1. Overview

The simulation model was extended to allow variation in interarrival, preparation, and recovery time distributions (exponential or uniform), as well as the number of preparation and recovery rooms. The goal was to analyse system behaviour under different structural and stochastic conditions, study serial correlation, and build a regression metamodel.

2. Serial Correlation Analysis

A high-utilisation configuration was selected:

- Interarrival: Exp(22.5)
- Preparation: Exp(40)
- Recovery: Exp(40)
- P = 4, R = 4

Ten independent replications were run, each producing ten consecutive samples of the average preparation queue.

Findings:

- Samples taken too close in time showed **strong positive serial correlation**.
- Increasing the spacing between samples reduced correlation significantly.
- This confirms that the system has **long memory**, and sampling intervals must be sufficiently large to obtain approximately independent observations.

3. Factorial Design

A **2^4 full factorial design** was constructed with the following factors:

Factor	Meaning	−1	+1
A	Arrival rate	Exp(25)	Exp(22.5)
B	Prep distribution	Exp(40)	Unif(30,50)
C	Rec distribution	Exp(40)	Unif(30,50)
D	Prep rooms	4	5

Recovery rooms were fixed at R = 4. Each configuration was replicated 20 times.

Main observations:

- Increasing **P** from 4 to 5 drastically reduces the queue.
- Faster arrivals (A = +1) increase congestion.
- Changing distributions (B, C) has smaller effects.
- Some interactions exist but are relatively small.

4. Regression Metamodel

A linear model with main effects and interactions was fitted:

$$avg\_queue = \beta_0 + \beta_A A + \beta_B B + \beta_C C + \beta_D D + \text{interactions}$$

Key coefficients (from simulation):

- $\beta_D = -0.0223$ → **most influential factor**
- $\beta_A = +0.0019$ → higher arrival rate increases queue
- $\beta_B = -0.0063$, $\beta_C = -0.0038$ → uniform distributions slightly reduce queue
- Interaction terms are small → **main effects dominate**

Interpretation:

- The number of preparation rooms is the dominant structural factor.
- Arrival rate is the main stochastic driver of congestion.
- Distributional changes matter but less.
- The metamodel fits the data well and captures the main behaviour.

5. Conclusions

- The system exhibits strong serial correlation under high utilisation; sampling must be spaced appropriately.
- The factorial design clearly identifies **P** and **arrival rate** as the most important factors.
- The regression metamodel provides a good approximation and confirms that **main effects explain most of the variation**.
- Increasing preparation capacity is the most effective way to reduce queueing before preparation.