Project Report

Atlanta Airport Ground Operations Simulation

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1. Introduction

This project presents a simulation of all the operations at the Hartsfield-Jackson Atlanta International Airport, one of the busiest airports in the world. We created a model using the power of Arena simulation software incorporated with real-world data of the arriving flights imported into an Excel sheet. We also set up the structure of the entire airport by dividing the gates into a set of concourses with all the standard processes of every arriving and departing airplane. Where necessary, assumptions were made, and these are detailed further within the report. The following simulation models airport operations to provide insight into the operation and show where any potential optimizations can be found.

2. Assumptions

1. **Aircraft Types**:
   Only two types of aircraft were considered:

   Domestic Flights: Represented by aircraft such as the Airbus A320.

   International Flights: Represented by larger aircraft like the Boeing 777.
   This differentiation was necessary as each aircraft type has unique requirements, including fueling, maintenance checks, and passenger boarding/disembarkation times.

2. **Fully Booked Flights:**
   All flights were assumed to be fully booked. This simplification helped standardize the baggage handling process and reduced variability in passenger-related processes.
3. **One baggage per traveller:**

   We decided to have one baggage per traveller to simplify the baggage handling process. 160 bags for domestic flights and 400 for international.

4. **Fueling Capacity:**
   Aircraft were assumed to be fueled to half their tank capacity for each flight. This assumption allowed us to simplify the fueling process without significantly compromising the simulation's accuracy.

5. **Cycle:** It was assumed that all flights arrive at Atlanta airport and leave again after a certain amount of time to emphasize this project's scope on minimizing flight delays and reducing throughput times.
6. **Gate numbers:** The model presented in this project assumed that a gate number is assigned to each flight and that the daily flight schedule repeats everyday. This was to accurately represent that almost everyday the same flights arrive and depart the airport and simplify the assignment of gates to each aircraft.
7. **Resources**: It was assumed there are two sets of resources, including the cleaners, caterers, staff and flight crew required for the processes available at each terminal, domestic and international. The capacity was determined to be for the domestic terminal:
   - 50 cleaners
   - 20 caterers
   - 10 staff members
   - 10 flight crews
   - 10 baggage handlers

   For the international terminal:

   - 20 cleaners
   - 10 caterers
   - 10 staff members
   - 10 flight crews
   - 20 baggage handlers
8. **Transporters:** The number of transporters included at each concourse was also determined by half of the gates present at each concourse.

   At concourse T: 11 tow-tractors and 11 bag trucks.

   At concourse A, 13 tow-tractors and bag trucks.

   At concourse B, 16 tow-tractors and bag trucks.

   At concourse C, 17 tow-tractors and bag trucks.

   At concourse D, 20 tow-tractors and bag trucks.

At concourse E, 14 tow-tractors and bag trucks.

At concourse F, 6 tow-tractors and bag trucks.

3. Data Gathering

- **Fueling:** The fueling time was calculated using the formula Time=Fuel Capacity/Fuel Flow Rate.

  As previously said we found what is the half capacity of the A320 and Boeing 777 and the respective fuel flow rate. We found that the data was distributed uniformly between 10 and 15 for domestic flights and UNIF(20,30) for international flights.

- **Catering:** Unloading the catering truck was found to be uniformly distributed between 10 and 30 minutes for the A320 and 20 to 45 for the Boeing 777. Loading the kitchen was found to be UNIF(15,30) for domestic and UNIF(20,45) for international flights. [1]

- **Cleaning:** Cleaning time was found to be uniformly distributed between 15 and 25 minutes for the A320 and 20 to 40 for the Boeing 777.[2]

- **Visual check:** Maintenance check was found to be uniformly distributed between 15 and 30 minutes for the A320 and 20 to 35 for the Boeing 777.[3][4]

- **Baggage handling process:** We chose that each bag would take around 10 seconds to load by the domestic and international baggage controllers. One controller is needed in the domestic and 2 controllers in the international baggage handling process. Therefore, after calculations it was found to be UNIF(20,25) minutes.

4. Arena Model

a. Variable Table

To begin the simulation of the ground operations at Atlanta Airport, detailed information regarding the flight schedules needed to be entered in Arena and used when needed. To do so, a variable table was created consisting of 7 columns and 455 rows for the total number of flights included. The first column represents the departure time of the aircraft from Atlanta airport with their arrival times at the airport included in the second column. The third column was not used in the model, the fourth one represents whether or not the flight was domestic or international with regard to its destination. The next column contains information regarding the capacity of the aircraft, which depends on whether or not it is a domestic or an international flight, with respective values of 160 and 400 representing the average number of passengers that can board these aircrafts. Afterwards, the flight number is assigned in the 6th column and the last column includes the gate number each flight is assigned to, which is used in the beginning of the model to guide the plane to its respective gate.

b. Gates

There are a total of 192 gates in the Atlanta airport which are divided depending on concourses and if the flight is domestic or international. In our Arena model, we created a station for each concourse with the gates in the station as station sets, each concourse has the right number of gates named with the letter of the concourse followed by the number of the gates, for example, if it is the gate number 10 in the concourse C, the station set is going to be called C10. As for the actual gates, they don't usually follow each other number wise, we can go in a concourse from gate 3 to 5 for example, we didn't model it this way in Arena we considered that the gates are successive for example, if the concourse T has 10 gates we are going to have gates number from 1,2,3 to 10 successively, this doesn't affect our model negatively it is just easier to model. Now as for the data, we followed exactly the number of gates in each concourse that we had to add manually as a station in the station sets, for the concourse T: 21 gates, A: 29 gates, B: 32 gates, C: 34 gates, D: 40 gates, E: 28 gates and F: 12 gates. Concourses are split between International flights and Domestic flights. In our simulation, domestic gates are separated from international gates, which is the physical situation of the airport; both terminals are far from each other. We separated the gates with the help of the decide block that has a condition on the flight type, domestic or international,

then another decide block for each splitting the gates, 1 to 152 for domestic flights and 153 to 191 for the international flights, the condition is checking the gate number of the flight which is an attribute, then routing the flights to the correct routes. Now that the flights are in their correct terminals, they are directed to the gates after the second decision block, they follow the proper routes taking them from the terminals to the correct gates, for example from the domestic arrival station to gate T15, which is already in our station set in the concourse T mentioned earlier. For the false condition of the decide blocks, the false of the domestic flights are disposed of because there isn't a gate number for the flights meaning that it wasn't assigned or that it isn't an actual flight but for the international flights, the false goes to either the last gate which is F12 or is disposed. After the concourse station, the flight goes through many processes with their actual processing times and resources needed as mentioned earlier in the data gathering.

c. Domestic Concourses

In total, there are 7 concourses in the airport with each one of them having a number of gates, the domestic concourses are the first 5 stations which are T,A,B,C & D having a total of 156 assigned gates which is the largest types of flights in the Atlanta airport, going from Atlanta to another state. For the Arena model, as mentioned there is a station for each of these concourses in this case, the first 5 are for the domestic flights with their gates in the station sets. As assumed, there are 160 passengers in a flight, either domestic or international, but the time of leaving an aircraft varies; it is 15 min for a domestic flight and 25 min for an international flight both in their respective delay blocks. The processes are cleaning, catering, fueling, and the visual checks with their processes time in the data gathering. Once the plane goes through all these processes, it needs to wait for its departure time, and when there are no other aircraft in the queue, it is towed to the runway using a tow tractor. Simultaneously there is the baggage handling happening with the processes, they are batched with the same number as the passengers and transported to the airport bag station while using a bag truck that is then freed and disposed of.

d. International Concourses

Then for the international concourses, we only have two concourses, E and F, with 40 gates going from E1 to F12, the last gate of the airport. The Arena simulation is similar for both international and domestic concourses except for the leaving time of the aircraft and the

number of passengers in the aircraft, which is assumed to be 400. Both of these terminals go through the same processes mentioned before with their allocated time and resources, they have different processes, time, and resources shown in the data gathering. The Atlanta airport is mainly a hub for domestic flights, so most of the work is done in the domestic concourses. The international concourses have the same baggage handling system in our simulation and the same towing to the respective runway, the runway station for domestic, and the runway 1 station for international.

e. Runway

Once the required operations are done and the plane is ready for takeoff, a delay was added to consider the flight crew and the passengers boarding the plane and getting ready for takeoff. When the time now (TNOW) is less than 20 minutes before the flight's departure time, a tow-tractor is requested to help guide the plane until the domestic or international runway, depending on the aircraft type and the tow-tractor is freed upon arrival. Once the aircraft arrives at its respective runway, it begins takeoff when TNOW is equal to the flight's departure time.

f. Replication Parameters

Before running the model, replication parameters were set as 30 for the number of replications to ensure randomness is generated for each replication to make our model is more realistic, each replication is 5 days and each day is 24 hours.

5. Alternative

When analyzing the results of this simulation, it was noticed that the number in queue for cleaners was high as well as the average time spent in the queue which was also the case for other processes. For the scope of this project, to properly evaluate an alternative, we decided to focus on the cleaners for concourse D since it has the largest amount of gates which is 40. We decided to increase the number of cleaners to 70 in our alternative and compared both scenarios in the next section using an output analyzer.

6. Output Analyzer

After generating the statistics from both files and using them as inputs in Output Analyzer, we compared both alternatives by using confidence intervals on their means. After applying the necessary procedure, the following figure was obtained:

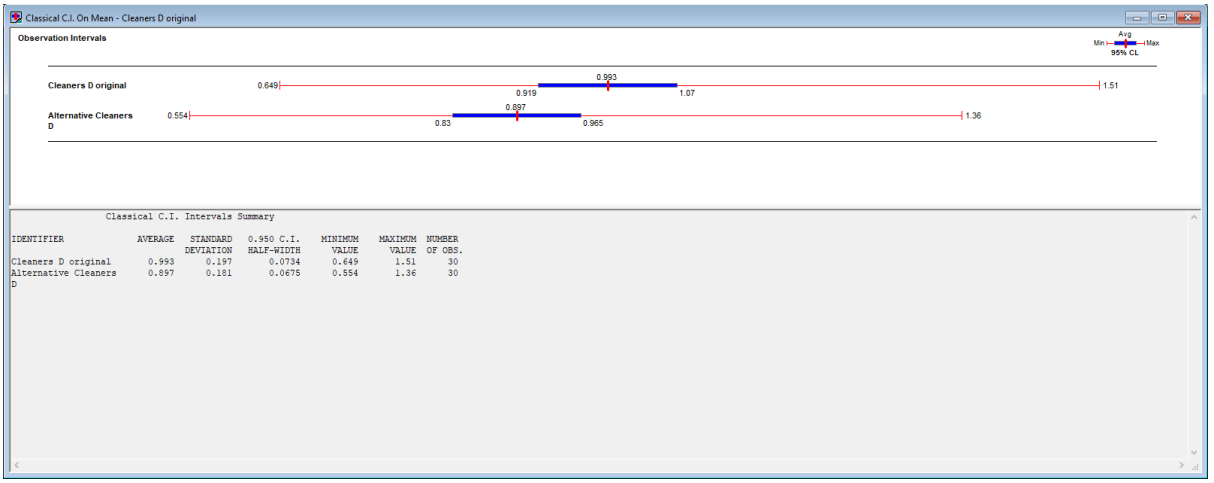

Figure 1: Output Analyzer results

As we can see in the figure above, the average waiting time in the original scenario was 0.993 hours with a confidence interval of 0.919 and 1.07 hours. After increasing the number of resources for cleaners, the average waiting time decreased to 0.897 hours with a confidence interval between 0.83 and 0.965 which shows the model improved.

7. Conclusion

In conclusion, as the objective of this project was to minimize flight delays and maximize resource utilization we can see from the alternative that increasing the number of resources such as the cleaners decreased the average waiting time in queue for that process which is a positive outcome and should be considered when trying to improve this model. To go further, we could have analyzed the increase of resources for the different concourses as well as the transporters which is outside the scope of this project but would guarantee that the entire operations are taken into consideration and improved as much as possible.

8. References

[1] On Time Aircraft Catering Delivery: Mastering the Art and Science of Flight Ready Food. Aviation Pros. Accessed: Dec. 14, 2024. [Online]. Available: https://www.aviationpros.com/ground-handling/press-release/53095492/on-time-aircraft-catering-delivery-mastering-the-art-and-science-of-flight-ready-food

[2]"Tips for Turnaround Cleans," Aviation Pros. Accessed: Dec. 14, 2024. [Online]. Available: https://www.aviationpros.com/ground-handling/ground-handlers-service-providers/article/21294178/tips-for-turnaround-cleans

[3] "ATL Fact Sheet," Hartsfield-Jackson Atlanta International Airport. Accessed: Dec. 14, 2024. [Online]. Available: https://www.atl.com/about-atl/atl-factsheet/

[4] A. Gutzwiller, "A Complete Guide to Atlanta's Hartsfield-Jackson International Airport (KATL)," Infinite Flight Community. Accessed: Dec. 14, 2024. [Online]. Available: https://community.infiniteflight.com/t/a-complete-guide-to-atlantas-hartsfield-jackson-international-airport-katl/829779