Modelling of the Airport and Understanding the Impact of Infrastructure Improvements

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Overview

Airports are intricate systems where multiple terminal operations, such as passenger movement, check-in, security screening, waiting halls, and boarding procedures , must operate in harmony to ensure smooth and efficient functioning. Each process within the terminal is interdependent, and inefficiencies or congestion at any stage can create a ripple effect across the entire system, leading to longer waiting times and reduced passenger satisfaction.

As air traffic continues to increase, maintaining optimal passenger flow and minimizing delays have become critical challenges for airport management. The situation becomes even more complex when operational changes, such as terminal closures or flight redistribution , occur. Such changes alter the balance of passenger loads across terminals and can strain available resources if not planned and monitored effectively.

A simulation-based approach provides a practical and analytical framework to study passenger flow dynamics, identify bottlenecks, and evaluate the performance of terminals under different traffic redistribution strategies. By replicating real-world passenger arrivals, service times, and resource constraints, simulation models enable airport planners to test various scenarios and determine the most efficient operational configurations.

Introduction

Delhi's *Indira Gandhi International Airport (IGIA)* is among the busiest airports in India, handling millions of passengers annually through its three major terminals, Terminal 1 (T1), Terminal 2 (T2), and Terminal 3 (T3). With the continual rise in passenger traffic, ensuring smooth operations and maintaining high service standards have become increasingly difficult. Recently, the *closure of T2* has posed significant operational challenges, as all its flight operations have been shifted primarily to *Terminal (T1)*.

This redistribution has resulted in increased congestion , longer queues , and extended waiting times at critical service points such as check-in and security checkpoints. The imbalance in passenger load across terminals has impacted both service efficiency and passenger comfort, emphasizing the need for a systematic analysis of how such changes affect overall terminal performance.

To address this issue, a discrete-event simulation model can be developed to represent the flow of passengers across different service points and terminals. Such a model allows for experimentation with various traffic distribution strategies, such as shifting all T2 passengers to T1, to T3, or splitting them rationally between both terminals. Through this analytical approach, planners can observe how resource utilization, queue lengths, waiting times, and overall throughput change under each scenario.

The ultimate goal of this study is to propose operational measures and optimization strategies that minimize congestion, reduce delays, and improve the overall efficiency of the airport's terminal operations.

Background

In modern airports, terminal operations form a complex network of interrelated processes that must function seamlessly to achieve a high level of service and operational reliability. From passenger check-in and handling to security clearance and boarding, every stage contributes to the airport's key performance indicators (KPIs) , including waiting time, throughput, and terminal utilization rate.

The efficiency of an airport terminal depends not only on the capacity of its facilities but also on the distribution of passenger flow and the coordination of resources such as check-in counters, security lanes, and boarding gates. Disruptions in one terminal, due to maintenance, construction, or temporary closure, necessitate the redistribution of traffic across other terminals, which can alter passenger dynamics and create congestion at new points in the system.

At Delhi's IGIA, the closure of Terminal 2 has necessitated such a redistribution . While T1 and T3 are capable of handling substantial passenger volumes, the sudden influx of additional passengers has strained existing infrastructure, especially during peak hours. This has resulted in uneven utilization , with some service points operating beyond optimal capacity while others remain underused.

To objectively evaluate the impact of these changes, it becomes essential to use simulation modeling as a decision-support tool. Simulation enables the examination of different "what-if" scenarios in a controlled environment, testing variations in passenger arrivals, service rates, and resource allocations. By analyzing performance measures such as average waiting times , queue lengths , and terminal utilization rates , airport authorities can make data-driven decisions to improve efficiency and passenger experience.

Furthermore, the model allows for the evaluation of infrastructure enhancement options , such as adding check-in counters or increasing the number of security gates. These experiments provide valuable insights into how different resource configurations influence congestion and overall system performance.

This background forms the basis for the present study, which focuses on developing a simulation-based passenger flow model for Delhi Airport to analyze the operational implications of Terminal 2's closure and to identify strategies that promote balanced load distribution and optimized terminal performance

Objectives of the Study

The primary objective of this study is to determine the optimal redistribution of passenger flow across Delhi Airport terminals following the closure of Terminal 2 (T2). The study aims to develop a simulation-based optimization framework that identifies the most efficient allocation of passengers between Terminals 1 (T1) and 3 (T3), ensuring minimal congestion, reduced waiting times, and balanced utilization of terminal capacities. The analysis focuses on enhancing overall airport performance by optimizing passenger flow through data-driven decision-making.

The secondary objective is to evaluate the impact of infrastructure enhancements on passenger processing efficiency and terminal performance. This involves assessing how changes in the number of check-in counters and security checkpoints influence total time spent by passengers within the airport system. The findings are intended to support strategic planning for capacity expansion and resource allocation, contributing to improved operational efficiency and passenger experience.

Performance Measures

Terminal Utilization Rate

- Measures the usage level of check-in counters, security lanes, and gates at Terminal 1 and Terminal 3.

- Evaluates load balance when T2 operations are redistributed:

  1. Entirely to T1
  2. Entirely to T3
  3. Split between T1 and T3

Average Passenger Waiting Time

- Average time passengers spend in queues across key stages:

  1. Entry gates, Check-in counters
  2. Security checkpoints
  3. Boarding gates

- Indicates overall passenger processing efficiency and congestion severity.

Queue Lengths

- Tracks *maximum and average queue lengths* at check-in and security to identify bottlenecks.

- Helps assess queue buildup patterns under varying passenger loads.

Passenger Throughput

- Represents the number of passengers processed per unit time at each terminal process.

- Compares throughput across *pre-closure (T2 active)* and *post-closure (T2 redistributed)* scenarios to measure system efficiency.

Scenario Comparison Metrics

- Compares congestion levels, waiting times, and utilization balance across redistribution strategies:

  1. T2 → T1
  2. T2 → T3
  3. T2 → T1 + T3 (Split)

- Identifies the most efficient and balanced configuration for post-closure operations.

Airport terminal operations Simulation in Arena & SimPy

Model Diagram
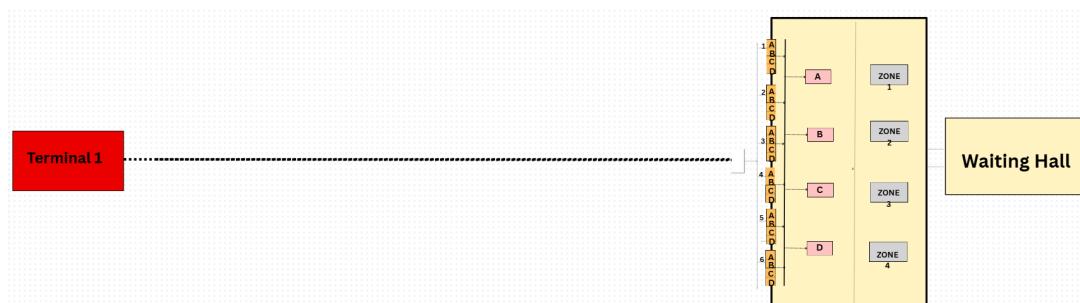
Figure 1: Terminal 1 Model
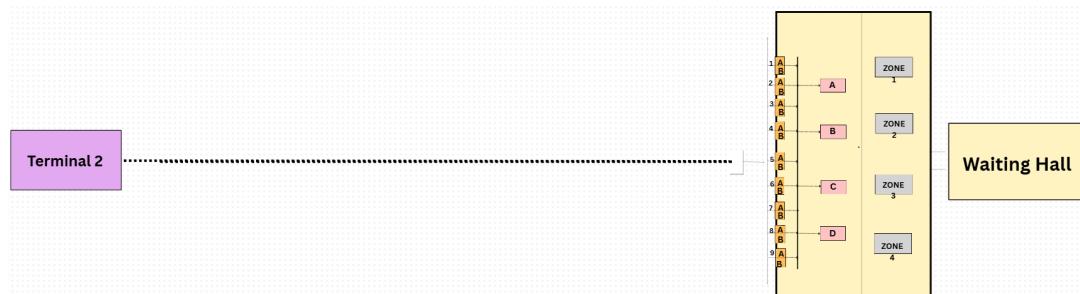
Figure 2: Terminal 2 Model
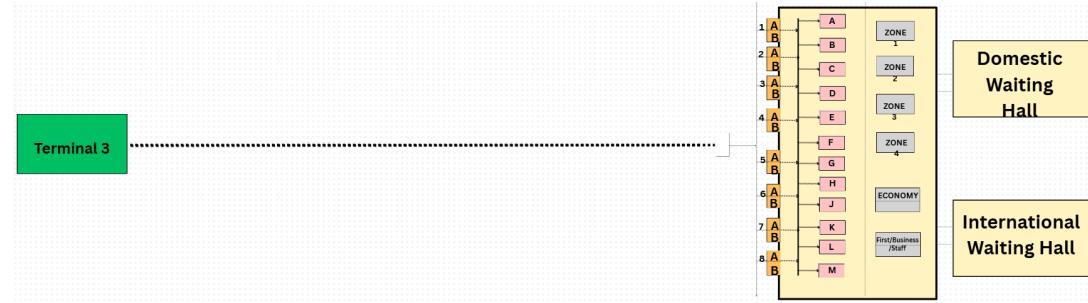
Figure 3: Terminal 3 Model

	Entry Gates		Check-in Counters
	Security Check Counters		Passenger flow area

The above model gives an overview of the working of various terminals in the airport and provides an overview of the passenger flow.

Conceptual Model

System Overview

System Boundary: Passenger flow from arrival at airport → entry gates → check-in → security → waiting halls → boarding.

Entities: Passengers are modelled as entities and are categorized at each step in the following ways:

- **Terminal-based classification:** Terminal 1 (T1) and Terminal 2 (T2) are designated exclusively for domestic passengers, while Terminal 3 (T3) handles both domestic and international flights.

- **Check-in based:** At each terminal, two types of check-in and gate entry processes are implemented — one for DigiYatra passengers and the other for regular passengers.

- **Travel type:** T1 and T2 cater solely to domestic travel, all passengers using these terminals are domestic travelers. In contrast, Terminal 3 accommodates both domestic and international passengers. The class of travel is categorized into Economy and Business/First class.

Resources:
Entry gates: Each terminal features a combination of Regular and DigiYatra entry gates based on its passenger load and capacity.

Terminal	Total Gates	Regular Gates	DigiYatra Gates
Terminal 1	30	24	6
Terminal 2	28	24	4
Terminal 3	22	16	6

Resources	Terminal 1	Terminal 2	Terminal 3
Check-in Counters	2 zones for 2 airlines (IndiGo and SpiceJet)	2 zones for 2 airlines (IndiGo and Akasa Air)	12 zones for both domestic and international travellers
Security Lanes	Domestic passengers: 50 security lanes	Domestic passengers: 4 security lanes	Domestic: 40 lanes, International: 24 lanes split as Economy / Business/First Class
Boarding Gates	22 gates	7 gates	62 gates

The flow of passenger movement through the terminals follows a structured sequence, differing slightly between Terminals 1 and 2 (domestic only) and Terminal 3 (domestic and international).

Flow of Events (Terminal 1 & 2)

For Terminals 1 and 2, which handle only domestic flights, passengers arrive at the terminal according to a *Poisson arrival process*. Upon arrival, they enter the terminal through either a DigiYatra or a Regular entry gate, both modeled as resources. After entering, passengers proceed to the check-in counters, where they complete their baggage and boarding formalities. Once check-in is done, all passengers move to the domestic security check, which is represented as a resource with multiple lanes. Following security clearance, passengers enter the waiting hall, modeled as a Delay module, where they spend a certain time before boarding. Finally, they proceed to the boarding gates, also modeled as a resource, and depart for their respective flights.

Flow of Events (Terminal 3)

In Terminal 3, which accommodates both domestic and international passengers, the process begins similarly with passenger arrivals modeled using a Poisson distribution. Passengers first choose between the DigiYatra and Regular entry gates before proceeding to the check-in counters. After check-in, the flow diverges based on the type of travel: domestic passengers proceed to the domestic security area, while international passengers

are directed to the international security section. Domestic passengers then pass through domestic security lanes, move to the domestic waiting hall (modeled as a Delay), and finally proceed to the domestic boarding gates for departure. International passengers, on the other hand, are classified by travel class — Economy or Business/First Class — and pass through their respective international security lanes, where Business and First Class travelers have access to priority lanes. After security, they move to the international waiting hall (Delay module) and finally to the international boarding gates for flight departure.

Queues

Four types of queues exist within the system: Entry gates queue, Check-in Counter queue, Security lane queue and Boarding gate queue. The FCFS (First Come, First Serve) policy is followed for all queues.

Attributes: Each passenger (entity) entering the system has the following attributes: Passenger type (Regular / DigiYatra and International / Domestic), Class of Service (Economy / Business).

Starting and Termination Condition:

- **Starting Condition:** Terminal is empty at the start of the simulation. No passengers in queues. All check-in counters, security counters, and boarding gates are idle.

- **Termination Condition:** Simulation ends after a *full day of operations (24 hours)*.

Arena Model
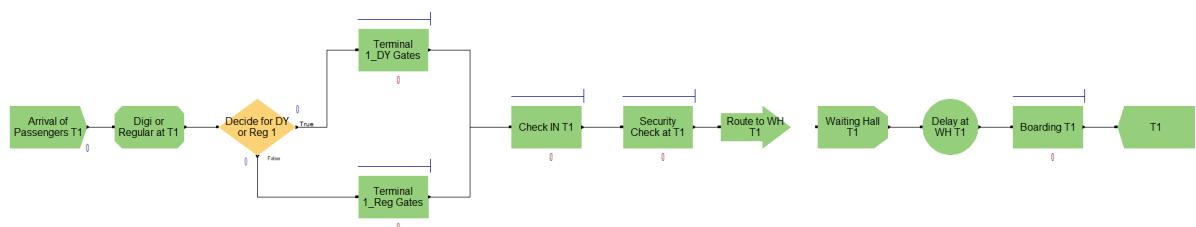
Figure 4: Terminal 1 Arena Model
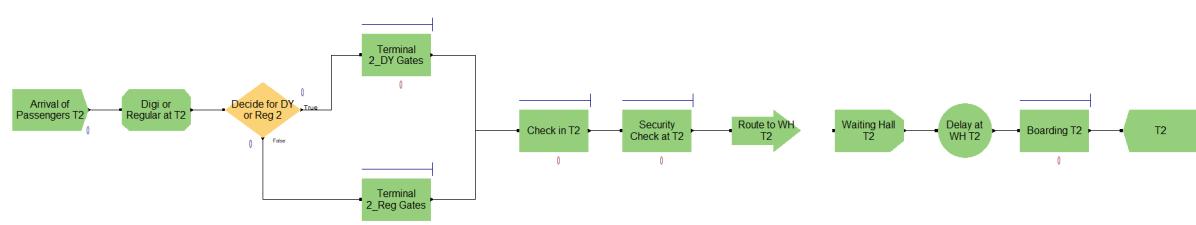


Figure 5: Terminal 2 Arena Model
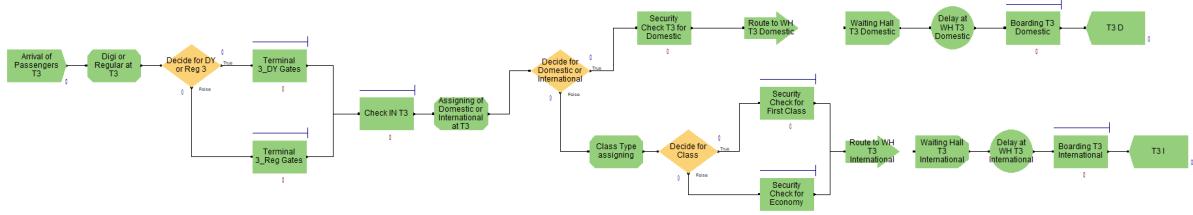
Figure 6: Terminal 3 Arena Model

Data Collection and Input Analysis

Determination of arrival rates at each terminal:

Flight data was collected to determine the distribution of flights across terminals at six-hour intervals. For each time block, the flight numbers operating from each terminal were identified using publicly available flight information websites. Based on this data, the type of each flight (domestic or international) was classified, and the maximum passenger capacity for each aircraft type was obtained. Using the capacities of all flights arriving at a terminal, the terminal capacity was determined.

Using this information, the number of passengers handled at Delhi Airport every six hours was estimated. The proportion of transfer passengers was determined from a referenced research article, and the fraction (1-transfer ratio) was used to calculate the number of originating passengers boarding at Delhi. Finally, the *arrival rate parameter (λ)* for the simulation was computed as:

$$\lambda = \frac{\text{Number of passengers boarding at Delhi in each 6-hour block}}{\text{Total time (in minutes or hours)}} \tag{1}$$

This value represents the average passenger arrival rate at the terminal, used as an input to the Poisson arrival process in the model.

Terminal	Yearly Passenger Traffic	Arrival Rates(λ)(per min)
Terminal 1	6,711,620	7.3720
Terminal 2	10,333,150	11.3499
Terminal 3 (Domestic)	9,665,565	10.6166
Terminal 3 (International)	12,222,390	11.3630

The above arrival rates are determined for the entire day.

Time Slots	Number of Arrivals	Arrival Rate
00:00 − 06:00	1698	2.732
06:00 − 12:00	5969	9.572
12:00 − 18:00	6155	9.871
18:00 − 24:00	4566	7.322

Table 4: Terminal 1 Arrival Rates

Time Slots	Number of Arrivals	Arrival Rate
00:00 − 06:00	2850	4.57
06:00 − 12:00	8910	14.288
12:00 − 18:00	9607	15.406
18:00 − 24:00	6943	11.134

Table 5: Terminal 2 Arrival Rates

Time Slots	Number of Arrivals	Arrival Rate
00:00 − 06:00	14007	19.967
06:00 − 12:00	16988	25.29
12:00 − 18:00	14117	21.076
18:00 − 24:00	14855	21.583

Table 6: Terminal 3 Arrival Rates

The waiting times at each point of the simulation (entry gates, check-in, security lane and boarding gates) were found from Delhi Airport's official page.

The above calculated wait times were utilized to determine the Service rate at each service point (Gates, Check-in counters and Security) using *(M/M/1)* logic.

Poisson Process

$$W_q = \frac{\lambda/c}{\mu - \lambda/c} \tag{2}$$

(found μ → inverse of μ is service time of server)

Waiting Hall: Average waiting time before boarding is between 20 and 40 minutes.
Walking Time: Security $\rightarrow$ Waiting Hall has distribution TRIA(5,10,10) minutes.
Boarding Time: Time to board aircraft follows TRIA(15,20,30) minutes.

Process Distributions

Process	Terminal(s)	Distribution Type / Expression (minutes)
Gate Entry	T1, T2	Exponential EXPO(2)
	T3	Exponential EXPO(0.7)
Check-in	T1, T2	Exponential EXPO(2.5)
	T3	Exponential EXPO(2.5)
Security	T1, T2	Exponential EXPO(5)
Domestic Security	T3	Exponential EXPO(2)
International Security	T3	Exponential EXPO(5)

Passenger arrivals across Delhi Airport's terminals are modeled based on *empirical flight schedules* and passenger statistics to ensure realistic simulation inputs. Arrivals follow an *exponential interarrival time distribution*, capturing the inherently random and independent nature of passenger inflow. At Terminal 1, passengers of IndiGo and SpiceJet typically arrive about two hours before departure, while Terminal 2 accommodates IndiGo and Akasa Air passengers arriving one to two hours prior to their flights. Terminal 3 handles international carriers, primarily Air India and Air India Express, with passengers generally arriving one to two hours before departure, depending on flight schedules. These arrival streams serve as the input to terminal operations, including digital and regular check-in, security screening, and boarding, directly influencing queue lengths, service utilization, and overall congestion within each terminal.

Service Times at Each Service Point:

Service times at all service points across Terminals 1, 2, and 3 (such as check-in, security, and boarding) are modeled using exponential distributions. The mean service rate dynamically changes every hour, reflecting variations in staff efficiency, passenger load, and operational conditions. This hourly variation captures realistic fluctuations in service speed observed during peak and off-peak periods, allowing the simulation to accurately represent real-world airport operations and their impact on passenger waiting times and queue lengths.

SimPy Code Implementation

A discrete-event simulation model was developed using Python's SimPy framework to represent the passenger processing system across all terminals of the airport. The model captures the end-to-end journey of passengers from arrival to boarding, incorporating stochastic service times, resource constraints, and queueing behavior at each stage of the process.

For Terminals 1 and 2, which handle only domestic passengers, the modeled sequence of activities includes gate entry, check-in, security screening, waiting hall delay, and boarding. Each process is defined as a resource in SimPy with limited capacity (e.g., number of gates, check-in counters, or security lanes), and the associated service times follow probability distributions obtained from input data analysis (such as Exponential). Passengers arrive according to a Poisson process, with interarrival times generated using exponential sampling, and move through the system based on resource availability.

For Terminal 3, the simulation extends this framework to accommodate both domestic and international passengers. After check-in, passengers are probabilistically routed to the domestic security area or the international security area. Within the international stream, passengers are further divided into Economy and Business/First Class, with separate security lanes for priority processing. Each of these service points uses its own distribution parameters and resource capacities to reflect realistic operational differences.

Throughout the simulation, key performance metrics are continuously tracked, including waiting times, queue lengths, resource utilization, throughput per hour, and total passenger time in the system. These outputs are summarized through descriptive statistics and visualized using plots (histograms, boxplots, and time-series trends) to assess passenger congestion, bottlenecks, and service efficiency across all terminals.

In essence, while Terminals 1 and 2 share a uniform domestic-only process flow, Terminal 3 incorporates an additional layer of complexity due to the presence of international passengers and class-based routing. This unified model structure allows comparative analysis of terminal performance and supports evaluation of different passenger redistribution or capacity scenarios within the airport system.

Simulation Modeling Framework for Airport Terminals

1. Passenger Flow Structure

All passengers follow the standard processing sequence:
Entry Gate → Check-in → Security Screening → Waiting Hall → Boarding Gate
For Terminal 3, the process branches as:

- **Domestic:** Gate → Check-in → Domestic Security → Domestic Boarding

- **International:** Gate → Check-in → International Security → Boarding

2. Key Modeling Assumptions

1. **Passenger Arrival Window:**

   Passengers arrive *60 to 120 minutes prior* to departure. Arrivals within this window follow *exponential inter-arrival times*, capturing real peak clustering.

2. **Service Discipline:**

   All stations operate under *First-Come-First-Served (FCFS)*, except:

   - DigiYatra users skip manual gate processing.
   - International First/Business passengers use priority security lanes.

3. **Resource Availability:**

   Counters, security lanes, gates, and boarding areas are assumed to be fully operational without breakdowns or personnel shift constraints.

4. **Passenger Completion:**

   All passengers entering the system are assumed to complete processing (i.e., no missed flights are modeled).

5. **No Inter-Terminal Transfers:**

   Passengers do not switch between terminals during the simulation.

6. **Passenger Count per Flight:**

   The number of passengers per flight is taken directly from the dataset, assumed to be accurate and final.

3. Passenger Mix and Flow Ratios

- Around *19% of total passengers use DigiYatra*, benefiting from faster biometric entry gates. The remaining *81% enter through regular manual gates*, where queueing is comparatively higher.

- In Terminal 3, the passenger distribution is approximately:

  - *63% Domestic passengers*, utilizing domestic security lanes which are faster due to higher lane availability.
  - *37% International passengers*, requiring additional documentation and scanning, resulting in longer security times.

- Among the international passenger segment, around *10–20% travel in First or Business class*, who are routed through priority security lanes, reducing their waiting time significantly. The remaining *80–90% are Economy class* passengers who pass through regular international security lanes.

4. Key Performance Metrics Measured

The simulation tracked the total passenger time in the system from entry to boarding, along with the average waiting times at each processing stage such as gates, check-in, and security. It also recorded the average and peak queue lengths to identify congestion points. Resource utilization levels were measured to understand how busy each counter or lane was during operations. Additionally, passenger throughput per hour and the number of passengers in the system over time were monitored to capture peak-hour load variations. Performance was further analyzed by airline and passenger type to understand how different passenger mixes impacted terminal operations.

Operational Performance Analysis of Airport Terminals Simulation

Terminal 1 Simulation Report

The simulation for Terminal 1 processed a total of 10,687 passengers, with an average total time in the system of 96.29 minutes. The primary waiting contributors were check-in for IndiGo (22.20 min) and security screening (14.74 min), while gate entry had comparatively low waiting times and boarding delays were negligible. The average queue lengths at check-in and security were 7.64 and 3.04 passengers respectively, indicating moderate congestion. Resource utilization showed that security operations were busier (29.36%) than check-in counters (15.65%), suggesting underutilized check-in capacity. Overall, Terminal 1 operated efficiently with manageable queues, though passenger surges during peak hours slightly increased total system time.
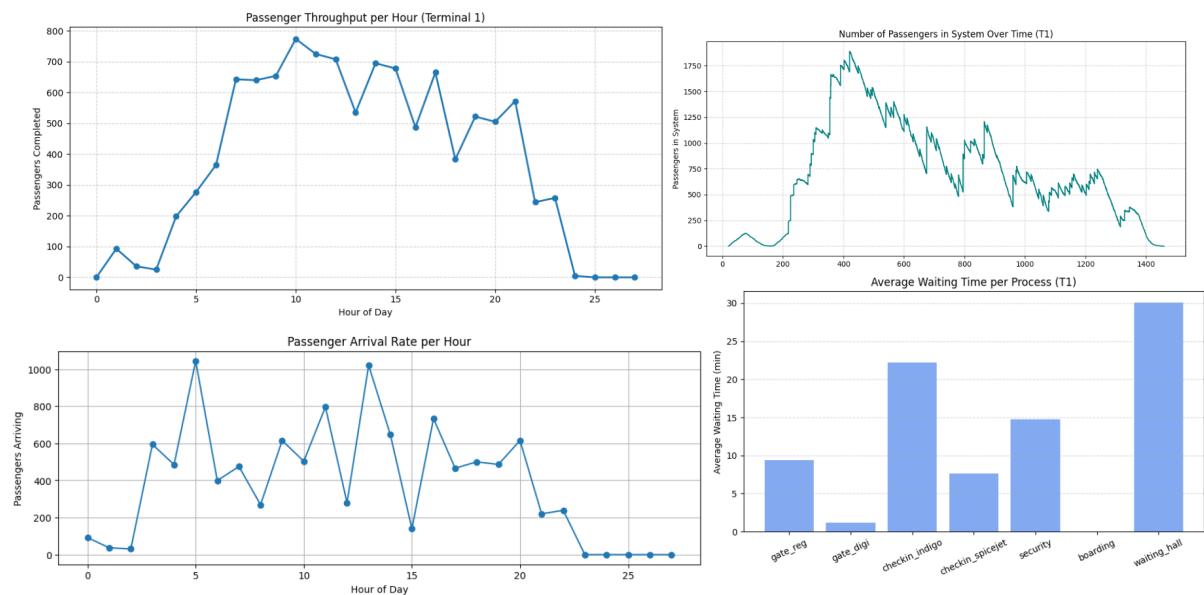

Figure 7: Terminal 1 Graphical Analysis for 24 hours
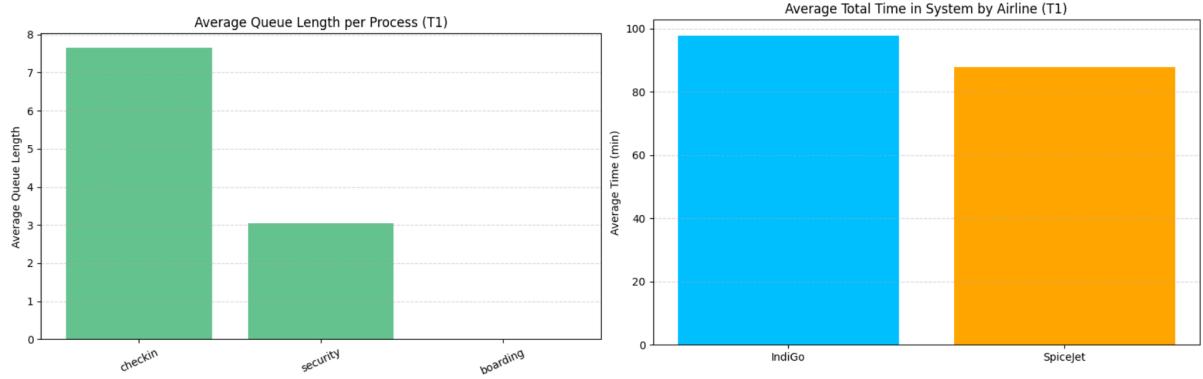
Figure 8: Terminal 1 Graphical Analysis for 24 hours

Terminal 2 Simulation Report

Terminal 2 handled 16,147 passengers, resulting in a higher average time in the system of 119.75 minutes due to increased passenger density. The major delays occurred at check-in (IndiGo ∼24.87 min, Akasa Air ∼25.23 min) and security (28.49 min average), leading to larger queue lengths (check-in: 10.57; security: 6.53). Resource utilization was notably higher here, with security operating at ∼44% capacity, indicating sustained load during the day and prominent bottlenecks. While the gate entry and boarding processes performed efficiently, the combined load of two airlines at limited check-in counters contributed significantly to system-wide delay. This suggests a need for redistribution of check-in counters or increased staffing during peak flight clusters.
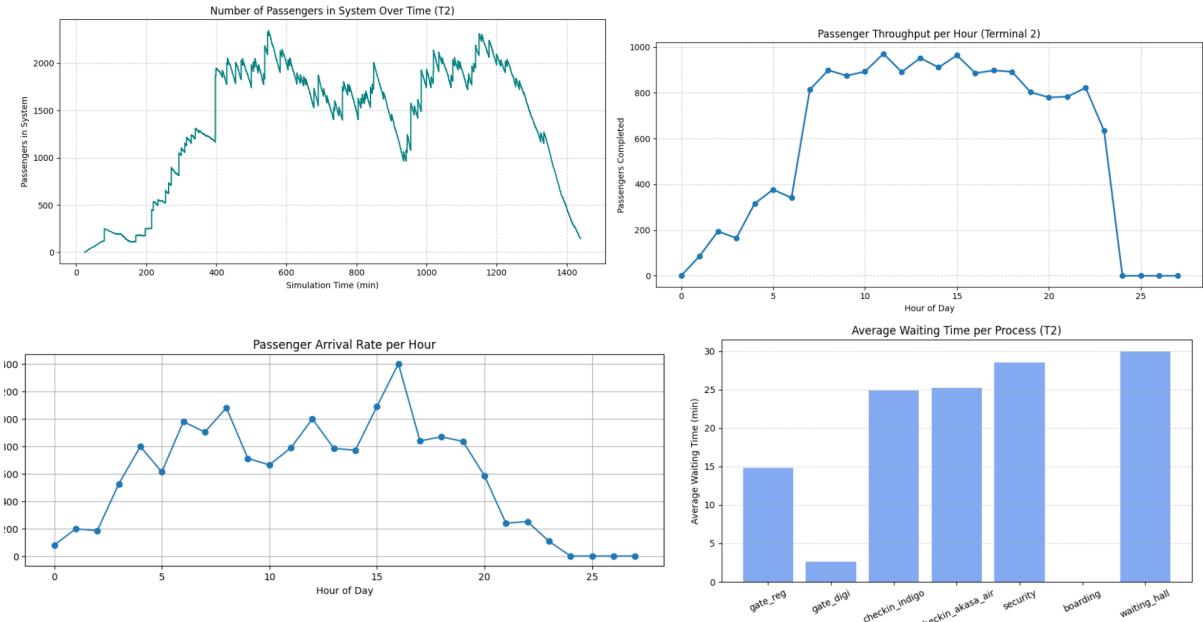
Figure 9: Terminal 2 Graphical Analysis for 24 hours
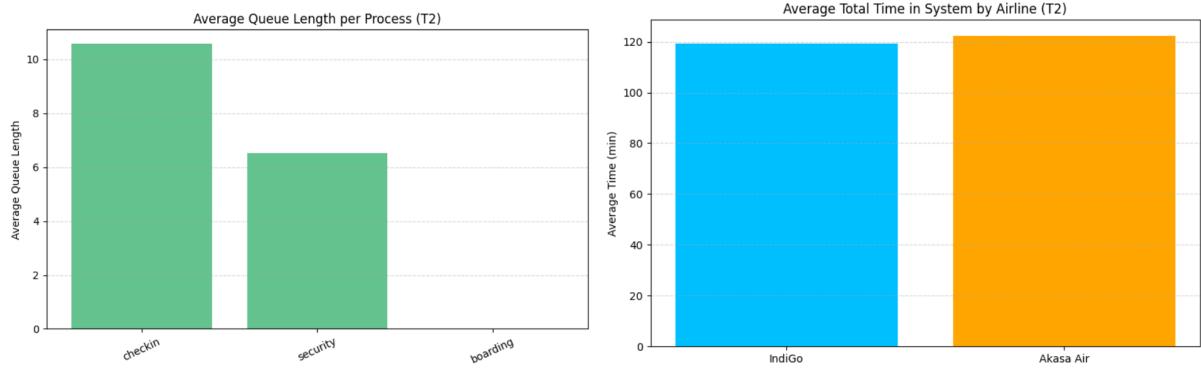
Figure 10: Terminal 2 Graphical Analysis for 24 hours

Terminal 3 Simulation Report

Terminal 3 processed the highest volume of 41,901 passengers, with 41,862 completing the full system and an average time in system of 117.46 minutes. The waiting times varied by passenger type: domestic passengers experienced moderate security delays ($\sim$23.62 min), while international passengers faced longer waits ($\sim$35–36 min) due to separate first-class and economy security processing. Check-in delays were moderate (15.27 min), but security queues were significantly larger, especially in the international section (peak queue: 94 passengers). Resource utilization further confirmed this, with international security operating at $\sim$84% utilization, marking it as a critical bottleneck. The boarding and waiting hall processes did not contribute much to delays. Overall, Terminal 3 performance is strongly influenced by high passenger density and uneven security workload distribution, suggesting that adding security counters or rebalancing domestic vs international screening capacity would improve flow.
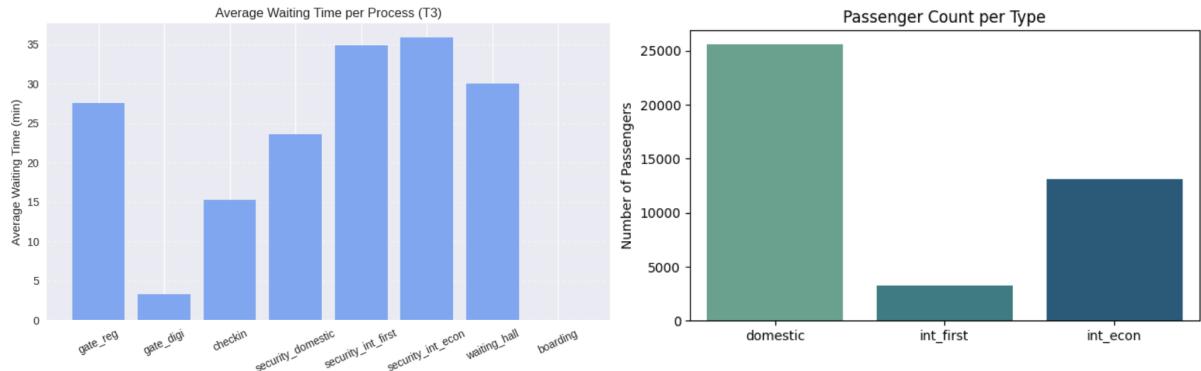
Figure 11: Terminal 3 Graphical Analysis for 24 hours
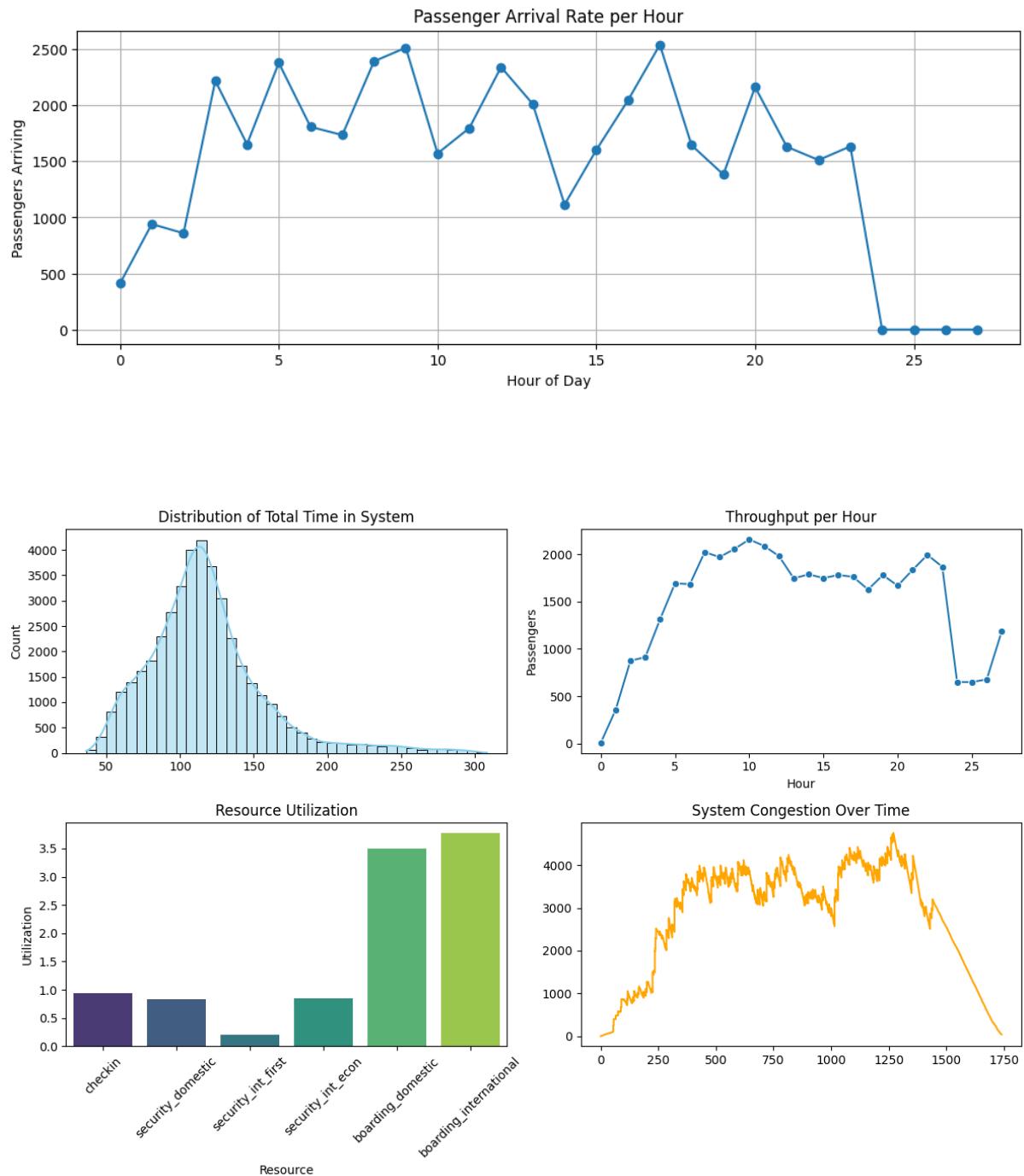
Figure 12: Terminal 3 Graphical Analysis for 24 hours

Model Verification and Validation

1. Comparison of Observed and Simulated Waiting Times

The simulation output was compared with actual observed operational data for key passenger processes at Terminal 1, Terminal 2, and Terminal 3. The goal was to determine how closely the simulation replicates real airport performance.

Observed vs Simulated Wait Times

Terminal	Process	Subtype	Observed (min)	Simulated (min)
T1	Entry	Regular	9.4	9.0
T1	Entry	DigiYatra	1.2	2.0
T1	Check-in	Common	14.9	15.0
T1	Security	Common	14.74	9.0
T2	Check-in	Common	25.78	25.0
T2	Entry	Regular	16.66	14.8
T2	Entry	DigiYatra	2.52	2.67
T2	Security	Common	26.0	28.0
T3	Check-in	Common	15.26	22.0
T3	Entry	Regular	27.58	27.0
T3	Entry	DigiYatra	3.26	3.0
T3	Security	Domestic	23.62	23.0
T3	Security	International	34.88	35.0

Table 8: Comparison of Observed and Simulated Processing Times Across Terminals

Paired Statistical Test Result

Test Applied	T-Statistic	P-Value	Interpretation
Paired t-Test	0.022	0.983	No significant difference → Model Valid

Table 9: Comparison of Observed and Simulated Processing Times Across Terminals

Summary of Model Accuracy

The p-value (0.983) is greater than 0.05, indicating that the simulated waiting times are statistically similar to real-world observations. Therefore, the developed simulation model is accurate and reliable for analyzing passenger flow and evaluating improvements.
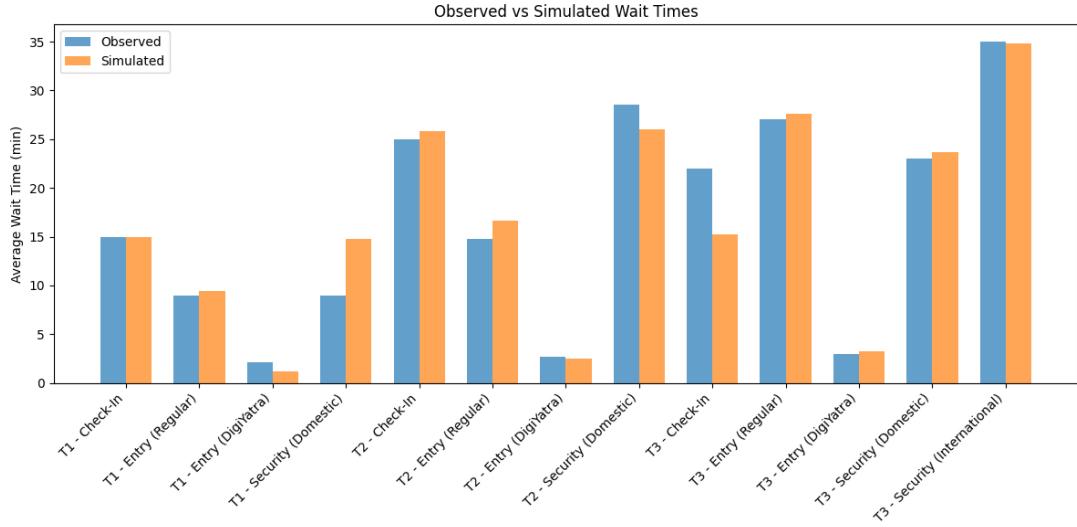
Figure 13: Observed vs Simulated Wait Times

2. Sensitivity Test: Impact of 20% Drop in Passenger Arrivals

To evaluate how the system behaves under reduced demand, the passenger arrival rate was decreased by 20% ($\alpha = 0.8$). The resulting performance metrics were compared against the baseline scenario ($\alpha = 1.0$).
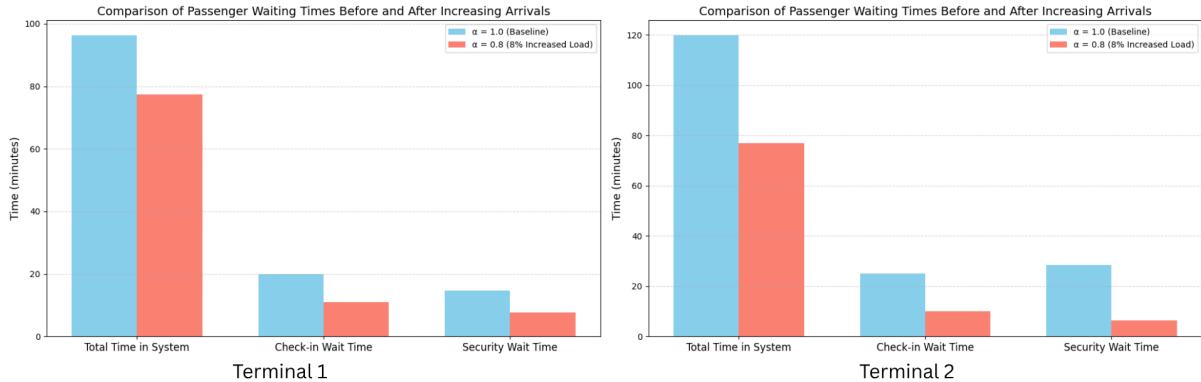

Figure 14: Comparison of Passengers Waiting Times for T1 and T2
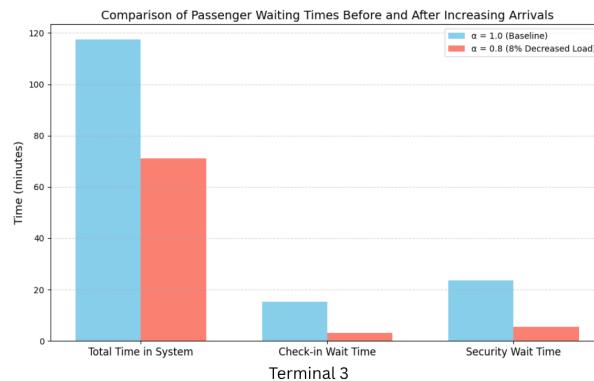
Figure 15: Comparison of Passengers Waiting Times for T3

Terminal	Performance Metric	Baseline ($\alpha = 1.0$)	Reduced Load ($\alpha = 0.8$)	Observed Impact
T1	Total Time in System	96.29 min	77.45 min	Noticeable reduction in overall time
	Check-in Wait	14.93 min	9.25 min	Check-in congestion significantly relieved
	Security Wait	14.74 min	7.68 min	Strong improvement due to lower crowding
T2	Total Time in System	119.75 min	76.97 min	Moderate improvement
	Check-in Wait	25.05 min	12.99 min	Reduced queueing pressure
	Security Wait	28.49 min	6.40 min	Smoother passenger throughput
T3	Total Time in System	117.46 min	71.17 min	Major decrease in total processing time
	Check-in Wait	15.27 min	3.26 min	Queue formation eased significantly
	Security Wait	31.08 min	14.41 min	Previously critical bottleneck dramatically relieved

Table 10: Terminal Performance Comparison under Different Load Factors

Summary of Sensitivity Analysis

The sensitivity test with a 20% reduction in passenger arrivals shows a clear system-wide improvement in processing efficiency. Waiting times at check-in and security decrease noticeably across all terminals, with the most significant gains observed at Terminal 3, where international security waits drop sharply, indicating that this area was previously operating near capacity limits. Terminal 1 also benefits substantially, particularly at the check-in counters, highlighting this as a key congestion point under normal load. Terminal 2, meanwhile, shows moderate improvement and appears to maintain more balanced capacity utilization. Overall, the analysis confirms that the simulation model effectively captures how congestion emerges and subsides in response to passenger demand, while also helping identify critical bottlenecks—specifically T1 check-in and T2 international security—as strategic priority areas for resource strengthening and operational planning.

Overall Validation Conclusion

The results of both the statistical validation using a paired t-test and the sensitivity stress test confirm that the simulation model is:

- **Accurate** in reproducing real airport performance

- **Sensitive** to operational changes such as increased passenger volume

- Suitable for evaluating policy interventions, resource allocations, and terminal configuration improvements.

This validated model forms a sound analytical basis for decision-making and scenario planning in airport passenger flow management.

Output Analysis

To ensure statistically reliable results, the simulation model was executed for *30 independent replications* for each terminal. For each performance measure — total time in system, waiting time at check-in, waiting time at security, and utilization of service counters — the *mean, standard deviation*, and *95% confidence intervals* were calculated. This approach allows us to evaluate both the average performance and the variability of operations under normal passenger demand conditions.

Metric	Terminal 1 (Mean ± CI)	Terminal 2 (Mean ± CI)	Terminal 3 (Mean ± CI)
Avg. Total Time in System (min)	98.03 ± 1.98	117.57 ± 3.71	118.86 ± 1.92
Avg. Wait – Check-in (min)	20.61 ± 0.98	23.20 ± 1.16	21.53 ± 2.46
Avg. Wait – Security (Domestic) (min)	15.49 ± 1.63	26.66 ± 3.37	15.60 ± 2.64
Avg. Wait – Security (International) (min)	–	–	37.32 ± 1.46
Utilization – Check-in (%)	15.69 ± 0.11	23.59 ± 0.11	94.20 ± 0.30
Utilization – Security (Domestic) (%)	29.30 ± 0.15	44.67 ± 0.25	82.10 ± 0.30
Utilization – Security (International) (%)	–	–	53.30 ± 0.30

Table 11: Comparison of Key Performance Metrics Across Terminals

Terminal 1

Terminal 1 demonstrates stable and manageable performance. The average total time a passenger spends in the system is roughly 98 minutes, with check-in wait times around 21 minutes and domestic security waits around 15 minutes. The utilization of both check-in and security resources remains well below saturation, indicating that Terminal 1 has

remaining capacity and can accommodate additional passenger load without immediate performance deterioration.
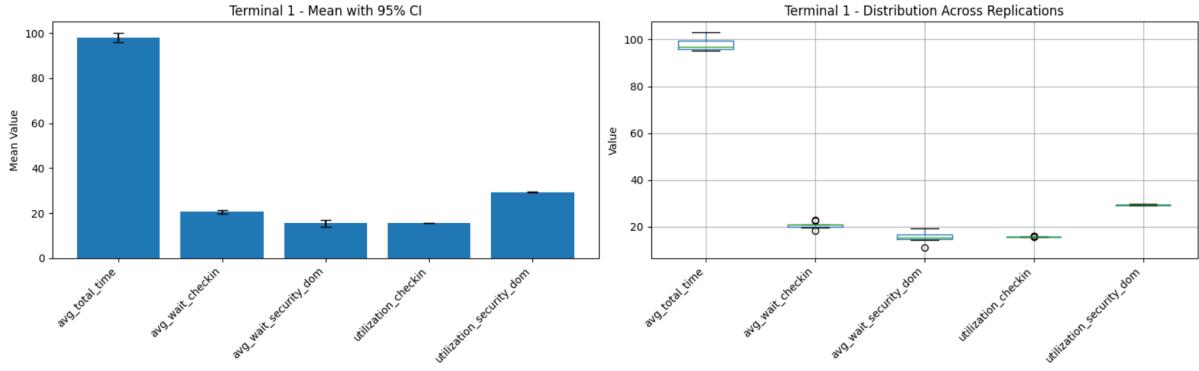

Figure 16: Terminal 1: Mean Performance and Consistency Across Runs

Terminal 2

Terminal 2 shows higher operational pressure compared to Terminal 1. The average total time in the system increases to approximately 118 minutes, driven by longer waits at both check-in (23 minutes) and domestic security (27 minutes). The utilization at these resources is also significantly higher, suggesting that Terminal 2 operates closer to its capacity limits. This implies that Terminal 2 is more sensitive to demand fluctuations, and even moderate increases in arrivals could lead to noticeable congestion.
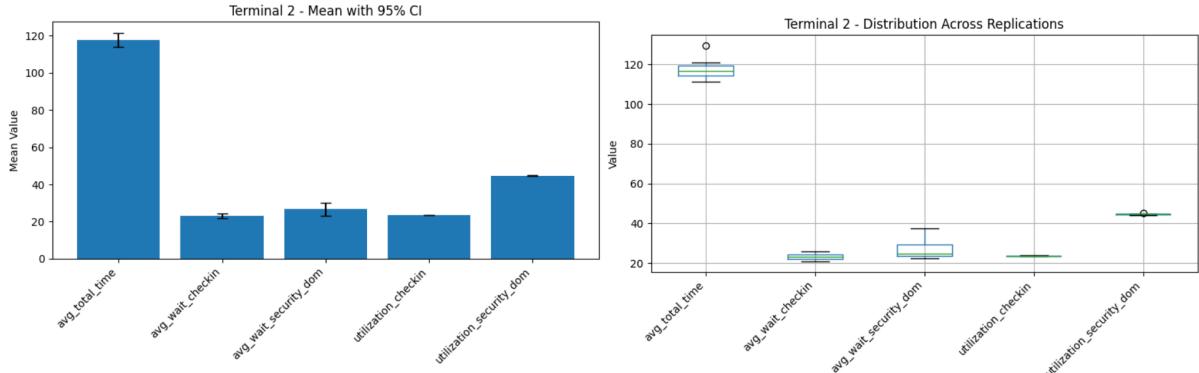
Figure 17: Terminal 2: Mean Performance and Consistency Across Runs

Terminal 3

Terminal 3 experiences the greatest congestion, particularly for international passengers. While domestic processing times are comparable to those at Terminal 2, international security wait times average 37 minutes, making it the primary source of delay at this terminal. The utilization measurements confirm this: domestic check-in and security resources are operating near full load (very high utilization levels), indicating limited flexibility to absorb additional traffic. Thus, Terminal 3 is the most capacity-constrained terminal among the three.
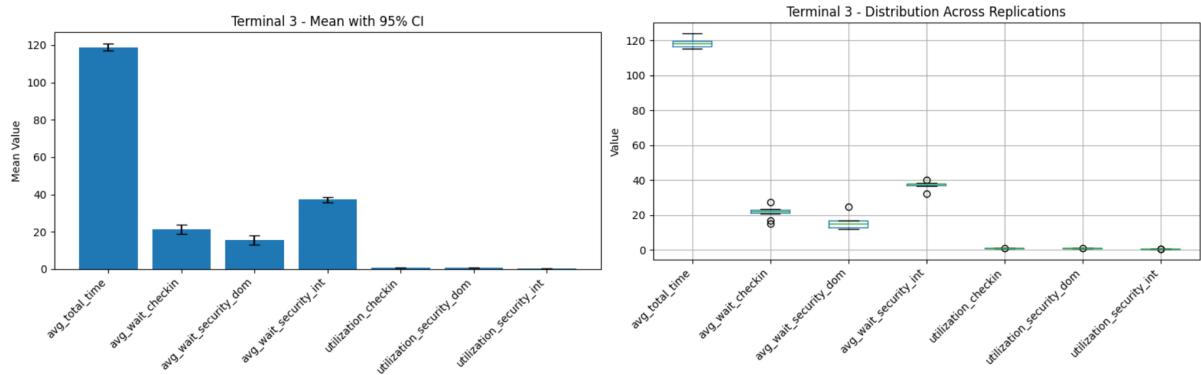
Figure 18: Terminal 3: Mean Performance and Consistency Across Runs

Impact of Infrastructure Improvements

Optimization of Terminal Operations Through Capacity Enhancements

To reduce congestion and improve passenger movement efficiency across terminals, we performed a simulation-based optimization of operational resources. The counts of entry gates, check-in counters, security lanes, and boarding gates were varied to determine the configuration that minimizes overall passenger waiting time while remaining realistic and feasible to implement in an actual airport environment.

Unlike static analytical models, airport operations involve stochastic (random) arrivals, hourly passenger surges, and service time variability. Therefore, the optimization process was carried out using a simulation-driven search, where each configuration was evaluated through multiple runs of the simulation model.

Objective of Optimization

The objective guiding the optimization was:

$$\textbf{Minimize} \quad W_{\text{total}} = W_{\text{entry}} + W_{\text{check-in}} + W_{\text{security}} + W_{\text{boarding}}$$

This ensures improvement across the *entire passenger journey*, rather than focusing on only one processing stage.

Decision Variables (What We Optimized)

- Number of Entry Gate Scanners

- Number of Check-in Counters

- Number of Security Lanes (Domestic & International)

- Number of Departure/Boarding Gates

These variables are *integers*, since fractional counters have no real-world meaning.

$$x_1, x_2, x_3, x_4 \in \mathbb{Z}^+$$

Constraints Considered in the Optimization

The optimization respected several realistic operational and infrastructure constraints:

1. **Space Constraints:** Maximum counters and security lanes are limited by physical layout of each terminal.

2. **Staffing Constraints:** Each additional counter requires additional trained employees; expansion must be staff-feasible.

3. **Service Rate and Throughput Limits:** Each counter has a fixed handling capacity (passengers per hour), which cannot be exceeded.

4. **Operational Feasibility/Budget Constraint:** The solution avoids excessive counters that provide no meaningful performance improvement.

Formally,

$$0 \leq x_i \leq x_{i,\max}, \quad x_i \in \mathbb{Z}$$

Where $x_{i,\max}$ is the maximum feasible resource capacity.

Algorithm Used

A *Resource Sweep + Greedy Hill-Climbing* approach was applied:

1. Begin with current (baseline) resource levels.

2. Increment counters by small steps (e.g., +1 or +2 at a time).

3. Simulate each configuration and measure average waiting time.

4. Accept the change only if performance improves sufficiently.

This decision is guided by threshold parameters in the code:
If adding counters reduces waiting time by *less than 0.5 minutes*, or less than *2%*, the algorithm *stops* increasing that resource.Running 3 replications ensures results are stable and not random noise.

Behavior of the Optimization

The optimization exhibits a clear performance pattern. When the number of available counters is too low, passenger queues begin to build up rapidly, leading to long waiting times and congestion in the processing areas. As additional counters are introduced, these waiting times decrease because the system gains more capacity to handle the incoming passenger flow. However, this improvement continues only up to a certain point. Beyond this threshold, further increasing counters does not significantly reduce waiting times, since other stages or limitations in the system begin to dominate. The optimization algorithm identifies this equilibrium point, where the reduction in waiting time becomes minimal, and selects that configuration as the optimal solution. This ensures that the terminal achieves smoother passenger flow, reduced bottlenecks, and efficient use of resources without overspending or deploying unnecessary

Optimization Results Overview

1. Optimization Result (Terminal 1)

The optimization process identified that only selective increases in resources were necessary to improve performance at Terminal 1. The number of IndiGo check-in counters was increased from 20 to 25, and the number of security screening lanes was increased from 12 to 15, while all other resources—including regular gate counters, digital self-check terminals, SpiceJet check-in counters, and boarding gates—remained at their original levels. With this optimized configuration, the average total passenger waiting time decreased from approximately 42.46 minutes to about 33.15 minutes, representing a reduction of nearly 22%. This outcome confirms that targeted adjustments at the check-in and security stages are sufficient to alleviate congestion and significantly enhance passenger flow efficiency at Terminal 1, without requiring structural expansion or major resource additions.
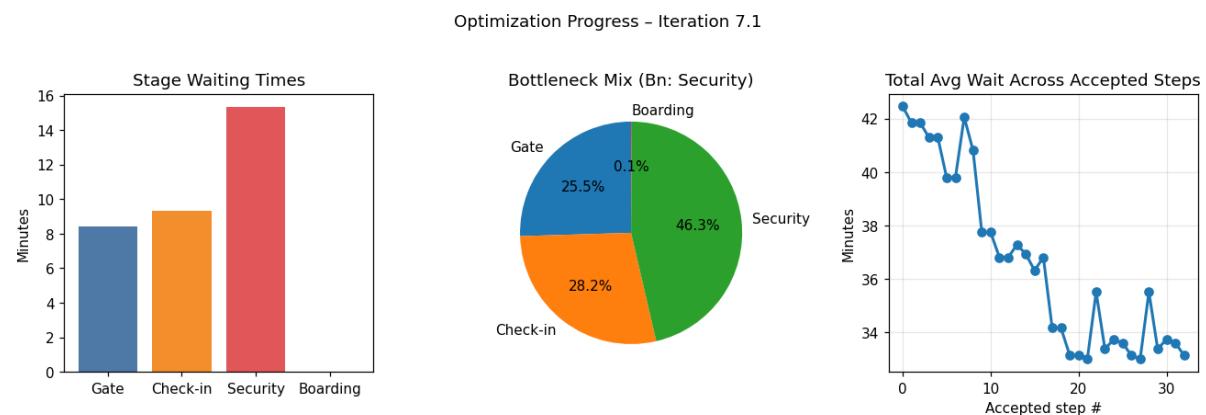

Figure 19: Optimization Progress

Before–After Impact on Passenger Waiting Times

The stage-wise comparison (shown in your first bar chart) indicates the largest improvement occurred at the check-in counters:
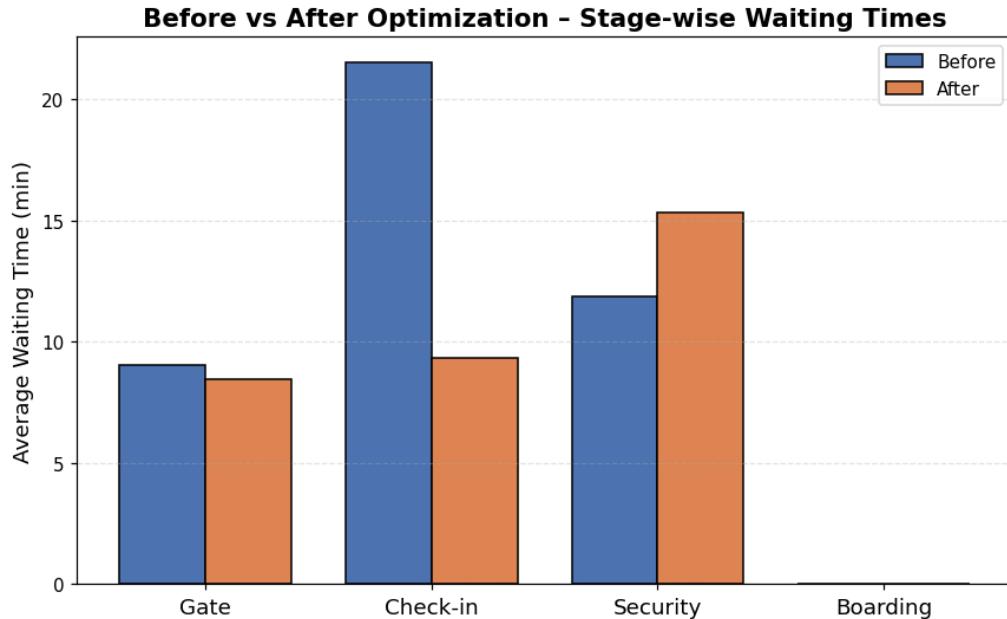

Figure 20: Stage Wise Waiting Times

The introduction of additional check-in counters removed the queue buildup, shifting the bottleneck toward security, which is expected when relieving a major upstream delay.

Bottleneck Shift
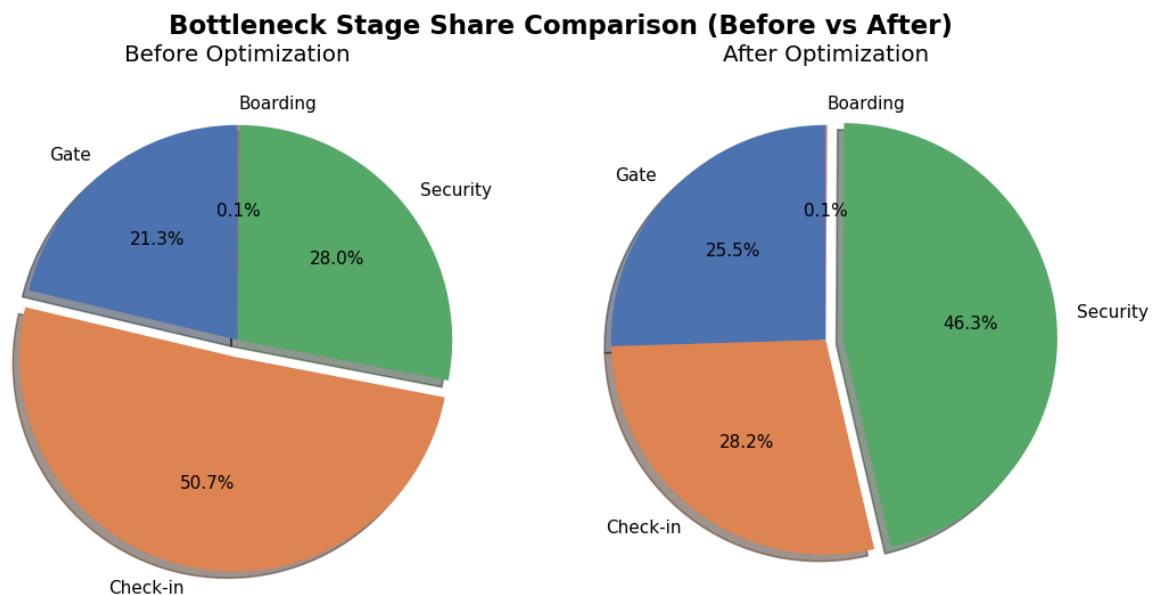
Figure 21: Terminal 2 Bottleneck Stage Share Comparison

- Before Optimization: Check-in accounted for 50% of total waiting time → clear bottleneck.

- After Optimization: Security now accounts for 46% of waiting time, while check-in's share drops to 28%.

This indicates that the check-in bottleneck has been successfully resolved, and security is now the marginal constraint, which is a more manageable and balanced system state.

Resource Capacity Comparison (Before vs After)

The comparison of resource capacities before and after optimization shows that only targeted adjustments were necessary to reduce congestion at Terminal 1. The number of IndiGo check-in counters was increased from 20 to 25, and security lanes were expanded from 12 to 15 to better handle passenger flow. All other resources, including gate counters, SpiceJet check-in counters, digital self-check terminals, and boarding gates, remained unchanged. This confirms that the bottleneck was primarily concentrated at the check-in and security stages, and that increasing capacity specifically at these points was sufficient to significantly improve overall system performance without requiring large-scale infrastructure expansion.
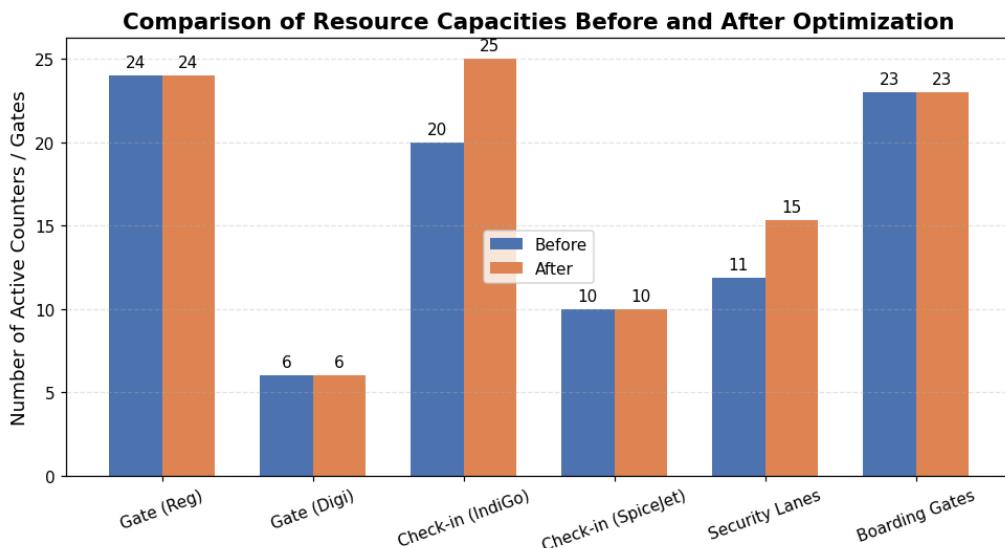
Figure 22: Comparison of Resource Capacities Before and After Optimization

Resource Utilization Changes

- **Check-in utilization dropped significantly**, indicating sufficient counters are now available and queues no longer form.

- **Security utilization increased**, reflecting that the passenger flow is now smoother and more continuous, moving the bottleneck forward.
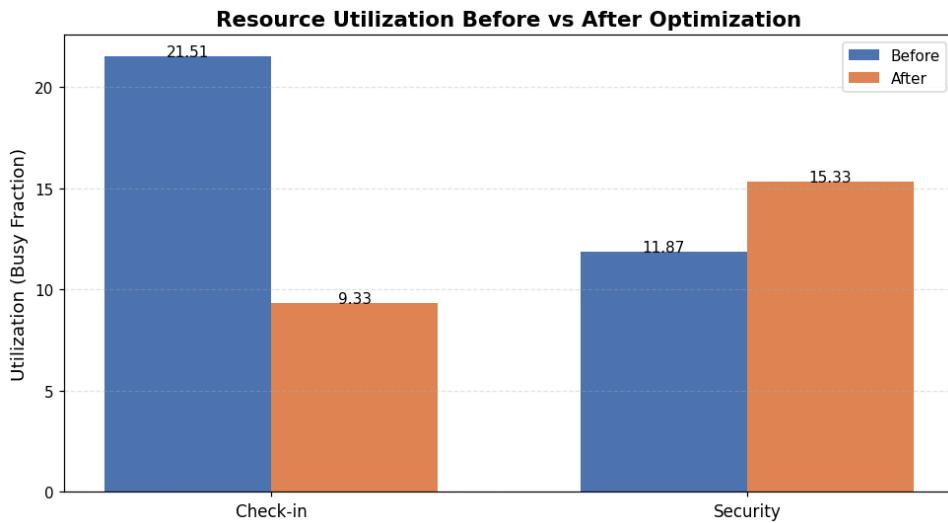
Figure 23: Resource Utilization Before vs After Optimization

- This shift is expected and desirable; it indicates flow balancing, not overloading.

Trend of Optimization Progress (Line Chart Interpretation)

The total average waiting time reduced steadily across iterations:Start: 42 min, Final: 33 min
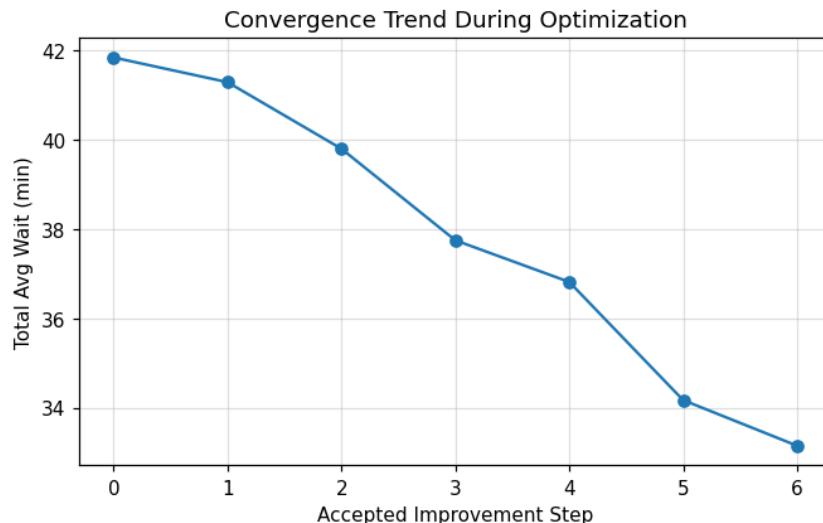
Figure 24: Convergence Trend During Optimization

This downward trend confirms that each incremental resource adjustment contributed to meaningful congestion reduction, until reaching the equilibrium point where additional resources yielded little further benefit.

2. Optimization Result (Terminal 2)

The optimization revealed that Terminal 2's primary bottleneck was at the security screening stage. Increasing the number of security lanes led to the most significant reduction in waiting time, with additional small improvements from increasing the number of IndiGo and Akasa check-in counters. Gate counters and boarding gates did not require expansion, as their utilization remained within efficient levels. With these targeted adjustments, the total average passenger waiting time at Terminal 2 was reduced from approximately 63 minutes to around 34 minutes, representing nearly a 46% decrease in overall congestion.

Before–After Impact on Waiting Times

The largest improvement occurred at the security screening stage, where the average waiting time dropped dramatically. Check-in wait times also reduced noticeably, while waiting at the gate and boarding stages remained largely unchanged. This indicates that the flow through the terminal is now more balanced, with fewer queue spikes and smoother passenger movement throughout the terminal.
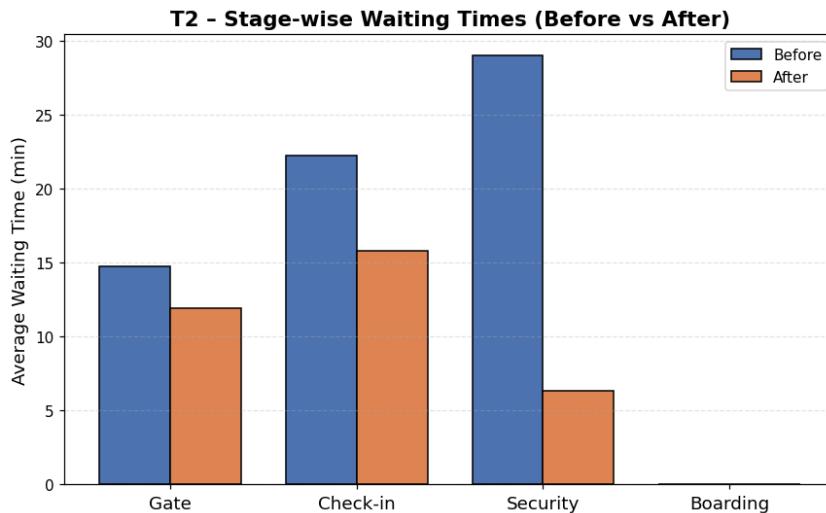

Figure 25: Terminal 2 Stage-wise Waiting Times (Before vs After)

Bottleneck Shift Interpretation

Before optimization, security screening accounted for the majority of passenger delay, making it the dominant bottleneck at Terminal 2. After increasing the number of security lanes, the waiting time at security decreased significantly, causing the system bottleneck to shift toward the check-in stage. This shift is expected and represents a more manageable flow pattern where delays are distributed across stages rather than concentrated in one location.
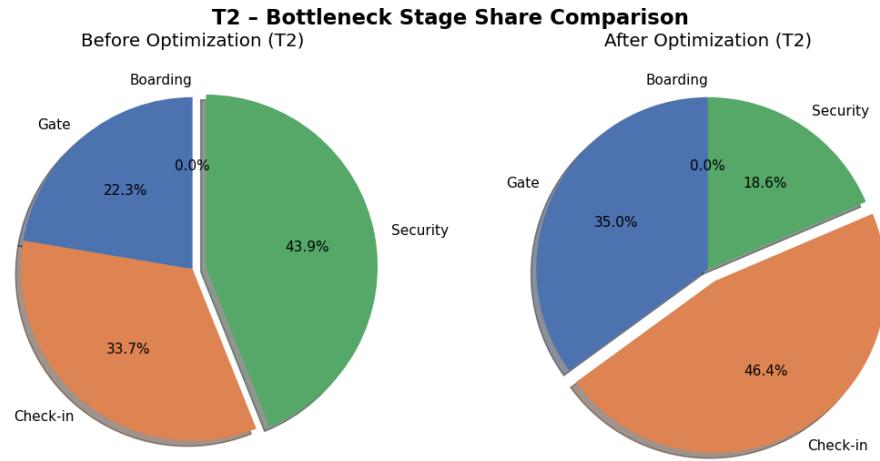
Figure 26: Terminal 2 Bottleneck Stage Share Comparison

Resource Counters Before vs After Optimization

This graph shows that only specific resources were increased to reduce congestion. Security lanes were expanded the most, and a few additional check-in counters were added, while gates and boarding counters remained unchanged. This indicates that the bottleneck was mainly at security and check-in, not at gate operations.
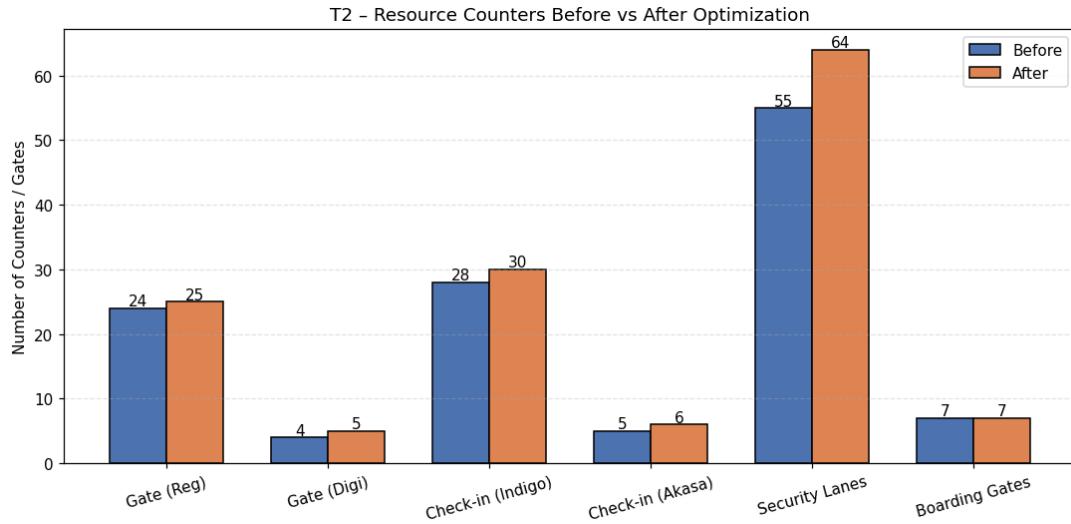

Figure 27: Terminal 2: Resource Counters Before vs After Optimization

Utilization Comparison (Before vs After)

After optimization, utilization levels at security and check-in became more balanced, showing reduced workload concentration at any single stage. Boarding utilization remained almost the same, confirming that gate capacity was already sufficient and not a source of delays.
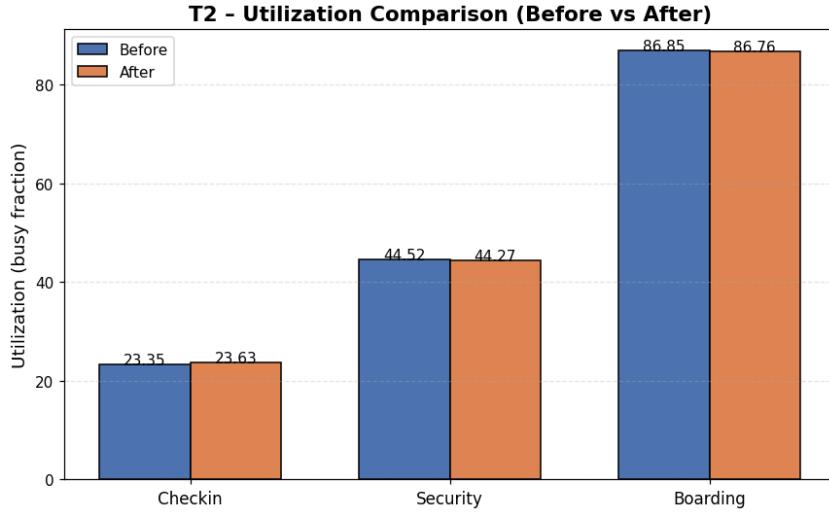
Figure 28: Terminal 2: Utilization Comparison (Before vs After)

Optimization Trend and System Behavior

The reduction in total waiting time was gradual and consistent across optimization iterations. Each accepted step contributed to incremental performance improvement until the system reached a point where additional resource increases produced little benefit. This confirms that the terminal has reached a balanced and efficient operating configuration.
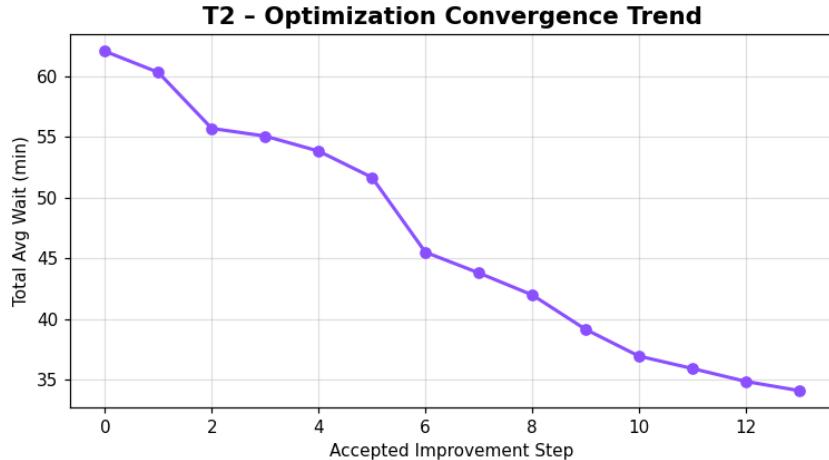

Figure 29: Terminal 2 Optimization Convergence Trend

3. Optimization Result (Terminal 3)

At Terminal 3, the major contributor to delays in the baseline scenario was the check-in and security processing stages, which resulted in long total waiting times of around 64 minutes. During optimization, the number of check-in counters and security lanes was gradually increased. As security capacity was expanded, the bottleneck shifted toward the gate processing stage, meaning the system began flowing more smoothly up to the gate area.

Through these targeted adjustments, the total average waiting time reduced from $\tilde{6}4$ minutes to $\tilde{3}5$ minutes, representing a reduction of nearly 45% in overall congestion.
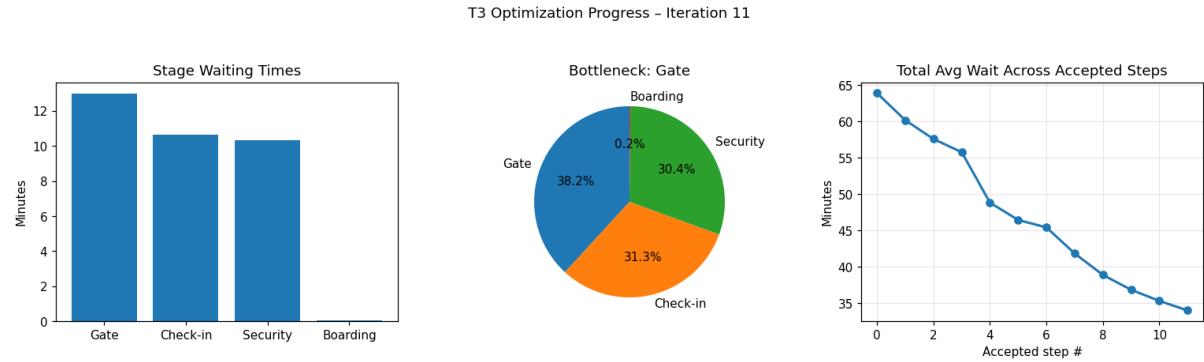

Figure 30: Terminal 3 Optimization Progress

Before–After Impact on Waiting Times

The reductions in waiting times were seen across all major service stages:

- **Gate waiting time** decreased significantly, indicating smoother passenger flow once upstream congestion was relieved.

- **Check-in waiting time** fell sharply after increasing counter availability, removing initial queue buildup.

- **Security waiting time** dropped from high levels to nearly half after increasing security capacity.

- **Boarding stage waiting time** remained negligible, confirming that boarding was never a bottleneck.Overall, the flow through T3 became much smoother, and peak pressure points were relieved.
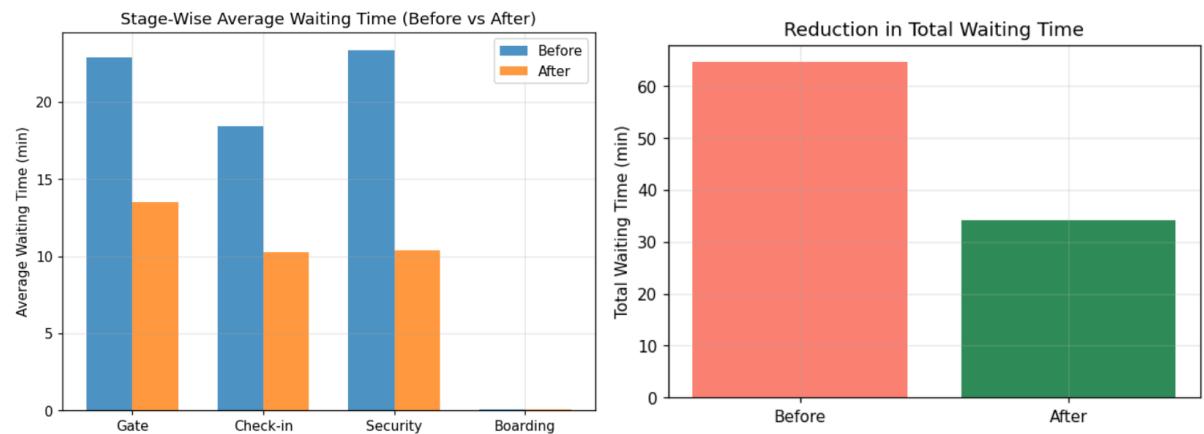

Figure 31: Terminal 3 Stage Wise Waiting Times

Bottleneck Shift Interpretation

Initially, accounted for the largest share of total waiting time, forming the dominant bottleneck. After adding security lanes, the bottleneck shifted toward gate occupancy, which is a natural and controlled system balance — once upstream queues clear, passengers arrive at gates more steadily. This indicates that Terminal 3 is now operating with a more uniform flow rather than heavy queue buildup in one area.
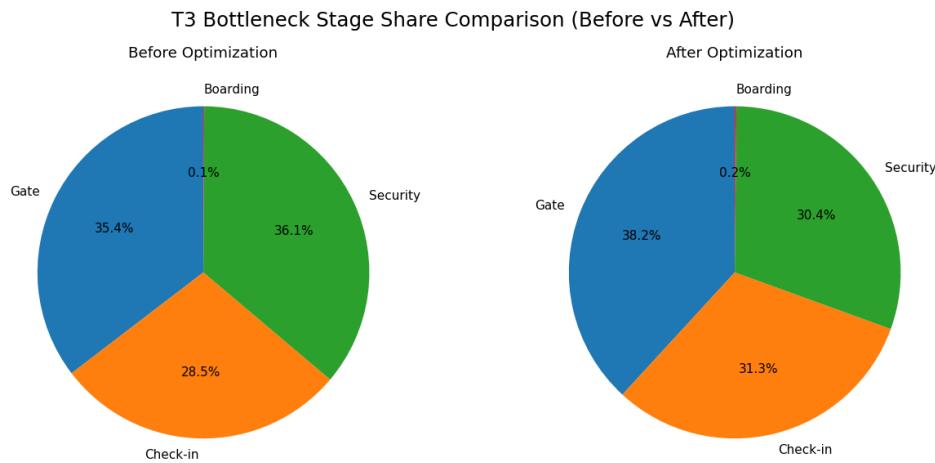

Figure 32: Terminal 3 Bottleneck Stage Share Comparison (Before vs After)
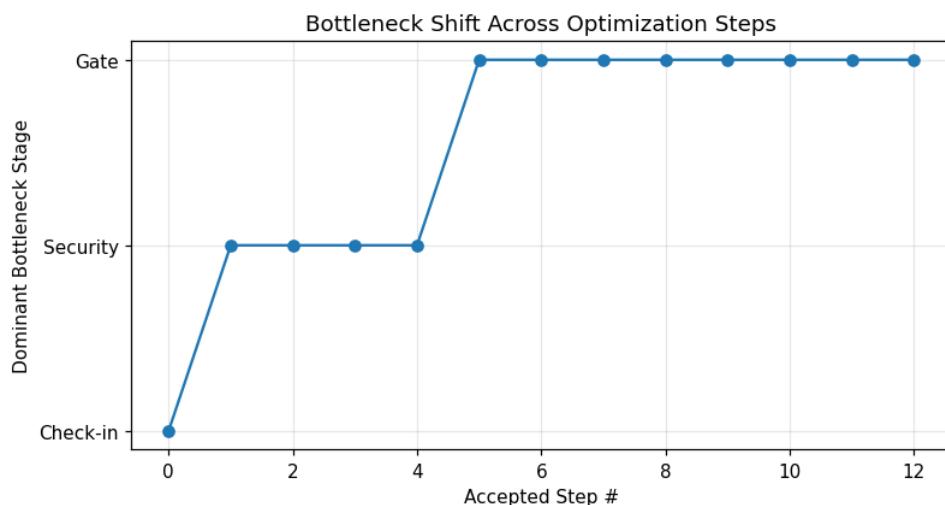
Figure 33: Terminal 3 Bottleneck Shift Across Optimization Steps

Increase in Service Counters (Before vs After)

The graph shows that Terminal 3 required increases mainly in check-in counters and security lanes to reduce congestion. Check-in counters were slightly expanded to handle peak passenger inflow more efficiently, while security capacity was increased more substantially because it had the highest impact on reducing delays. Gate counters and digital

self-service points remained almost unchanged, indicating that these were not major bottlenecks. Overall, the adjustments improved passenger movement across the terminal without unnecessary resource expansion.
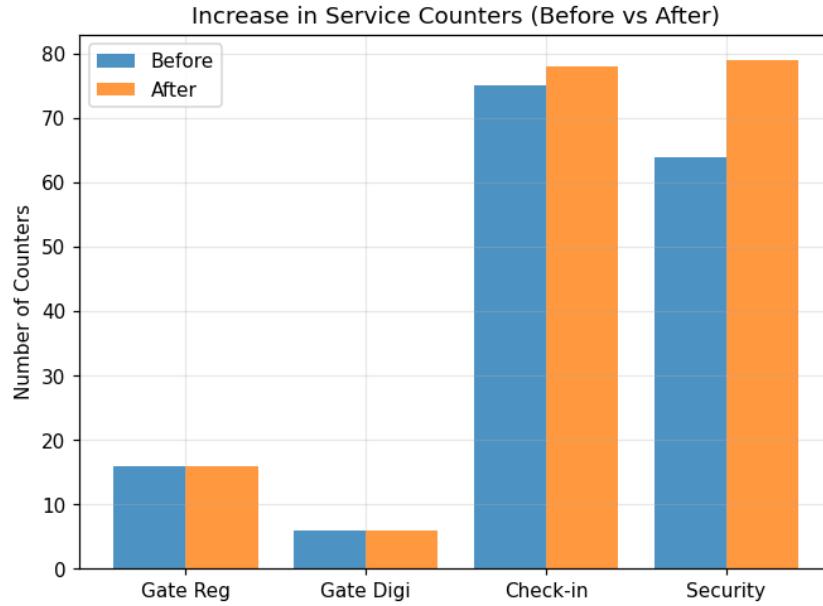

Figure 34: Terminal 3: Increase in Service Counters (Before vs After)

## Overall Impact of Optimization Across All Terminals
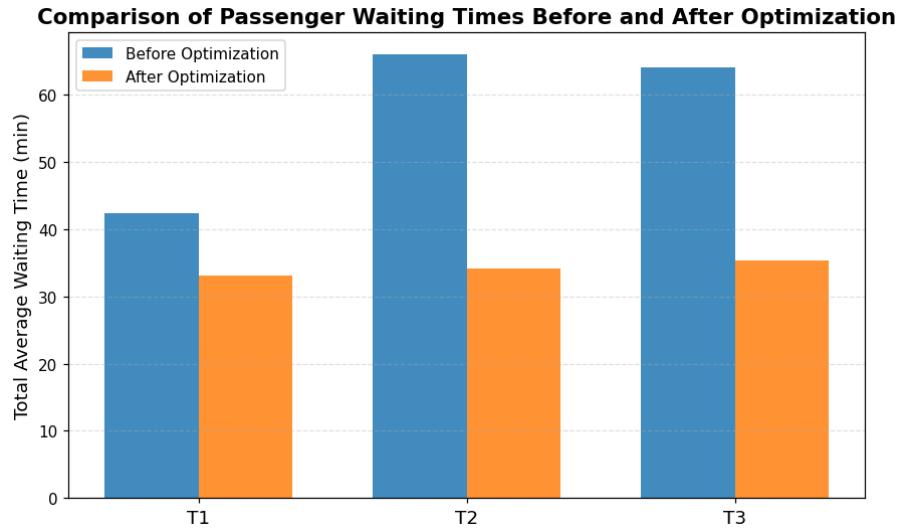
Figure 35: Comparison of Passenger Waiting Times Before and After Optimization

The comparison of total passenger waiting times before and after optimization across T1, T2, and T3 shows a significant reduction in congestion and delay at all terminals. Terminal 1 experienced a decrease from about 42 minutes to 33 minutes, Terminal 2 from around 66 minutes to 34 minutes, and Terminal 3 from roughly 64 minutes to 35

minutes. These improvements were achieved by strategically increasing service capacities at critical processing stages such as check-in counters and security lanes, rather than expanding gate infrastructure. The results demonstrate that targeted and data-driven resource adjustments can greatly improve operational efficiency, leading to faster passenger movement, reduced queue buildup, and an overall enhanced airport experience without requiring major physical expansion.

Impact Assessment of Terminal 2 Closure

The closure of Terminal 2 required redistributing its scheduled flights and passengers to Terminals 1 and 3. Since both terminals were already operating near their capacity limits during peak periods, the reassignment had significant effects on gate utilization and passenger waiting times. To understand this impact, we simulated flight operations after T2 closure and evaluated different passenger redistribution strategies.

Operational Logic Behind Terminal Reassignment and Gate Scheduling using Simulation

To evaluate the operational impact of the closure of Terminal 2 (T2), a scheduling and reassignment model was developed. The model reallocates flights originally scheduled at T2 to either Terminal 1 (T1) or Terminal 3 (T3) based on gate availability and estimated waiting times. The objective is to minimize passenger delays while maintaining realistic gate utilization levels and operational feasibility.

Input Data and Baseline Performance Summary

Flight schedule data for T1, T2, and T3 was extracted from the provided dataset. For each flight, departure times were standardized into minutes, and arrival times at the terminal were set to 30 minutes before departure to reflect passenger check-in and processing activity. Passenger counts were taken directly from the dataset, with a default value of 180 applied where missing. All flights were then ordered chronologically to maintain a realistic flow of terminal operations.

Each terminal operates with a fixed number of departure gates (23 at T1 and 38 at T3), and the baseline average passenger waiting times prior to any reassignment were used as reference benchmarks. These baseline waiting times were 96.29 minutes for T1, 119.75 minutes for T2, and 117.46 minutes for T3, representing the system performance before the closure of T2. These values serve as the comparison foundation to evaluate the impact of redistributing T2 flights to T1 and T3.

Dynamic Gate Utilization and Waiting Time Adjustment

At the time each flight arrives, the algorithm checks how many gates are currently occupied. Gate utilization is calculated as:

$$\text{Utilization} = \frac{\text{Number of Gates Occupied}}{\text{Total Gates Available}}$$

Passenger waiting time increases non-linearly as gate utilization approaches full capacity. This is modeled using:

$$\text{Adjusted Wait} = \frac{\text{Base Wait}}{(1 - \text{Utilization})^2}$$

This ensures:

- **Low crowding** $\rightarrow$ waiting times stay near baseline

- **High crowding** $\rightarrow$ waiting times rise sharply, simulating real congestion effects

Reassignment Logic (Decision-Making Rules)

When flights originally belonging to T2 need to be assigned:

1. If both T1 and T3 have free gates:

   - The flight is assigned to whichever terminal has the lower predicted waiting time at that moment.

2. If only one terminal has a free gate:

   - The flight is assigned to that terminal.

3. If no gates are free in either terminal:

   - The flight is assigned to the terminal that first opens a gate.

This ensures *passenger load distribution is adaptive*, not fixed.

Performance Measurement

After all flights are assigned, the total waiting time impact is computed based on:

- The number of passengers handled at each terminal

- Their predicted waiting times at the moment of assignment

A *weighted average waiting time* per terminal is calculated, ensuring terminals with higher passenger traffic influence results appropriately.

Post-Closure System Performance - Scenario-Based Comparison

To evaluate the operational impact of Terminal 2 closure, multiple redistribution strategies were tested to reassign T2 flights and passengers to Terminals 1 and 3. Four scenarios were simulated:

1. **Optimized** (Dynamic load-based assignment)

2. **All to T1** (Every T2 flight moved entirely to Terminal 1)

3. **All to T3** (Every T2 flight moved entirely to Terminal 3)

4. **50–50 Split** (Alternate assignment of T2 flights between T1 and T3)

i. Overall System Stability (Combined Waiting Time)

The first graph compares the combined average waiting times for T1 and T3 across the four reassignment strategies. In the Optimized scenario, the overall waiting time is approximately $(158.10 + 193.20) \approx 351.30$ minutes. The All-to-T1 scenario performs similarly with a combined waiting time of $(171.60 + 188.38) \approx 359.98$ minutes, indicating that T1 is more capable of absorbing additional passenger load without extreme congestion. However, sending all T2 flights to T3 leads to the worst performance, with a total waiting time of $(117.59 + 241.44) \approx 359.03$ minutes and exceptionally high delays at T3. The 50–50 split scenario shows moderate improvement with a combined waiting time of $(138.98 + 211.26) \approx 350.24$ minutes, but still underperforms relative to the optimized approach due to peak-time imbalances.

Terminal 3 experiences severe congestion if overloaded, making the All-to-T3 approach operationally unfeasible. Dynamic or balanced reassignment strategies (such as Optimized or All-to-T1) deliver lower total waiting times and better overall system stability.
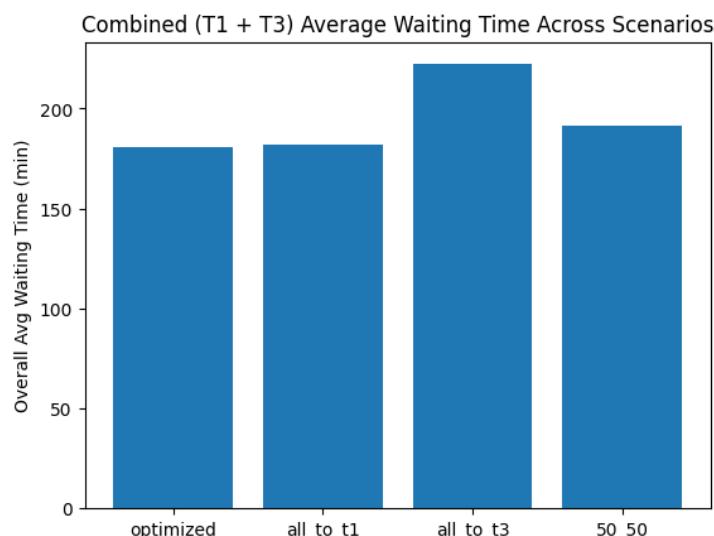

Figure 36: Combined Average Waiting Time

ii. Terminal-Level Waiting Time Comparison

The second graph shows how waiting times change at each terminal under different re-distribution strategies. In the Optimized case, waiting times rise moderately at both terminals (T1: 158.10 min, T3: 193.20 min) but remain manageable. All-to-T1 further increases congestion at T1 (171.60 min), while T3 improves slightly (188.38 min). How-ever, All-to-T3 causes severe overload at T3 (241.44 min), even though T1 becomes much faster (117.59 min). The 50–50 split reduces the burden on T1 (138.98 min), but T3 still faces high congestion (211.26 min).
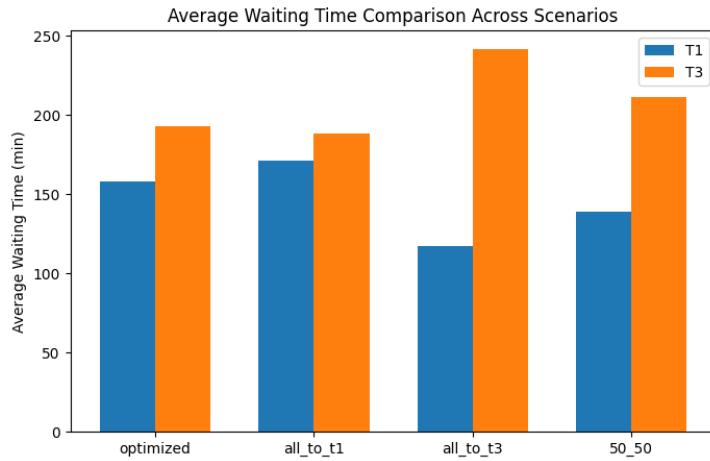

Figure 37: Average Waiting Time Comparison Across Scenarios

## iii. Passenger Distribution Across Scenarios
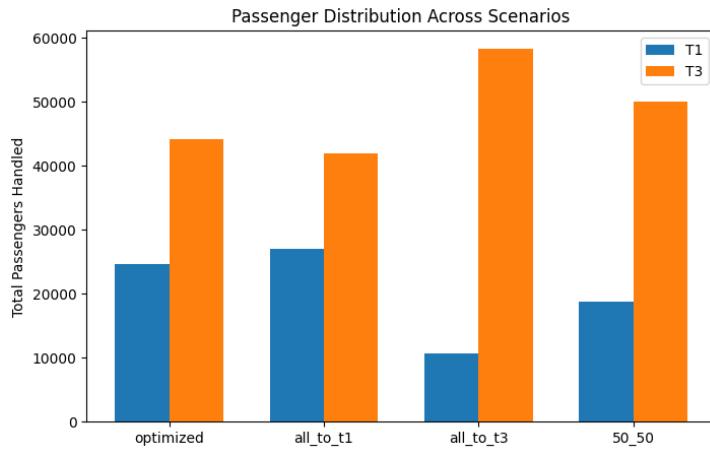
Figure 38: Passenger Distribution Across Scenarios

The passenger distribution graph shows how different reassignment strategies shift op-erational load between T1 and T3. The Optimized strategy achieves a more balanced distribution by assigning flights based on real-time congestion levels. In contrast, All-to-T1 pushes too much load onto T1, while All-to-T3 overwhelms T3 and causes severe

crowding. The 50–50 split improves balance compared to extreme allocation, but still leads to uneven peak congestion since passenger arrival patterns are not uniform. Overall, the results indicate that dynamic, demand-responsive allocation is more effective than fixed or extreme reassignment strategies.

Optimal Redistribution Strategy

After the closure of Terminal 2, its flights were redistributed between Terminal 1 and Terminal 3. The optimization model dynamically assigned each T2 flight based on real-time gate availability and predicted congestion levels. However, due to higher early gate clearance at T1, the resulting allocation was not balanced, with most flights being redirected to T1.

Observed Post-Reassignment Performance

Following reassignment, Terminal 1 handled 24,673 passengers (up from 10,687 originally), while Terminal 3 handled 44,207 passengers (slightly up from 41,901). This substantial increase in T1's passenger load led to a significant rise in waiting time from 96.29 minutes to 158.10 minutes per passenger. Similarly, T3 experienced an increase in waiting time from 117.46 minutes to 193.20 minutes, driven by additional traffic and longer gate occupancy patterns.

In total, 85.7% of T2 flights and passengers shifted to T1 (120 flights), while only 14.3% were routed to T3 (20 flights). This imbalance created disproportionate congestion, particularly during morning and evening peak departure windows.

Graphical Analysis of Terminal 2 Closure and Flight Reallocation

### i. Reassigned Terminal 2 Flights Split (T1 vs T3)
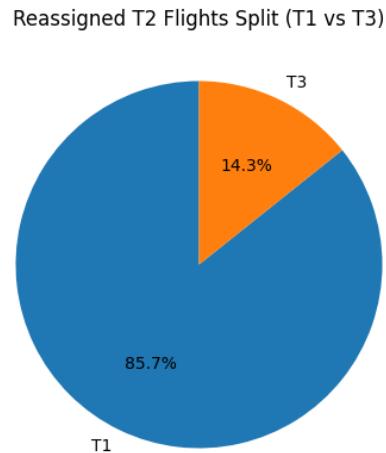
Figure 39: Reassigned T2 Flights Split

This pie chart shows how flights from T2 were redistributed after its closure. A large majority of the reassigned flights shifted to T1, with only a small share routed to T3. This indicates that the scheduling logic prioritized T1 more frequently, due to earlier gate availability or lower predicted congestion at the time of assignment.

**ii. Passenger Load Distribution (T1 vs T3)**
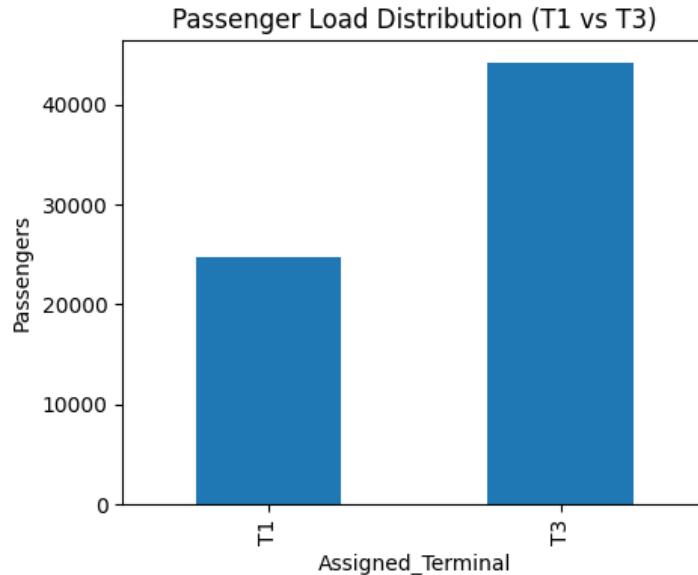
Figure 40: Passenger Load Distribution

After reassignment, T1 absorbed a noticeable increase in passenger volume, while T3 also saw a moderate rise. The distribution reflects the shift in operational burden, with T1 becoming significantly busier. This change in passenger handling is consistent with the flight redistribution observed above.

**iii. Hourly Departure Volume by Assigned Terminal**
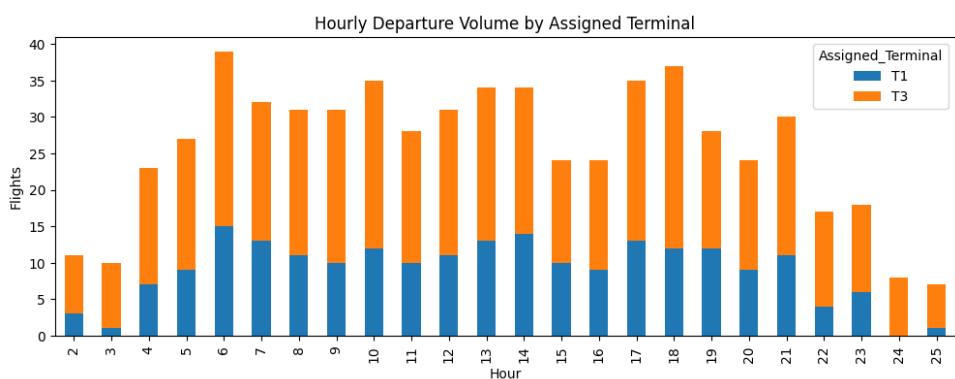
Figure 41: Hourly Departure Volume

This stacked bar visualization compares how flights were distributed across T1 and T3 throughout the day. Both terminals experience peak departure activity in the early morning and evening hours. However, T3 handles a larger share during peak times, suggesting higher gate occupancy pressure and greater congestion risk under the new allocation.

iv. Before vs After Reassignment – Waiting Time

This chart compares the average passenger waiting times before and after closure adjustments. Both terminals saw a clear increase in waiting times following reassignment. The rise is more pronounced at T3, indicating that the additional load introduced noticeable congestion and slower processing.

Figure 42: Waiting Time

v. Before vs After Reassignment – Passenger Load

This chart highlights how total passengers handled at each terminal changed post-closure. T1 experienced a substantial increase in passenger throughput, while T3 showed a smaller yet significant growth. These load shifts help explain the increased waiting time observed in the previous chart, as both terminals were required to handle more passengers without additional service capacity.
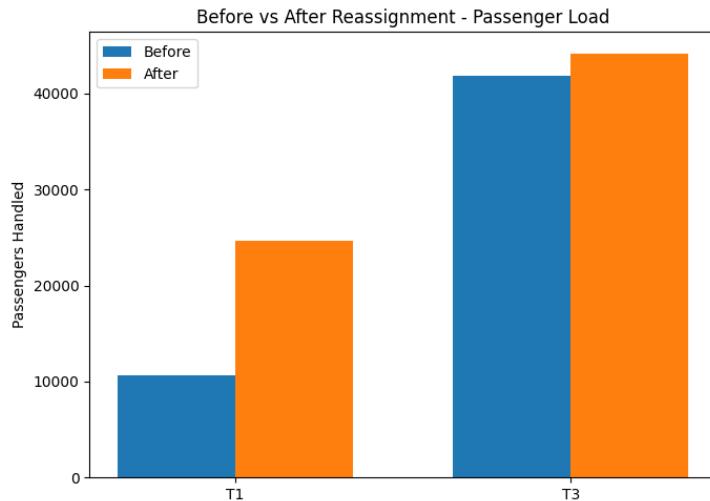
Figure 43: Passenger Load

Conclusion

This study analyzed passenger flow and operational efficiency across the terminals of Indira Gandhi International Airport under changing traffic conditions, including the closure of Terminal 2. Using simulation-based modeling, passenger movements through key processing stages—check-in, security, waiting halls, and boarding—were examined to identify where congestion forms and how it propagates through the terminal system. The results showed that uneven passenger distribution and insufficient resource allocation at certain processing stages lead to long waiting times, queue buildups, and reduced service quality.

By testing multiple redistribution strategies for T2 passengers and evaluating various infrastructure enhancement options, the study demonstrated that no single terminal can absorb the full T2 load without experiencing major congestion. Instead, the most effective approach involves balanced redistribution supported by targeted increases in processing capacity—such as adding check-in counters and security lanes at bottleneck points. Optimization experiments further confirmed that small, strategic adjustments in resource allocation can produce significant reductions in waiting time and improve overall system stability without requiring major structural expansion.

Overall, the study highlights the importance of data-driven planning and dynamic operational decision-making in airport management. Simulation provides a reliable framework to predict congestion behavior, evaluate capacity decisions, and plan for demand fluctuations. By adopting balanced load sharing and selective resource enhancement, the airport can improve passenger experience, maintain smoother terminal flow, and build greater resilience against future increases in travel demand.

References

Data sources and references used for this study include:

- For flight numbers and their respective terminals: https://www.delhiairport.com/igi-indira-gandhi-departures

- For aircraft type and capacities: https://www.flightaware.com/live/fleet/

- Flights shifted from terminal 2 to terminal 1:

  - INDIGO: https://www.goindigo.in/airport-directory/india/delhi-del.html

  - Akasa Air: https://www.livemint.com/companies/news/after-indigo-now-akasa-air-html

  - Only Indigo and Akasa: https://economictimes.indiatimes.com/industry/transportation/airlines-/-aviation/akasa-air-moves-all-operations-to-termina articleshow/120334542.cms?from=mdr

- Capacities:

  - https://www.seatguru.com/browseairlines/browseairlines.php

  - https://www.seatmaps.com/airlines/

- Passenger transfer data: https://travel.economictimes.indiatimes.com/news/aviation/domestic/delhi-airport-handles-over-14-5-million-passengers-phase-3a-ex 99931115?utm_source=chatgpt.com

- Wait time data: https://www.newdelhiairport.in/wait-time/

- Reference Google Colab Notebooks for Code Implementation:

  - Terminal 1 and Terminal 2 Operation

  - Terminal 3 Operation

  - Paired t-Test Implementation

  - Scenario Check Implementation

  - Output Analysis for Confidence Interval

  - Code Implementation for Terminal 2 Flight Reassignment

  - Terminal 1 Optimization of Counters

  - Terminal 2 Optimization of Counters

  - Terminal 3 Optimization of Counters

- Reference for Excel Sheets:

  - Terminal 1 Wait Times Data Sheet

  - Terminal 3 Wait times Data Sheet

  - Flight Arrival and Capacities Data Sheet

- Excel Files to be used for the Implementation of Code: Terminals Flight Data

- Reference Outputs of Implemented Codes:

  - SIMULATION REPORT – TERMINAL 1,2,3

  - Optimization Results in different Cases