Final Project: Simulation of an Emergency Department

BUDT758Z: Computer Simulation for Business Applications

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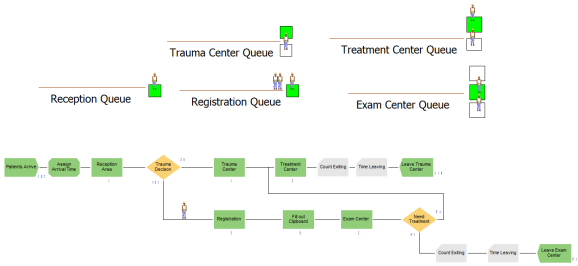
a) Assume starting conditions are empty and idle. Run the model for 30 days and 10 replications. Animate your queues and resources with human-like entities and make a plot of the Total Patients in System (can be trauma + non-trauma patients together). Determine the following*:

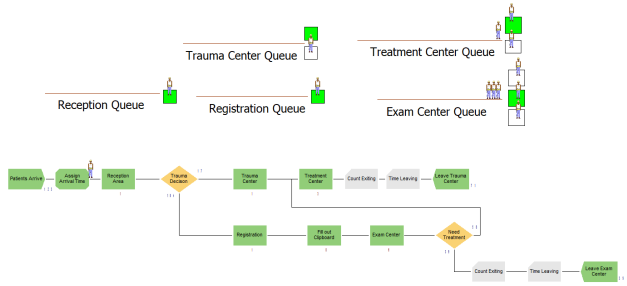
• # of patients seen
• Time-average (WIP) and maximum number of patients in the entire system
• Average and maximum total time in system of patients who exited the system

	mean	95%CI
# of patients seen	4605.4	[4572.24, 4638.56]
Time-average (WIP) and	9.26	[8.92, 9.6]
maximum number of patients in the entire system	31	/
Average total time in system of patients who exited the system	86.72	[83.79, 89.65]
maximum total time in system of patients who exited the system	4696	/

• For each of the five "ED" centers (listed separately): utilization, average time waiting in queue before starting service, and the time-average number of patients in each queue

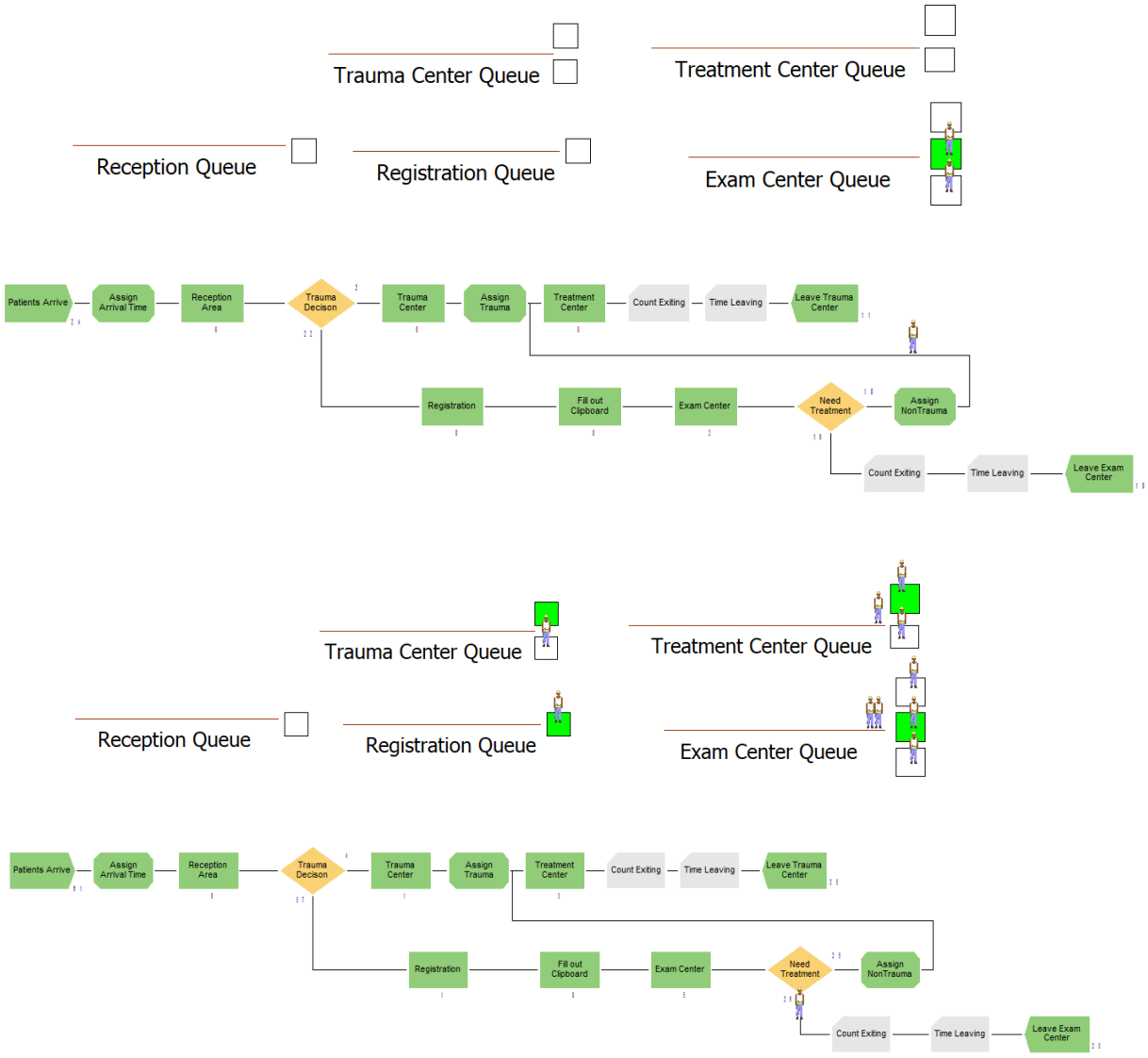
	Utilization%	Avg. time waiting in queue before starting service	Time-average number of patients in each queue
Reception Area	39% - 39.4%	[1.22, 1.28]	[0.130, 0.138]
Registration	56.6% - 57.6%	[2.84, 3.12]	[0.27, 0.31]
Trauma center	27.8% - 29.8%	[2.43, 3.17]	[0.026, 0.034]
Treatment center	84.7% - 86.1%	[31.15, 39.65]	[2.12, 2.72]
Exam center	74.2% - 75.4%	[6.79, 7.91]	[0.65, 0.77]





b) It is likely that trauma patients spend more time at the treatment center than non-trauma patients. Up until now, we assumed they had the same processing time. Let's assume that non-trauma patients follow TRIA (5, 20, 40) min, and the trauma patients follow TRIA(30, 45, 90) as before. Re-run the model with these new treatment times, and report on whether any of the resource utilizations or total time in the system for patients have changed.

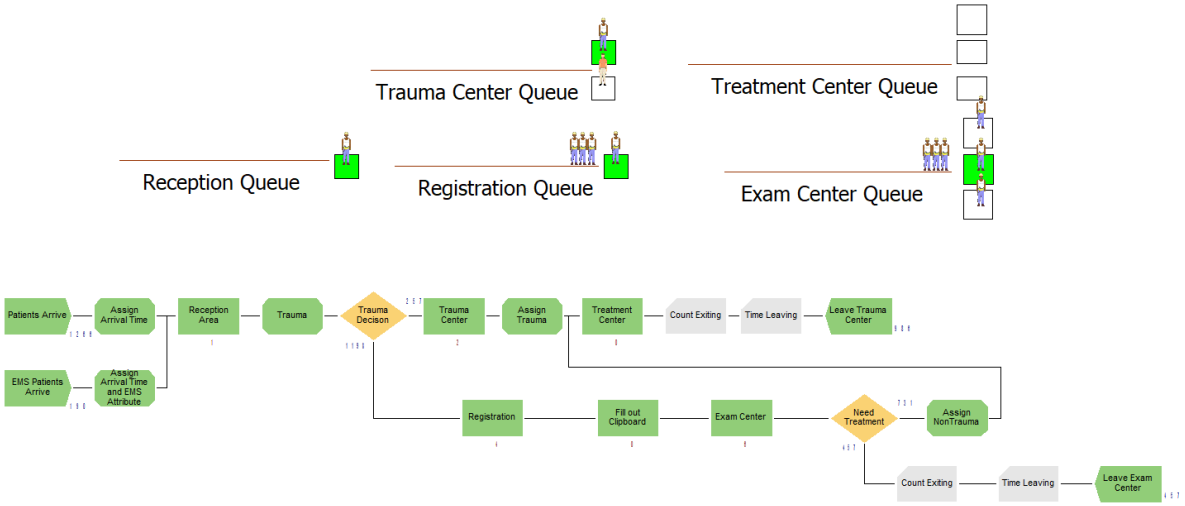
	Utilization% (new)	Avg. time waiting in queue before starting service (new)	Utilization% (previous)	Avg. time waiting in queue before starting service (previous)
Reception Area	38.6% - 39.4%	[1.2, 1.3]	39% - 39.4%	[1.22, 1.28]
Registration	56.5% - 57.5%	[2.89, 3.15]	56.6% - 57.6%	[2.84, 3.12]
Trauma center	27% - 29.2%	[2.14, 2.96]	27.8% - 29.8%	[2.43, 3.17]
Treatment center	88.4% - 92.4%	[29.08, 143.54]	84.7% - 86.1%	[31.15, 39.65]
Exam center	74.1% - 75.5%	[6.49, 8.13]	74.2% - 75.4%	[6.79, 7.91]

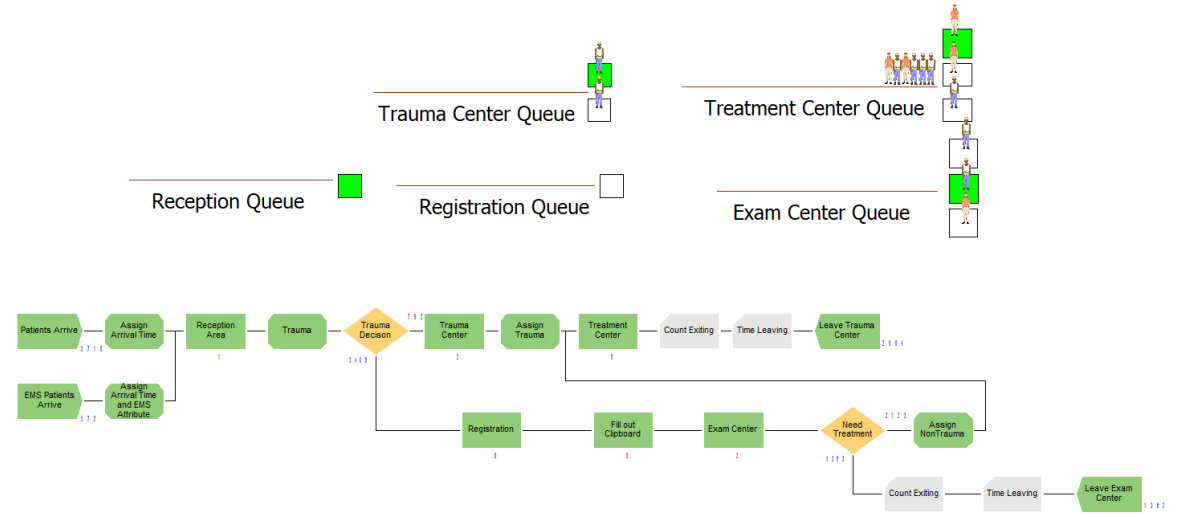


c) Up until now, the arrivals have been “walk-in” patients who arrive by walking in, driving themselves in, or brought in by a family member or friend, or by public transit. The hospital is considering incoming patients from emergency medical services (EMS) composed of public or private ambulances, law-enforcement vehicles, and helicopters. These patients arrive one at a time and less frequently, following exponential interarrivals with a mean of 1 hour. EMS arrivals go through the same process as part(a) and (b), but they tend to be a little sicker, with about 70% of arrivals being trauma patients (as compared to the 10% of the walk-ins). To care for these extra arrivals, the hospital would hire a third person to work in the treatment center. All other staffing remains the same. Run this model with the same conditions as before, and report on the utilization of each of the five ED centers. Hint: using an attribute will be helpful here.

	Utilization%

Reception Area	44.7% - 45.7%
Registration	59.5% - 60.7%
Trauma center	58.2% - 62%
Treatment center	81.4% - 85.2%
Exam center	78.1% - 79.5%

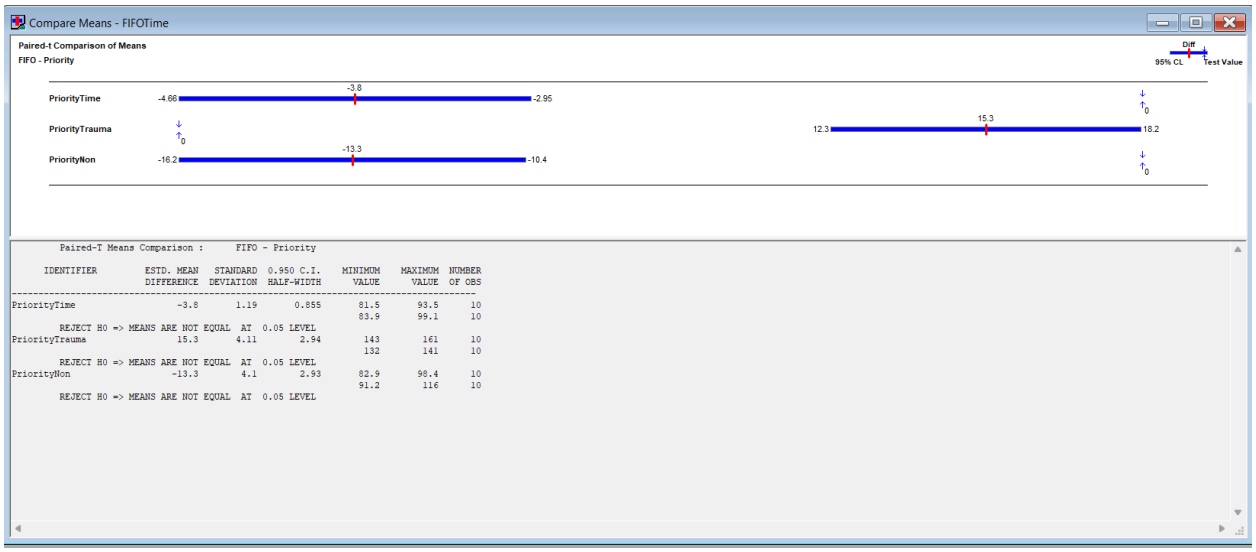




d) Using the model in part (c) with the EMS patients and separate treatment center times, consider that it might be better for trauma patients to be placed ahead of the non-trauma patients at the treatment center queue (but they will not “kick out” or preempt someone who is already in treatment). Use Arena Output Analyzer to do comparisons between FIFO versus trauma-patient prioritized queues for:

(i) Overall total time in system, or length of stay (LOS)

(ii) LOS for non-trauma patients
(iii) LOS for trauma patients.
Is there a statistically significant difference in LOS for each of these categories when we consider priority? State your hypothesis and explain your results. Use 95% confidence level. For the comparisons, place them all on the same output analyzer project file. Hint: you will need to separate the tracking of the trauma vs non-trauma patients.



H_0: There is no statistically significant difference in means between FIFO and prioritized queues.
H_1: There is a statistically significant difference in means when trauma patients are prioritized.

For overall time in the system for all patients, patients that had traumatic injuries and patients without traumatic injuries we reject the null hypothesis that there is no difference in means between FIFO and prioritized queues.

For all patients and for patients without traumatic injuries, the overall time in the system increased when using prioritized queues. This makes sense as the trauma patients have a longer treatment distribution and the patients that would have a quicker treatment time are potentially not being seen for a while.

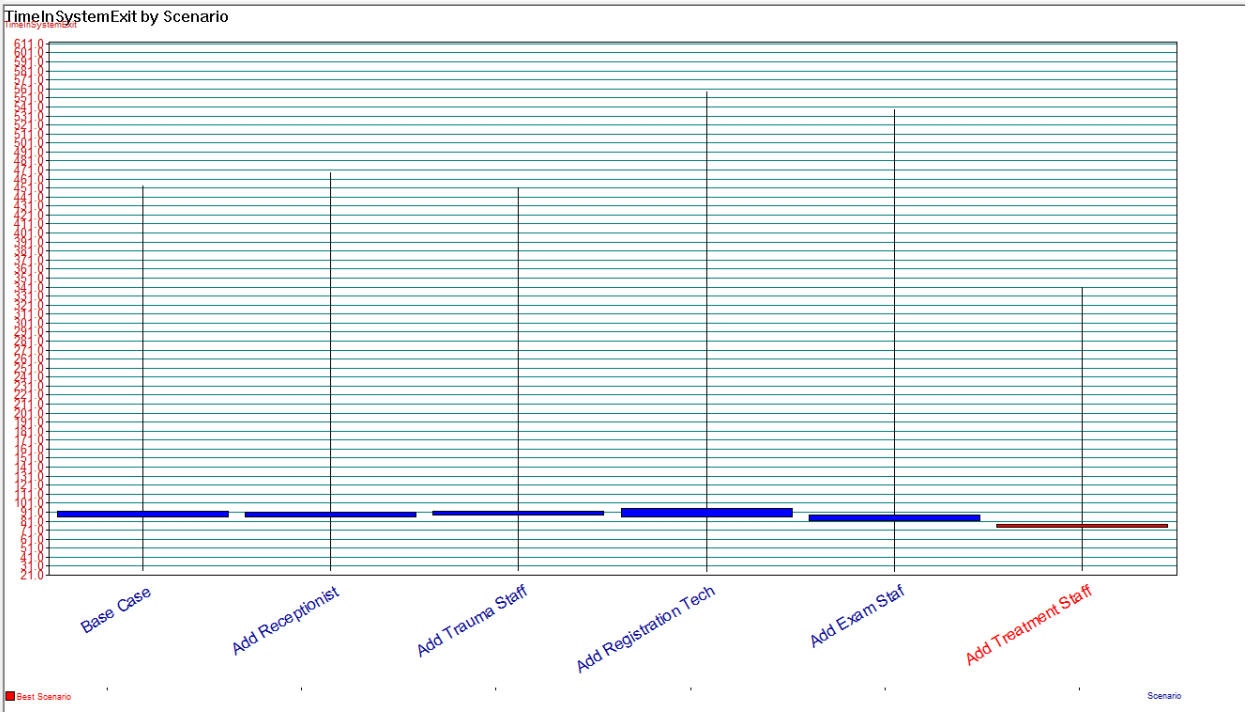
For patients with traumatic injuries, the overall time in the system decreases when using priority queues. This makes sense as they are moving to the front of the line and moving through the system faster.

e) Using your model from part (c) with EMD arrivals and the FIFO queue at the trauma center, suppose you could hire one more staff person – reception, trauma center, registration, exam center, or treatment center. Based only on the total time in the system (lower is better), what is your recommendation? Set up and run a Process Analyzer (PAN) experiment and include the

base case of no new staff as well as your scenarios of adding one staff person at a time to each station. Make 10 replications of each of your six scenarios and add a Box and Whisker plot for the output metric. Explain your recommendation(s).

	Scenario Properties				Controls					Response
	S	Name	Program File	Reps	Receptionist	Trauma Staff	Registration Tech	Exam Staff	Treatment Staff	TimeInSystem Exit
1		Base Case	1 : (e) with ani	10	1	2	1	3	3	88.466
2		Add Receptionist	1 : (e) with ani	10	2	2	1	3	3	88.180
3		Add Trauma Staff	1 : (e) with ani	10	1	3	1	3	3	89.828
4		Add Registration Tech	1 : (e) with ani	10	1	2	2	3	3	90.230
5		Add Exam Staf	1 : (e) with ani	10	1	2	1	4	3	84.514
6		Add Treatment Staff	1 : (e) with ani	10	1	2	1	3	4	76.013

Double-click here to add a new scenario.



Based on the PAN experiment, adding one Treatment Staff resulted in the lowest average total time in the system (76.013 minutes) and the narrowest confidence interval. This indicates both improved performance and reliability. Therefore, we recommend adding one staff member to the Treatment Center to maximize overall efficiency and reduce patient wait times.

f) Let's bring salary into the decision in part (e) above and try to optimize staffing to provide the best patient service possible. According to a quick and lazy search, some average salaries:

- Administrative assistants (for both registration and reception): $35,000
- Trauma center staff: $75,000
- Exam and treatment center staff (for both exam center and treatment center): $185,000

Suppose you could spend an additional $300,000 a year to hire additional people – ANY additional people in any combination – so long as you can stay within your budget. If you want to minimize average patient LOS (length of stay/total time in system), what's the best hiring plan for additional people? You cannot reduce staff from part (c), which is 1 registration tech, 1 receptionist, 2 trauma bed staff, 3 exam bed staff, and 3 treatment center staff. Ask OptQuest to help and provide your recommendation. Besides the "best" solution, are there any others you would consider? Expand your reasoning. In OptQuest, try setting a min replication of 2 and a max replication of 10 in your settings.

Optimization 1*

Best Solutions **Optimal solution found.**

					Best Solutions				
	Included	Simulation	Objective	Status	Exam Staff	Receptionist	Registration	Trauma Staff	Treatment
	☐	64	71.493621	Feasible	3	2	1	3	4
	☐	63	72.066507	Feasible	3	1	1	3	4
	☐	19	72.14705	Feasible	3	1	2	2	4
	☐	20	72.180161	Feasible	3	1	2	3	4
	☐	18	72.919693	Feasible	3	2	2	2	4
	☐	61	73.100483	Feasible	3	2	1	2	4
	☐	46	73.738239	Feasible	3	2	3	2	4
	☐	11	74.508649	Feasible	3	4	1	2	4
	☐	15	75.058544	Feasible	3	3	2	2	4
	☐	98	76.058643	Feasible	3	3	1	2	4
	☐	43	76.662695	Feasible	4	2	2	2	3
	☐	120	76.978135	Feasible	4	3	2	2	3
	☐	41	77.799307	Feasible	3	1	3	2	4
	☐	45	77.799307	Feasible	3	1	4	2	4
	☐	42	78.137161	Feasible	3	1	1	2	4
	☐	121	78.657658	Feasible	4	4	1	2	3
	☐	24	78.674984	Feasible	4	1	2	3	3
	☐	118	78.73523	Feasible	4	2	3	2	3
	☐	48	78.947157	Feasible	4	2	1	2	3
	☐	117	79.552323	Feasible	4	2	1	3	3
	☐	115	80.344038	Feasible	4	1	3	2	3
	☐	116	80.344038	Feasible	4	1	4	2	3
	☐	17	80.832229	Feasible	3	2	2	2	3
	☐	23	80.860034	Feasible	4	1	2	2	3
	☐	25	81.539626	Feasible	3	1	4	3	3

The optimal hiring plan includes adding **1 receptionist**, **1 trauma staff**, and **1 treatment staff**. This combination stays within the $300,000 budget (total cost: $295,000) and achieves the lowest average patient length of stay (LOS = 71.49). By enhancing front-desk efficiency and expanding both critical (trauma) and downstream (treatment) capacity, this staffing mix delivers the most impactful improvement to patient flow within the given constraints.

I pledge in my honor that I have not given or received any unauthorized assistance on this exam.