

Evolving Aircraft Turnaround Operations and Cost Calculation in a Post-Pandemic World

Dr. Meenakshi Kaushik¹, Meenakshi Jain²

¹Department of Computer Science, Meewar University, India
Jain.meenakshi1978@gmail.com

²Department of Computer Science, Meewar University, India
findmeenaxi@gmail.com

Abstract

International movement is greatly facilitated by air travel, which necessitates stringent security and safety procedures. However, the pandemic scenario right now has had a substantial impact on aircraft ground operations, prompting a rethink of normal operating procedures to meet future sanitary standards. In particular, physical separation between passengers and the requirement to sanitize the cabin after each trip provide difficulties for passenger boarding. We evaluate potential changes to these aircraft cabin processes in light of a pre-pandemic reference aircraft turnaround in order to solve these problems. Our findings show that, despite the introduction of process adjustments, sustaining pre-pandemic turnaround times with the same seat load becomes difficult. To achieve pre-pandemic turnaround speeds without the need for additional cleaning staff, a seat allocation plan that uses empty middle seats (equivalent to a seat load of 67%) and an apron position (boarding through the back aircraft door) is used. Terminal positions would need between 10% (with additional people) and 20% (without additional employees) more ground time for aircraft turnarounds.

Keywords: Air Travel, Aircraft, Cabin, Turnaround Operations, Turnaround times, Post- Pandemic World.

1. Introduction

Air transportation plays a crucial role in facilitating broad travel on both domestic and global scales, encountering a wide range of issues encompassing safety, security, operational efficiency, and the pressing need for environmental sustainability. The ongoing global epidemic has compelled the aviation sector to implement substantial modifications, resulting

in a nearly complete halt in air travel as a measure to mitigate the transmission of COVID-19.

The establishment of the multi-crew coordination concept can be attributed to the Tenerife catastrophe in 1977 as a direct response to the incident. Similarly, the implementation of limits on hand luggage liquids can be traced back to significant security events that occurred in 2006. Nevertheless, the implementation of these procedural modifications, which are crucial for ensuring safety and security, frequently leads to extended service durations and interferes with the smooth transportation encounter for both passengers and operational activities [1-2].

In addition to taking into account safety and security factors, it is anticipated that the persistent epidemic will bring about enduring transformations in the domains of aircraft ground operations and passenger handling. The set of procedures involved in managing airplanes on the airport apron is commonly known as aircraft turnaround. Throughout the years, airlines have made efforts to enhance the effectiveness of their turnaround operations in order to optimize aircraft flight durations and the usage of resources. The pursuit of efficiency in the aviation business has been shaped by significant advancements introduced by low-cost airlines. These developments have prompted the sector as a whole to make modifications, reconceptualize, or simplify turnaround operations, spanning a period of around thirty years. The cleaning and catering procedures have experienced notable reductions, as certain turnarounds are now limited to occurring every second or third flight throughout the day. Additionally, these tasks are often only superficially addressed by cabin crew members, reserving more comprehensive executions for nocturnal periods.

When considering the integration of current passenger de-/boarding procedures and new disinfection methods into a turnaround reference mode, it becomes apparent that the inclusion of longer ground time is necessary for both airline and airport operations (see Fig.1). Hence, aircraft rotations during the course of a day may encounter substantial consequences, especially for flights lacking any additional time allowances beyond the minimal ground durations required for the aircraft. The current investigation diverges from existing research by examining the maximum acceptable level of additional ground time that can be incorporated into the airline network without compromising its overall operational efficiency. Previous studies have predominantly concentrated on determining the optimal reduction of ground times to enhance aircraft utilization [3-5].

2. Data Set and Collection

The experiment was conducted using the Python 3.6.9 programming language within the Colaboratory environment (version 2X @2020-21 from Google Research). Colaboratory notebooks possess the functionality to be kept within Google Drive or accessed using GitHub. The primary aim of the pre-processing step was to create a structured database within a GPU (Graphics Processing Unit) framework .

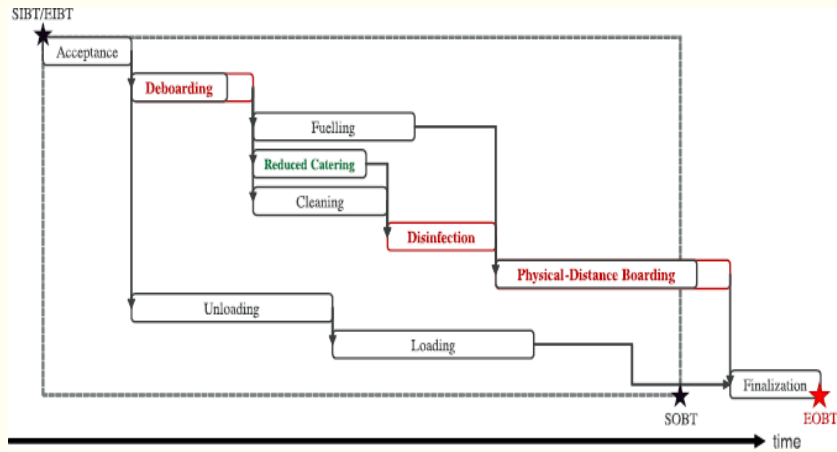


Figure 1: Modified turnaround framework with cabin sanitization, limited catering, and implementation of passenger physical-distancing during deboarding and boarding. Due to the changed process arrangements, the overall turnaround duration is expected to increase, leading to extended required ground times, causing the estimated off-block times (EOBT) to exceed the previously scheduled off-block times (SOBT).

Data Definition

We used a dataset including roughly 7,213,445 records showing flight arrival delays for 18 Indian carriers for our purpose. Each row of the dataset summarises delay statistics for a single carrier-airport pair over the course of a month. The dataset was created in January 2021 and includes data from the Bureau of Transportation Statistics from January 1, 2018, to December 31, 2019. We used the pandas, matplotlib, and seaborn libraries to help with our analysis [6-7].

MetaData

FL_DATE = Flight Timetable

OP_CARRIER = Identifier of an airline

OP_CARRIER_FL_NUM = Flight Identity Number

ORIGIN = Initial Airport Code

DEST = Code for the Destination Airport

CRS_DEP_TIME = Departure Time/Date

DEP_TIME = Actual Departure Time

DEP_DELAY = Departure Delay (min)

TAXI_OUT = duration of time that transpires between the moment an aircraft departs from the gate at the origin airport to the point at which it initiates takeoff.

WHEELS_OFF = precise time when an aircraft's wheels disengage from the ground surface.

WHEELS_ON = specific moment when an aircraft's wheels come into contact with the ground surface.

TAXI_IN = duration of time that elapses from the moment an aircraft's wheels make contact with the runway until it reaches its designated gate at the intended airport.

CRS_ARR_TIME = Arrival time projected

ARR_TIME = Actual Arrival Time

ARR_DELAY = Total Arrival Delay in Minutes

CANCELLED = Flight cancelled

CANCELLATION_CODE Reason for Flight Cancellation : A - Airline/Carrier; B - Weather; C - National Air System; D - Security

DIVERTED = The aircraft arrived at an alternative airport in contrast to the originally intended destination

CRS_ELAPSED_TIME = designated duration allocated for the flight journey.

ACTUAL_ELAPSED_TIME = calculated by summing the air time, taxi-in time, and taxi-out time

AIR_TIME = duration from the moment the aircraft's wheels leave the ground (wheels_off) and the moment they touch the ground again (wheels_on).

DISTANCE = measure of separation between two airports.

CARRIER_DELAY In minutes, the airline's delay

WEATHER_DELAY = delay in a certain activity or event that is caused by adverse weather conditions.

NAS_DELAY = delay in air transportation that is caused by issues within the air system.

SECURITY_DELAY = delay that occurs as a result of concerns related to security.

LATE_AIRCRAFT_DELAY = Delay due to security

Data Analytics Tasks

If this material is acquired from other sources, we must remember to properly cite the sources. Plagiarism can have major academic and ethical ramifications, so always give credit where credit is due.

2. Feature Selection

Note: The process was executed by Python

The constant variable was eliminated since it provided no useful information to the model. Attributes that were strongly correlated with one another were investigated in order to prevent the multi-collinearity impact on the model by picking the best predictive one. The correlation between planned elapsed time, airtime, distance, and actual elapsed

time is more than 0.8. Several characteristics were highly associated in this group. A random forest method was used to estimate the feature relevance of each characteristic before deciding which ones to eliminate. Thus, the actual elapsed time was not eliminated because it was the most important feature when compared to other qualities (as seen in Table 1 below).

Attributes	Importance Score
Actual elapsed time	0.43
Planned elapsed time	0.35
Distance	0.15
Airtime	0.07

Table 1 : Attributes with an importance score

Figure 2 depicts the characteristics provided by the random forest classifier, together with their relevance score, in descending order. It's worth noting that the anticipated arrival day, month, and destination airport had no impact on a flight's arrival delay. Attributes with low significance ratings were removed since maintaining all of them did not improve training model performance. As a result, the subsequent models were trained using only the top nine characteristics.

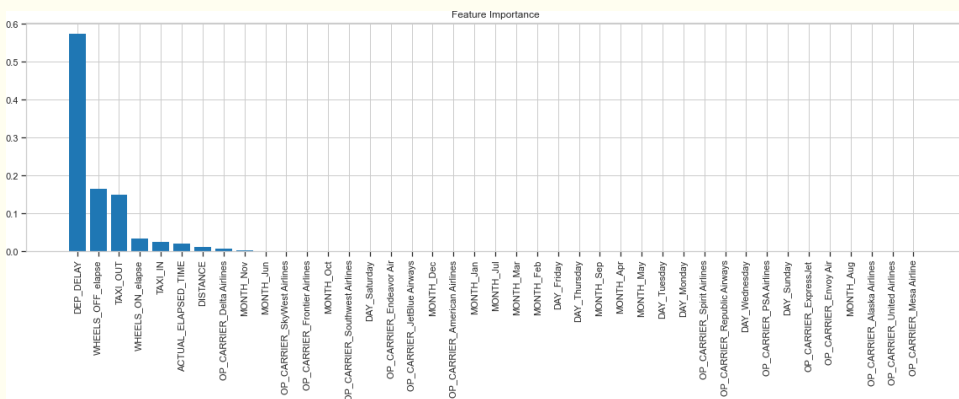


Figure 2: Random Forest Classifier [8]

3. Discussion and Prospects

Nevertheless, these alterations incur supplementary costs for airlines across three strategic dimensions: (1) the opportunity cost stemming from reduced seat occupancy and extended scheduled ground durations; (2) increased expenses for ground handling due to

the need for additional cleaning personnel; and (3) investments in modified gate infrastructure and walk-boarding facilities [9-10].

Based on an investigation of six different seat distribution algorithms, it has been determined that it is not feasible to maintain previously stipulated ground times while achieving both equal seat loads and low transmission risk throughout the boarding process. Consequently, it becomes necessary to strike a balance between reducing the duration of scheduled ground times and minimising the number of seats occupied on each trip. The reduced passenger capacity imposes a burden on the economic efficiency of several trips, particularly for airlines operating on narrow profit margins. The implementation of reduced seat loads is a more feasible approach compared to reducing the number of daily flights. The latter may lead to a decrease in network connectivity and diminish the attractiveness of the product, considering the gradual recovery of demand following the outage. Currently, maintaining vacant middle seats within each row appears to be the more favourable option. Future research may focus on the modification of ticket price strategies to ensure efficient operations with reduced ticket sales per flight. Additionally, there may be an exploration of including extended land segments for certain fleet members inside the aircraft rotation [11].

The results of our study indicate that implementing a one-door boarding strategy and maintaining the pre-pandemic quantity of cleaning agents, a seat load factor of 67% (referred to as the "empty middle-seat" scenario) necessitates a 20% increase in the minimum ground time at terminal positions. Moreover, augmenting the workforce of cleaning personnel can effectively contribute to the maintenance of minimal overall turnaround durations, particularly when supplementary disinfection procedures are implemented subsequent to routine cleaning. Given a single-door boarding method and a 67% seat load factor (SLF), increasing the number of cleaning agents from 3 to 6 during each turnaround would result in a mere 10% increase in ground time compared to operations prior to the pandemic. A concurrent study is being conducted to explore further seat allocation options, with consideration given to the fact that individuals belonging to the same group do not require physical distancing when boarding and can occupy adjacent seats during the journey. Future research should also investigate the deboarding process and provide recommendations for effectively managing this mostly unregulated function within the aircraft interior. Consequently, walk-boarding positions and their corresponding pre-boarding areas within the terminal were predominantly constructed in subsidiary airports or within the low-cost terminals of primary airports. In order to mitigate the decreased transmission hazards associated with physical-distance boarding resulting from inadequately ventilated jetway bridges and apron buses, it is advisable to create additional stands in close proximity to key airport terminals [12-13]. This would enable passengers to board the aircraft from two entrances located in open areas.

4. Conclusion and Review Remarks

The calculation of the appropriate schedule buffer time is based on notional cost estimates that are obtained by analysing the operational expenses of aircraft. The present study presents numerical analyses that provide empirical evidence in favour of the notion that the implementation of appropriate schedule buffer time for various categories of turnaround aircraft can lead to system optimisation. This optimisation is achieved by lowering overall system costs and maximising the performance of schedule timeliness. The suggested approach for assessing Schedule Punctuality Performance (SPP) is regarded as a valuable managerial instrument for airlines and airports. It enables them to estimate and assess SPP prior to and following the implementation of flight schedules, given the availability of historical data on flight punctuality performance and aircraft turnaround efficiency for analysis.

5. Future Scope

While Air Traffic Control (ATC) operations may still result in delays, the implementation of a well-structured flight schedule can contribute to the improvement of punctuality performance. The appropriate allocation of schedule buffer time for the return aircraft enhances the reliability of airport flight connections. Consequently, an airline has the potential to enhance its aircraft rotation schedule within a flight network, so reducing operational expenses while still maintaining a positive reputation among customers for punctuality.

6. References

- [1] AhmadBeygi, S., Cohn, A., Lapp, M., 2010. Decreasing airline delay propagation by re-allocating scheduled slack. *IIE Trans.* 42, 478–489. <https://doi.org/10.1080/07408170903468605>.
- [2] Ali, H., Guleria, Y., Alam, S., Schultz, M., 2019. A passenger-centric model for reducing missed connections at low cost airports with gates reassignment. *IEEE Access* 7, 179429–179444. <https://doi.org/10.1109/ACCESS.2019.2953769>.
- [3] Andreatta, G., De Giovanni, L., Monaci, M., 2014. A fast heuristic for airport ground- service equipment–and–staff allocation. *Procedia - Soc. Behav. Sci.* 108, 26–36. <https://doi.org/10.1016/j.sbspro.2013.12.817>.
- [4] Bachmat, E., Elkin, M., 2008. Bounds on the performance of back-to-front airplane boarding policies. *Oper. Res. Lett.* 36, 597–601. <https://doi.org/10.1016/j.orl.2008.03.008>.
- [5] Bachmat, E., Khachaturov, V., Kuperman, R., 2013. Optimal back-to-front airplane

boarding. *Phys. Rev. E, Statist. Nonlinear Soft Matter Phys.* 87, 062805 <https://doi.org/10.1103/PhysRevE.87.062805>.

- [6] Bazargan, M., 2007. A linear programming approach for aircraft boarding strategy. *Eur. J. Oper. Res.* 183, 394–411. <https://doi.org/10.1016/j.ejor.2006.09.071>.
- [7] Beatty, R., Hsu, R., Berry, L., Rome, J., 1999. Preliminary evaluation of flight delay propagation through an airline schedule. *Air Traffic Contr. Q* 7, 259–270. <https://doi.org/10.2514/atcq.7.4.259>.
- [8] Bernstein, N., 2012. Comment on "Time needed to board an airplane: a power law and the structure behind it". *Phys. Rev. E, Statist. Nonlinear Soft Matter Phys.* 86, 023101 <https://doi.org/10.1103/PhysRevE.86.023101>.
- [9] Burstedde, C., Klauck, K., Schadschneider, A., Zittartz, J., 2001. Simulation of pedestrian dynamics using a two-dimensional cellular automaton. *Phys. Stat. Mech. Appl.* 295, 507–525. [https://doi.org/10.1016/S0378-4371\(01\)00141-8](https://doi.org/10.1016/S0378-4371(01)00141-8).
- [10] Cook, A., 2015. European Airline Delay Cost Reference Values - Updated and Extended Values. University of Westminster, London. Technical Report 4.1. Cotfas, L.A., Delcea, C., Milne, R.J., Salari, M., 2020. Evaluating classical airplane boarding methods considering COVID-19 flying restrictions. *Symmetry* 12, 1087. <https://doi.org/10.3390/sym12071087>.
- [11] Delcea, C., Cotfas, L.A., Paun, R., 2018. Agent-based evaluation of the airplane boarding strategies— efficiency and sustainability. *Sustainability* 10, 1879. <https://doi.org/10.3390/su10061879>.
- [12] Dijk, B., Santos, B.F., Pita, J.P., 2019. The recoverable robust stand allocation problem: a GRU airport case study. *OR Spectrum* 41, 615–639. <https://doi.org/10.1007/s00291-018-0525-3>.
- [13] Dorndorf, U., Jaehn, F., Pesch, E., 2017. Flight gate assignment and recovery strategies with stochastic arrival and departure times. *OR Spectrum* 39, 65–93. <https://doi.org/10.1007/s00291-016-0443-1>