Costco Gas Station Simulation Analysis & Modeling

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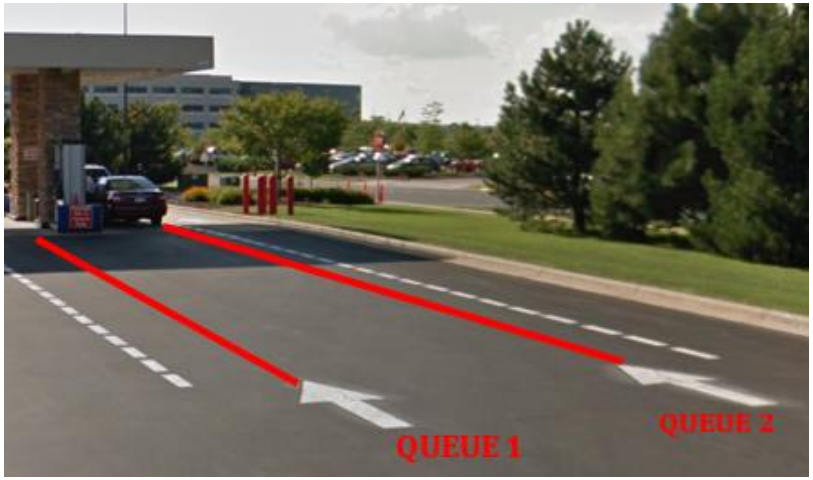
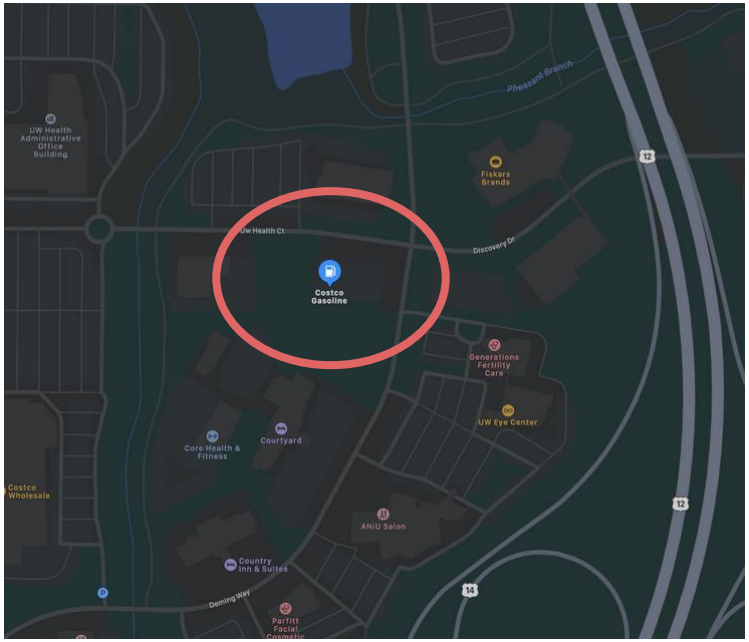
Introduction

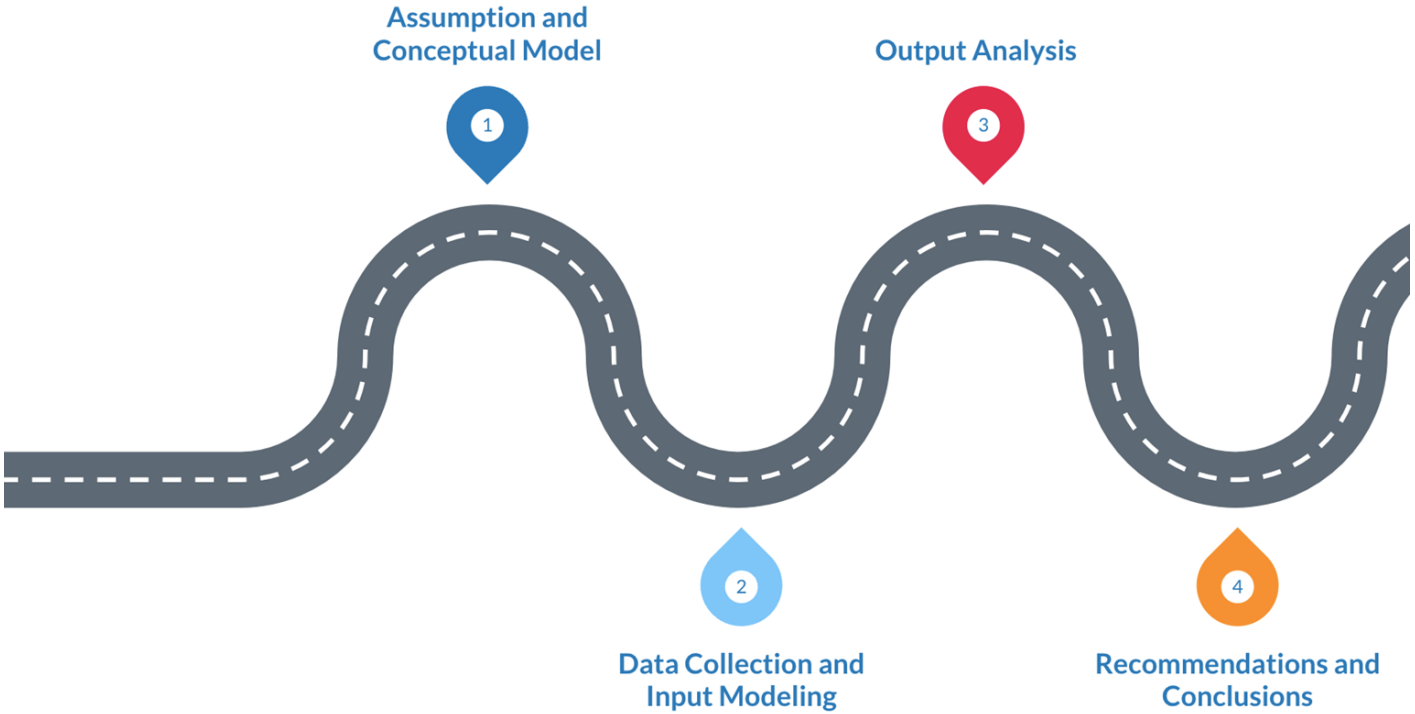
My Objectives

1. to build an Arena model that accurately represents the Costco gas station system
2. to propose and compare potential system improvements, and
3. to provide a final recommendation on the best feasible alternative system.





Roadmap


Assumption and Conceptual Model
1
Output Analysis
3
2
Data Collection and Input Modeling
4
Recommendations and Conclusions

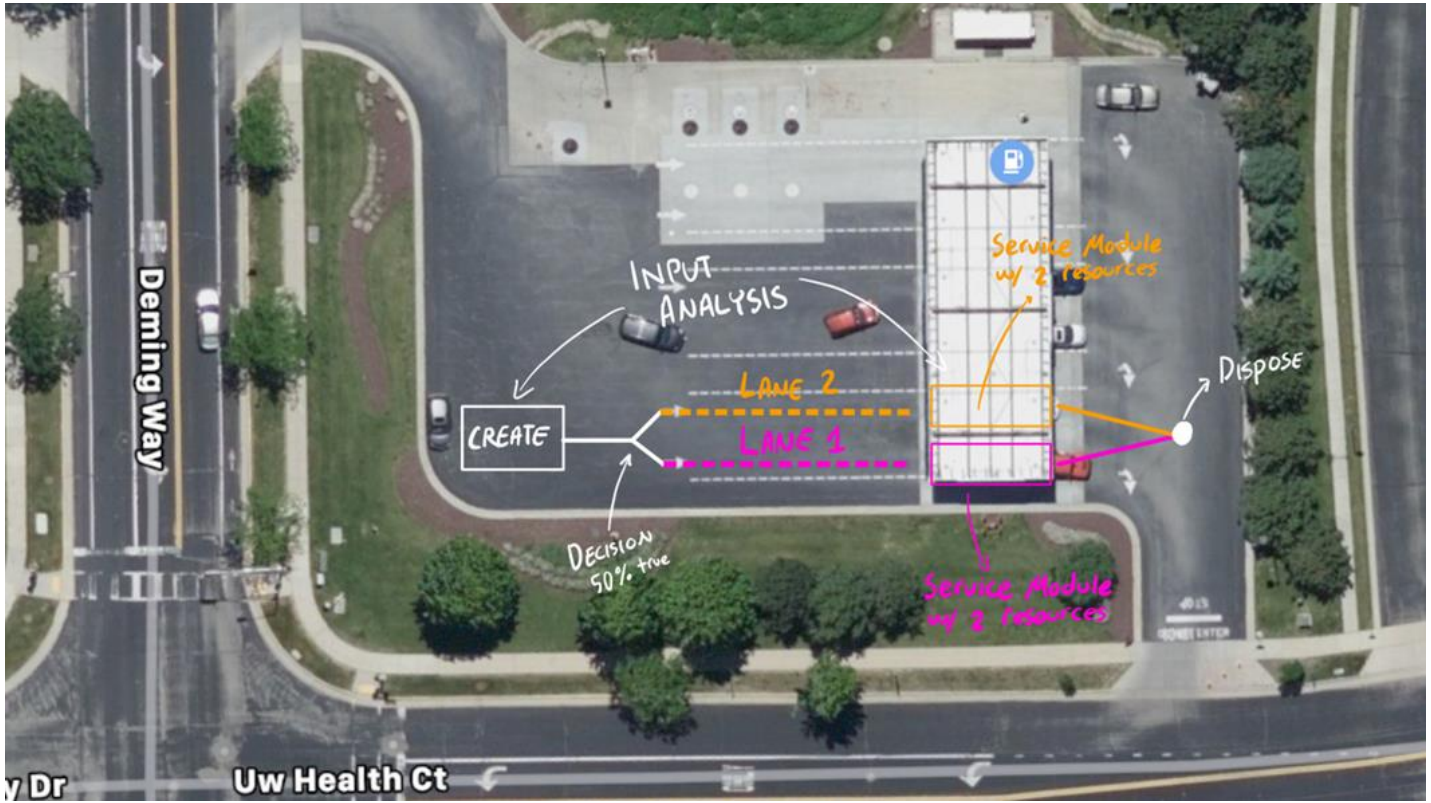
1.

Assumptions and Conceptual Model

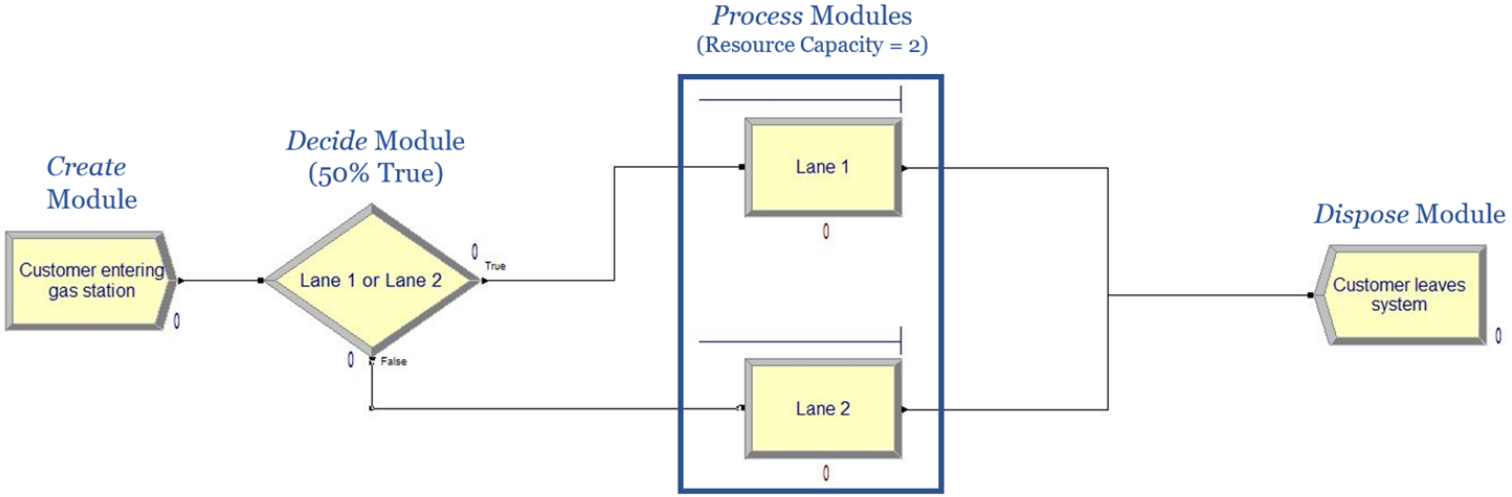
Key Simulation Details & Structural Assumptions

- Entities:
  - Temporary: arriving vehicles & drivers
  - Permanent: 4 gas pumps
- Attributes: FIFO queuing discipline
- Key events: vehicle arrivals, pump starts, and vehicle departures
- Activities: interarrival times & service times
- Variables: fuel tank size, desired level of refueling, & driver familiarity/speed of using the pump

Model Drawing



Building the Arena Model



Let's take a look at the model in Arena!

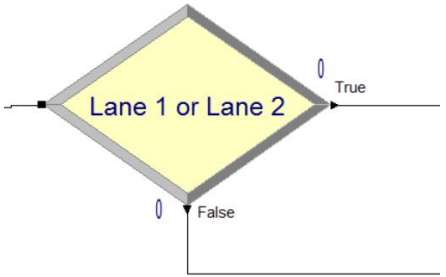
Model Verification & Data Assumptions

- Verify with Vanessa Sawkmie
- Arena process analyzer
- Tracing 16 customers

More details on next slides

Verification with Vanessa Sawkmie

- Preliminary verification of model
- Ignore balking/jockeying/reneging due to low probability
- Set *decide* module to 50% true (more on this in validation section)



Arena Process Analyzer

	Controls		Responses				
Scenario	Rate	Speed	System Num. Out	Lane 1 Queue Time (sec)	Lane 2 Queue Time (sec)	Lane 1 pump utilization	Lane 2 pump utilization
1	1	1	36.5	739.8	959.2	95.7%	95.9%
2	2	1	26.6	61.7	93.7	67.0%	74.7%
3	1	0.5	57.5	31.8	55.9	70.3%	76.2%
4	2	0.5	29.0	0.0	0.00	34.9%	39.3%

Tracing 16 Customers through System

	A	B	C	D	E	F	G	H
1	Customer	Interarrival Time	Lane	Arrival Time	Wait Time	Service Time Starts	Service Time	Departure Time
2	1		1	0	0	0	100	100
3	2	20	2	20	0	20	100	120
4	3	20	1	40	0	40	100	140
5	4	20	2	60	0	60	100	160
6	5	20	1	80	20	100	100	200
7	6	20	2	100	20	120	100	220
8	7	20	1	120	20	140	100	240
9	8	20	2	140	20	160	100	260
10	9	20	1	160	40	200	100	300
11	10	20	2	180	40	220	100	320
12	11	20	1	200	40	240	100	340
13	12	20	2	220	40	260	100	360
14	13	20	1	240	60	300	100	400
15	14	20	2	260	60	320	100	420
16	15	20	1	280	60	340	100	440
17	16	20	2	300	60	360	100	460

Terminating Condition:

EntitiesOut(Customer) == 16

	Manual Simulation	Arena Model Simulation
Avg. Customer Total Time	130 sec	130 sec
Avg. Customers Wait Time	30 sec	30 sec
Lane 1 Avg. Wait Time	30 sec	30 sec
Lane 2 Avg. Wait Time	30 sec	30 sec
Lane 1 Pump Utilization	86.96%	86.96%
Lane 2 Pump Utilization	86.96%	86.96%
System Number Out	16	16

2.

Data Collection and Input Modeling

Data Collection

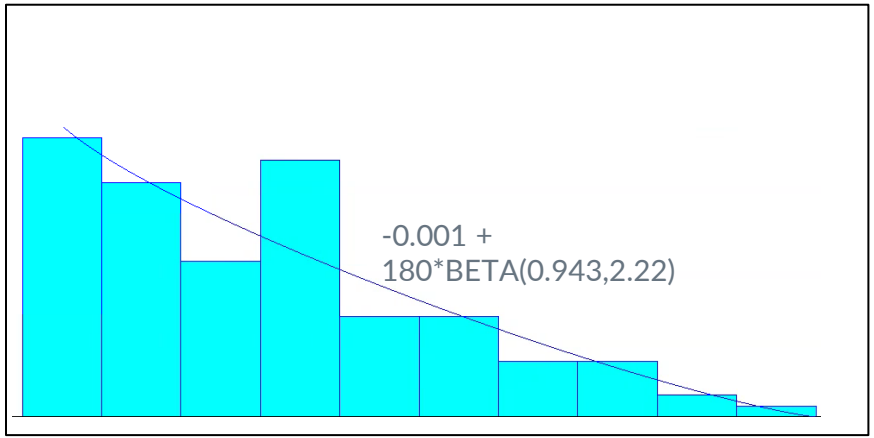
Vehicle Description	Pump Location *(West or East)*	Arrival Time	Pump Start Time	Departure Time
Black GMC	East	1:15:50 PM	1:17:01 PM	1:24:30 PM
Blue Hyundai	West	1:18:30 PM	1:20:45 PM	1:24:59 PM
Blue Ford	East	1:19:20 PM	1:24:10 PM	1:25:03 PM
Red Toyota	East	1:22:14 PM	1:25:15 PM	1:27:20 PM
Red Ford	West	1:22:40 PM	1:25:30 PM	1:28:14 PM

Data Processing

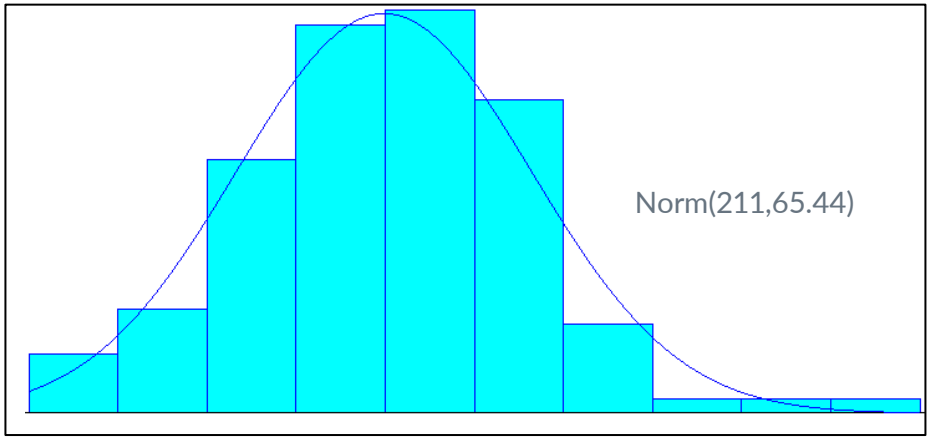
- The data was processed to determine the interarrival and service times.

Input Analysis

Interarrival Time



Service Time



Model Validation

- Face validity
- Collected Data vs. Arena Simulation Data
- T-Tests

More details on next slides

Face Validity and Model Comparison

- Face validity
  - Average data approximation found *decide* module to be 50% true (validated original assumption)
  - Approximated distributions (covered in previous slide)
- Compared collected summary data to Arena simulation data (see photo to right)

	From Data Collection	From Arena Model Simulation	Percent Difference
Customer Output over 63.35 minutes	58.5	61.5	5.13%
Avg. Service Time	208.9	209.2	0.16%
Avg. Wait Time	202.2	212.5	5.10%
Avg. Time in System	395.3	421.7	6.69%
Avg. Lane 1 Pump Utilization	79.1%	86.2%	9.06%
Avg. Lane 2 Pump Utilization	85.0%	88.6%	4.21%
Avg. Interarrival	54.7	53.8	1.67%

Service Time *t*-Test

H_0: the average Service Time = 209.2

H_a: the average Service Time ≠ 209.2

α = .05 n = 110

t-value of 0.04769 < 1.982 ⇒ fail to reject H_o

We fail to reject the null hypothesis that the average service time is 209.2.

Wait time *t*-Test

H_0: the average Customer Wait Time = 212.5

H_a: the average Customer Wait Time ≠ 212.5

α = .05 n = 112

t-value of 0.711 < 1.982 ⇒ fail to reject H_o

We fail to reject the null hypothesis that the average customer wait time is 212.5.

Interarrival time *t*-Test

H_0: the average Interarrival Time = 53.8

H_a: the average Interarrival Time ≠ 53.8

α = .05 n = 113

t-value of 0.2439 < 1.981 ⇒ fail to reject H_o

We fail to reject the null hypothesis that the average interarrival time is 53.8.

3.
Output Analysis

Replication-Deletion Method

Parameter of interest	Confidence Interval*	Parameter Value from Real Data
Interarrival time	[51.75, 56.09]	54.7
Wait time	[171.58, 277.56]	202.2
Service time	[204.93, 213.83]	208.9
Total Time in system	[379.72, 488.18]	395.3
Lane 1 Server Utilization	[0.8561, 0.9361]	0.791 or 79.1%
Lane 2 Server Utilization	[0.8853, 0.9453]	0.850 or 85.0%

**Arena reports confidence intervals with confidence level of 95%.*

Sensitivity Analysis

	Controls		Responses				
Scenario	Rate	Speed	System Num. Out	Avg. Lane 1 Queue Time	Avg. Lane 2 Queue Time	Lane 1 pump utilization	Lane 2 pump utilization
1	1	1	58.45	262.3	210.2	89.6%	91.5%
2	2	1	31.25	14.5	24.7	47.9%	50.4%
3	1	0.5	61.85	11.7	11.3	49.8%	46.6%
4	2	0.5	31.60	1.4	1.4	24.4%	24.8%

4.
Recommendations and Conclusions

Overall Conclusion

- Model accurately represents system
  - t-tests
- Input modeling distributions
  - -0.001 + 180*BETA(0.943, 2.22)
  - Norm(211, 65.44)
- Majority of true values captured in model's 95% CI