

# AIRPLANE BOARDING STRATEGIES FOR REDUCING TURNAROUND TIME

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## ABSTRACT

The need to simultaneously increase efficiency, profitability and customer satisfaction puts airline industry under pressure. The turnaround time of an airplane is crucial for utilization of an airplane since airlines obtain revenue when the airplane is in the air. Airlines make every effort to minimize the time their flight is grounded. While the boarding process is only one component of the turnaround time event set, it is on its critical path. The substantial reduction of the boarding time can reduce turnaround time in most cases. Adopting fast and easy boarding strategy can benefit the airlines, but also airport operators and passengers. It increases utilization of the ground equipment and the level of service at the airports departure hall. Inefficient boarding processes effect the passenger`s perception of quality of service. The purpose of the paper is to identify the various strategies in boarding of passengers onto an airplane which can reduce the turnaround time.

### Keywords:

Airplane boarding, boarding strategies, airplane turnaround time

## 1 INTRODUCTION

The airline industry is highly capital intensive, and its profitability is highly influenced by fuel efficiency and airplane utilization. Considering the fact that airlines obtain revenue only when the airplane is in the air, the common goal of all airlines is to minimize the time that the airplane spends on the ground. However, the minimization of airplanes' time on the ground must not compromise or in any way diminish safety in airline industry. Airplanes' time on the ground is usually referred to as turnaround time. By definition it is a time required to unload an airplane after its arrival at gate and to prepare it for departure again [1].

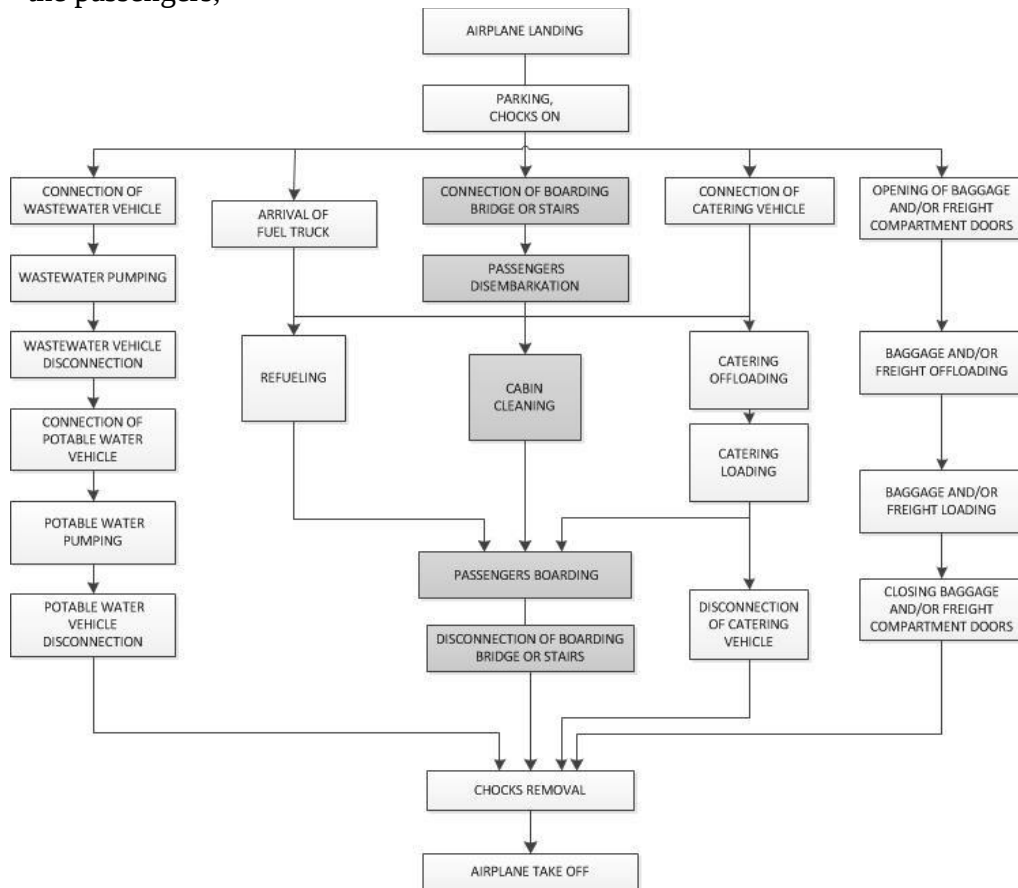
Optimizing airplane utilization, amongst others, includes efficient, i.e. shorter, airplanes' turnaround time. There are two basic turnaround models: full turnaround model and short turnaround model [2]. In a full turnaround model several different

operations are performed during turnaround time, and most of them are performed at once. However, there are operations, such as passengers boarding, which cannot be performed simultaneously with other operations, such as refueling, cabin cleaning and catering (off) loading, either for safety reasons, or for passengers' satisfaction. In a short turnaround model some operations are not performed, such as cabin cleaning and catering loading, which provides the boarding process to start sooner than performing the full turnaround model. Additionally, special procedures can be applied for the refueling process, so it can be performed along with passenger boarding. These procedures involve assistance from a fire brigade and presence of a fire truck while refueling, for safety

reasons<sup>1</sup>. The full turnaround model consists of several different operations (in accordance with the requirements of the flight), shown in Figure 1, and can (broadly) be divided into groups:

- disembarkation and boarding of the passengers,

- refueling the airplane,
- cabin servicing,
- catering servicing,
- toilet and potable water servicing.



Source: Adapted from [6]

**Figure 1: Airplane full turnaround model scheme**

All operations which influence the duration of turnaround time are determined as critical [3]. Therefore, passenger boarding, as seen in Figure 1, is on a, so called, critical path [4] of a turnaround since it significantly influences the course of other operations. Even though the boarding is only one of the operations in a turnaround event set, it is much easily adaptive and

modifiable than some other operations. In the last 20 years numerous boarding strategies were proposed to optimize airplane utilization and shorten turnaround time. This paper identifies proposed boarding strategies and evaluates their advantages and disadvantages.

<sup>1</sup> Low cost carriers usually use these procedures at their en route stations to shorten their turnaround time.

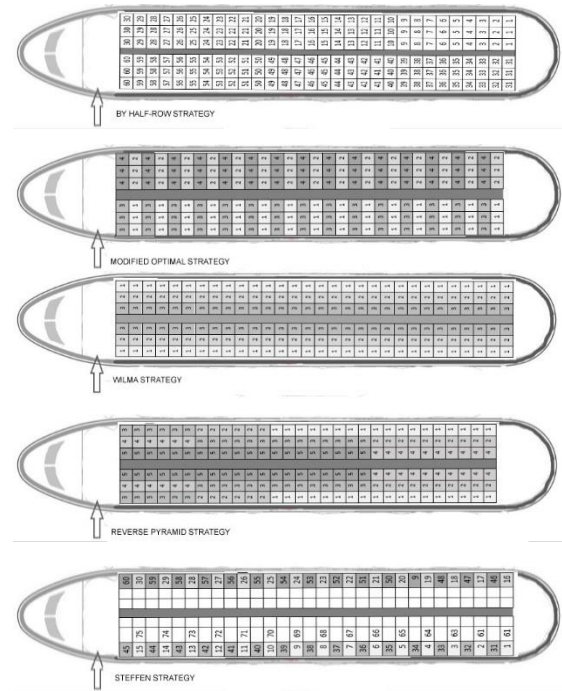
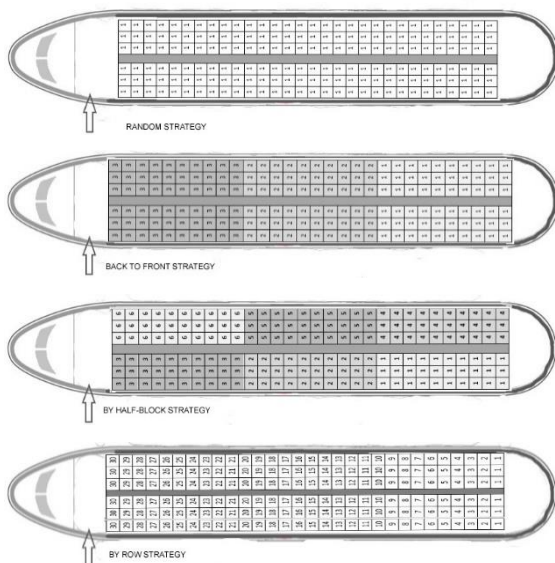
## 2 BOARDING STRATEGIES

The boarding process consists of a simple set of rules for the passenger movement [5]:

- entrance in the airplane at the assigned door,
- move forward along the aisle until reaching the assigned seat row,
- store the carry on in the overhead compartment (while the aisle is blocked for other passengers) and take the seat.

This, at first a simple process, can be complicated if added more variables, such as more points of entrance (front, back, and in some cases, if an airplane configuration permits, a middle entrance), more aisles in a cabin, restrictions (or a lack of it) on number of carry-ons, etc. There is also a possibility of open seating, without prior seat assignment, which will not be considered in the following strategies.

To illustrate various boarding strategies, all of them were reviewed on a model of a narrow body airplane with a single aisle layout (Figure 2). The aisle divides 30 rows into 3 seats on the left and 3 seats on the right side. There are no first class and business seats, since most of the airlines that provide such a service, board these passenger classes first, nevertheless the strategy they are applying. The same goes for passengers with reduced mobility.



Source: Adapted from [2]

**Figure 2: Various boarding strategies schematic illustrations**

The first, and most broadly applied boarding strategy is a *random* strategy. There are no conditions given to the passengers before boarding. They are not divided into groups, or assigned with any particular order of entering in an airplane. There is only one zone in an airplane, and passengers are boarded in a First-Come First-Serve principle.

In other strategies passengers' movements from gate to their seat are somewhat pre-managed. The theoretical assumption of those strategies is to develop a sequence in which passengers are boarding without interfering one another [2]. The objective of proposed strategies is to reduce the boarding time by reducing the number of times passengers wait for or come across each other inside a cabin, whether in the aisle (an aisle interference) or within a given row (a seat interference).

One of the widely used strategies is a *back to front* strategy (also referred to *by block*). It requires a division of passengers into groups. Boarding begins at the back of the airplane and works its way forward. Quite

similar strategy is *by half-block*. This strategy proposes that opposite sides (right vs. left) of cabin has different boarding sequence. The *by row* strategy, as well as *by half-row*, groups passengers according to the row their assigned seat is in. This strategies also apply back to front principle, i. e. back rows board first, front rows board last. A combination of *by half-row* and of *by half-block* is a strategy called *modified optimal*. Passengers are divided into (usually) four groups and boarded sequentially at predetermined order.

Mentioned strategies are based on a premise that passengers are grouped by row or by block. Some authors [6, 7] refer to these as traditional strategies. According to that non-traditional approaches group passengers by seat or seatgroup. There are two basic strategies that group passengers by their seat group. *WilMA* strategy, or *outside in* strategy, propose boarding of window seat passengers first, following with middle seats, and finally aisle seats (acronym *WilMA* comes from: window, middle, aisle order). The *reverse pyramid* strategy is somewhat of a hybrid between traditional and non-traditional boarding strategies. Designed by [8] the *reverse pyramid* strategy is an attempt to board diagonally so that a boarding group consists of passengers who are actually boarding a few seats in the front of the airplane, while other passengers within the same group are boarding in the middle of the airplane [6].

Finally there is an approach solely by seat, in which there are as many divisions as there are blocked seats. Each passenger is given a number of airplane entrance sequence by which he/she enters the airplane. This is commonly known as *Steffen* method, and has its modification *Steffen-lug* method. The *Steffen* boarding strategy was proposed by Jason H. Steffen [9] using a Markov Chain Monte Carlo optimization algorithm. Sequence numbers are assigned in such a manner that two adjoining numbers are divided with exactly one row (for example: 30A, 28A, 26A...).

The *Steffen-lug* boarding strategy considers basic principle of the *Steffen* method, but it assigns passengers to seats so that their carry-on luggage is spread roughly evenly throughout the airplane [7, 10]. This strategy requires a prior knowledge on number of carry-ons'.

Proposed boarding strategies only address the management of the passengers' behavior by generating boarding sequences or reducing the amount of carry-ons, but with implementation of the innovative technology such as Side-Slip Seat [5], the cabins layout can be dynamically changed providing a wider aisle. This concept provides passengers to pass each other without aisle interference. This concept, applied with a specifically proposed *left right random* strategy could provide a low level of complexity and a more stable boarding process.

### 3 STUDIES ON THE IMPLEMENTATION OF BOARDING STRATEGIES

As priory stated, the proposed boarding strategies are only simplified principles and can be modified in numerous ways by adding more variables (classes, more entrance points, multiple aisles, etc.) but provide a basic overview on boarding strategies which are a subject matter of numerous studies carried out in the last two decades.

The very first study of boarding strategies was a study carried out by Marelli, Mattocks and Merry for Boeing [1], and is referred to as Boeing study. Self-developed computer simulation call PEDS was used along with the empirical test to validate the simulation. A comparison was made between a traditional boarding strategy (not specified which one) and an *outside in* strategy with following results: the use of *outside in* strategy can reduce boarding time for 46% while the use of both doors as an entrance point can reduce it for 20% (compared to traditional boarding strategy using only one door as an entrance point).

Van Landeghem and Beuselinck [11] from Ghent University, carried out a computer simulation study of different boarding strategies (*random*, *back to front*, *by half-block*, *by row*, *by half row*, *WilMA* and *by seat*). Simulation has shown that the choice of boarding strategies highly influences the boarding time, both in total and individually per passenger. The *by seat* approach reduce total boarding time with 100% or more versus *random* strategy.

At the request of America West Airlines, Van den Briel et al. [8] conducted a study in pursuit of finding an optimal boarding strategy. A computer simulation tested boarding times for two commonly known strategies: *back to front* and *WilMA*, and a new strategy was proposed: *reverse pyramid*. The results of the study were that when a *reverse pyramid* strategy is applied boarding time can be reduced for 26% compared to *back to front* strategy. They also simulated the situation of implementing a second agent to the gate. The simulation resulted with reduction of 39%.

In 2008, Nyquist and McFadden [6] calculated potential cost savings on account of boarding time reduction. According to Nyquist and McFadden an airline accrues a cost of approximately US\$30 per minute on ground. They've concluded that applying non-traditional strategies like *outside in* or *reverse pyramid* over traditional strategies could save 35% annually. If airlines would consider implementing non-traditional strategy combined with two doors concept and reduce the number of carry-ons on one per passenger, the cost savings would be 66% annually over the traditional strategy. They did not consider any *by seat* strategies while conducting their study.

In his paper, Steffen [9] ran a simulation on *random*, *back to front*, *front to back*, *WilMA*, *modified optimal* and *by seat*, i.e. *Steffen method* strategies. His simulations showed that the worst case scenario is when *front to back* strategy is used, followed with the *back to front* strategy. He compared

every other simulation to the worst case scenario, *front to back*, which is a strategy that is purely hypothetical and not even intuitively applied in practice. The results were therefore harder to compare with other studies, but provide an illustration of every simulated strategy. *WilMA* strategy reduced the boarding time for 57% compared to the worst case, and *Steffen method* strategy reduced it for up to 80% compared to worst case (i.e. half of the time needed for non-traditional strategies).

Steiner and Philipp [4] developed Airplane Boarding Simulator (ABS) which was used to simulate different scenarios by varying different factors: number of carry-ons, pre-boarding area, used boarding strategy and procedures at the gate. They've studied *random* and *back to front* strategy, and concluded that the *random* strategy outperforms the *back to front* strategy, and if there is a 15% to 5% reduction in number of carry-ons boarding time can be reduced by two to four minutes. Having that in mind they also concluded that both of proposed actions influence customer satisfaction, as they either restrict their freedom of choice (reduced number of carry-ons) or increase the number of aisle or seat interferences in an airplane (for *random* strategy).

Steffen and Hotchkiss [12] conducted an empirical experiment of different boarding strategies in a mock Boeing 757 airplane layout. They have compared *back to front*, *WilMA*, *Steffen* and *random* strategy. Their test supported the premise that the boarding time for strategies that parallelize the boarding process by utilizing the aisle more effectively (more passengers stow their carry-ons' simultaneously) is shorter from those that do not. They have concluded that the best strategy is the *Steffen method*, but also stated that even in the controlled environment of their experiment there were some practical hindrances during the implementation (such as boarding of passengers with small children).

A simulation study by Mas et al. [13] focused on *back to front*, *WilMA*, *block* and

*random* strategy. Their computer based simulation only confirmed that the most common boarding method, *back to front*, is not the most efficient one. Their results helped to quantify how the time difference among boarding strategies increases as the occupancy level raises.

Kierzkowski [2, 14] presented advantages and disadvantages of currently proposed boarding strategies. Their study covered the duration of activities during passenger boarding and the occurrence of seat and aisle interferences. They recommend passenger boarding strategies which divide them according to rows, not columns. They justify this proposal with the fact that passenger groups book their seats in the same row (parents with children, passengers with reduced mobility with their accompanied person, etc.) and is practically impossible to separate them at the terminal. This claim is in consistence with the conclusions of the empirical experiment conducted by Steffen and Hotchkiss [12].

In [2] authors provided a ranking of methods according to the average time of boarding shown in the Table 1.

**Table 1: Boarding strategy ranking according to the average time of boarding**

| Rank | Strategy         |
|------|------------------|
| 1    | Steffen method   |
| 2    | WilMA            |
| 3    | Reverse pyramid  |
| 4    | By half block    |
| 5    | Back to front    |
| 6    | By half row      |
| 7    | By row           |
| 8    | Random           |
| 9    | Modified optimal |

Source: [2]

#### 4 CONCLUSION

Considering all the proposed methods there are considerable amount of pros and cons for each strategy. It is quite obvious that if only considering a financial impact the proposed *Steffen method* strategy and its modifications, can reduce boarding time significantly and consequently save the loss

of an airlines' revenue. However, even the author admits that there are some obstacles in the use of *by seat* strategies. They are commonly considered complicated and passenger-unfriendly. Even though the purpose of boarding strategy implementation is to reduce the boarding time, and consequentially the turnaround time, it is not at the expense of passengers' satisfaction. It is inevitable to evaluate boarding strategies in terms of passengers' satisfaction, since none of the mentioned studies have fully dedicated their research to that aspect. With detailed empirical data considering passengers' preferences more detailed analysis is possible on which strategy is more applicable for the concrete airline. Considering the vast implementation of modern technologies in the check-in process, possible implementation of the same technologies should be reviewed in the boarding process, which is a proposition for further research.

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