# ALOHA

## Aircraft Design for Low-Cost Ground Handling

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» Low-cost airlines (LCA) have been particularly successful with the reduction of ground handling costs. Well-known examples of LCA are Southwest Airlines, Ryanair, easyJet, Air Berlin, and Germanwings. Ryanair was the first European LCA and was established in 1985. LCA fly short- and medium-range aircraft, in particular the Boeing B737 and the Airbus A320. The B737 was developed in the 1960s, the A320 in the 1980s. This explains why the requirements of low-cost airlines regarding ground handling operations were not considered in the design of the B737 and A320. The manufacturers have already announced successors to the B737 and A320. For the first time in history, the requirements of LCA can be taken into account when designing new aircraft. This article identifies the differences between common and LCA-specific ground handling operations in order to address the requirements of an aircraft optimised for low-cost ground handling.

The well-positioned low-cost airline Ryanair has sustained a growth rate of 27 % in carried passengers per year. In comparison, the growth rate of conventional passenger air traffic amounts to up to 5 % per year. Thus, LCA are an increasingly interesting market segment, and recently they have become especially interesting to aircraft manufacturers and airports (compare [1], p. 15, 29 f.). Airbus with its A320 family and Boeing with its B737 family consider their short- to medium-range aircraft to be the best-selling jet airliner family. Successors to the A320 and the B737 [2] are expected to follow up as "cash cows" in the aircraft manufacturers' product portfolios. It is therefore especially important to consider and to adapt to potential customer needs already in the conceptual design phase. As a result, LCA will have a keen influence on the overall concept of the single-aisle successor aircraft.

Ground handling comprises the many services to an aircraft between the time it arrives at a terminal gate and the time it departs from the gate for its next flight. Speed, efficiency, and accuracy are important in ground handling operations in order to minimise turnaround times and ground handling costs. Basically, ground handling activities are highly dependent on the airlines' favoured business model and strategy. In contrast to traditional airlines, LCA use optimised and simpler ground handling operations in combination with more favourable conditions to be found at secondary airports. This leads to reduced turnaround times, a more efficient use of the aircraft fleet, and therefore to an increase in passenger miles. By means of innovative ground handling procedures together with the outsourcing of servicing jobs, LCA are able to save up to 70% of their ground handling costs over established airlines ([3], p. 33). In fact, ground handling should be considered one of the key factors of LCA business models. Ground handling operations can be classified into different, mostly independent ground handling tasks (compare Figure 1) to be carried out in a specific order. Common ground handling operations may include the following:

Passenger loading bridges or mobile stairs are available for passenger (de-)boarding. Air bridges can only be used at the forward passenger door(s) of an aircraft, which are usually loca-

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ted on the left-hand side (LHS). If the aircraft is parked at a remote apron, ground support equipment (GSE) has to be provided on-site enabling the "displaced" ground handling of the aircraft. In such cases, no passenger loading bridge is available and mobile stairs are used instead. As an alternative to mobile stairs, so-called air stairs might be used if available on the aircraft. On some single-aisle aircraft types, such as the A320 and the B737, aircraft manufactures offer customers the option to integrate such an air stair into the aircraft. When stairs are used, airport buses might also be necessary if the distance from the remote apron to the terminal is so long that passengers would (besides walking) have to cross taxiways or other highly secure areas of the airport.

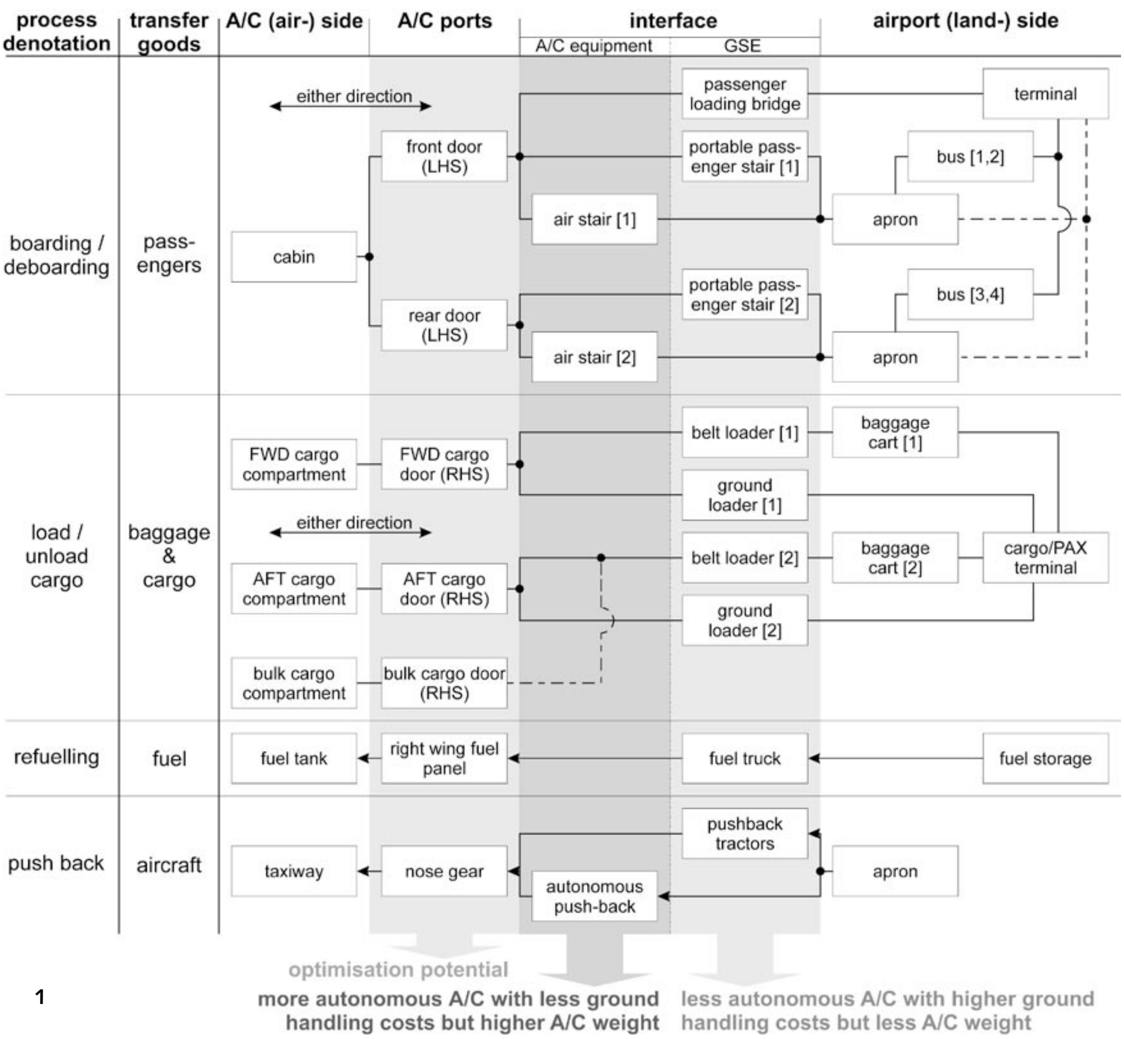
The loading/unloading of cargo and baggage takes place simultaneously with and independently of the passenger de-boarding process. If the passenger baggage is below a certain amount, the use of cargo containers becomes inefficient and the bulk cargo is stored unpackaged. Ground support is provided by belt loaders which assist in loading or unloading loose baggage that is carried to the aircraft with the help of baggage carts. The baggage carts additionally require a tow tractor. Likewise, tow tractors can be used to carry any equipment that cannot move by itself, such as mobile air conditioning units, air starters, lavatory carts, and other equipment that is not always, or only under abnormal circumstances, necessary for a turnaround process (e.g. if the auxiliary power unit fails). If it becomes more appropriate to store baggage and cargo in containers or pallets, ground loaders are required in order to load the aircraft at sill height. In this case, a belt loader might be additionally necessary for the bulk cargo compartment. This is because a small percentage of the baggage always remains as bulk cargo, such as foldable baby carriages, bulky sports equipment, baggage from late check-in passengers, etc.

Once all passengers are off the airplane, the refuelling process might start. Only in certain circumstances is it possible to refuel the airplane while passengers are on board. The dispenser can be either a fuel truck or a hydrant cart. A hydrant cart taps into a central pipeline network and pumps fuel from the airport fuel storage into the aircraft tank. After refuelling, passengers are allowed to board the aircraft. The loading or unloading of baggage and cargo might still be in progress at this time.

With all doors locked, a pushback is performed by pushback tractors. The pushback operation might not be necessary for aircraft parked at the remote apron. However, with new technologies such as an autonomous pushback system, i.e. an electrically driven nose gear, the aircraft becomes independent of parking positions and pushback tractors [6].

In order to understand how LCA manage their ground handling and turnaround process with minimum turnaround times and ground handling costs, a comparison of LCA ground handling with common ground handling procedures has been conducted. The results include the following main differences and characteristics (compare [5]):

If possible, LCA park in front of and parallel to the terminal building. This enables "taxi in and taxi out" and eliminates the need for a pushback



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1 Structuring of the "main" ground handling processes

with a towing truck. To avoid ground handling charges related to air bridges and mobile stairs, passengers are almost always boarded by means of air stairs. In addition, the second air stair at the rear door is deployed to speed up the boarding and de-boarding process. The aircraft park at walking distance to the terminal gate in order to avoid transporting passengers by bus. Onboard passenger services and amenities are reduced. Less food and drinks cause less waste and dirt. Thus, cabin cleaning might not be required at every turnaround. Because of the poor airport infrastructure often found at secondary airports, cargo is rarely transported by LCA, so only baggage has to be loaded. In an ideal case, all baggage will fit into the bulk cargo compartment and only one belt loader will be required for the loading operation.

In most cases, LCA fly short-range routes. However, an aircraft is capable of carrying enough fuel to meet the aircraft-specific design range (according to the reference mission) which is much higher than a typical LCA short-range flight. For this reason, more fuel than necessary can be carried, avoiding aircraft refuelling at every stop-over. This process (referred to as the tankering technique) saves turnaround time and compensates for the additional cost of purchasing fuel at the designated destination airport. However, due to the higher amount of fuel carried, the aircraft weight and therefore the fuel burn increases.

Finally, if less GSE is needed for the turnaround, ground handling costs in terms of ground handling charges can be reduced. Avoiding ground handling operations such as cargo loading, refuelling, and catering further reduces the required manpower and possibly the turnaround time. In addition, any possible delay caused by GSE that is not available during the requested time can be avoided.

LCA achieve utilisations of 4000–4200 h per year. In contrast, conventional airlines focus on business travellers and reach utilisations of only 2500–2700 h per year ([4], p. 39). This high utilisation of LCA can be achieved only in combination with short turnaround times.

Using the example of ground handling processes adapted to LCA requirements, it is apparent that ground handling costs and turnaround times can be reduced by simplifying the ground handling process. This can be achieved by reducing the working time of ground handling staff, reducing the number of required GSE, and optimising individual turnaround processes (**Figure 2**). A reduction in required turnaround equipment can be achieved, in general, by reducing the interfaces between the aircraft and the airport (terminal). This automatically implies that the aircraft has to become more independent of external GSE. As a result, in order to reduce ground handling costs, the aircraft has to become more autonomous by including an autonomous pushback system and onboard air stairs, for example (see above and **Figure 1**).

In conclusion, a direct reduction in turnaround times can be achieved (compare **Figure 2**) by reducing the required manpower (1) and optimising individual turnaround processes (2). A reduction in delays (i.e. an indirect reduction in turnaround times) can be achieved by reducing the number of required GSE (3) and the complexity of the turnaround process (2). A reduction in ground handling costs can be achieved by reducing the number of required GSE (3) and the required manpower (1). A reduction in manpower (1) (such as no ground handling staff required for cargo loading, refuelling, and catering) is primarily dependent on the airline's and airport's business model and strategy and is therefore no longer considered in this context.

Furthermore, the following requirements can be established: A reduction in required GSE (3) implies a more autonomous (independent) aircraft. Optimising and reducing the complexity of the turnaround process (2) involves, on the aircraft side, interfaces that are optimised with respect to ground handling, e.g. door dimensions and the position of aircraft ports as in Figure 1. To achieve this, technologies such as autonomous pushback and onboard air stairs have to be included (3), and adaptations to the aircraft design with respect to ground handling requirements become necessary (2).

Both aspects are interdependent on each other. Technologies for a more autonomous aircraft increase the aircraft weight and have an influence on the overall system aircraft (such as drawbacks in cruise performance and DOC). Likewise, the aircraft must be designed to accommodate the new technology (onboard stairs). Additionally, door dimensions and positions as well as other aircraft design parameters (such as wing position, etc.) have to be considered. However, airlines are interested in looking at a reduction of all cost elements that comprise direct operating costs (DOC), because DOC include not only ground handling costs, but also depreciation, interest, insurance, fuel costs, maintenance costs, crew costs, landing fees, and navigation fees. Improvements to ground handling operations always aim at reducing turnaround times and ground handling costs. Thus, it is important to look closely at whether improvements to ground handling operations also reduce DOC. This has to be done because, in some cases, a reduction in ground handling costs increases the aircraft

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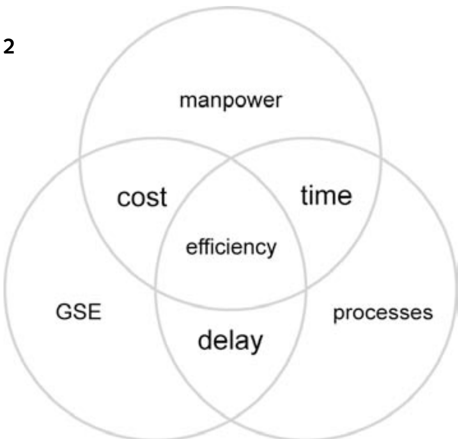
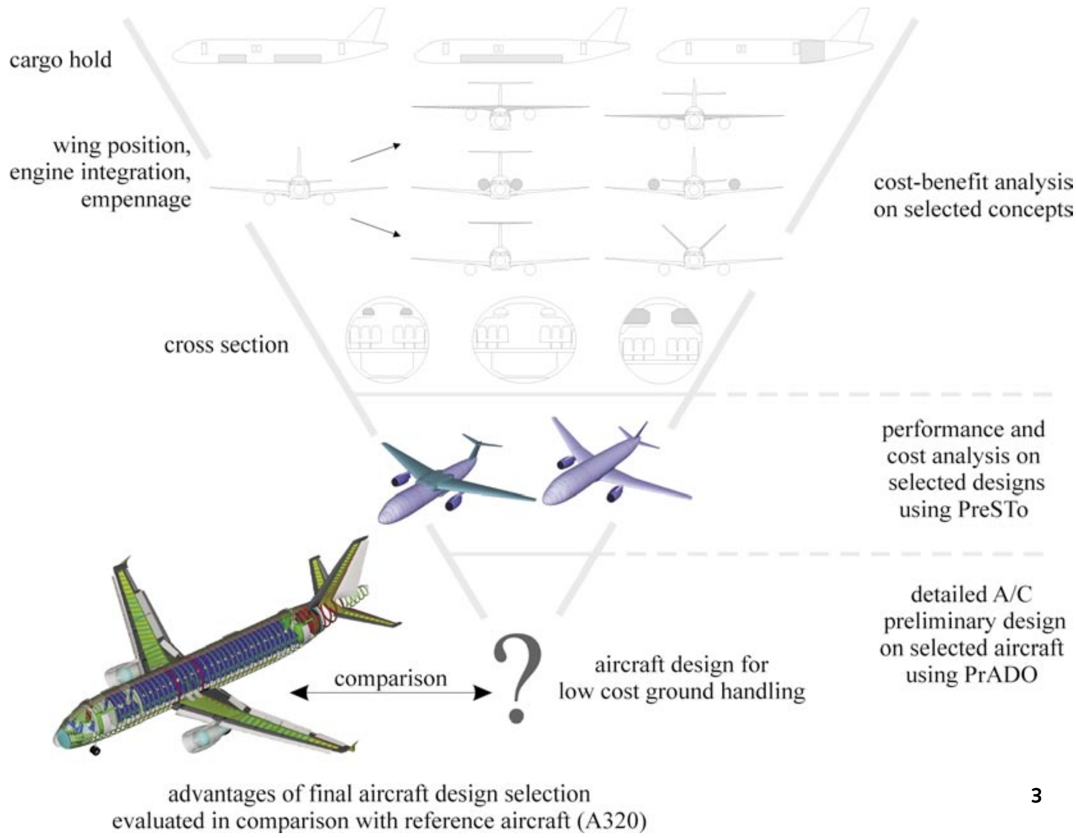



**2** Interactions for optimising ground handling by reducing ground handling costs, time, and delays (numbers as referred to in respective paragraphs) weight and delivery price, which leads to an increase in other DOC cost items like fuel costs and depreciation. Such complex interactions between disciplines can only be handled by means of multidisciplinary design analysis (MDA) and optimisation (MDO). MDO computer programs for aircraft (preliminary) design are capable of simultaneously manipulating variables to optimise the overall system aircraft with respect to a pre-selected target function (in our case, low DOC and ground handling costs) and design constraints. This optimisation and analysis can be performed at an early stage of the aircraft design process.



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3 Approach applied to evaluate an aircraft design for low-cost ground handling

In order to estimate the potential of possible aircraft design modifications to reduce ground handling costs, ground handling operations were analysed by means of video analysis (143 ground handling operations at four different airports in total and by the Airport Research Center), questionnaires, and interviews with experts. Ground handling costs – if possible, as a function of aircraft parameters – can now be derived to judge aircraft designs that feature new technologies and new aircraft configurations. Furthermore, new technologies that have the potential to improve ground handling have been identified:

1. Use of an automatic pushback system and/or air stairs for a more autonomous aircraft.
2. Use of wider doors and aisles, foldable passenger seats, and bigger overhead bins to speed up the boarding and de-boarding process.
3. Use of ramp snakes, power stows or sliding carpet systems for a better and faster process of baggage and/or cargo loading.

In the best-case scenario, using an A320 as example, the reduction of DOC was estimated to be 3.5 % if all the compatible modifications to ground handling operations were taken into account simultaneously (mounting two air stairs, an automatic pushback system, and a sliding carpet). In the final step of the ALOHA joint research project, many aircraft configurations (from brainstorming and morphological analysis) will be evaluated with respect to their potential to reduce ground handling costs and DOC. To do so, a three-step selection process (**Figure 3**) was chosen:

1. Cost-benefit analysis.
2. Selection based on a performance and cost analysis with the Aircraft Preliminary Sizing Tool (PreSTo).
3. Detailed aircraft preliminary design on the selected aircraft configuration using the Preliminary Aircraft Design and Optimization tool (PrADO).

The final aircraft will then be compared with an A320 that was selected as the reference aircraft and was also modelled with PrADO. «

**References:**

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