2022 IM^{2}C
Aboard! Boarding and Disembarking a Plane

Background

In air transportation, efficiency is time and time is money. Even small delays in the schedules of passenger airplanes result in lost time for both air carriers and their passengers. During any passenger flight, there are two time-consuming operations that depend mostly on human behavior: boarding and **disembarking** the aircraft.

In commercial passenger air travel, airlines use various boarding and disembarking methods from completely unstructured (passengers board or leave the plane without guidance) to structured (passengers board or leave the plane using a prescribed method). Prescribed methods may be based on row numbers, seat positions, or priority groups. In practice, however, even when the prescribed method is announced, not all passengers follow the instructions.

The boarding process includes the movement of passengers from the entrance of the aircraft to their assigned seats. This movement can be hindered by aisle and seat interference. For example, many passengers have **carry-on bags** which they stow into the **overhead bins** before taking their seats. Each time a passenger stops to stow a bag, the queue of other passengers stops because narrow aircraft aisles allow only one passenger to pass at a time. Another hindrance is that some seats (e.g., window seats) are unreachable if other seats (e.g., aisle seats) are already occupied. When this occurs, some passengers must stand up and move into the aisle so other passengers can reach their seats.

The disembarking process is the opposite of boarding with its own possible hindrances to passenger movement. Some passengers are simply slow getting out of their seat and row, or slow moving to the exit. Passengers also block the aisle while collecting their belongings from either their seat or from the overhead bin forcing passengers behind them in the aircraft to wait.

Requirements

Your team is to create plane boarding and disembarking methods that will be the most time-effective in real practice.

1. Construct a mathematical model or models to calculate total aircraft boarding and disembarking times. Ensure your model is adaptable to various prescribed boarding/disembarking methods and varying numbers of carry-on bags to be stowed, as well as accounts for passengers who do not follow the prescribed boarding/disembarking methods.

2. Apply your model to the standard "narrow-body" aircraft shown in **Figure 1**.

a. Compare the average, practical maximum (95th percentile) and practical minimum (5th percentile) boarding times for the following widely used boarding methods:

- Random (unstructured) boarding.
- Boarding by Section: Examine varying the order of aft section (rows 23-33), middle section (rows 12-22), and bow section (rows 1-11).
- Boarding by Seat: In the order of window seats (A and F), middle seats (B and E), and aisle seats (C and D).

b. Analyze how these times vary based on the percentage of passengers not following the prescribed boarding method and on the average number of carry-on bags per flight (i.e., perform a basic sensitivity analysis). Based on your analysis, which of the above boarding methods is the best?

c. Consider the situation when passengers carry more luggage than normal and stow all their carry-ons in the overhead bins. How does this change affect the results?

d. Describe two additional possible boarding methods. Explain and justify your recommended optimal boarding method (from your two and the three in part 2.a.).

e. Explain and justify your optimal disembarking method.

3. Modify your model for the following passenger aircraft and recommend your optimal boarding and disembarking methods for each aircraft.

- The Flying Wing aircraft with relatively wide and short passenger cabins as shown in **Figure 2**.
- A Two-Entrance, Two-Aisle aircraft as shown in **Figure 3**.

4. Due to the pandemic situation, capacity limitations are sometimes implemented on passenger airliners. Will your recommended prescribed methods for boarding and disembarking of the three aircraft change if the number of passengers is limited to 70%, 50%, or 30% of the number of seats?

5. Write a one-page letter to an airline executive describing and explaining your results, recommendations, and rationale about passenger aircraft boarding and disembarking in a non-mathematical way.

Note that IM^{2}C is aware of available resources and references that address and discuss this question. It is not sufficient to simply re-present any of these models or discussions, even if properly cited. Any successful paper MUST include development and analysis of your own team's model and a clear explanation of the difference between your model and any referenced aircraft boarding and disembarking models.

Your PDF submission should consist of:

- One-page Summary Sheet.
- Table of Contents.
- One-page letter to an airline executive.
- Your solution of no more than 20 pages (A4 or letter size), for a maximum of 23 pages with your summary, table of contents, and letter. Note that your font size must be no smaller than 12-point type.

Note: Reference List and any appendices do not count toward the page limit and should appear after your completed solution. You should not make use of unauthorized images and materials whose use is restricted by copyright laws. Ensure you cite the sources for your ideas and the materials used in your report.

Glossary

Carry-On Bag – a piece of luggage a passenger carries onto an airplane with dimensions such that it can fit in the overhead bin.

Disembarking – leaving (an airplane).

Overhead Bins – storage compartments attached to the ceilings of aircraft for baggage stowage during a flight.

Airline Figures

Figure 1. “Narrow-Body” Passenger Aircraft

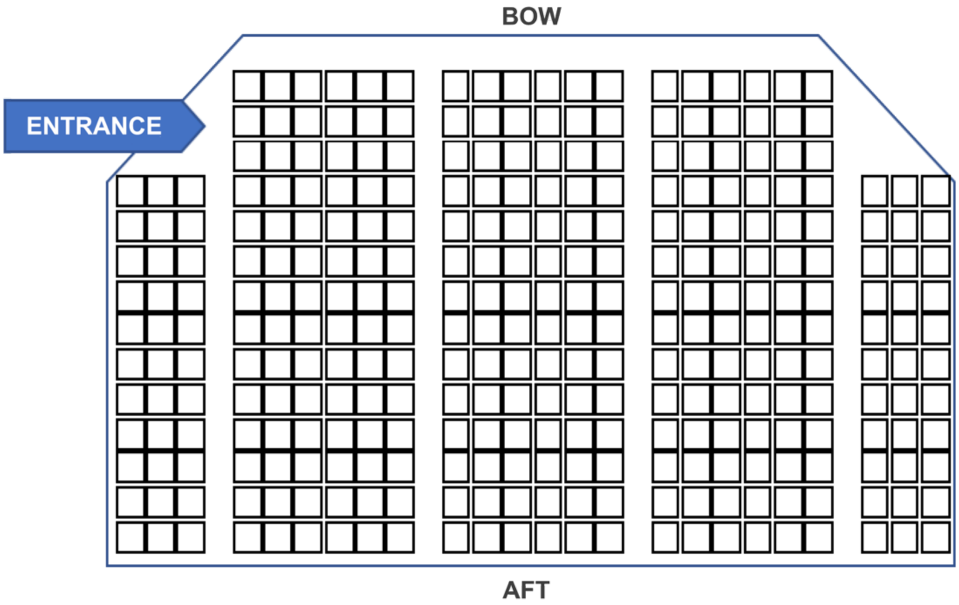

Figure 2. “Flying Wing” Passenger Aircraft

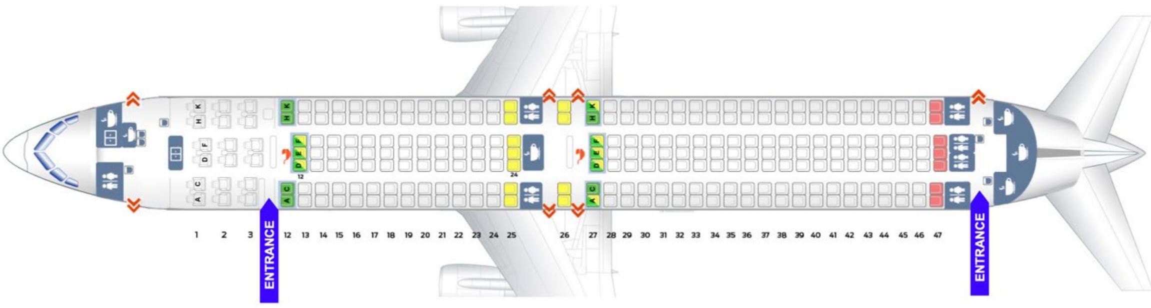

Figure 3. “Two-Entrance, Two Aisle” Passenger Aircraft