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Stochastic Optimization to Reduce Aircraft Taxi-in Time at IGIA, New Delhi

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Airport congestion is a common phenomenon all over the world due to rapidly increasing air traffic, inadequacy in infrastructural support and operational planning, and several uncontrollable factors like visibility issues during adverse weather, flights arriving earlier than expected, or landing later than their scheduled time, etc. Such congestion results in unusual delays for the arriving and departing aircraft since one aircraft turns into an obstruction for the other. Many times, arriving aircraft take more than the ideal taxi-in time after landing to reach its allocated stand. The consequences of delay are a poor level of service and customer satisfaction and huge operating costs to the aviation companies.

Indira Gandhi International Airport (IGIA), New Delhi, is suffering from a high average taxi-in time (time taken between the landing of an aircraft and reaching its allocated parking stand) compared to all other international airports. IGIA comes in the top 4% of international airports where the average taxi-in time in 2021 is more than 10 minutes (Das et al., 2022).

IGIA, situated in Palam, southwest of New Delhi, is the busiest airport in India as far as total passenger traffic is concerned. In May 2023, 600 plus aircraft, on average, land at IGIA on 3 operational runways, and 223 plus parking stands are available to handle the departure and arrival of passengers (flightradar24.com). While stands and runways are allocated to flights on receipt of the flight schedule plans around 24 to 48 hours early, the actual arrival time of a flight varies due to various random events, including weather, operational issues, visibility, etc. As soon as the flight plan is received by Airport Traffic Control (ATC), a runway and the nearest parking stand are allocated to ensure the lowest possible taxi-in time. However, due to uncertainty in the arrival times of flights and first-come-first-served treatment, the pre-scheduled allocation of runways and stands fails. It results in a sub-optimal allocation of runways and stands. This is the prime reason for the unusual delays in taxi-in times at IGIA.

This paper investigates the root cause of this ground delay problem and recommends short-term as well as long-term solutions by applying stochastic optimization techniques. It attempts to develop a model to resolve the problem considering the optimum combination of runways-stands dynamically.

Literature Review

The International Air Transport Association (2016b) reported that when demand for a facility approaches or exceeds its capacity, congestion occurs. Technology, smart design, and operational procedures can alleviate capacity problems and postpone the need to expand. When an airport faces unacceptable congestion and delays, gradual strategies should be implemented, starting with the efficiency enhancement of the existing facilities.

Meier and Eriksen (2006) suggested that the Departure Manager assisted the Controller by maintaining maximum operational runway capacity, slot compliance, minimizing taxi-out delays, and helping to make optimum use of the available airport capacities by reducing unnecessary delays on stands, on taxiways, and at departure runway holding points.

Ashford and Paul (2011) postulated four different approaches to the determination of runway capacity and delay, including (i) Empirical approach, (ii) Queuing models, (iii) Analytical approach, and (iv) Capacity handbook approach.

Horonjeff et.al (2010) identified the factors that influence the capacity of a runway system used only for arriving aircraft as – (i) the aircraft mix, (ii) the approach speeds of the various classes of aircraft, (iii) the length of the taxi path from the stand to the runway threshold, (iv) speed variation of aircraft while taxiing, and (v) the mean runway occupancy times.

Mori (2015) claimed that she developed a fast-time stochastic simulation model to decrease airport congestion levels under existing uncertainties. The results inferred that the airport traffic congestion seemed to be most affected by the uncertainty of taxi-out or taxi-in and the traffic concentration, not by the traffic volume and weather conditions.

Carr (2001) developed a stochastic model for airport surface traffic using a Monte Carlo technique. This research provides substantial improvements to the method of calibrating unimpeded travel-time distributions for the free-flow period.

Trani and Baik (2003) argued that animation could be applied in airport modeling and simulation to identify potential airspace/runway logic problems and analyze the simulation in real time or faster. This modeling can also help visually identify potential queueing problems at various airfields.

IATA (2016a) recommended that airfield layouts should include the shortest possible and most direct taxiway routes between rapid exit taxiways and aircraft parking positions and between aircraft parking positions and holding/bypass positions at runway thresholds.

Our review of the literature entails that solutions to the ground delay programs can be classified into three areas – (i) Demand Analysis, (ii) Facility Layout design, and (iii) Queueing Structure. However, the enhancement of operational efficiency by optimised queuing structure (scheduling, allotment of parking stand, arrival times, etc.) is not paid due attention by the researchers. Noteworthy, the arrival time of aircraft follows a probabilistic distribution. There is always a mismatch between the actual arrival time and the scheduled arrival time. The resultant model considers both the perspective of Airport layout design as well as the stochastic nature of arrivals. Airport ground traffic management in most airports is pre-structured, which fails due to uncertainty of arrival times. Therefore, the actual allocation of runway-parking stands turns heuristic. No research is traced which addressed the probabilistic nature of interarrival times for dynamic allocation of runaway-parking stand. There could have been better allocation of the stands for the arriving flights than the existing practices. The present study captures the gap

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and attempts to develop a model taking real-time data of the IGIA so that the taxiing time of the arriving aircraft is minimised.

Methodology

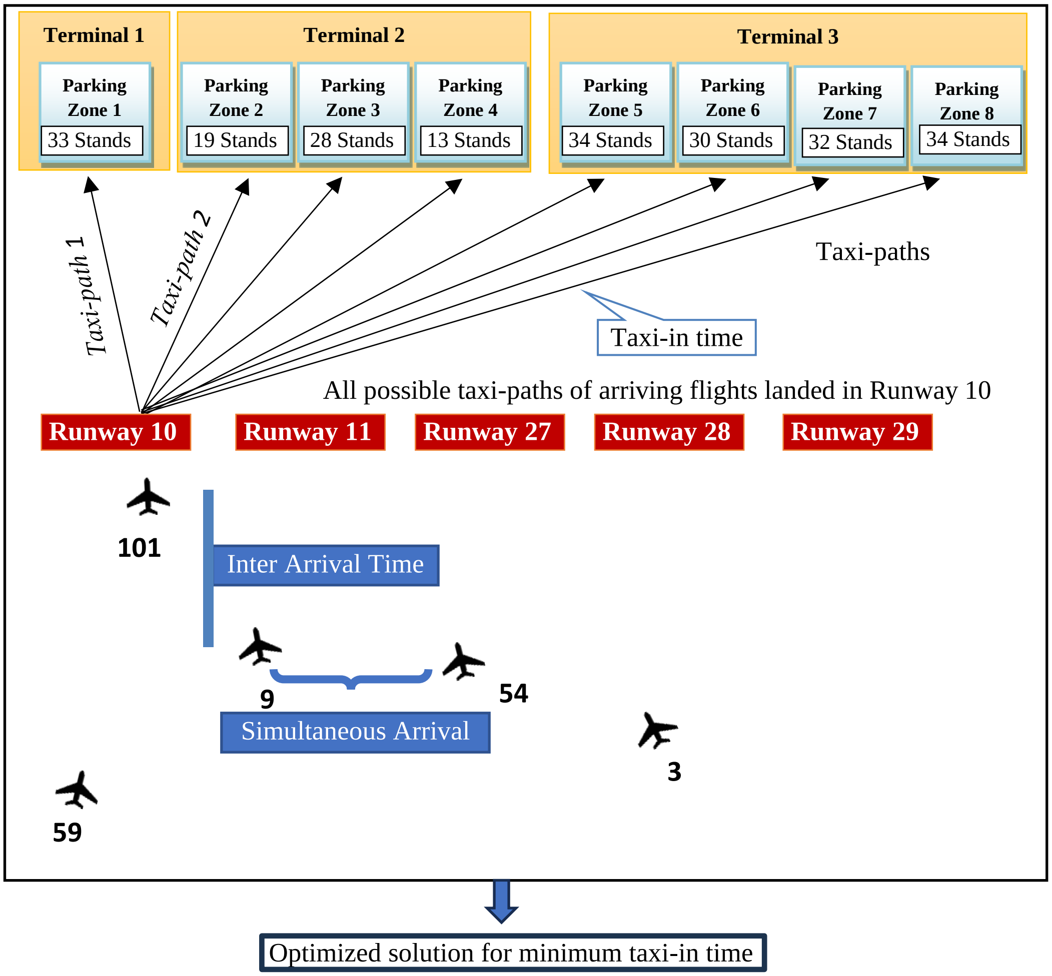
The prime focus of the present research is to develop a model for optimizing aircraft taxi-in time of IGIA, New Delhi, indicating enhancement of airport operational capacity. We have considered two random dates, 2 April and 1 May of 2023, for conducting the study to capture the arriving flights from either side of the runways. On 2 April 2023, runways 27, 28, and 29 were used and flights landed from east. On 1 May 2023, flights landed from the west, and runways 10 and 11 were used. Runway 09 is never used for arrivals because its extended centreline intercepts the extended centreline of runway 10. The data on taxi-in time (period from landing to reaching a parking stand) of all arriving aircraft were derived from the website of FlightRadar24 (www.flightradar24.com), which tracks the positions of aircraft in real-time and turns that data into information for consumer and business applications.

A stochastic optimization model is developed to minimize the taxi-in time of aircraft at IGIA with the help of an MS-Excel-based software called Frontline Systems Analytic Solver.

Theoretical Framework

Figure 1 elucidates the framework of the research design for the present research objective. All possible taxiways of arriving flights landed on Runway 10 End to the probable parking stand (223 parking stands are in 8 parking zones of 3 terminals) are presented here.

Figure 1
Theoretical Model of Stochastic Optimization



Note that Runway 09 is non-operational for incoming flights. Therefore, this is not included in the model. The diagram also shows the situations on simultaneous arrivals of the flights, taxi-in time, and interarrival time. Hypothetical Flight 101 is landing on Runway 10, followed by Flight 9 and Flight 54 arriving simultaneously. Fight 31 and Flight 59 are in the queue. This is the real-time situation on which the present simulation model is erected, and the optimum solution is sought.

The mathematical formulation of the model (known as an objective function), data analysis tools, and a step-by-step procedure of the model development are presented in the following sections.

Objective function

The objective function of the present analysis can be stated as -

$$\textit{Minimize } z = \sum_{j=1}^{m} \sum_{i=1}^{n} (t_{ij} * y_{ij})/n \quad \ldots\ldots \quad (1)$$

where, t_i = *Taxi-in time for a flight i from runway j to its stand*

y_{ij} = *1 if runway j is allocated to flight i*

= *0 otherwise*

Subject to $\lambda_{ij} > 1$ $\quad t_{ij} = l_{ij} \;\; \forall ij$

$\lambda_{ij} \leq 1$ $\quad t_{ij} = 10 \;\; \forall ij$

$\sum_j y_i = 1 \; \forall i$

l_{ij} = *minimum taxi–in time from runway j to stand allocated for flight i*

λ_{ij} = simulated interarrival time for flight i on runway j

We have considered the maximum taxi-in time during simultaneous landings in April 2023 is 8.56 min & in May 2023 is 10.9 minutes when two flights land on the runway within one minute, 1000 simulations run for each flight i; GRG Non-Linear algorithm applied to (1) and search for optimal $R_i^* \rightarrow S_j^*$ allocation. This maximum taxi-in time during simultaneous landing differs for different scenarios based on the average extra taxi-in time taken for flights to go to the stand, which is far.

Data Analysis Tools

Distribution of Interarrival Time: We calculated the mean inter-arrival time (IAT) (λ) for the flights and estimated the best distribution fit for the interarrival time across the April and May data of 2023. This was found to be exponential. The exponential distribution is the best fit with an average IAT of 0.0017 minutes with a K-S fit statistic of 0.25 (See Table 1 for details).

Table 1
Fitness Statistics for Inter-Arrival Time

Study Data	May 2023
Fit Statistic (KS)	0.252872612775647
Fit Limit (KS)	0.99
Formula	= Psi Exponential (0.00175292335798317, PSI Truncate (-1E+30, 1E+30))
Minimum	0
Maximum	∞
Mean	0.00175292335798317
Mode	0
Std. Dev.	0.00175292335798317
Variance	3.072740298863E06
Skewness	2
Kurtosis	9
Independent Test	0.541750179909087
Sig.	$p < 0.000$

Simulation of Model: To develop our model, we have done simulation on the input data using Frontline Analytic Solver. Inputs, constraints, and output variables for simulation (simulation inputs and outputs) are presented in Table 2.

Table 2
Inputs and Output Variables for the Simulation Model

Sl.	**Simulation Inputs**	**Sl.**	**Simulation Outputs**
1.	IAT Mean	1.	Simulated Mean Taxi Time
2.	Upper Limit IAT	2.	Optimized Mean Taxi Time
3.	Runways under use because of wind directions(east/west)	3.	Std Error
4.	Max average taxi-in time for simultaneous landing	4.	Min Taxi Time
5.	Simultaneous Arrival IAT	5.	Max Taxi Time
6.	Max No of flights for the model	6.	Quartile1 (Q1)
7.	Runways 9, 10, 11, 27, 28 and 29	7.	Quartile1(Q2)
8.	Stands – for all six runways	8.	Quartile3 (Q3)
9.	No flights arriving at the stand	9.	Quartile 9 (Q9)
10.	Simulation of IAT	10.	Quartile 10 (Q10)
11.	Min Taxi Time	11.	Average
12.	Taxi Time if Stand Runway Y10(i)=1	12.	% below Percentile

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13.	Taxi-in Time - If Simultaneous Arrival Occurs	13	Actual Average
14.	*Y10(i) = 1 if it is allocated and 0 if not allocated.		
Note. Sl. No. 8 to 14 are applicable for all six runways (09, 10, 11, 27, 28, 29) *Y = Runway			

The Model

A step-by-step procedure for the simulation and optimization of the model is presented below.

[1] Collected data are tabulated under the captions (i) *Flight No,* (ii) *the runway end flight is landing*, (iii) *the stand number the flight is reaching*, (iv) *taxi-in time*, (v) *time of landing*, (vi*) Inter arrival time (IAT) of landing* and (vii) time of arrival.

[2] We have developed two simulation models, considering 600 arrivals data for each day.

[3] Found the minimum taxi-in time of all the flights of each model from the whole month's arrival data to look for the *minimum taxi times from each runway to the stands* ($t_1 \dots t_n$).

[4] We created the simulated values of IAT ranging between 0 (minimum IAT during simultaneous landings) to the maximum time of IAT for 600 flights.

[5] Calculated the maximum taxi-in time during simultaneous landing for each model.

[6] Structured the model for all six runways 09, 10, 11, 27, 28, and 29 under the captions (i) Stand number, (ii) No of flights arriving at the stand, (iii) Simulation of IAT, (iv) Minimum taxi-in time, (v) Taxi-in time if stand Runway Y10(i)=1 that is the maximum taxi-in time during simultaneous landing, (vi) Taxi-in Time - If simultaneous arrival occurs, viii) Y10(i) runway allocated by the model after running the optimization (If 1 is filled, it means the runway has been allocated, and if it is filled with 0, means it is not allocated).

[7] Extracted the 600 *Stands* ($S_1 \dots S_n$) and their actual taxi-in times for 600 flights for all the runways of all the models from Step 1.

[8] Applied all the formulas in the model wherever applicable to identify objectives, variables, and constraints.

[9] Uncertainty of Inter-flight arrival times is modelled using simulation with the best-fit distribution on 02 April and 01 May 2023. If two flights arrive within a critical limit (typically set to 1 minute) of each other, the subsequent flight must be directed through a longer route to its designated stand, which is far, and the taxi time is set to its average maximum limit.

[10] For each Stand ($S_1...S_n$), the simulation is run for 1000 iterations. If the (λ) is above the critical limit (more than 1 minute), the flight is assumed to utilize the optimal runway for landing, and the minimum taxi time is assumed for this flight)

[11] Found the outputs as optimized average taxi-in time from all the models by creating the optimal allocation of runways to the *Stands* ($S_{1...}S_n$) using the analytical solver.

[12] The optimal solution from step 11 is the best taxi times if there are no uncertainties. However, uncertainties in the inter-flight arrival times, ground conditions, availability of runways, and stands will add to the achievable taxi times for the flights.

[13] We have created boxplots for all the models, which show the potential improvements in the optimized taxi-in time from the actual average taxi-in time.

[14] The validity of the model is confirmed by measuring the arithmetically optimized mean taxi-in time, which reflects the reality. The arithmetically optimized average is calculated as the total minimum time taken for runways plus extra time taken for simultaneous landings divided by the number of flights.

[15] Other uncertainties may be similarly incorporated into a more complex model – in this model, we restrict our exploration to the two simultaneous arrivals of flights within a minute. This is the limitation of the present model.

A glimpse of the simulation model for a stochastic optimised solution using the Frontline Analytic Solver is exhibited in Figure 2.

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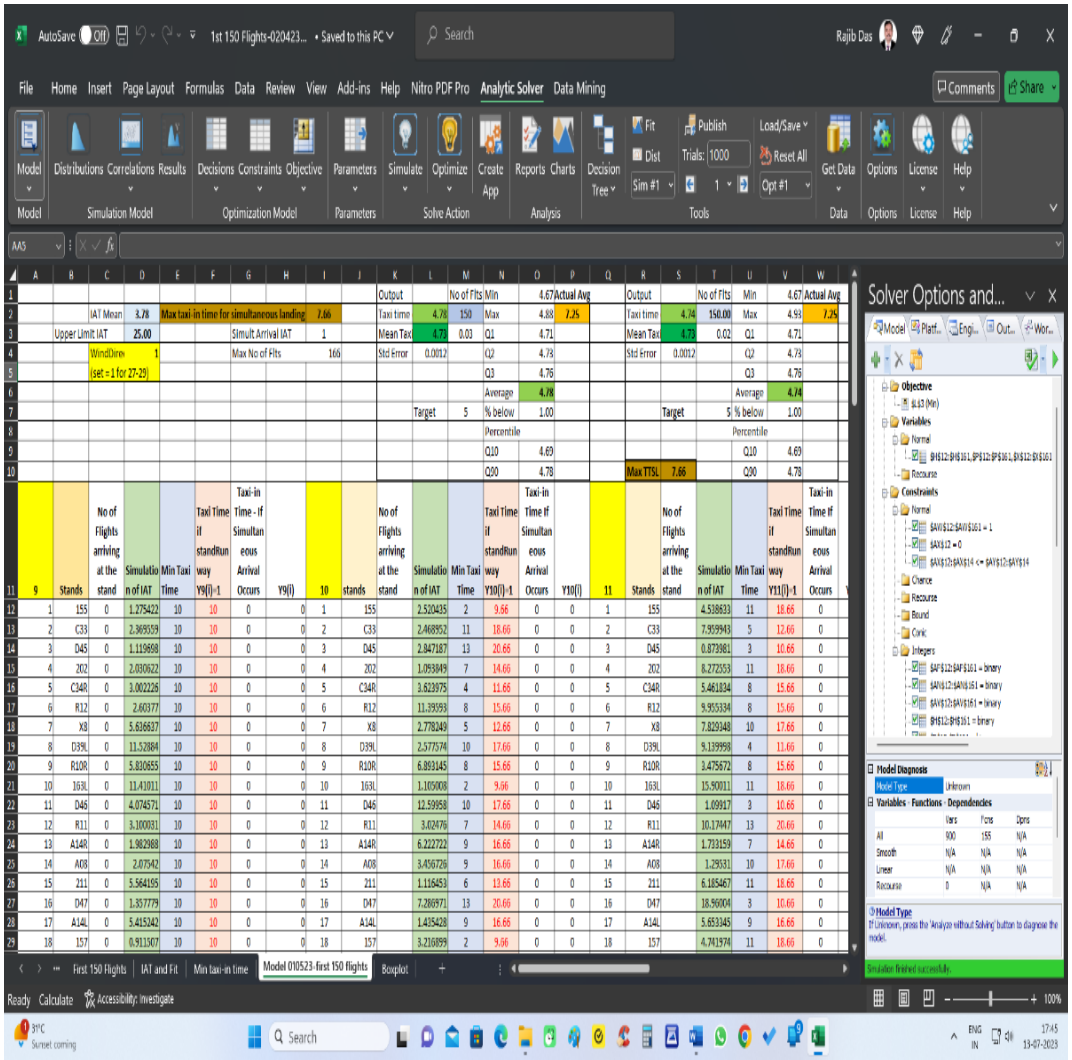
Figure 2

Example of Stochastic Optimized Solution



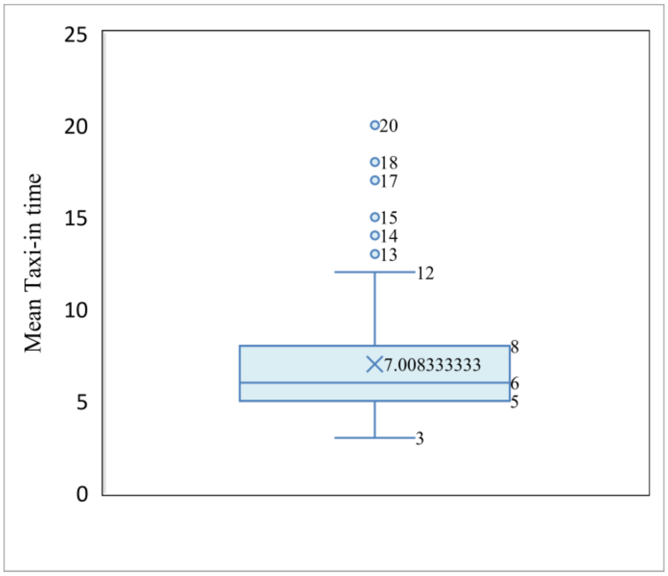
Analysis

The model outcomes are presented with the help of tables having captions of actual taxi-in time, optimized taxi-in time, actual average taxi-in time, optimized average taxi-in time, and arithmetically optimized average taxi-in time for each day. Q1, Q2, Q3, Q10 and Q90 stand for the first quartile, second quartile, third quartile, tenth and ninetieth percentile range of taxi-in time, respectively.

Simulation and optimization outputs 02 April 2023

Figure 3

Boxplot for Taxi-in time: 02 April 2023



Average taxi-in time is computed as 7.01 minutes against the maximum of 12 minutes and a minimum of 3 minutes (five outliers are present in the frequency distribution).

The simulation and optimization outcomes are presented in Table 3. The left column shows the actual situation on that day. Maximum taxi-in time taken for simultaneous landing is calculated as 8.56 minutes, and arithmetically optimized average taxi-in time is calculated as 4.79 minutes.

Simulation run optimized output for taxi-in time is remarkable. The optimized average taxi-in time is reduced to 4.82 minutes from the actual average of 7.01 minutes. Originally, Q1 is 5 minutes, i.e., 25% of the flights take 5 minutes or less time; Q2 is 7 minutes, i.e., 50% of the flights take 7 minutes or less time; Q3 is 9 minutes, i.e., 75% of the flights take 9 minutes or less time. The range of Q1 to Q3 is 3 minutes (Q3 minus Q1). However, after simulation, Q1, Q2 and Q3 get changed to 4.79, 4.82 and 4.85 minutes, ranging only 0.06 minutes.

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Table 3

The Output of the Simulation Model: 02 April 2023

Actual Situation		**Optimised Output**	
No of Flights	600	Simulated Mean Taxi-in Time	4.80
Target Taxi-in time	5	Std Error	0.0014
Min Taxi-in Time	3	Min Taxi-in Time	4.71
Q1	5	Q1	4.79
Q2	6	Q2	4.82
Q3	8	Q3	4.85
Max Taxi-in Time	12	Max Taxi-in Time	5.03
Actual Avg. Taxi-in time	7.01	Optimised Average Taxi-in time	4.82
Arithmetically optimised Taxi-in time	4.79	Q10	4.77
Max. Taxi-in Time for Simultaneous Landing	8.56	Q90	4.88

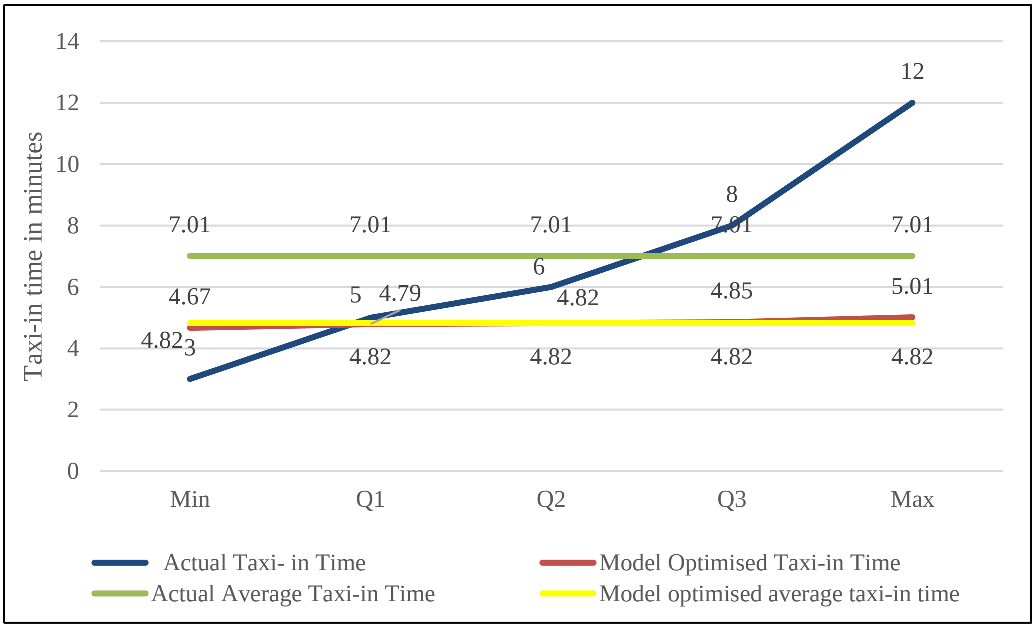
Note: *All figures are in minutes except the number of lights*

Our investigation on percentile distribution of simulated mean taxi-in time shows that 10% of flights (Q10 = 4.77) will take 4.77 minutes or less time, and 90% of flights will take 4.88 minutes or less. Our target mean taxi-in time for the present simulation was set at 5 minutes, but interestingly, the maximum time could be taken by arriving flight as 5.03 minutes in this model.

A diagrammatic presentation is prepared (See Figure 4) considering the actual taxi-in time, actual average taxi-in time, model optimized taxi-in time, and optimized average taxi-in time ranging from the minimum to maximum, including three quartiles.

Figure 4

Quartile Graph for Actual and Optimized Taxi-In Time: 02 April 2023

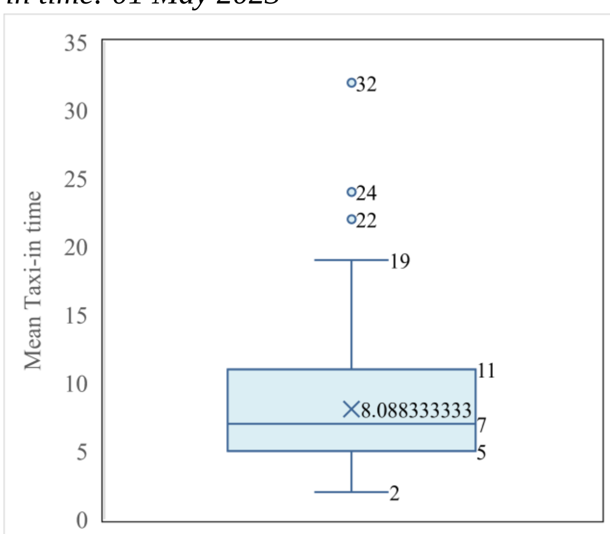


Simulation and Optimization outputs 01 May 2023

Likewise, the boxplot of taxi-in time of 600 flights as of 1 May (See Figure 5) shows that the average taxi-in time is 8.08 minutes, the maximum is 19 minutes, and the minimum is 2 minutes (three outliers are present).

Figure 5

Boxplot for Taxi-in time: 01 May 2023



Optimised outcomes of simulation run model are presented in Table 4. The maximum taxi-in time taken for simultaneous landing is calculated as 10.9 minutes, and the arithmetically optimized average taxi-in time is 4.62 minutes. The Optimised average taxi-in time in our model comes to 4.62 minutes, far below the actual average of 8.08 minutes. Minimum, maximum and Q1, Q2, Q3 for actual and optimum values are noted.

Table 4

The Output of the Simulation Model: 01 May 2023

Actual Situation		**Optimised Output**	
No of Flights	600	Simulated Mean Taxi-in Time	4.62
Target Taxi-in time	5	Std Error	0.0009
Min Taxi-in Time	2	Min Taxi-in Time	4.55
Q1	5	Q1	4.60
Q2	7	Q2	4.62
Q3	11	Q3	4.64
Max Taxi-in Time	19	Max Taxi-in Time	4.71
Actual Avg. Taxi-in time	8.08	Optimised Average Taxi-in time	4.62
Arithmetically optimized Taxi-in time	4.62	Q10	4.58
Max. Taxi-in Time for Simultaneous Landing	10.9	Q90	4.66

Note. All figures are in minutes except the number of flights.

Q10 and Q90 results show that 10% of flights (Q10 = 4.58) will take 4.58 minutes or less time, and 90% of flights will take 4.66 minutes or less. Maximum time could be taken by arriving flight as only 4.71 minutes.

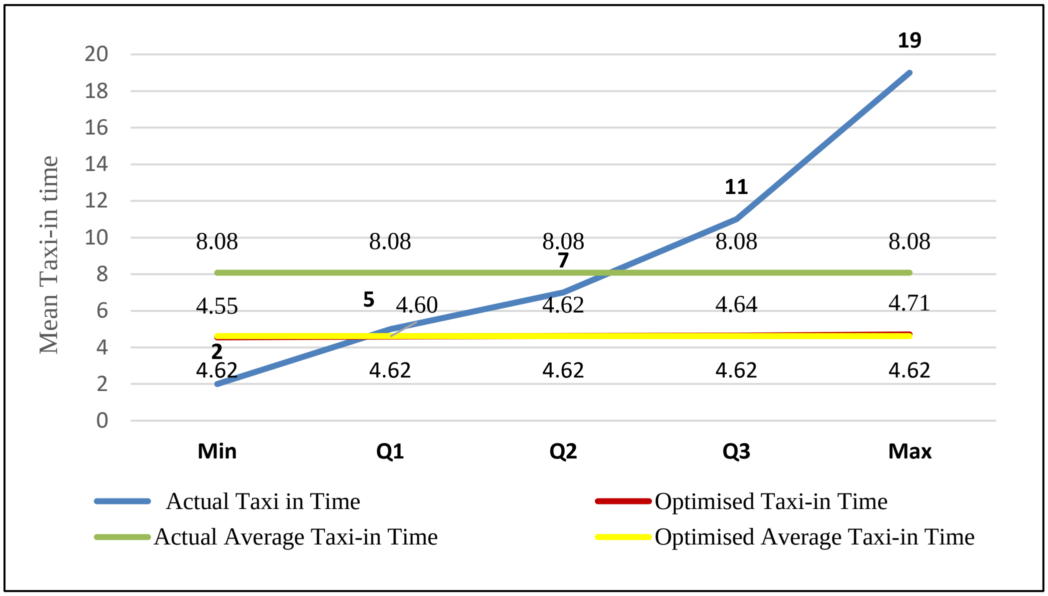
Actual taxi-in time, actual average taxi-in time, model optimized taxi-in time, and optimized average taxi-in time ranging from the minimum to maximum, including three quartiles for the day, are presented in Figure 6.

Validity

A comparison of arithmetically optimized values calculated for all the models and corresponding optimised values are found to be very close, and the difference is non-significant ($p > 0.05$). For instance, the model-optimised average taxi-in time of 02 Apr is 4.82 minutes, and the arithmetically optimised average taxi-in time is 4.79 minutes (See Table 3). The difference is only 0.03 minutes.

Figure 6

Quartile Graph for Actual and Optimized taxi-in time: 01 May 2023



Similarly, the model-optimized average taxi-in time of 01 May is 4.62 minutes, and the arithmetically optimized average taxi-in time is 4.62 minutes (See Table 10). There is absolutely no difference.

Therefore, we can see that the model-generated outputs (average taxi-in time) are identical or close to reality. This proves that our model perfectly fits for optimizing the taxi-in time.

Discussion

The current practice of assigning stands and the nearest runways to aircraft as soon as a flight plan is received would work if there were no other uncertainties in the flight arrival times. However, since the arrival of the flights is probabilistic, pre-scheduled allocation of runways and stands fails to optimize aircraft traffic management, resulting in unusual delays in taxi-in times. Aiming at resolving the decades-long taxi-in delay problems of IGIA and other airports, our stochastic optimization technique reveals that the average taxi-in time for any day can be reduced substantially.

The optimized simulation results considering the stochastic interarrival time of the arriving aircraft for two representative scenarios are presented in Table 5. The simulated model reflects that improvements in mean taxi-in time for the arriving aircraft are approximately 31% on 2 April and 43% on 1 May 2023.

Table 5
Summary of Taxi-in time Optimization

Scenario	Improvement in taxi-in time in minutes		
	Actual taxi- in time	Optimized taxi-in Time	Improvement in Percentage
Flights landed from the east on runways 27, 28 and 29 on 01 Apr 2023	7.01	4.82	31.24%
Flights landed from the west on runways 10 and 11 on 01 May 2023	8.08	4.62	42.82%

We considered flight IAT of 1 minute or less as ‘simultaneous’ arrivals. The addition of more ground-level constraints may reduce the improvement percentages. Applying the present stochastic optimization model, on average, the total time saved for all arriving aircraft on 2 April is approximately 1314 minutes [600 × (7.01-4.82) =1314], and on 01 May is about 2076 minutes [600 × (8.08-4.62) =2076]. If we divide the time saved by the optimised average taxi-in time, we can accommodate a further 272 flights (1314/4.82= 272) on 2 April 2023 and 450 flights (2076/4.62=450) on 1 May 2023. But finally, we have to consider the lesser value of 272 flights as the flow of wind direction keeps changing from day to day. This can be considered as a measure of huge capacity enhancement without altering any physical infrastructure.

Conclusion

Due to uncertainty in the flight arrival times, a first-come-first-serve treatment is followed on runway allocations, resulting in sub-optimal allocation of runways and an increase in taxi-in times. Our effort is to reallocate runways and parking stand using a stochastic optimization model so that mean taxi-in time get reduced substantially to an internationally set practice of 5-minute taxi-in time.

The current research shows that without altering any physical infrastructure and applying a stochastic optimization model, there is a 37% potential improvement in the average taxi-in time at IGIA. The significant difference between the performance of the model on actual taxi-in time and optimized taxi-in time needs further testing, considering more constraints. This simulation model can resolve the decade-long ground delay problem of IGIA. It can also be applied to estimate the savings in passenger's time, fuel costs, operational costs of airports and airlines, and most importantly, carbon emissions.

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ADDITIONAL INFORMATION

A. Arrivals of First 150 flights on 01 May 2023

Sl. No	Time	Flight	Airline	Aircraft	From Run way End	Time of Landing	Time of Arrival	Taxi-in Time in Minutes	Stand No.	Terminal
1	12:10 AM	AI808	Air India	A320 (VT-EDE)	11	23:31	23:38	7	C30L	3
2	12:05 AM	AI854	Air India	A321 (VT-PPI)	11	23:40	23:45	5	C29R	3
3	12:10 AM	UK950	Vistara	A20N (VT-TQG)	11	23:52	23:57	5	D58	3
4	12:25 AM	AI480	Air India	A321 (VT-PPQ)	11	23:57	0:03	6	R07	3
5	12:05 AM	UK838	Vistara	A20N (VT-TQJ)	11	00:00	0:13	13	R11	3
6	12:05 AM	6E6235	IndiGo	A21N (VT-IUE)	10	00:03	0:07	4	150	1
7	12:30 AM	6E2189	IndiGo	A21N (VT-IUX)	10	00:13	0:22	9	202	2
8	12:40 AM	6E2336	IndiGo	A21N (VT-IME)	11	00:25	0:37	12	R10R	3
9	12:40 AM	UK856	Vistara	A20N (VT-TQH)	11	00:32	0:47	15	R10L	3
10	1:05 AM	ET688	Ethiopian Airlines	B788 (ET-AOU)	11	00:39	0:50	11	A13	3
11	12:05 AM	6E5605	IndiGo	A21N (VT-IBH)	11	00:42	0:48	6	D39R	3
12	1:00 AM	6E2083	IndiGo	A21N (VT-ILH)	11	00:45	0:55	10	Y6	2
13	12:05 AM	6E2716	IndiGo	A20N (VT-IVB)	11	00:47	1:00	13	212	2
14	12:20 AM	6E6102	IndiGo	A20N (VT-IVI)	11	00:50	1:07	17	151	1
15	12:45 AM	6E6813	IndiGo	A21N (VT-ILD)	11	00:51	0:08	17	163R	1
16	1:30 AM	6E5912	IndiGo	A20N (VT-ISX)	11	00:54	1:04	10	X5	2
17	1:00 AM	UK986	Vistara	A21N (VT-TVC)	11	00:57	1:04	7	A14R	3
18	12:15 AM	G8118	Go First	A20N (VT-WGH)	11	00:59	1:11	12	203	2
19	1:20 AM	AZ770	ITA Airways	A332 (EI-EJG)	28	01:01	1:13	12	A03	3
20	12:55 AM	LH760	Lufthansa	B744 (D-ABVZ)	11	01:07	1:18	11	A09	3
21	1:50 AM	6E1464	IndiGo	A20N (VT-IVS)	11	01:09	1:15	6	D41	3
22	1:25 AM	I5775	AirAsia India	A20N (VT-ATE)	11	01:14	1:21	7	E64	3
23	1:40 AM	6E2098	IndiGo	A20N (VT-ISN)	11	01:16	1:26	10	206	2
24	1:55 AM	QR578	Qatar Airways	A359 (A7-AMJ)	10	01:18	1:31	13	B17	3
25	2:00 AM	6E1308	IndiGo	A20N (VT-ISI)	11	01:22	1:30	8	A06	3

26	1:15 AM	I5749	AirAsia India	A20N (VT-ATH)	11	01:24	1:29	5	E74	3
27	12:05 AM	6E2202	IndiGo	A320 (VT-IHZ)	11	01:27	1:39	12	217	2
28	1:55 AM	I5722	AirAsia India	A20N (VT-ATD)	11	01:29	1:35	6	D54	3
29	12:10 AM	G8714	Go First	A320 (VT-GOR)	11	01:32	1:45	13	208	2
30	1:55 AM	KL871	KLM	B78X (PH-BKA)	11	01:40	1:52	12	B15	3
31	1:00 AM	6E6146	IndiGo	A21N (VT-ILB)	11	01:42	1:57	15	171	1
32	2:10 AM	AI112	Air India	B788 (VT-ANS)	11	01:46	1:53	7	B21	3
33	1:00 AM	6E5284	IndiGo	A20N (VT-IIZ)	11	01:49	1:55	6	R08L	3
34	12:35 AM	G8345	Go First	A20N (VT-WGD)	11	01:52	2:05	13	Y8	2
35	1:35 AM	I5774	AirAsia India	A320 (VT-VTZ)	11	01:54	1:58	4	E78	3
36	1:05 AM	9I628	Alliance Air	AT76 (VT-AIZ)	11	01:57	2:04	7	R01	3
37	2:10 AM	6E5658	IndiGo	A20N (VT-IZK)	11	02:04	2:10	6	D45	3
38	3:05 AM	GF132	Gulf Air	A320 (A9C-AG)	11	02:08	2:20	12	A10L	3
39	2:30 AM	IA443	Iraqi Airways	B738 (YI-ASW)	11	02:16	2:29	13	A14L	3
40	2:55 AM	LO71	LOT	B789 (SP-LSC)	11	02:19	2:37	18	A13	3
41	1:30 AM	AI916	Air India	B788 (VT-ANG)	11	02:21	2:30	9	B17	3
42	2:45 AM	EK512	Emirates	B77W (A6-EGC)	11	02:25	2:34	9	B19	3
43	3:25 AM	XY329	flynas	A20N (HZ-NS52)	11	02:32	2:43	11	A10R	3
44	3:10 AM	FZ431	flydubai	B38M (A6-FMT)	28	02:36	2:42	6	A08L	3
45	3:15 AM	AI974	Air India	A321 (VT-PPO)	11	02:43	2:48	5	C33	3
46	2:25 AM	TK6565	AirACT	B744 (TC-ACF)	11	02:46	3:03	17	263	2
47	3:20 AM	SU232	Aeroflot	B77W (RA-73148)	11	02:50	3:04	14	A11	3
48	3:10 AM	EY218	Etihad	B789 (A6-BLF)	11	02:52	3:16	24	A09	3
49	2:58 AM	CI5640	China Airlines Cargo	B744 (B-18722)	11	02:55	3:27	32	257	2
50	2:15 AM	TG331	Thai Airways	B788 (HS-TQB)	11	02:58	3:11	13	A12	3
51	3:00 AM	I5738	AirAsia India	A320 (VT-KUL)	11	03:01	3:06	5	R08R	3
52	4:05 AM	GF130	Gulf Air	A320 (A9C-AB)	10	03:09	3:22	13	A08L	3
53	3:35 AM	AI948	Air India	A20N (VT-EXI)	10	03:18	3:31	13	B20R	3
54	2:57 AM		-	GL5T (G-OMTX)	10	03:23	3:39	16	GA2	3
55	4:00 AM	G9463	Air Arabia	A320 (A6-ANS)	10	03:29	3:39	10	A08R	3
56	3:45 AM	AI383	Air India	A20N (VT-EXV)	10	03:39	3:55	16	B22R	3

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57	3:30 AM	SG12	Corendon Airlines	B38M (TC-MKF)	10	03:46	4:02	16	A07L	3
58	4:00 AM	6E2082	IndiGo	A21N (VT-ILC)	10	03:49	3:56	7	202	3
59	2:00 AM	6E2746	IndiGo	A20N (VT-IVY)	10	03:54	4:01	7	Y3	2
60	4:10 AM	AI884	Air India	A319 (VT-SCF)	10	03:56	4:07	11	B24R	3
61	4:15 AM	6E681	IndiGo	A20N (VT-IZI)	10	03:59	4:05	3	172	3
62	3:55 AM	G876	Go First	A20N (VT-WJG)	10	04:06	4:15	9	A14L	3
63	4:40 AM	6E2111	IndiGo	A21N (VT-IMX)	10	04:09	4:15	6	Y7	2
64	4:50 AM	AI972	Air India	A20N (VT-CIN)	10	04:13	4:24	11	C31L	3
65	4:55 AM	AI996	Air India	B788 (VT-AND)	10	04:29	4:45	16	B26	3
66	5:00 AM	6.00E+12	Turkish Airlines	B77W (TC-LKA)	10	04:37	4:49	12	A03	3
67	4:45 AM	SG66	SpiceJet	B738 (VT-SZN)	10	04:41	4:55	14	D53	3
68	4:33 AM	ET8802	Ethiopian Airlines	B788 (ET-ARF)	10	04:47	5:04	17	A12	3
69	4:40 AM	TK716	Turkish Airlines	B77W (TC-LKC)	10	04:51	5:07	16	A01	3
70	5:20 AM	AY121	Finnair	A333 (OH-LTR)	10	05:04	5:17	13	A11	3
71	5:25 AM	6E1406	IndiGo	A20N (VT-ISD)	11	05:15	5:18	3	D55	3
72	6:10 AM	6.00E+158	IndiGo	A320 (VT-IAO)	10	05:49	5:52	3	150	1
73	6:40 AM	6.00E+84	IndiGo	A20N (VT-IJY)	10	05:56	6:06	10	A08L	3
74	7:00 AM	AI140	Air India	B788 (VT-ANA)	11	06:07	6:15	8	A09	3
75	6:40 AM	6E5163	IndiGo	A20N (VT-IPH)	11	06:13	6:19	6	D43	3
76	6:25 AM	AI284	Air India	A320 (VT-EDF)	11	06:18	6:24	6	C28R	3
77	6:55 AM	WY241	Oman Air	A332 (A4O-DG)	10	06:22	6:36	14	B24R	3
78	6:50 AM	6E1232	IndiGo	A20N (VT-IPJ)	10	06:23	3:33	10	A08R	3
79	6:55 AM	6E5182	IndiGo	A20N (VT-IVX)	11	06:25	6:29	4	D51	3
80	6:45 AM	G8176	Go First	A20N (VT-WGA)	10	06:27	6:34	7	208	2
81	6:40 AM	G8424	Go First	A20N (VT-WDA)	10	06:30	6:39	9	209	2
82	6:25 AM	SG88	SpiceJet	B38M (VT-MXA)	11	06:33	6:36	3	D53	3
83	7:35 AM	SG26	SpiceJet	B738 (VT-SYZ)	11	06:46	6:52	6	D58	3
84	7:15 AM	6E6247	IndiGo	A21N (VT-IBL)	10	06:50	6:53	3	161L	1
85	7:15 AM	6E2056	IndiGo	A21N (VT-IMG)	10	06:54	7:04	10	R11	3
86	7:20 AM	I5744	AirAsia India	A320 (VT-GWH)	11	06:58	7:02	4	D49	3
87	7:40 AM	6E526	IndiGo	A21N (VT-IBJ)	10	07:05	7:08	3	148	1
88	7:25 AM	6E379	IndiGo	A20N (VT-IIL)	10	07:13	7:15	2	155	1

89	7:40 AM	UK974	Vistara	A20N (VT-TQP)	11	07:22	7:29	7	D39R	3
90	7:45 AM	6E2108	IndiGo	A20N (VT-IPF)	10	07:26	7:33	7	211	2
91	8:30 AM	UK26	Vistara	B789 (VT-TSQ)	11	07:32	7:40	8	B17	3
92	8:10 AM	AI138	Air India	B788 (VT-ANW)	11	07:35	7:42	7	B20	3
93	8:00 AM	G8329	Go First	A20N (VT-WJN)	10	07:39	7:45	6	205	2
94	7:55 AM	AI454	Air India	A321 (VT-PPU)	11	07:43	7:52	9	A14L	3
95	8:10 AM	6E6828	IndiGo	A21N (VT-IUE)	10	07:44	7:47	3	150	1
96	7:40 AM	G8116	Go First	A20N (VT-WGE)	10	07:48	7:58	10	A06	3
97	8:20 AM	6E1312	IndiGo	A20N (VT-ISW)	11	07:49	7:56	7	B18	3
98	7:15 AM	6E2344	IndiGo	A320 (VT-IHZ)	10	07:51	8:04	13	203	2
99	8:05 AM	6E5332	IndiGo	A21N (VT-IMC)	11	07:52	7:56	4	D45	3
100	8:05 AM	UK954	Vistara	A20N (VT-TQD)	11	07:54	8:00	6	D48	3
101	8:00 AM	6E5011	IndiGo	A20N (VT-IVS)	11	07:56	8:02	6	R07	3
102	7:55 AM	6.00E+72	IndiGo	A20N (VT-IZN)	10	07:59	8:08	9	213	2
103	8:15 AM	UK926	Vistara	A20N (VT-TNP)	11	08:06	8:12	6	D43	3
104	8:45 AM	AI559	Air India	A20N (VT-EXR)	11	08:08	8:15	7	C32R	3
105	8:45 AM	QR570	Qatar Airways	A332 (A7-ACT)	10	08:10	8:21	11	A01	3
106	8:40 AM	AI804	Air India	A20N (VT-EXF)	11	08:12	8:17	5	C29R	3
107	8:30 AM	6E9006	IndiGo	A20N (VT-IVN)	10	08:14	8:24	10	D51	3
108	8:35 AM	AI824	Air India	A320 (VT-EXE)	11	08:15	8:23	8	C27L	3
109	8:25 AM	SG160	SpiceJet	B737 (VT-SLP)	10	08:17	8:20	3	151	1
110	8:30 AM	AI120	Air India	B788 (VT-ANM)	10	08:19	8:28	9	B21	3
111	9:05 AM	EK510	Emirates	B77W (A6-ENJ)	11	08:20	8:30	10	A01	3
112	8:35 AM	6E6329	IndiGo	A20N (VT-ITZ)	10	08:23	8:25	2	153	1
113	8:40 AM	6E2116	IndiGo	A20N (VT-IIJ)	10	08:25	8:31	6	206	2
114	8:10 AM	ET686	Ethiopian Airlines	B788 (ET-ATG)	11	08:26	8:39	13	A12	3
115	8:10 AM	G8206	Go First	A20N (VT-WGC)	10	08:28	8:39	11	201	2
116	9:00 AM	SG8191	Corendon Airlines	B738 (9H-TJC)	11	08:28	8:34	6	D60	3
117	8:40 AM	UK928	Vistara	A20N (VT-TQO)	11	08:32	8:37	5	D52	3
118	8:50 AM	G8192	Go First	A20N (VT-WJG)	10	08:33	8:39	6	208	2
119	8:50 AM	I5767	AirAsia India	A20N (VT-ATH)	11	08:35	8:39	4	D54	3
120	8:45 AM	6E6736	IndiGo	A20N (VT-IZJ)	10	08:36	8:39	3	170	1

121	8:45 AM	6E2343	IndiGo	A20N (VT-IIZ)	10	08:38	8:46	8	212	2
122	8:50 AM	6E962	IndiGo	A21N (VT-IUD)	10	08:40	8:44	4	161R	1
123	8:55 AM	AI440	Air India	A321 (VT-PPM)	11	08:41	8:48	7	C34L	3
124	9:05 AM	VS300	Virgin Atlantic	A35K (G-VTEA)	10	08:42	8:55	13	A10	3
125	9:25 AM	AI466	Air India	A20N (VT-EXH)	11	08:44	8:50	6	C31R	3
126	8:25 AM	6E5021	IndiGo	A21N (VT-IMB)	11	08:45	8:52	7	D46	3
127	8:25 AM	9I844	Alliance Air	AT76 (VT-AII)	11	08:47	8:54	7	B18	3
128	9:10 AM	6E2026	IndiGo	A21N (VT-IUZ)	10	08:51	8:59	8	202	3
129	9:00 AM	6E2011	IndiGo	A21N (VT-IUX)	10	08:53	9:03	10	R10L	3
130	9:20 AM	6E5602	IndiGo	A21N (VT-ILE)	11	08:54	9:05	11	A06	3
131	9:10 AM	6E2398	IndiGo	A21N (VT-ILS)	10	08:56	9:06	10	R12	3
132	9:20 AM	6E5127	IndiGo	A20N (VT-IVB)	11	08:57	9:03	6	D41	3
133	9:15 AM	SG2951	SpiceJet	DH8D (VT-SQA)	10	08:58	9:00	2	160L	1
134	9:15 AM	AI864	Air India	A321 (VT-PPJ)	11	08:59	9:06	7	C30L	3
135	7:35 AM	AI158	Air India	B788 (VT-ANO)	10	09:00	9:11	11	B22	3
136	9:25 AM	AI830	Air India	A320 (VT-EXB)	11	09:02	9:07	5	C31L	3
137	9:30 AM	AI818	Air India	A320 (VT-EDD)	10	09:04	9:14	10	C33	3
138	9:25 AM	AI436	Air India	A20N (VT-EXP)	11	09:05	9:10	5	C27R	3
139	8:45 AM	SG8136	SpiceJet	B739 (VT-SLC)	11	09:07	9:14	7	D50	3
140	9:25 AM	AI444	Air India	A320 (VT-EXD)	10	09:07	9:19	12	C30R	3
141	9:25 AM	6E6221	IndiGo	A21N (VT-ILD)	10	09:09	9:12	3	161L	1
142	9:15 AM	AI763	Air India	A321 (VT-PPK)	11	09:10	9:17	7	C28R	3
143	9:00 AM	UK860	Vistara	A20N (VT-TNJ)	11	09:13	9:19	6	D53	3
144	9:15 AM	6E375	IndiGo	A21N (VT-IMI)	10	09:14	9:18	4	154	1
145	9:35 AM	UK720	Vistara	A20N (VT-TNY)	11	09:15	9:22	7	D39L	3
146	9:30 AM	SG122	SpiceJet	B737 (VT-SLB)	10	09:17	9:19	2	163L	3
147	9:40 AM	SG8937	SpiceJet	B38M (VT-MXI)	11	09:18	9:23	5	D62	3
148	9:45 AM	SV756	Saudia	B77W (HZ-AK22)	10	09:19	9:29	10	B15	3
149	9:40 AM	UK930	Vistara	A21N (VT-TVF)	11	09:21	9:25	4	D55	3
150	9:35 AM	I5710	AirAsia India	A320 (VT-NAG)	11	09:23	9:27	4	D49	3

B. Minimum Taxi-in Time Matrix for All Combinations of Runway Ends - Parking Stands

Sl No	Stand No	Runway 10	Runway 11	Runway 26	Runway 27	Runway 28
1	C30L	6	6	6	5	3
2	C28R	12	5	6	5	3
3	D57	13	4	5	8	3
4	R06	5	5	7	7	3
5	R11	6	8	5	5	6
6	150	3	11	3	4	11
7	202	5	10	3	3	5
8	R10R	6	9	5	5	6
9	R10L	6	9	5	5	6
10	A13	7	8	4	4	4
11	D38R	8	3	8	5	3
12	Y5	5	10	4	3	8
13	212	5	10	3	3	4
14	151	3	11	3	4	11
15	153R	2	16	4	4	11
16	X5	5	10	5	5	7
17	A14R	6	7	3	5	4
18	203	5	10	4	4	10
19	A03	7	8	5	5	5
20	A08	6	8	5	5	5
21	D41	12	4	8	6	3
22	E54	13	3	10	8	5
23	205	5	10	3	3	8
24	B16	8	5	5	6	3
25	A05	7	7	6	5	5
26	E64	10	3	8	7	5
27	216	4	10	3	3	7
28	D54	13	3	10	8	5
29	207	5	10	4	3	7
30	B15	7	5	5	6	3
31	161	3	15	3	3	11
32	B21	8	5	5	5	3
33	R07L	3	5	3	4	7
34	Y7	4	12	4	3	8
35	E67	10	4	8	7	5
36	R01	11	6	8	7	5

37	D45	13	3	8	8	3
38	A10L	6	8	3	4	5
39	A14L	6	8	3	5	4
40	A13	7	8	4	4	4
41	B17	7	5	5	6	3
42	B18	8	5	6	5	3
43	A10R	5	11	5	4	4
44	A07L	7	10	6	5	4
45	C33	10	4	7	5	3
46	253	4	10	5	5	11
47	A11	7	8	5	3	3
48	A08	5	8	5	5	5
49	256	5	10	5	5	12
50	A12	6	7	5	5	5
51	R07R	8	5	7	7	3
52	A07L	7	5	5	5	5
53	B20R	8	4	8	7	3
54	GA2	10	5	8	7	5
55	A07R	7	5	5	5	5
56	B22R	8	4	7	7	3
57	A06L	6	9	5	5	5
58	202	5	10	3	3	5
59	Y3	5	10	4	3	8
60	B24R	8	4	7	6	3
61	162	3	5	3	3	11
62	A14L	6	7	3	5	4
63	Y6	5	8	4	3	8
64	C31L	11	5	7	5	3
65	B26	8	5	7	6	3
66	A03	7	8	5	5	5
67	D53	13	3	7	7	3
68	A12	6	8	5	5	5
69	A01	7	8	5	5	3
70	A11	7	7	5	3	3
71	D55	12	3	7	7	3
72	150	3	11	3	4	11
73	A07L	7	7	5	5	5
74	A08	6	8	5	5	5
75	D43	13	4	8	6	3

76	C27R	12	5	6	5	3
77	B24R	8	4	7	6	3
78	A07R	7	8	5	5	5
79	D51	10	4	7	7	3
80	207	5	10	4	3	7
81	208	5	10	4	3	7
82	D53	13	3	7	7	3
83	D57	13	5	5	8	3
84	151L	2	11	4	5	6
85	R11	6	10	5	5	6
86	D48	13	3	7	7	3
87	147	2	11	3	4	11
88	155	2	11	3	4	11
89	D38R	10	3	8	5	3
90	211	5	10	3	3	5
91	B16	8	5	5	6	3
92	B20	10	5	7	6	3
93	205	5	10	3	3	8
94	A14L	6	7	3	5	4
95	150	3	11	3	4	11
96	A05	7	7	6	5	5
97	B17	10	6	8	7	3
98	203	5	10	4	4	10
99	D45	13	3	8	8	3
100	D47	8	5	7	7	3
101	R06	5	5	7	7	3
102	213	6	11	3	3	5
103	D43	13	4	8	6	3
104	C32R	6	5	7	5	3
105	A01	8	13	5	5	3
106	C28R	14	5	6	5	3
107	D51	10	4	7	7	3
108	C26L	8	5	6	5	3
109	151	3	11	3	4	11
110	B21	8	6	5	5	3
111	A01	8	13	5	5	3
112	153	2	11	3	4	11
113	205	5	10	3	3	8
114	A12	7	6	5	5	5

115	201	5	10	3	3	5
116	D50	8	4	11	8	3
117	D52	8	5	7	7	4
118	207	5	10	4	3	7
119	D54	13	3	10	8	5
120	160	3	11	3	3	11
121	212	7	13	3	3	4
122	151R	2	11	4	5	6
123	C34L	6	6	6	5	3
124	A10	4	11	5	4	4
125	C31R	8	5	7	5	3
126	D45	10	3	8	8	3
127	B17	9	4	8	7	3
128	202	6	11	3	3	5
129	R10L	7	7	5	5	6
130	A05	7	7	6	5	5
131	R12	7	7	5	5	6
132	D41	12	4	8	6	3
133	150L	2	11	3	4	11
134	C30L	8	6	6	5	3
135	B22	8	4	7	7	3
136	C31L	11	4	7	5	3
137	C33	11	4	7	5	3
138	C26R	11	4	6	5	3
139	D50	8	3	7	7	5
140	C30R	8	5	6	5	3
141	151L	2	11	4	5	6
142	C27R	13	4	6	5	3
143	D53	12	3	7	7	3
144	154	2	11	3	4	11
145	D38L	11	5	8	6	3
146	153L	2	11	4	4	11
147	D52	11	3	8	7	3
148	B15	10	6	5	6	3
149	D55	12	3	7	7	3
150	D48	13	3	7	7	3

C. Formulae Applied to the Model

Objective

$L$3(Min)

Variables Normal:

$H$12:$H$161,$P$12:$P$161,$X$12:$X$161,$AF$12:$AF$161,$AN$12:$AN$161,$AV$12:$AV$161

Constraint Normal:

$AW$12:$AW$161=1, $AX$12=0, $AX$12:$AX$14 <= $AY$12:$AY$14

Integers:

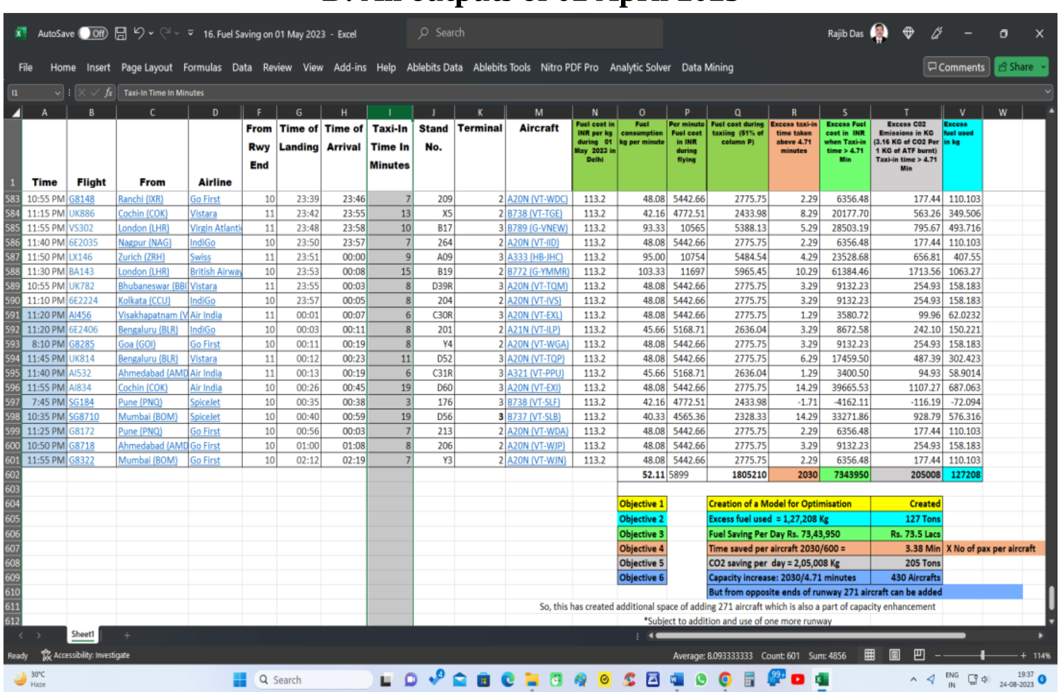
$AF$12:$AF$161=Binary, $AN$12:$AN$161=Binary, $AV$12:$AV$161=Binary
$H$12:$H$161=Binary, $P$12:$P$161=Binary, $X$12:$X$161=Binary

Uncertain Function: L2

Statistic Function:

$L$3:$L$4, $O$1:$O$5, $O$7, $O$9:$O$10

D. All outputs of 02 April 2023



Row	Time	Flight	From	Airline	From Rwy End	Time of Landing	Time of Arrival	Taxi-In Time In Minutes	Stand No.	Terminal	Aircraft	Fuel cost in INR per kg during 01 May 2023 in Delhi	Fuel consumption kg per minute	Per minute Fuel cost in INR during flying	Fuel cost during taxiing (51% of column P)	Excess taxi-in time taken above 4.71 minutes	Excess Fuel cost in INR when Taxi-in time > 4.71 Min	Excess CO2 Emissions in KG (3.16 KG of CO2 Per 1 KG of ATF burnt) Taxi-in time > 4.71 Min	Excess fuel used in kg
583	10:55 PM	G8148	Ranchi (IXR)	Go First	10	23:39	23:46	7	209	2	A20N (VT-WDC)	113.2	48.08	5442.66	2775.75	2.29	6356.48	177.44	110.103
584	11:15 PM	UK886	Cochin (COK)	Vistara	11	23:42	23:55	13	X5	2	B738 (VT-TGE)	113.2	42.16	4772.51	2433.98	8.29	20177.70	563.26	349.506
585	11:55 PM	VS302	London (LHR)	Virgin Atlanti	11	23:48	23:58	10	B17	3	B789 (G-VNEW)	113.2	93.33	10565	5388.13	5.29	28503.19	795.67	493.716
586	11:40 PM	6E2035	Nagpur (NAG)	IndiGo	10	23:50	23:57	7	264	2	A20N (VT-IID)	113.2	48.08	5442.66	2775.75	2.29	6356.48	177.44	110.103
587	11:50 PM	LX146	Zurich (ZRH)	Swiss	11	23:51	00:00	9	A09	3	A333 (HB-JHC)	113.2	95.00	10754	5484.54	4.29	23528.68	656.81	407.55
588	11:30 PM	BA143	London (LHR)	British Airway	10	23:53	00:08	15	B19	2	B772 (G-YMMR)	113.2	103.33	11697	5965.45	10.29	61384.46	1713.56	1063.27
589	10:55 PM	UK782	Bhubaneswar (BBI	Vistara	11	23:55	00:03	8	D39R	3	A20N (VT-TQM)	113.2	48.08	5442.66	2775.75	3.29	9132.23	254.93	158.183
590	11:10 PM	6E2224	Kolkata (CCU)	IndiGo	10	23:57	00:05	8	204	2	A20N (VT-IVS)	113.2	48.08	5442.66	2775.75	3.29	9132.23	254.93	158.183
591	11:20 PM	AI456	Visakhapatnam (V	Air India	11	00:01	00:07	6	C30R	3	A20N (VT-EXL)	113.2	48.08	5442.66	2775.75	1.29	3580.72	99.96	62.0232
592	11:20 PM	6E2406	Bengaluru (BLR)	IndiGo	10	00:03	00:11	8	201	2	A21N (VT-ILP)	113.2	45.66	5168.71	2636.04	3.29	8672.58	242.10	150.221
593	8:10 PM	G8285	Goa (GOI)	Go First	10	00:11	00:19	8	Y4	2	A20N (VT-WGA)	113.2	48.08	5442.66	2775.75	3.29	9132.23	254.93	158.183
594	11:45 PM	UK814	Bengaluru (BLR)	Vistara	11	00:12	00:23	11	D52	3	A20N (VT-TQP)	113.2	48.08	5442.66	2775.75	6.29	17459.50	487.39	302.423
595	11:40 PM	AI532	Ahmedabad (AMD	Air India	11	00:13	00:19	6	C31R	3	A321 (VT-PPU)	113.2	45.66	5168.71	2636.04	1.29	3400.50	94.93	58.9014
596	11:55 PM	AI834	Cochin (COK)	Air India	10	00:26	00:45	19	D60	3	A20N (VT-EXI)	113.2	48.08	5442.66	2775.75	14.29	39665.53	1107.27	687.063
597	7:45 PM	SG184	Pune (PNQ)	SpiceJet	10	00:35	00:38	3	176	3	B738 (VT-SLF)	113.2	42.16	4772.51	2433.98	-1.71	-4162.11	-116.19	-72.094
598	10:35 PM	SG8710	Mumbai (BOM)	SpiceJet	10	00:40	00:59	19	D56	3	B737 (VT-SLB)	113.2	40.33	4565.36	2328.33	14.29	33271.86	928.79	576.316
599	11:25 PM	G8172	Pune (PNQ)	Go First	10	00:56	00:03	7	213	2	A20N (VT-WDA)	113.2	48.08	5442.66	2775.75	2.29	6356.48	177.44	110.103
600	10:50 PM	G8718	Ahmedabad (AMD	Go First	10	01:00	01:08	8	206	2	A20N (VT-WJP)	113.2	48.08	5442.66	2775.75	3.29	9132.23	254.93	158.183
601	11:55 PM	G8322	Mumbai (BOM)	Go First	10	02:12	02:19	7	Y3	2	A20N (VT-WJN)	113.2	48.08	5442.66	2775.75	2.29	6356.48	177.44	110.103
602													52.11	5899	1805210	2030	7343950	205008	127208

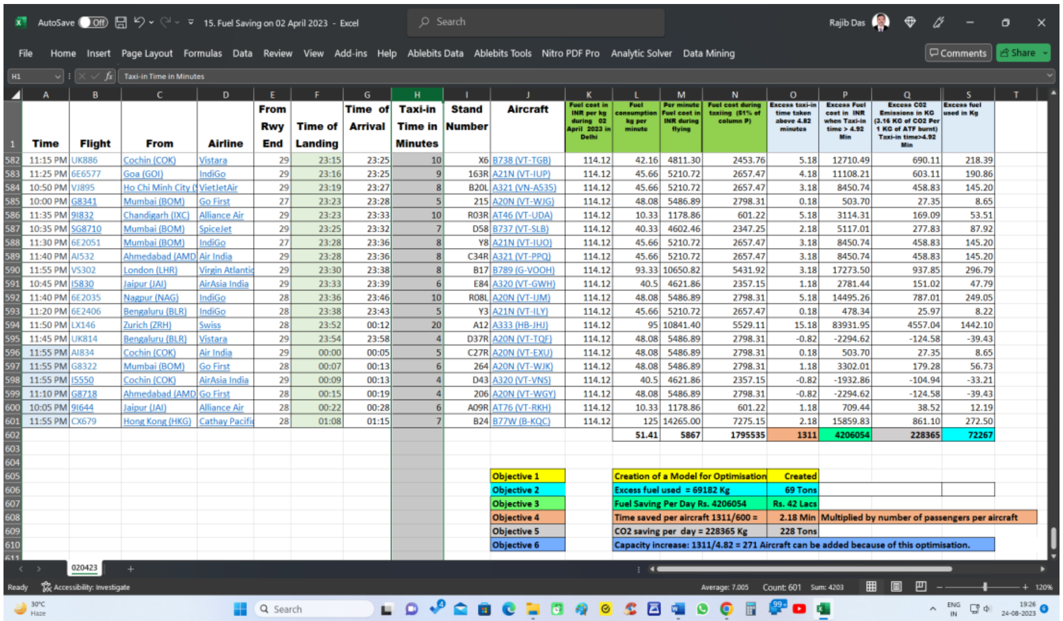
Objective 1	Creation of a Model for Optimisation	Created
Objective 2	Excess fuel used = 1,27,208 Kg	127 Tons
Objective 3	Fuel Saving Per Day Rs. 73,43,950	Rs. 73.5 Lacs
Objective 4	Time saved per aircraft 2030/600 =	3.38 Min X No of pax per aircraft
Objective 5	CO2 saving per day = 2,05,008 Kg	205 Tons
Objective 6	Capacity increase: 2030/4.71 minutes	430 Aircrafts

But from opposite ends of runway 271 aircraft can be added

So, this has created additional space of adding 271 aircraft which is also a part of capacity enhancement

*Subject to addition and use of one more runway

E. All Outputs of 01 May 2023



	Time	Flight	From	Airline	From Rwy End	Time of Landing	Time of Arrival	Taxi-in Time in Minutes	Stand Number	Aircraft	Fuel cost in INR per kg during 02 April 2023 in Delhi	Fuel consumption kg per minute	Per minute Fuel cost in INR during flying	Fuel cost during taxiing (51% of column P)	Excess taxi-in time taken above 4.82 minutes	Excess Fuel cost in INR when Taxi-in time > 4.92 Min	Excess CO2 Emissions in KG (3.16 KG of CO2 Per 1 KG of ATF burnt) Taxi-in time>4.92 Min	Excess fuel used in Kg
582	11:15 PM	UK886	Cochin (COK)	Vistara	29	23:15	23:25	10	X6	B738 (VT-TGB)	114.12	42.16	4811.30	2453.76	5.18	12710.49	690.11	218.39
583	11:25 PM	6E6577	Goa (GOI)	IndiGo	29	23:16	23:25	9	163R	A21N (VT-IUP)	114.12	45.66	5210.72	2657.47	4.18	11108.21	603.11	190.86
584	10:50 PM	VJ895	Ho Chi Minh City (	VietJetAir	29	23:19	23:27	8	B20L	A321 (VN-A535)	114.12	45.66	5210.72	2657.47	3.18	8450.74	458.83	145.20
585	10:00 PM	G8341	Mumbai (BOM)	Go First	27	23:23	23:28	5	215	A20N (VT-WJG)	114.12	48.08	5486.89	2798.31	0.18	503.70	27.35	8.65
586	11:35 PM	9I832	Chandigarh (IXC)	Alliance Air	29	23:23	23:33	10	R03R	AT46 (VT-UDA)	114.12	10.33	1178.86	601.22	5.18	3114.31	169.09	53.51
587	10:35 PM	SG8710	Mumbai (BOM)	SpiceJet	29	23:25	23:32	7	D58	B737 (VT-SLB)	114.12	40.33	4602.46	2347.25	2.18	5117.01	277.83	87.92
588	11:30 PM	6E2051	Mumbai (BOM)	IndiGo	27	23:28	23:36	8	Y8	A21N (VT-IUO)	114.12	45.66	5210.72	2657.47	3.18	8450.74	458.83	145.20
589	11:40 PM	AI532	Ahmedabad (AMD	Air India	29	23:28	23:36	8	C34R	A321 (VT-PPQ)	114.12	45.66	5210.72	2657.47	3.18	8450.74	458.83	145.20
590	11:55 PM	VS302	London (LHR)	Virgin Atlantic	29	23:30	23:38	8	B17	B789 (G-VOOH)	114.12	93.33	10650.82	5431.92	3.18	17273.50	937.85	296.79
591	10:45 PM	I5830	Jaipur (JAI)	AirAsia India	29	23:33	23:39	6	E84	A320 (VT-GWH)	114.12	40.5	4621.86	2357.15	1.18	2781.44	151.02	47.79
592	11:40 PM	6E2035	Nagpur (NAG)	IndiGo	28	23:36	23:46	10	R08L	A20N (VT-IJM)	114.12	48.08	5486.89	2798.31	5.18	14495.26	787.01	249.05
593	11:20 PM	6E2406	Bengaluru (BLR)	IndiGo	28	23:38	23:43	5	Y3	A21N (VT-ILY)	114.12	45.66	5210.72	2657.47	0.18	478.34	25.97	8.22
594	11:50 PM	LX146	Zurich (ZRH)	Swiss	28	23:52	00:12	20	A12	A333 (HB-JHJ)	114.12	95	10841.40	5529.11	15.18	83931.95	4557.04	1442.10
595	11:45 PM	UK814	Bengaluru (BLR)	Vistara	29	23:54	23:58	4	D37R	A20N (VT-TQF)	114.12	48.08	5486.89	2798.31	-0.82	-2294.62	-124.58	-39.43
596	11:55 PM	AI834	Cochin (COK)	Air India	29	00:00	00:05	5	C27R	A20N (VT-EXU)	114.12	48.08	5486.89	2798.31	0.18	503.70	27.35	8.65
597	11:55 PM	G8322	Mumbai (BOM)	Go First	28	00:07	00:13	6	264	A20N (VT-WJK)	114.12	48.08	5486.89	2798.31	1.18	3302.01	179.28	56.73
598	11:55 PM	I5550	Cochin (COK)	AirAsia India	29	00:09	00:13	4	D43	A320 (VT-VNS)	114.12	40.5	4621.86	2357.15	-0.82	-1932.86	-104.94	-33.21
599	11:10 PM	G8718	Ahmedabad (AMD	Go First	28	00:15	00:19	4	206	A20N (VT-WGY)	114.12	48.08	5486.89	2798.31	-0.82	-2294.62	-124.58	-39.43
600	10:05 PM	9I644	Jaipur (JAI)	Alliance Air	28	00:22	00:28	6	A09R	AT76 (VT-RKH)	114.12	10.33	1178.86	601.22	1.18	709.44	38.52	12.19
601	11:55 PM	CX679	Hong Kong (HKG)	Cathay Pacific	28	01:08	01:15	7	B24	B77W (B-KQC)	114.12	125	14265.00	7275.15	2.18	15859.83	861.10	272.50
602												51.41	5867	1795535	1311	4206054	228365	72267

Objective	Description	Result	
Objective 1	Creation of a Model for Optimisation	Created	
Objective 2	Excess fuel used = 69182 Kg	69 Tons	
Objective 3	Fuel Saving Per Day Rs. 4206054	Rs. 42 Lacs	
Objective 4	Time saved per aircraft 1311/600 =	2.18 Min	Multiplied by number of passengers per aircraft
Objective 5	CO2 saving per day = 228365 Kg	228 Tons	
Objective 6	Capacity increase: 1311/4.82 = 271 Aircraft can be added because of this optimisation.		