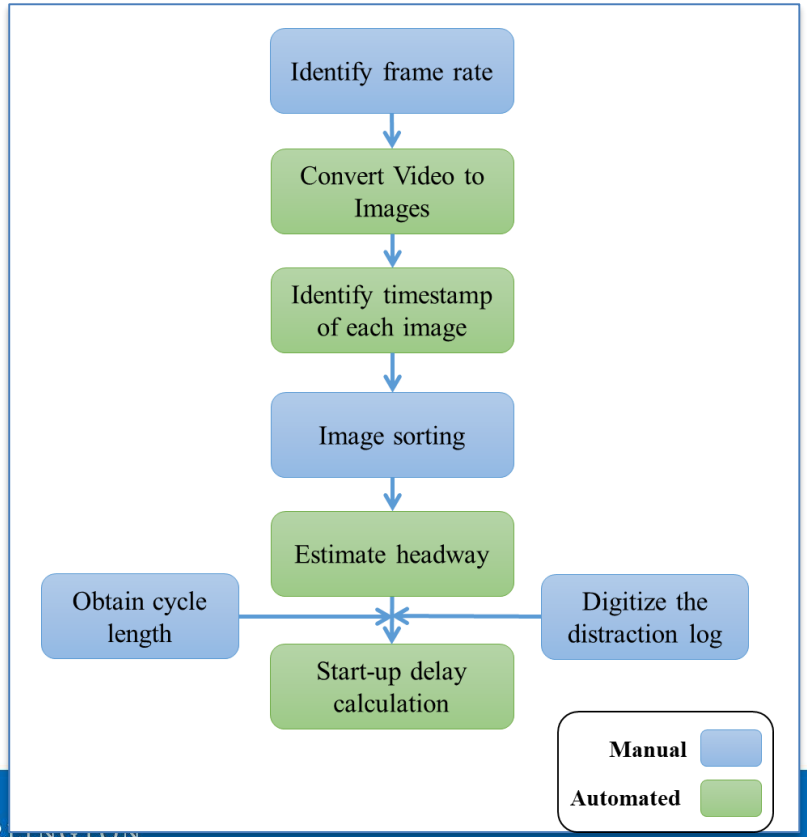
Vehicle type

Time, lane and vehicle color

Time	Zone/Lane	Car Color	Type of Distraction: Cellphone or Electronics	Eating	Talking	Moving Objects	Grooming	Outside person or object	Delay due to distraction	Car Type: Sedan	Hatchback	Minivan	SUV	Truck	Other
1:48:20															
1:50:47															
1:51:54	✓						✓		✓				✓		
1:54:01			✓						✓	✓			✓		
1:57:45			✓				✓		✓			✓			
2:01:05	✓		✓						✓	✓					
2:02:36	✓		✓								✓				
2:05:15	✓		✓		✓				✓	✓			✓		
2:08:20			✓						✓	✓				✓	
2:13:12							✓		✓	✓					
2:15:46	✓		✓			✓			✓	✓					

Data Analysis Tool

- Collected 20 hours of data
- Video captures vehicles every 34.48 millisecond
- Processed over 2 million image frames and manually matched the vehicles recorded on the distraction log
- Developed a programming code to automate headway calculation



Data Analysis

1. Frequency and Types of Distraction Characteristics
2. Start-up Delay and Total Start-up Lost Time
3. Statistical Tests
   - Does distraction affect start-up headway?
   - Does start-up delay affect total lost time?
   - Are there differences between tech- and non-tech induced distractions?

Number of Vehicles and Distraction Observed

Overall

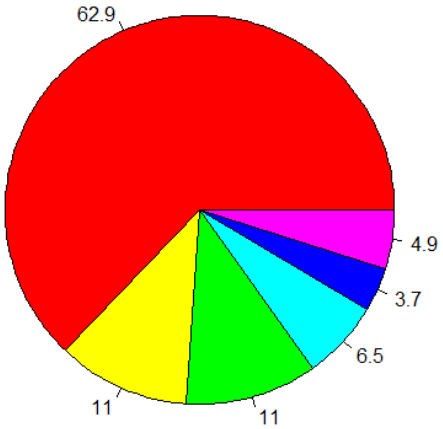
	# of cycles	# of vehicles	# distraction during red	# distraction during green
Matlock	131	2985	555 **(19% of total)**	200 **(7% of total & 35% of Red distraction)**
Pioneer	98	1876	419 **(22% of total)**	103 **(5% of total & 25% of Red distraction)**

By lane

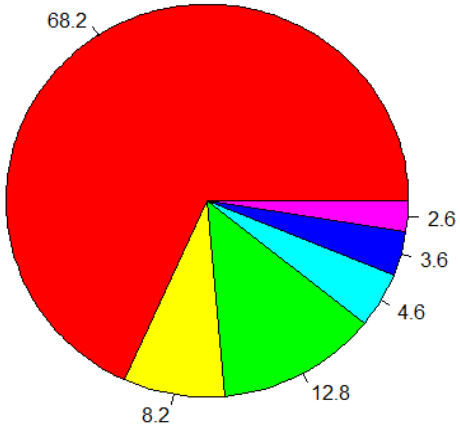
	Lane 1		Lane 2		Lane 3	
	# of vehicles	# of distractions Red (Green)	# of vehicles	# of distractions Red (Green)	# of vehicles	# of distractions Red(Green)
Matlock	1085	250 (87)	1012	200 (73)	888	115 (40)
Pioneer	660	161 (45)	673	153 (38)	543	105 (20)

Distraction Behavior in Each Lane (Matlock)

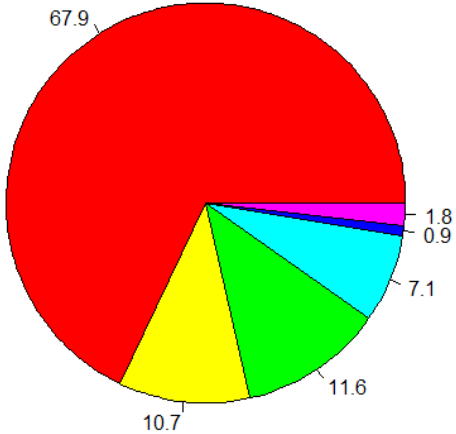
Lane 01

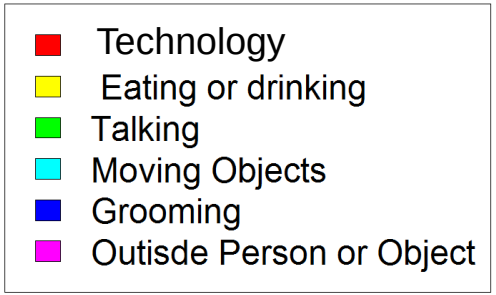


Lane 02



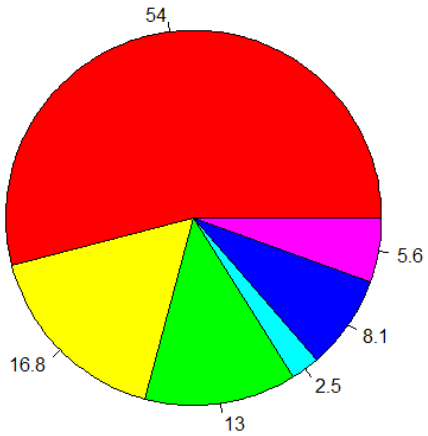
Lane 03



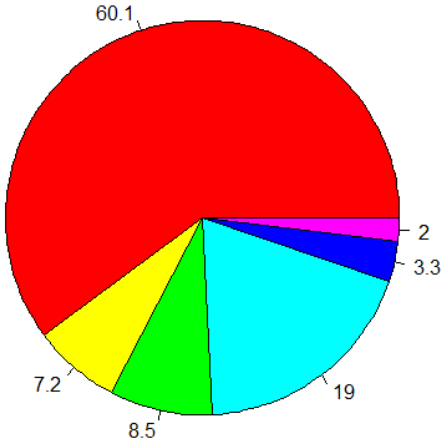


Distraction Behavior in Each Lane (Pioneer)

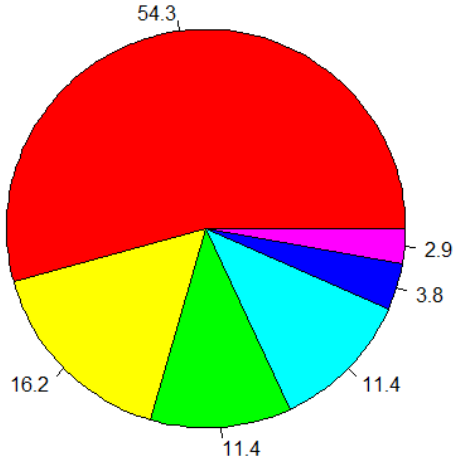
Lane 01

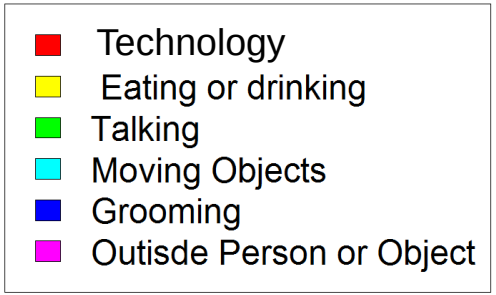


Lane 02

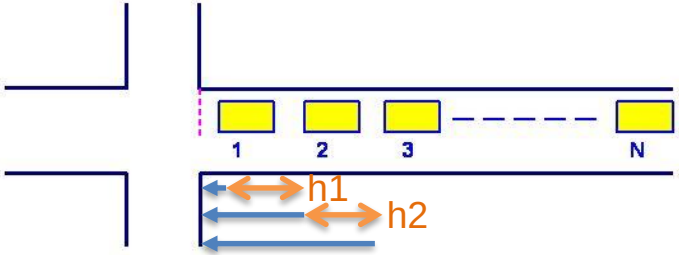


Lane 03

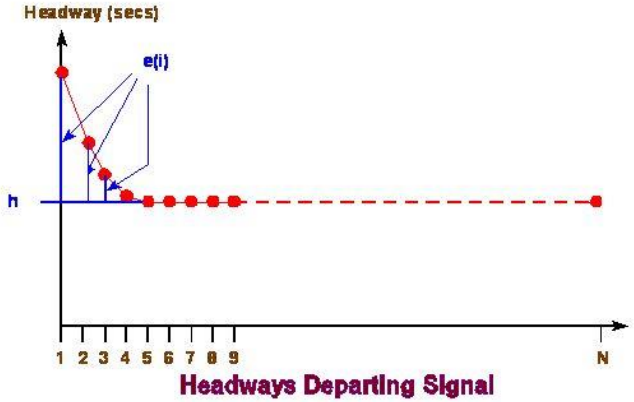




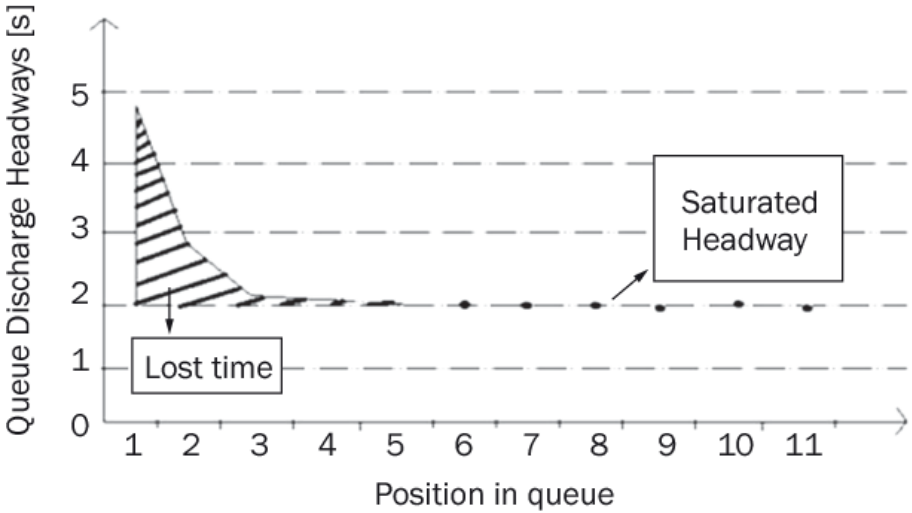
Start-up Lost Time



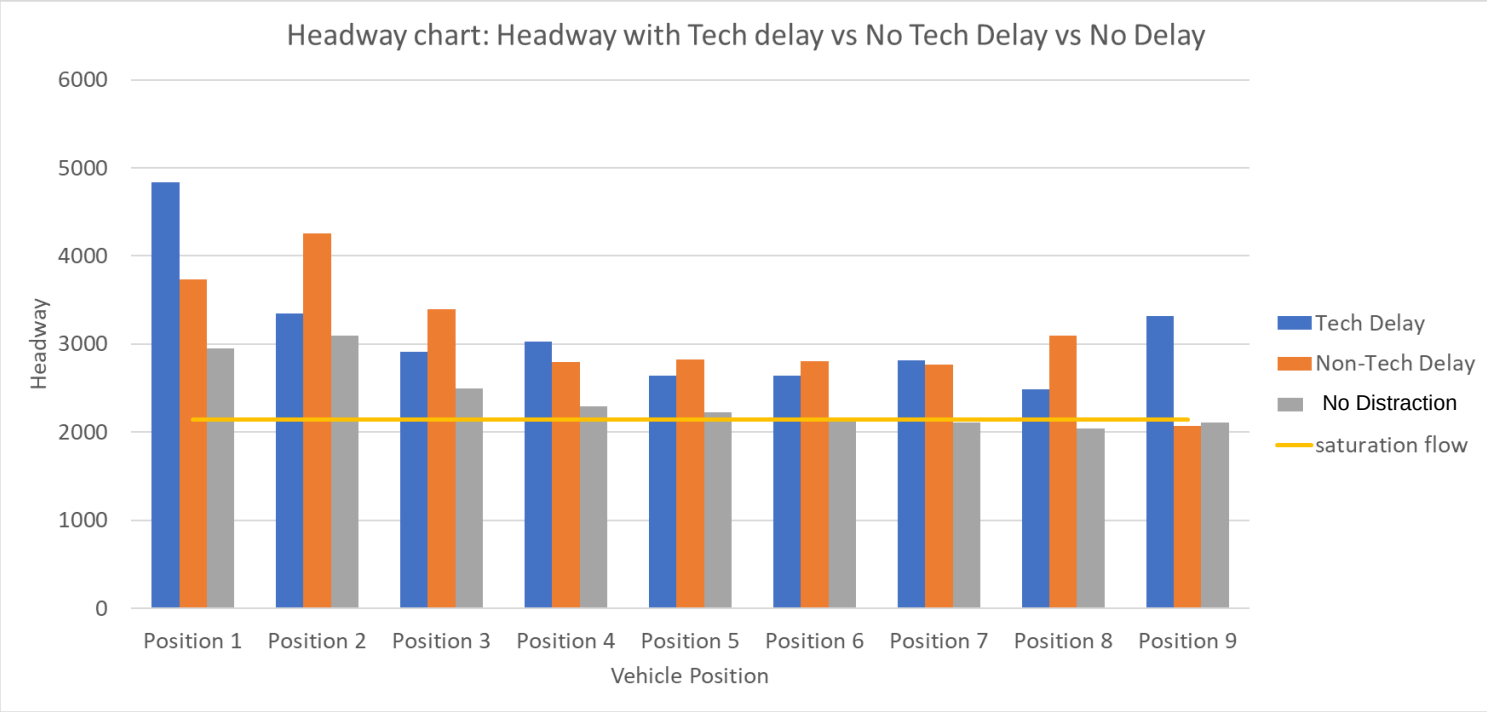
Vehicles at an Intersection Queue



Headways Departing Signal

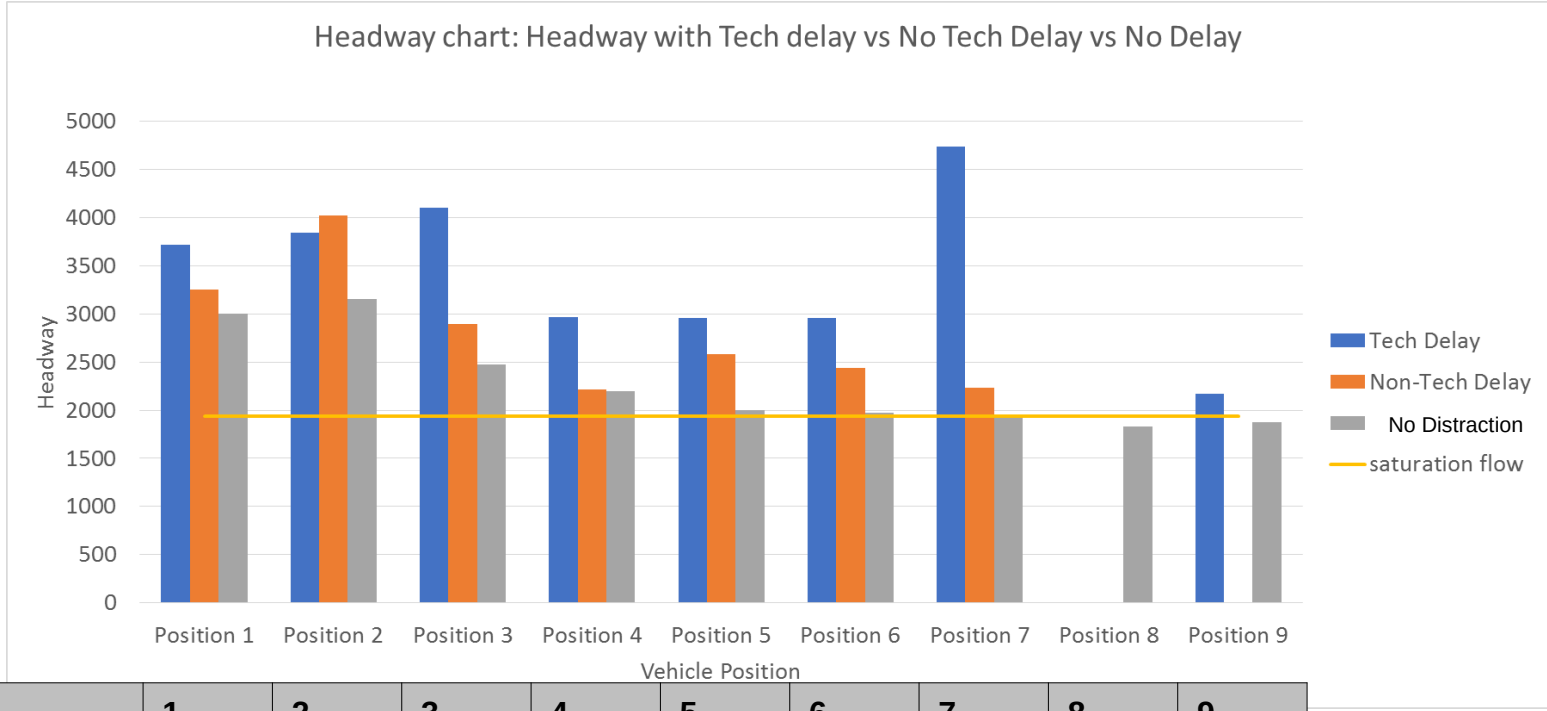


Vehicle Headway (Matlock)



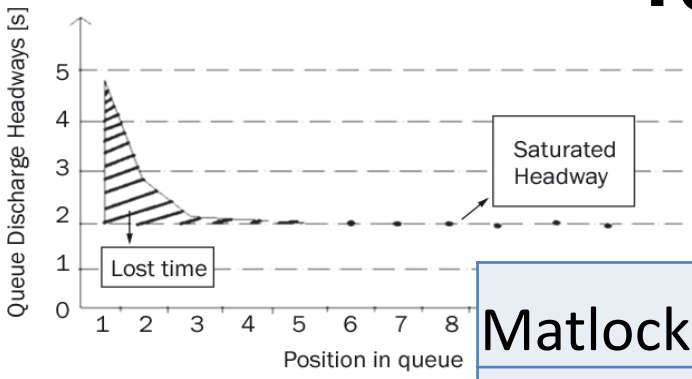
N	1	2	3	4	5	6	7	8	9
Tech Delay	12	15	14	17	23	17	13	8	3
Non-tech Delay	5	9	7	16	7	8	7	3	1
No Delay	305	328	310	282	251	206	161	124	83

Vehicle Headway (Pioneer)



N	1	2	3	4	5	6	7	8	9
Tech Delay	4	12	13	12	4	8	1	0	2
Non-tech Delay	7	10	11	3	4	6	1	0	0
No Delay	230	216	199	163	125	106	88	64	47

Total Lost Time

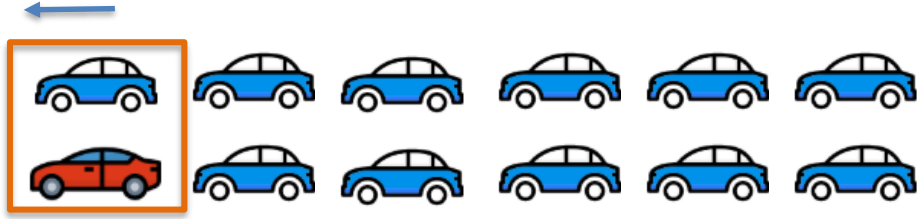


Matlock	Mean Lost Time	Std dev	Max Lost Time
No distraction	2189	1057	5076
Distraction	3056	1342	6677
Distraction and Non-distraction	2517	1360	6677

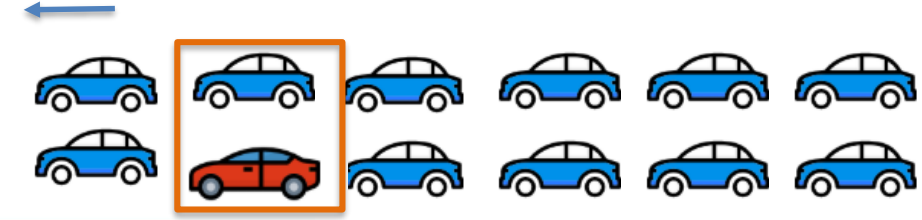
Pioneer	Mean Lost Time	Std dev	Max Lost Time
No distraction	3083	883	5320
Distraction	3666	1129	5353
Distraction and Non-distraction	3579	1073	5353

Statistical Tests – Start-up lost time comparisons by vehicle position

Vehicle position 1 comparison



Vehicle position 2 comparison



The statistical test examines whether …

H_0 : Drivers distraction has **no** impact on headway departing signal

$$Mean\ Headway_{\ distraction} = Mean\ Headway_{No\ distraction}$$

Or,

H_1: Drivers distraction **increases** headway departing signal

$$Mean\ Headway_{distraction} > Mean\ Headway_{No\ distraction}$$

		Pioneer		Matlock	
		Distraction	No distraction	Distraction	No distraction
position 1	Mean	1417 (N= 10)	1066(N= 230)	1584(N= 17)	807 (N= 305)
	P-value	0.09		0.0003	
	Result	Distraction increases headway		Distraction increases headway	
Position 2	Mean	1883(N= 23)	1218(N= 216)	1477 (N= 22)	950(N= 328)
	P-value	0.0009		0.005	
	Result	Distraction increases headway		Distraction increases headway	
Position 3	Mean	1311(N= 24)	533(N= 198)	930(N= 21)	350(N= 310)
	P-value	0.000		0.007	
	Result	Distraction increases headway		Distraction increases headway	
Position 4	Mean	952(N= 15)	258(N= 162)	765(N= 40)	153(N= 282)
	P-value	0.000		0.001	
	Result	Distraction increases headway		Distraction increases headway	

Use 10% significance level

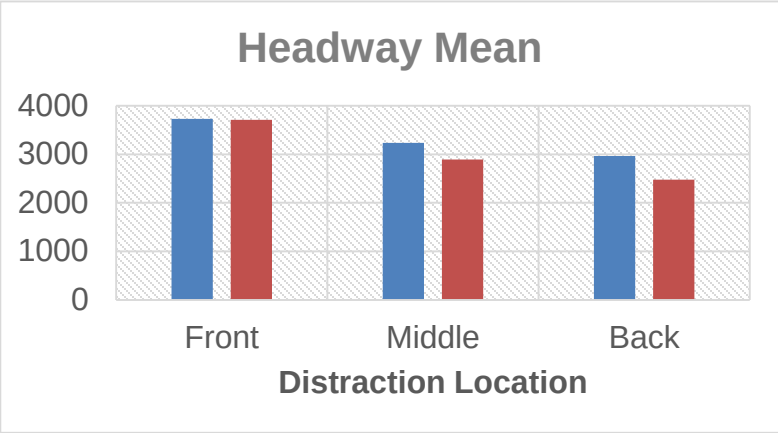
Headway comparisons between technology induced distraction vs non-technology induced distraction

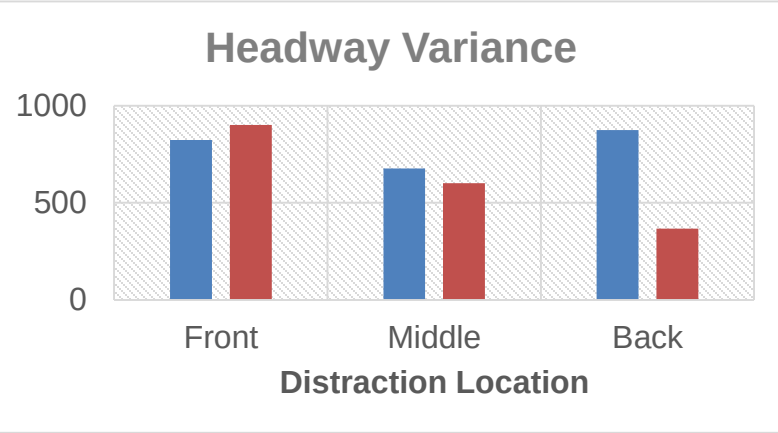
VS

Tech Distraction Non-Tech Distraction

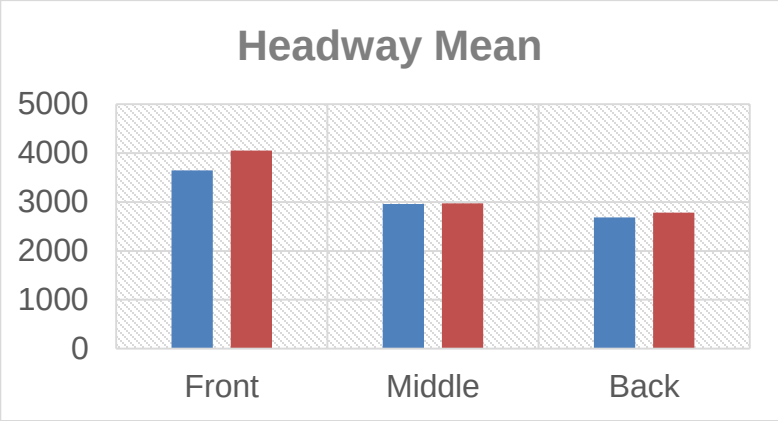
Front: Vehicle position 1&2, Middle 3&4, Back 5+

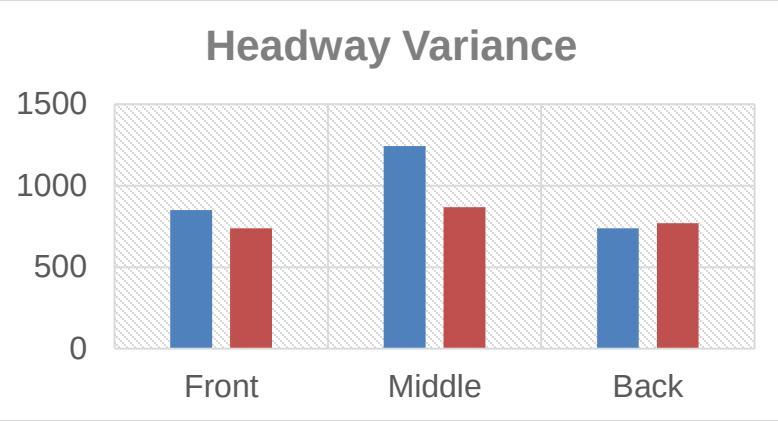
Pioneer



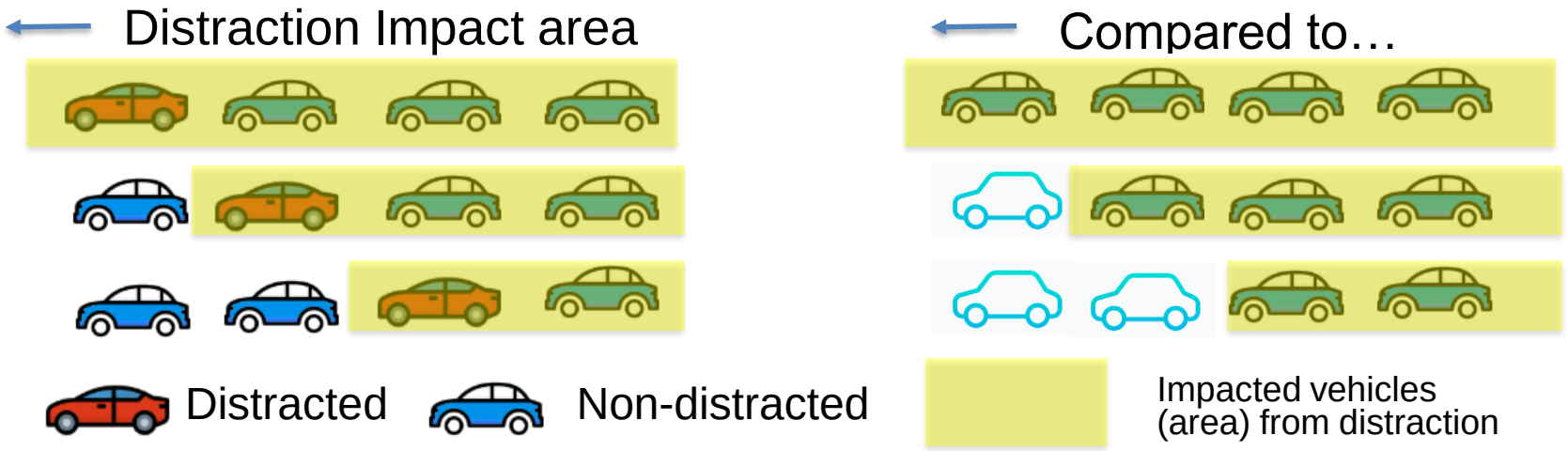


Matlock





Statistical Tests – Start-up lost time comparisons for aggregated vehicles



Hypothesis

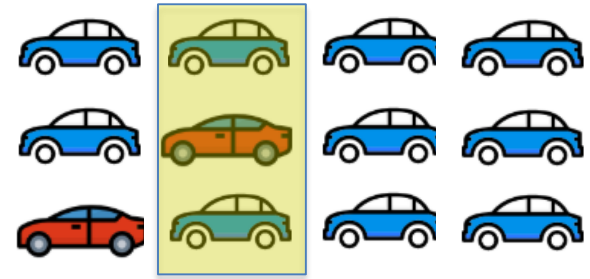
H_1: Start up lost time is higher when a lead vehicle is distracted than no vehicles are distracted in the impact area

Statistical Tests – Start-up lost time comparisons for aggregated vehicles

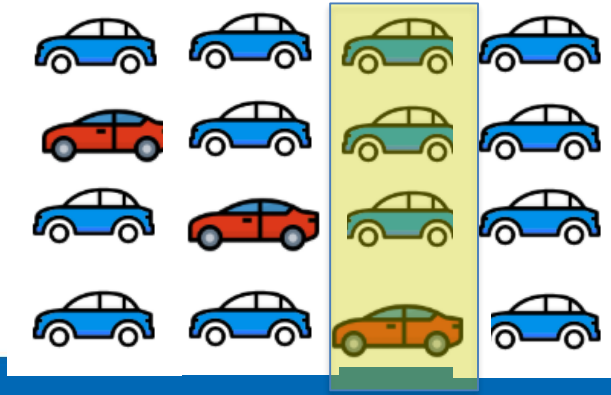
		Pioneer		Matlock	
		Distraction	No distraction	Distraction	No distraction
Vehicle 1-4	Mean	3666(N= 14)	3083 (N= 118)	3056 (N= 17)	2189 (N= 218)
	P-value	0.0407		0.0090	
	Result	Distraction causes higher loss		Distraction causes higher loss	
Vehicle 2-4	Mean	3394 (N= 21)	2062 (N= 117)	2145 (N= 22)	1313 (N= 218)
	P-value	0.0010		0.0023	
	Result	Distraction causes higher loss		Distraction causes higher loss	
Vehicle 3-4	Mean	1752(N= 24)	845(N= 117)	1185 (N= 21)	486 (N= 218)
	P-value	0.0000		0.0097	
	Result	Distraction causes higher loss		Distraction causes higher loss	

Start-up lost time comparisons by vehicle & delay positions

Vehicle position 2



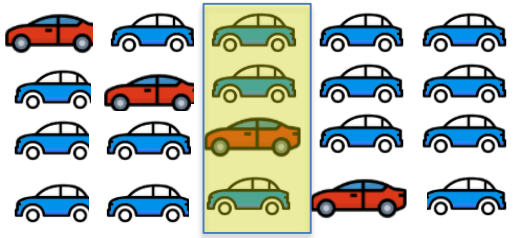
Vehicle positon 3



- The analysis investigates the relationships between vehicle position and distraction location

Headway comparisons by vehicle & delay positions (Pioneer)

Mean Headway



	Position 1	Position 2	Position 3	Position 4	Position 5 to 9
Delay at 1	3357	3401	2962	2208	2271
Delay at 2	3005	3823	2985	2342	2294
Delay at 3	3005	3158	3251	2382	2118
Delay at 4	3005	3158	2472	2892	2488
Delay at 5	3005	3158	2472	2198	2757

Non-Distraction	3005	3158	2472	2198	

Vehicle distracted

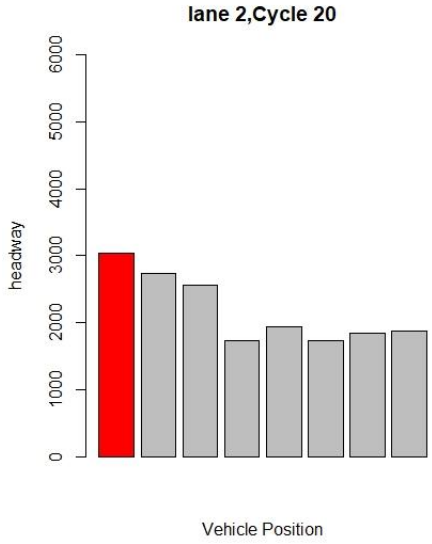
Remaining Tasks

- Complete 3rd intersection data analysis
- Focus on how truck presence and vehicle distraction affect start-up delay

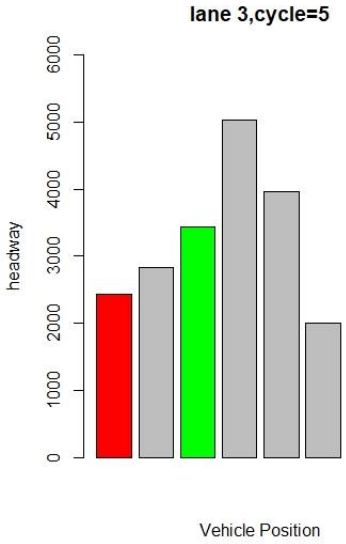
No truck in queue and 1st vehicle distraction	1 truck in queue and 1st vehicle distraction	2 trucks in queue and 1st vehicle distraction

Some Headway Patterns

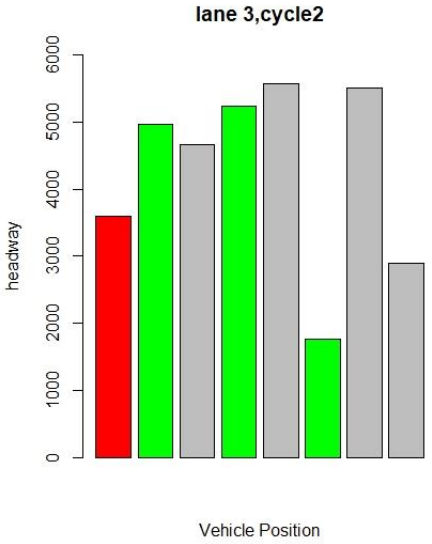
No truck

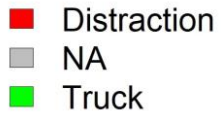


1 truck



2 trucks





Recommendation

- Understand the impact of uncertainty/high variance of start-up lost time
- Investigate safety and environmental impacts
- Additional analysis – Impact on platoon dispersion and progression
  - Will green band decrease when considering progression through multiple intersections?
  - Differences for fixed vs. actuated

Thank you

UNIVERSITY OF TEXAS ARLINGTON