June 19 - 20, 2025
Hollywood, FL

TRANSPORTATION SYMPOSIUM

TRIP GENERATION STUDY FOR COFFEE SHOP WITH DRIVE-THROUGH AND FAST FOOD WITH DRIVE-THROUGH

Drew Roark, PE, CTL, Alex Roark Engineering

Transportation Symposium Website

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Project Objectives

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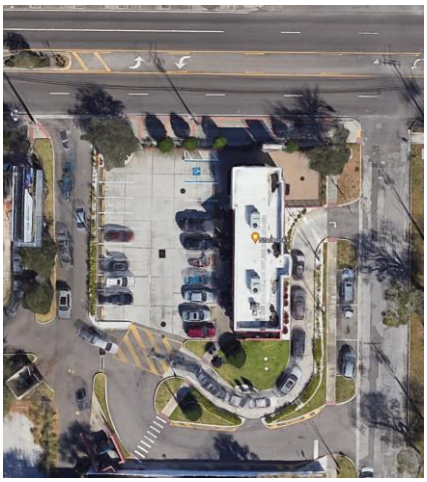
Project Benefits

Qualitative:

- A better understanding of trip generation and operational characteristics of these land uses in varying situations.

Quantitative:

- Specific requirements for approval (or denial) of new driveway permits for these land uses.



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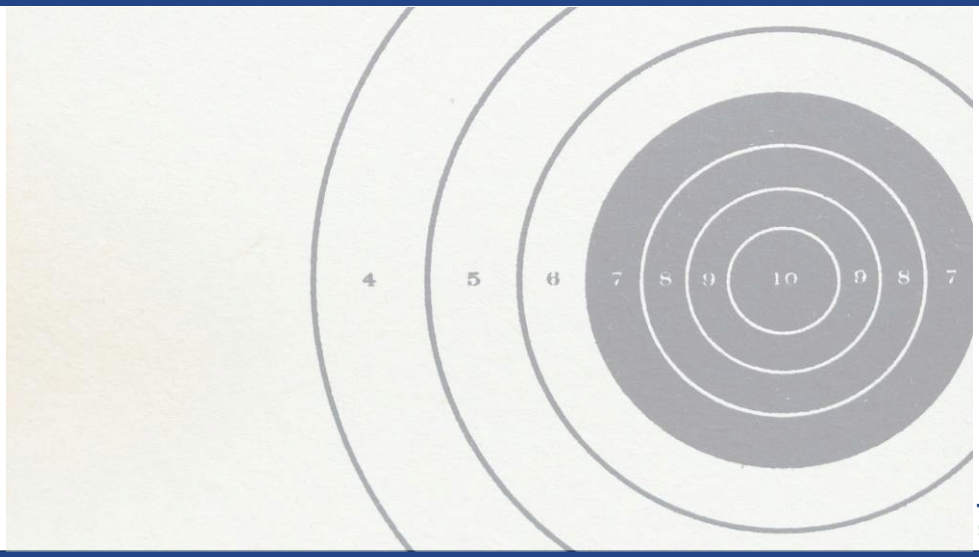
Scope



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Task 1 – Literature Review

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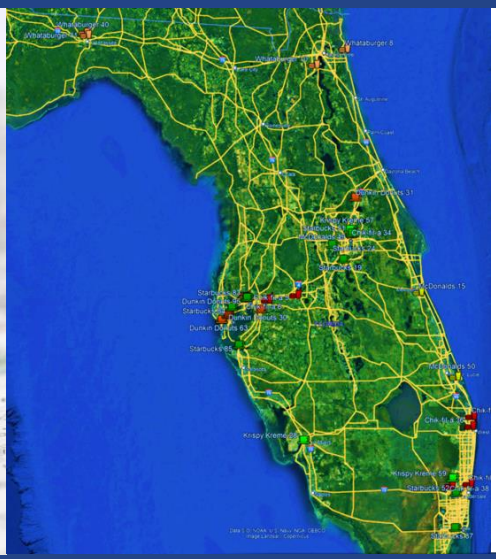
Task 2 – Site Selections



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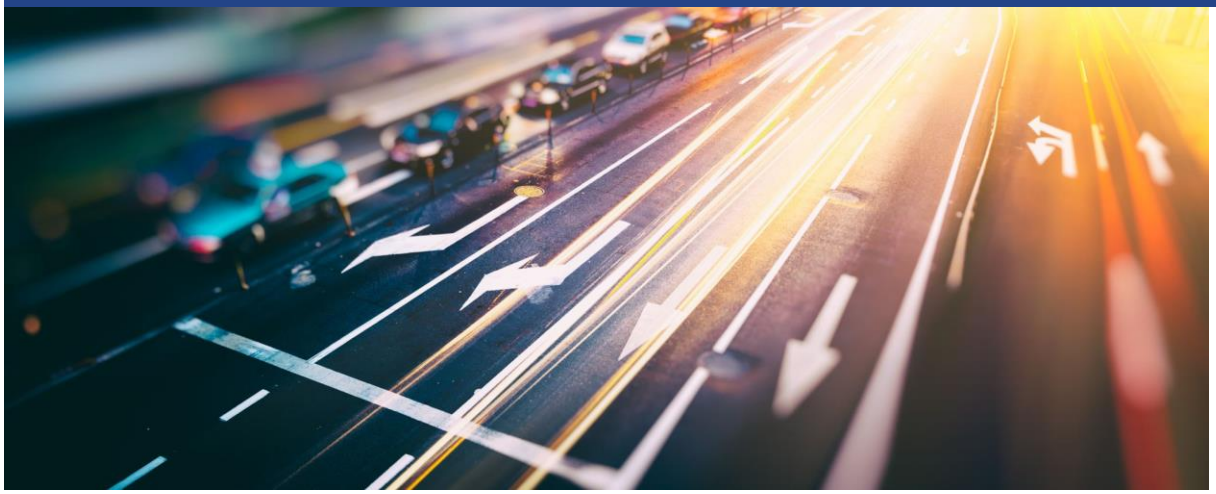
Task 3 – Traffic Data Collection



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Just the Facts

- For fast food restaurants we sampled 2,347 vehicles utilizing the drive through
- A total of approximately 24,000 vehicles (roughly 10%)
- Coffee shops included 1,157 samples in the drive through
- Generally recorded information:
  - Time of arrival at order station
  - Time order was completed
  - Time vehicle arrived at payment station (if applicable), and if the vehicle was “inhibited” by a vehicle ahead
  - Time payment transaction was completed (if applicable)
  - Time of arrival at pickup station (in some cases, this would be the time an attendant brought the order to the vehicle), and if the vehicle was “inhibited” by a vehicle ahead
  - Time of departure from the pickup lane

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Task 4 – Data Analysis

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Conditions We Saw

- Demands are higher than historically seen.
- At Fast-Food average 60% (range 25% to 95%) of entering vehicles use drive-through.
- At Coffee/Donut Shops average 62% (range 26% to 85%) of entering vehicles use drive-through .
- Some use of internet ordering in advance.
- Multi-lane ordering, multi-lane pickup operations.

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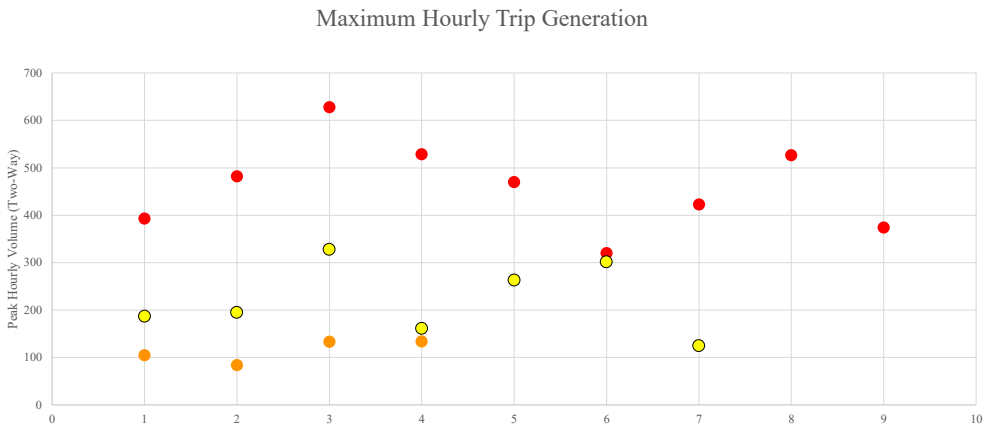
Actual Trip Generation



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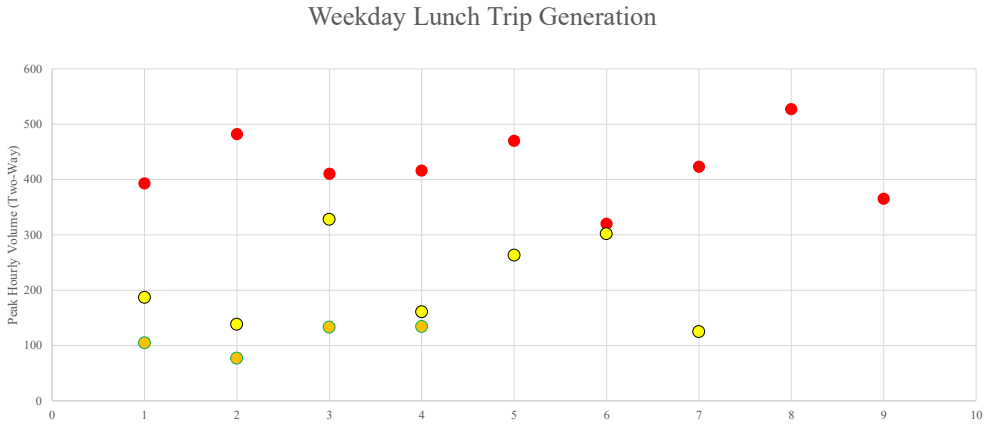
Weekday Lunch (highest) Trip Generation



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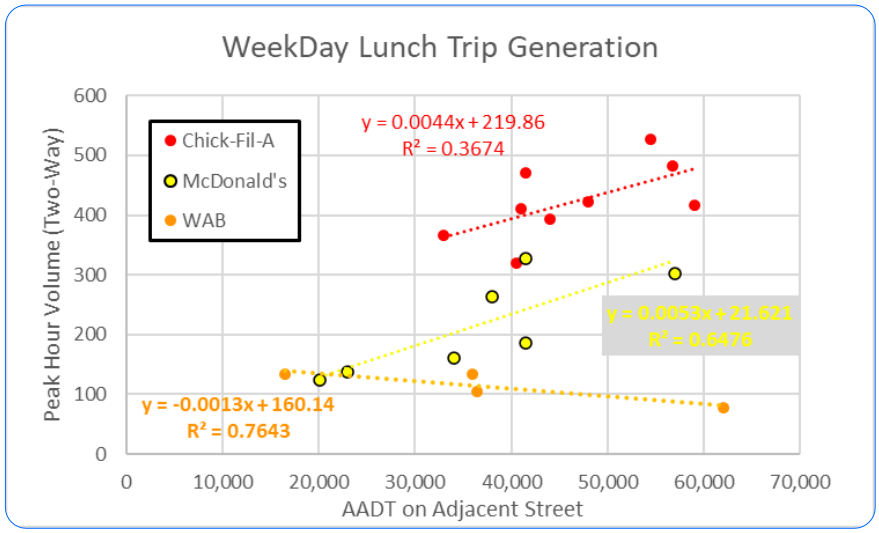
Weekday Lunch (highest) Trip Generation



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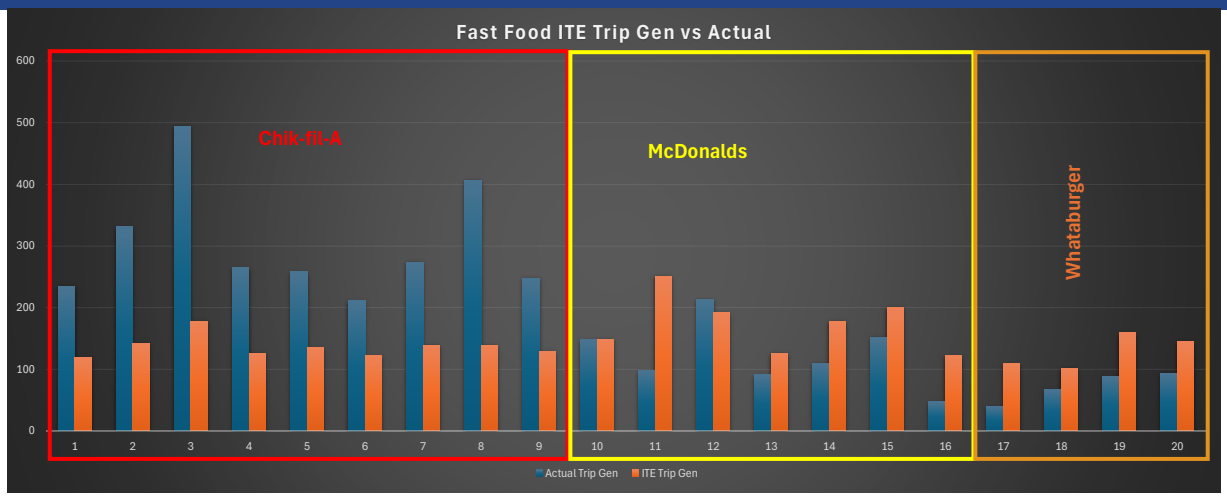
ITE vs. Actual – Fast Food



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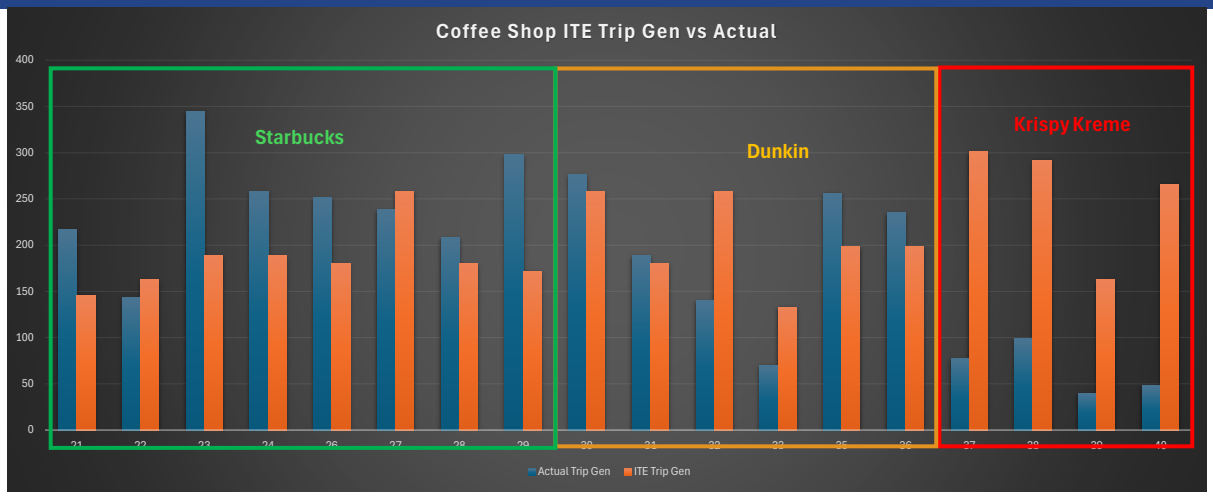
ITE vs. Actual – Coffee Shop



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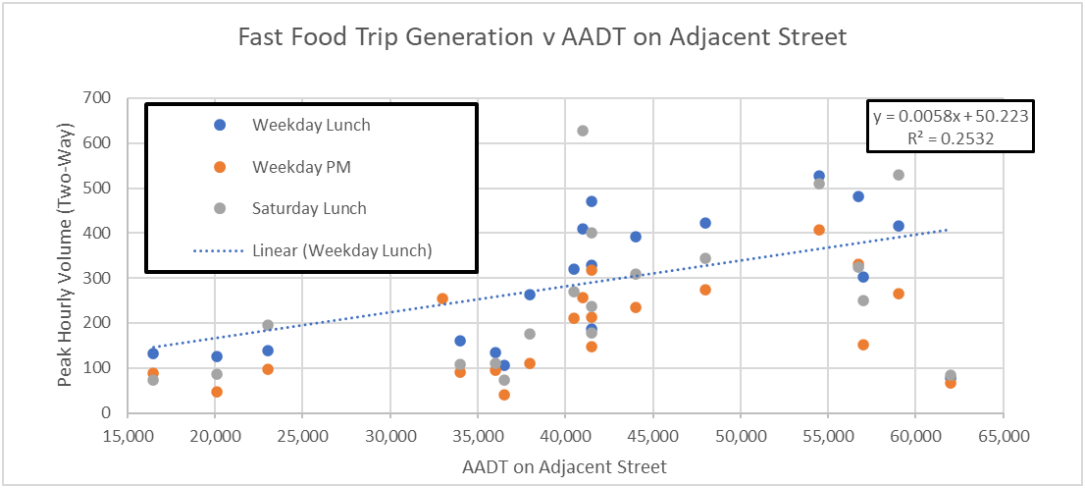
Is Adjacent Street Volume a Better Independent Variable?



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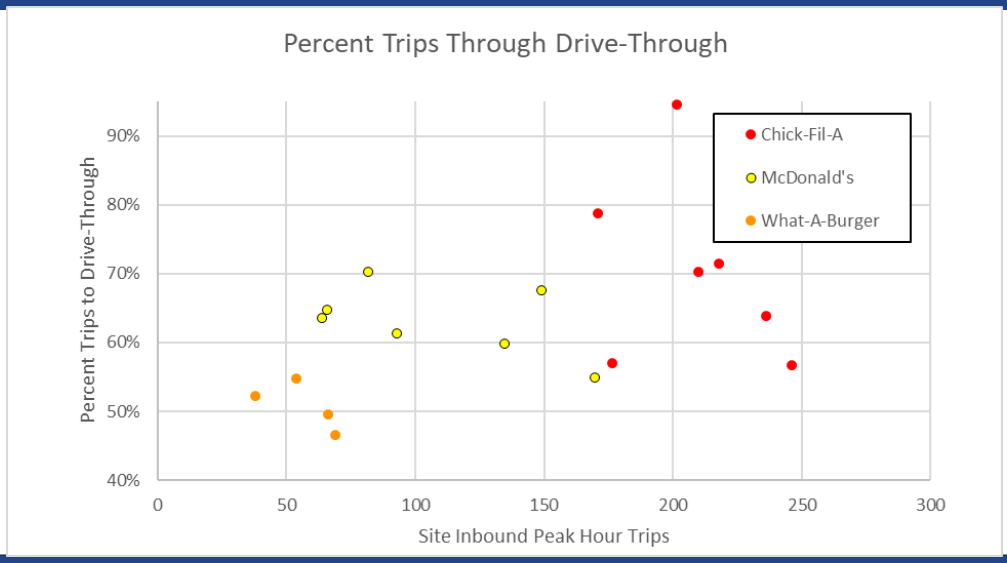
Queueing – Drive-Through Usage



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How To Estimate Queue Length

Queue lengths depend on three factors:

- Rate and duration of arrivals (e.g. trip generation). More arrivals, longer queues.
- Rate at which orders are filled and vehicles depart. Faster rate shortens queues.
- Lengths of vehicles in queue.

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How to Estimate Queue Length

Arrival Rates

- At Fast-Food Restaurants ranged from 40 To 628 veh/hr, averaged 245
- At Coffee-Donut Shops ranged from 22 To 485 veh/hr, averaged 199

Service Rates

- At Fast-Food Restaurants ranged from 21 To 205 veh/hr, averaged 86
- At Coffee-Donut Shops ranged from 33 To 107 veh/hr, averaged 73

Conclude: Different restaurants have different operating styles. These parameters even vary within store brands. **Cannot generalize**.

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How to Estimate Queues

We tried different methods:

- Applied classical equations
- Applied micro-simulation

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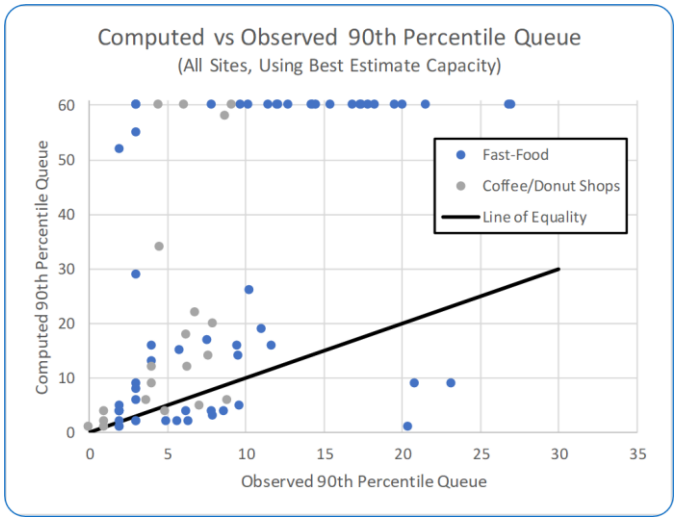
Application of Classical Equations



- RMS error > 30.24

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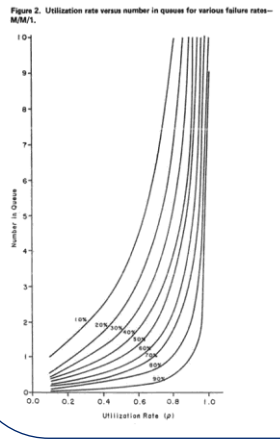
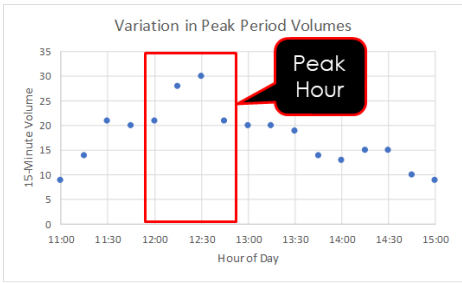
Classical Equations Don't Do a Good Job

- As volume:capacity ratios approach 1.00, queues increase exponentially. For queues to increase exponentially, vehicles need to arrive exponentially. But demands fall off after the peak period, and queues dissipate.





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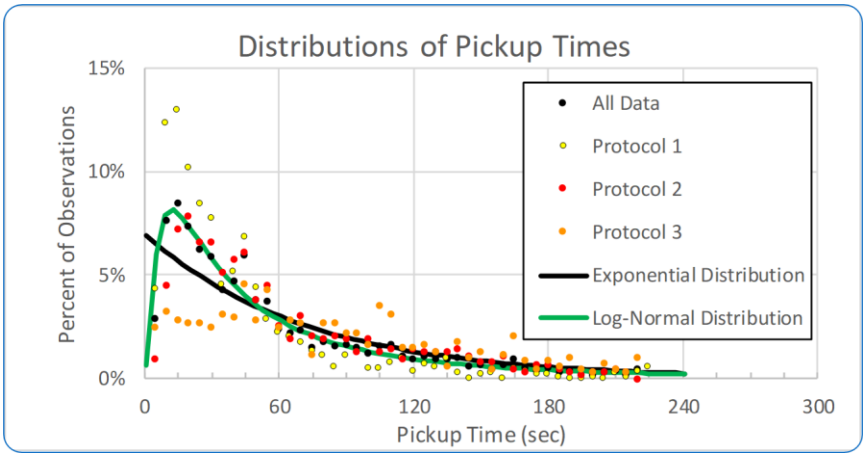
Classical Equations Don't Do a Good Job

- They are based on a "negative exponential" distribution of service times, actual service times follow a "log-normal" distribution.



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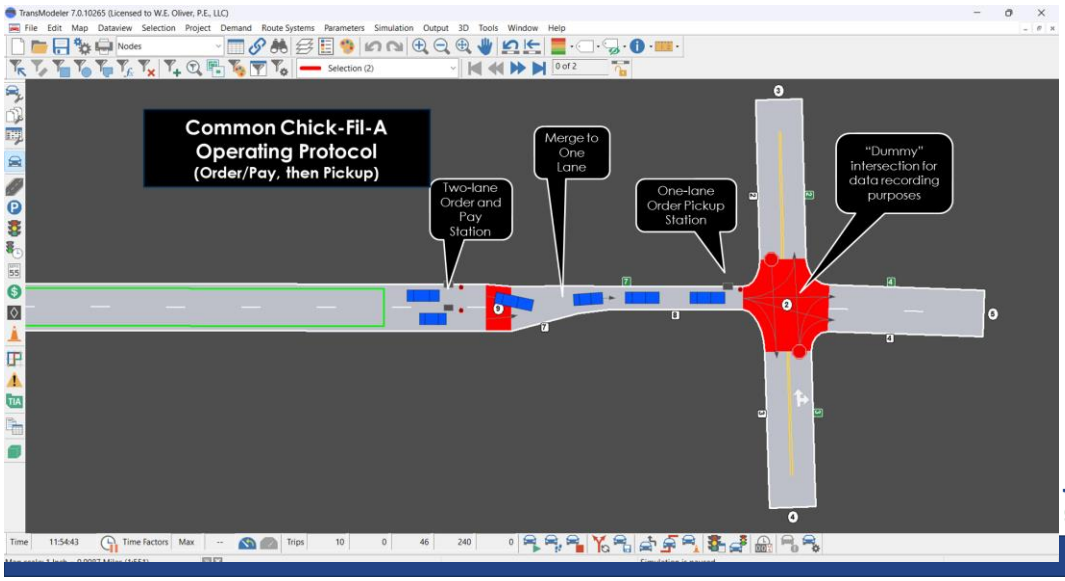
Simulation Setup



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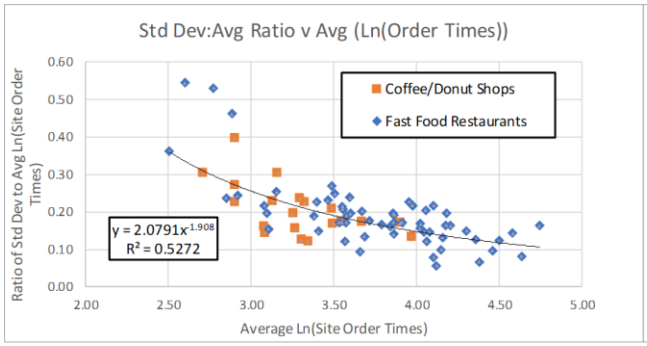
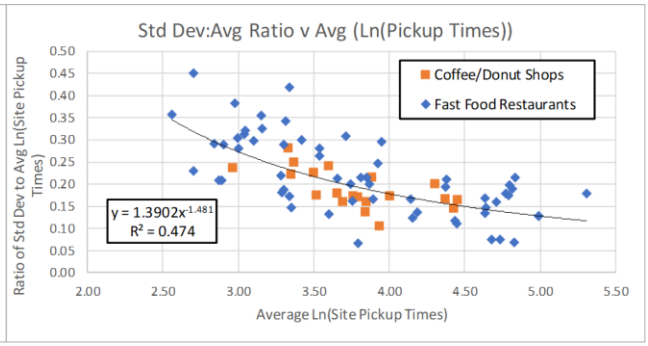
Natural Log Better Fit





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Service Time Distributions Into Simulation

Unique, log-normally-distributed service time distributions can be entered into TransModeler

Service Time Distributions for TransModeler

			Order Times				Pickup Times			
		Average:	47.0	42.5	54.3	75.1	27.9	40.3	55.7	144.0
		Standard Dev:	34.47	41.22	38.10	65.42	25.60	37.46	45.14	118.49
		Capacity:	77	85	66	48	129	89	65	25
Trans Modeler Table Row	Percentile	% to which Applicable	Order Time 1	Order Time 2	Order Time 3	Order Time 4	Pickup Time 1	Pickup Time 2	Pickup Time 3	Pickup Time 4
1	2%	3.5%	6.9	2.0	12.0	2.0	3.0	3.0	7.0	12.9
2	5%	4.0%	9.2	3.0	13.8	4.0	5.0	5.0	9.0	26.6
3	10%	4.5%	13.0	6.0	17.0	8.0	7.0	9.0	14.0	37.3
4	14%	5.5%	15.0	10.0	20.0	20.0	8.0	11.0	16.2	43.0
5	21%	5.5%	19.0	16.0	24.0	28.0	10.2	15.0	21.0	52.0
6	25%	6.0%	21.0	18.5	27.0	32.0	12.0	16.0	24.0	61.0
7	33%	6.5%	26.0	24.0	32.0	42.0	14.0	21.0	30.0	77.7
8	38%	5.5%	30.0	29.0	35.1	47.0	16.0	23.0	34.0	88.0
9	44%	6.0%	34.0	32.0	40.0	54.0	18.0	25.8	38.0	100.0
10	50%	6.0%	37.0	35.0	46.0	60.0	20.0	29.0	42.0	109.0
11	56%	6.0%	41.0	39.0	51.0	67.0	23.0	35.0	49.0	125.0
12	62%	5.5%	48.0	43.0	55.9	74.0	26.0	39.0	53.9	142.3
13	67%	5.5%	54.0	48.0	60.0	84.0	29.0	42.8	59.0	158.0
14	73%	5.5%	60.1	55.0	68.0	100.0	35.0	47.0	68.0	180.0
15	78%	5.0%	67.0	60.0	75.5	109.5	39.3	52.6	80.5	209.0
16	83%	5.0%	77.0	69.0	84.0	124.0	44.5	61.0	92.0	237.2
17	88%	5.0%	90.0	79.6	96.0	142.5	53.0	78.0	106.2	269.4
18	93%	4.5%	105.0	96.1	114.8	174.0	65.0	102.0	126.6	340.4
19	97%	3.0%	133.4	122.7	140.7	225.4	89.0	135.9	169.5	419.6
20	99%	2.0%	161.6	176.1	203.5	310.2	134.6	191.0	238.0	592.2
		100.0%								

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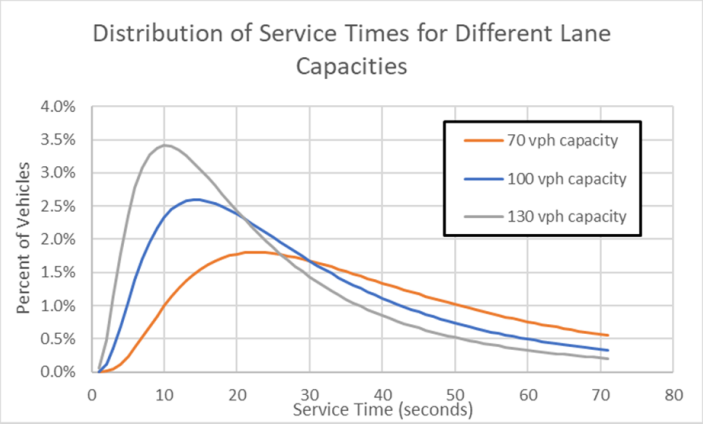
Lane Capacity and Service Time Distributions

- As capacity increases, distribution of service times "tightens up"



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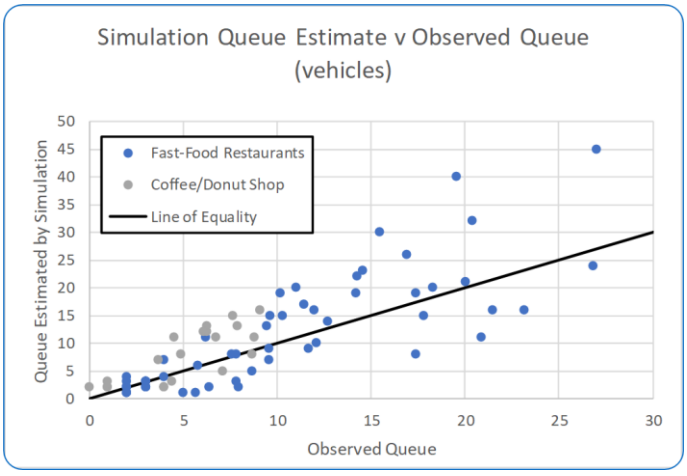
Application of Micro-Simulation

- RMS error = 5.5 veh
- (compared to >30.24)



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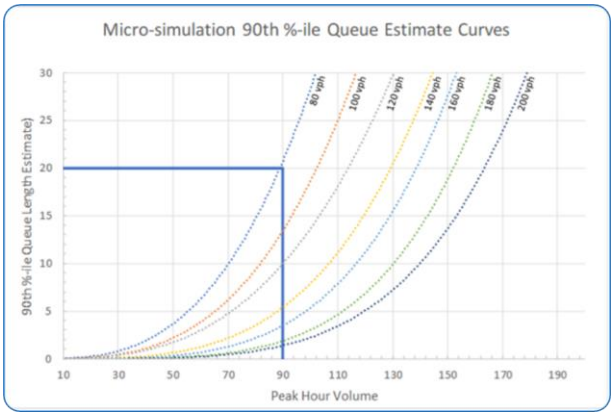
Queue Length based on Volume and Service Rate

Queue Length in Vehicles as a Function of Peak Hour Volume and Service Rate

Peak Hour Volume	Service Rate (veh/hr)>>>>>>>									
	2	1.5	1.2	1	0.86	0.75	0.67	0.6	0.55	0.5
	30	40	50	60	70	80	90	100	110	120
20	0	0	0	0	0	0	0	0	0	
40	12	3	0	0	0	0	0	0	0	
60	61	32	11	5	1	0	0	0	0	
80	113	77	49	26	12	7	2	0	0	
100		131	96	65	43	21	13	8	3	0
120				115	83	60	38	20	15	10
140					135	100	78	55	33	22
160						153	118	94	72	49



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Lessons

- Popularity among different brands varies dramatically, therefore trip generation rates vary dramatically.
- Using ITE Trip Generation for estimates may not be accurate by brand
- Peak hours for fast food are weekday lunch hour, however traffic impact analysis is typically weekday PM Peak Hour

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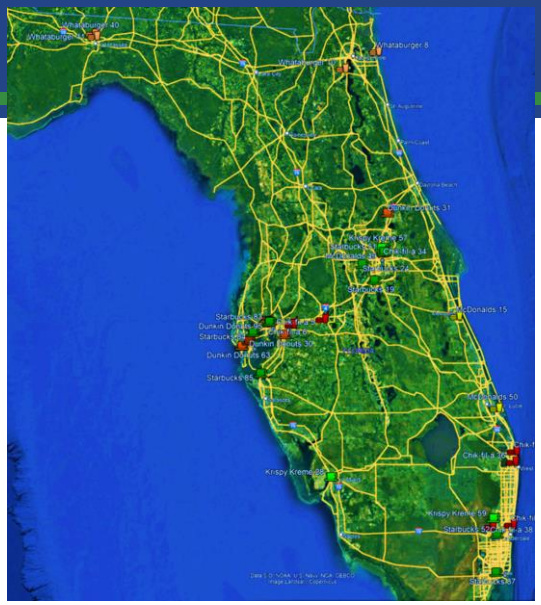
Lessons

- Through the pandemic, drive-throughs have seen dramatic changes (increased usage)
- No updates in traffic engineering queuing theory since the 70s. Queueing equations focused on roadway/intersections.
- Performance in drive throughs (service times) vary dramatically
- Different restaurant chains have different operating procedures



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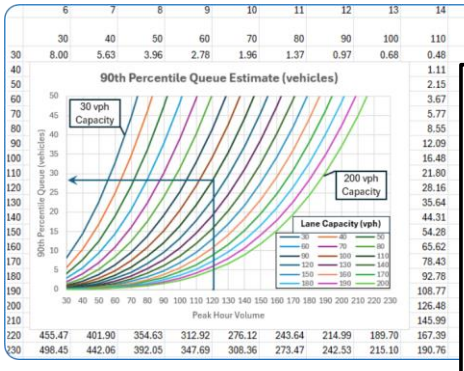
Implementation Item – "QTool"

- Excel based tool to estimate drive through queues for these land uses based on this research



Project Information	
Provide general project information for reference purposes only.	
Project Name:	Starbucks
Closest Intersection:	US 41 @ Blackburn Point Rd
Agency:	FDOT
Reference Number:	Project # 12345
City:	Venice
State:	Florida
Date:	10/7/2024
Analyst:	Roark

Total Queue Storage Available (ft):	350	feet
Drive-Through Lane Arrival Rate:	90	vph
Bottleneck Service Lanes:	1	lane(s)
Bottleneck Capacity per Lane:	80	vph
System Capacity:	80	vph
90th Percentile Queue (veh):	24.0	<<<Total queue in all lanes.
Average vehicle length in queue:	25	feet/vehicle
Total Queue Length (ft):	600	feet

Results
Expected queue exceeds queue storage.

Drive-Through Lane Queue Estimate Tool

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Safety Message

- Queue spillover from these types of sites with drive-throughs can create safety issues with the adjacent transportation facilities including the roadways and bike and pedestrian facilities.
- Ensuring that adequate queue storage is provided at the planning phase of a development project may prevent these safety issues from occurring.
- This research has developed an easy-to-use tool to better estimate the queues at these sites.

"LET'S GET EVERYONE HOME SAFELY"

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Contact Us

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- PI: Drew Roark, PE, CTL, Alex Roark Engineering
  - drew@alexroarkeng.com or 850.567.2044

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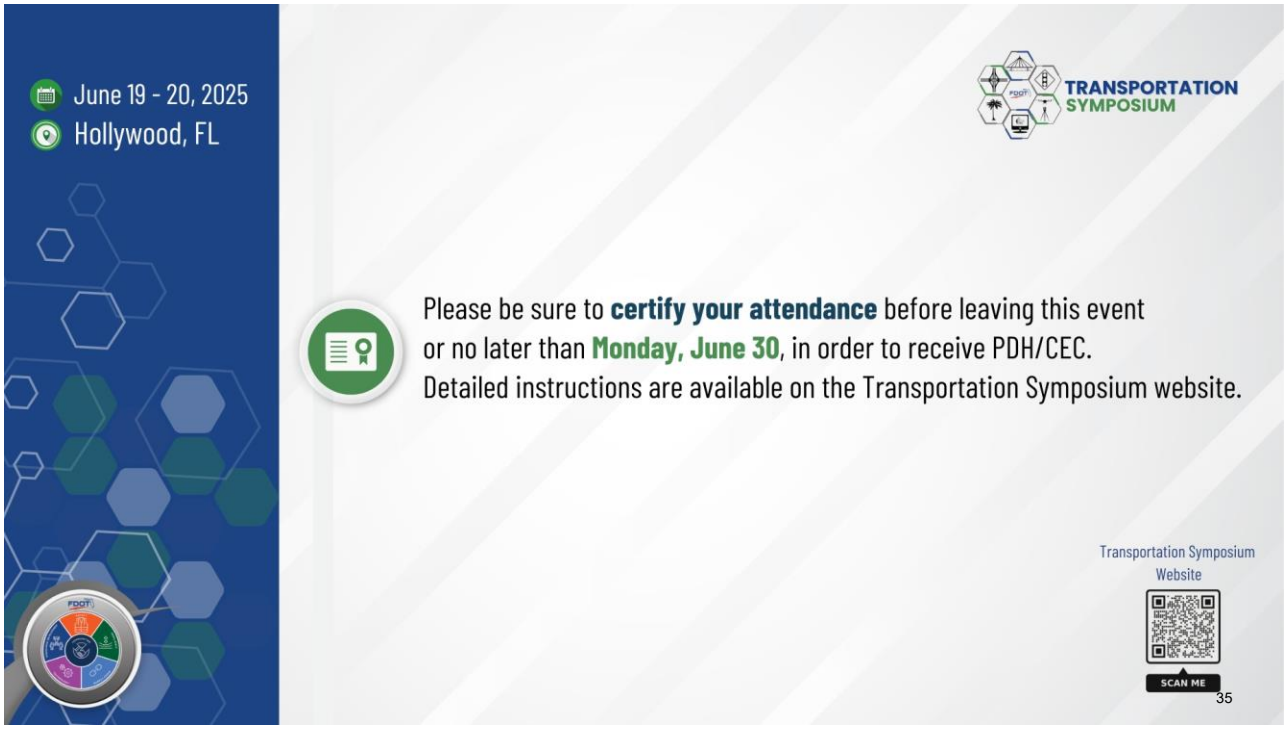
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