Discrete Event Simulation of Customer Flow Using SimPy

at PETRONAS UTP Petrol Station

Group Members & Roles

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Background

Location	PETRONAS UTP, Sri Iskandar
Customers	Students, Staff, and Local Sri Iskandar Residents
Services	Fueling, Air Pumps, Shop, Toilets, and Surau
Simulation	DES to model customer flow and resource usage.

Our aim with this project is to identify bottlenecks and support planning with data-driven insights

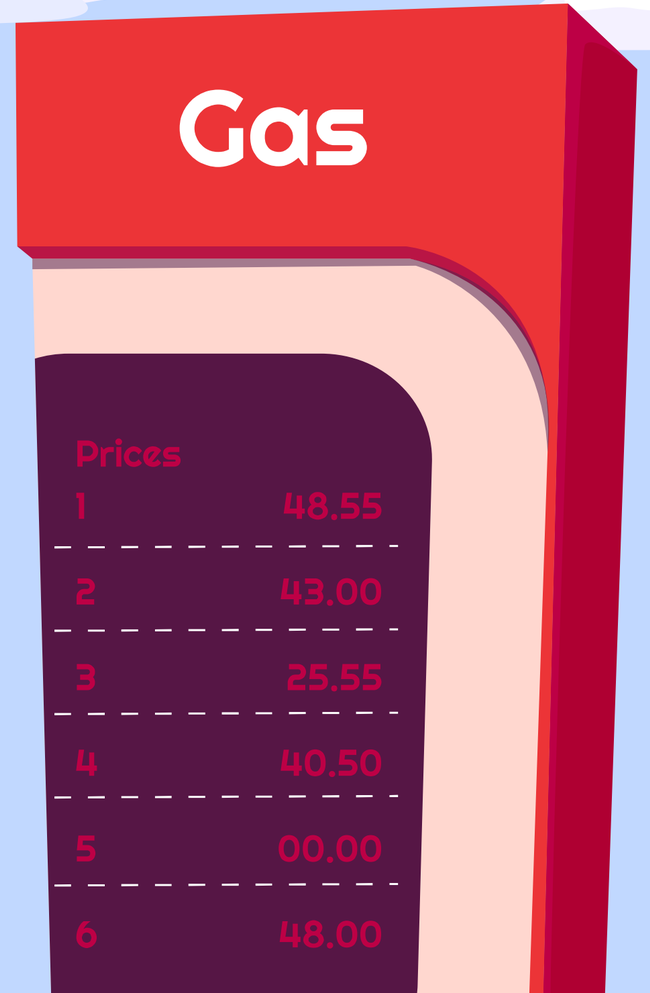
Objectives

To model the daily operations of PETRONAS UTP.

To analyse vehicle flow and service usage.

To evaluate station performance

To identify optimisation opportunities.



Scope and Limitations

Scope

Covers three vehicle types (Car, Motorcycle, Trailer) and six core services.

Uses SimPy to model a 12-hour period from 7AM to 7PM.

Incorporates pump reduction scenarios to test system resilience.

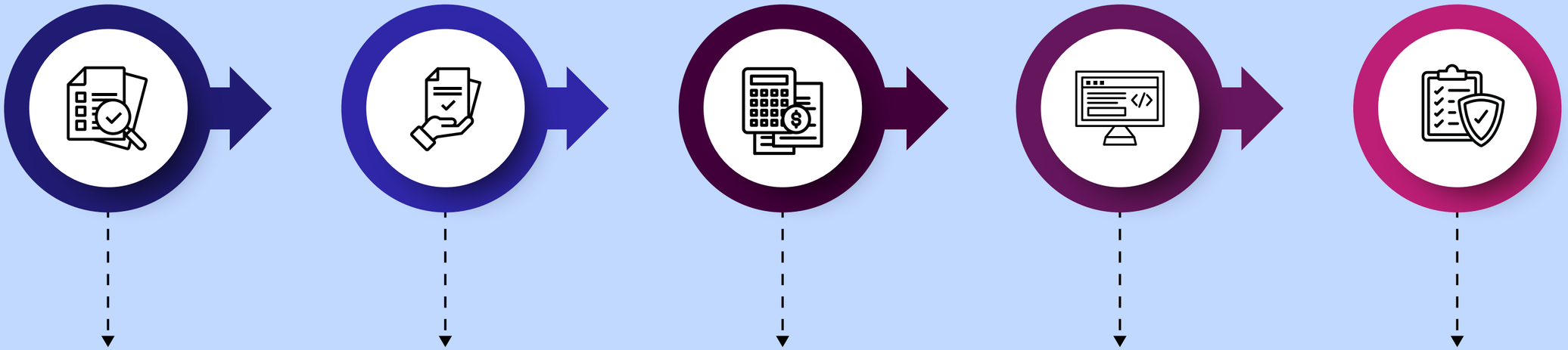
Limitations

Relied on manual observation.

Excludes staffing shifts, fuel pricing, and external traffic congestion.

Observations limited to daytime hours.

Our Approach



Site Selection

PETRONAS UTP petrol station was chosen due to its strategic location and high traffic.

Data Collection

Manual observation over 12 hours. Recorded vehicle types, arrival patterns, and service usage.

Data Preparation

Processed data to calculate interarrival rates, average service durations, service usage probabilities.

Model Dev

Simulated vehicle flow and resource contention using SimPy.

Testing & Analysis

Ran simulations with varying fuel pump capacities to measure impact on fueling success vs. rejection.

Literature Review

Petrol Station Simulation with Arena
Hawari et al. (2022)

- DES effective for testing operations without disrupting real station
- Inspired our use of simulation to test customer flow and operational changes at PETRONAS UTP.

SimPy for DES Modelling
Zinoviev (2020)

- Demonstrated SimPy's use for customer service systems and queuing
- Helped us implement SimPy to model services like fueling, queueing, and fallback logic.

Observation-Based Data Collection
Walidacja (2019)

- Highlighted that manual observation is effective when live data is unavailable.
- Justified our shift to manual observation when official data was unavailable.

Data Collection

Vehicle Type

Arrival Time

Service Usage

Stop Duration

7:00 AM - 11:00 AM
Mahadhir

11:00 AM - 3:00 PM
Dzulfan

3:00 PM - 7:00 PM
Suhayl

Simulation Design

Initialize Simulation Environment

- Simulated a 12-hour day using SimPy
- Defined key resources

Generate Vehicle Arrivals

- Vehicles arrive based on interarrival rates
- Each vehicle has a chance of using specific services

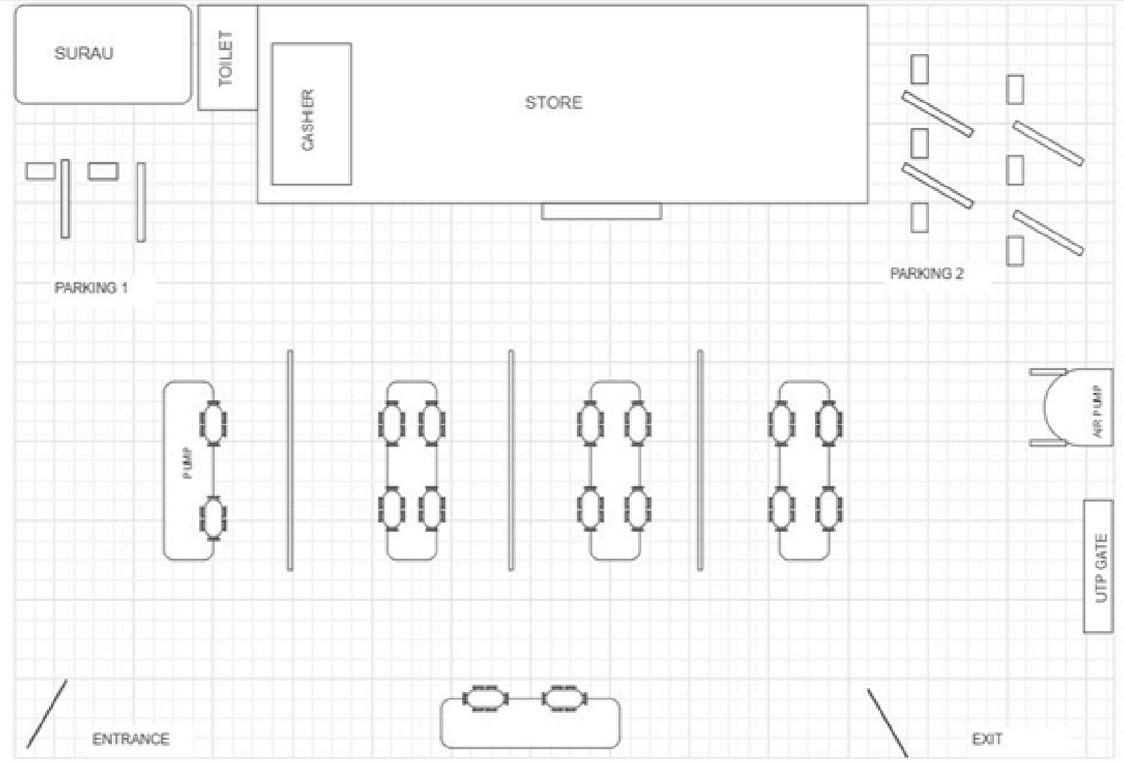
Handle Vehicle Process

- Vehicles queue for resources and are served based on availability
- Motorcycles have fallback logic

Track & Output Results

- Tracked how many vehicles arrived, used services, or were rejected
- Measured impact of pump availability across scenarios

Station Setup



2D Layout of PETRONAS UTP Petrol Station

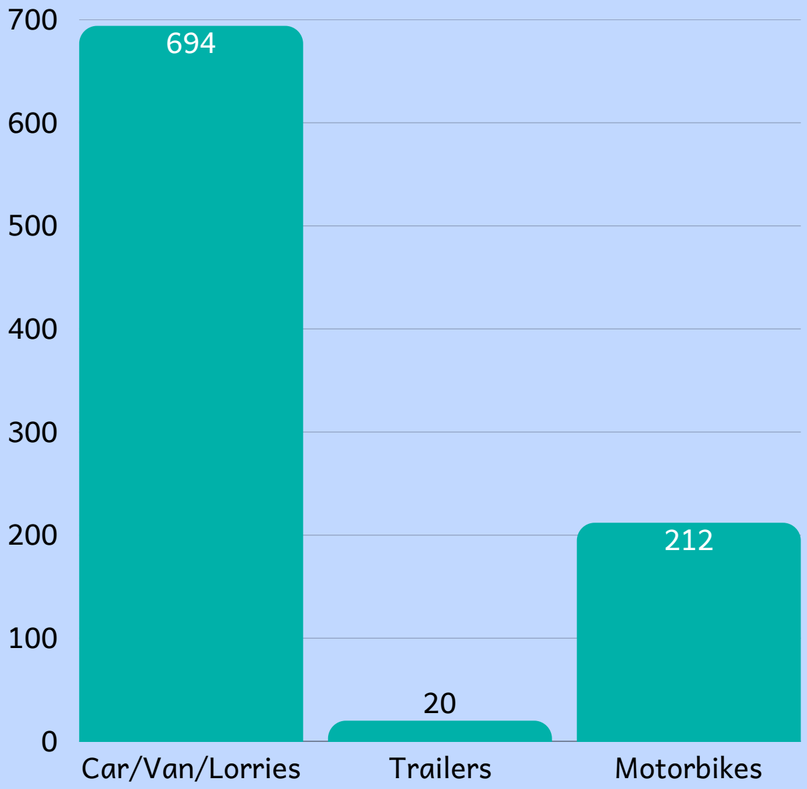
- 12 shared fuel pumps for cars.
- 2 motorcycle only fuel pumps.
- 1 trailer-dedicated fuel pump.

- 2 air pumps.
- 2 shop counters.
- 1 toilet & surau.

- 20 parking spaces.

Results and Insights

Total Vehicles



Service Usage by Vehicle Type

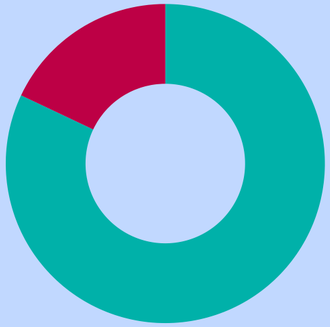
Results and Insights

12 Car Pumps

100% Cars Fueled
0% Cars Leaving

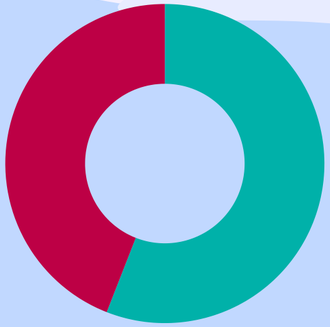
4 Car Pumps

100% Cars Fueled
0% Cars Leaving



3 Car Pumps

82% Cars Fueled
18% Cars Leaving



2 Car Pumps

56% Cars Fueled
44% Cars Leaving

The minimum number of pumps required to prevent car rejection is 4. Below that, significant bottlenecks occur.

Challenges and Experience

Challenges

- Data Collection Difficulties
- Modelling Constraints
- Accuracy vs. Realism

Experience

- Adaptability
- Teamwork

Conclusion

The simulation successfully modelled PETRONAS UTP operations and revealed how fuel pump capacity directly impacts service efficiency and customer satisfaction.

Data Enhancement	Request official station logs from owner to improve accuracy and extend data beyond 12 hours.
Extended Observation Period	Collect multi-day data across varied times to capture off-peak and weekend/weekday patterns.
External Factors	Include external factors like weather, traffic, or promotions that impact station usage.
Advanced Simulation Logic	Enhance realism with queue limits, multiple access points, or dynamic arrival rates.
More Scenarios	Test “what-if” cases like staff shortages, promos, or demand spikes.

Thank You