PASSENGER ACCEPTABILITY ASSESSMENT MODEL

-METHODOLOGY FOR FUTURE CUSTOMER-ORIENTATED AIRCRAFT CABIN DESIGN-

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Abstract

Especially during conceptual and preliminary design phase of a new aircraft, freedom of design has its maximum, whereas these phases are significant for their high degree of uncertainties according to acceptance and impact onto airlines as well as passengers.
This paper presents a methodology for assessing aircraft cabin regarding comfort. This methodology has been derived out of several surveys, real flight tests and bibliography studies.
With this methodology different cabin layouts can be evaluated and assessed. Based on quantitative assessment outputs, decisions regarding comfort issues in future cabin layouts can be made. The major focus of this paper is on passenger acceptance in aircraft cabins operating on long-haul routes because travellers on short-haul journeys tend to be less concerned about the type of aircraft and cabin flown.
In this paper, methodology will presented according to its structure, assessment capabilities (input parameters) as well as assessment results. The methodology based on a compensatory function with geometrical parameters of a cabin (membership functions) and passenger properties (weighting functions) on the other side.
For presenting this methodology, two different aircraft and cabin design are explained and further assessed with this methodology. The first aircraft configuration is a conventional A340-300 cabin, as a typical representative of a long haul aircraft. The second assessed aircraft is a blended wing body aircraft (BWB) as one example of an unconventional aircraft.
Even if the methodology can assess the entire aircraft cabin with its different classes, due to complexity, the structure and output of the assessment approach bases only on the economy class properties of these two configurations.

1. Introduction

To maintain competitive advantage it is vital for new aircraft standing at the beginning of a long life and product cycle to be as attractive as possible for the manufacturer, the airlines and the passengers over a maximum period of time. Moreover to make air transportation service economically feasible, one must understand to design the system to be attractive to the user community – being airlines or passengers.
The purpose of this paper is to present a technique for evaluating the passenger acceptance of an aircraft. This includes the passenger's reaction to the motion, noise, temperature, seating, etc. Although the methodology is not completely limited to the air mode, it is herein applied to assess and to predict the reaction of passengers to both conventional and unconventional aircraft configurations. Latter emphasises that the method is applicable to both existing and future systems and can be used to evaluate, design, and make decisions regarding the interior of passenger aircraft. Especially during preliminary design phase of new products, high uncertainties with a high degree of design freedom mark this phase. The presented

methodology will give more qualitative information about a new aircraft cabins and their effects onto passengers.

Passengers are known to exhibit a preference for particular aircraft types driven by the comfort, well-being and functionality on board the aircraft. Since travellers on short-haul journeys tend to be less concerned about the type of aircraft flown, the major focus of this paper is on passenger acceptance in aircraft operating on long-haul routes.

2. Passenger Acceptability Assessment Methodology

The used technique for the assessment of passenger's acceptability regarding current and future aircraft cabins is based on compensatory functions. These functions assume that each passenger makes his booking decision for a long haul flight based on four drivers. These can be directly assigned to four categories, namely:

- Ticket
- Schedule
- Comfort
- Airline's reputation

As shown in Figure 1, the different importance of each booking decision criterion varies between different travellers in certain classes.

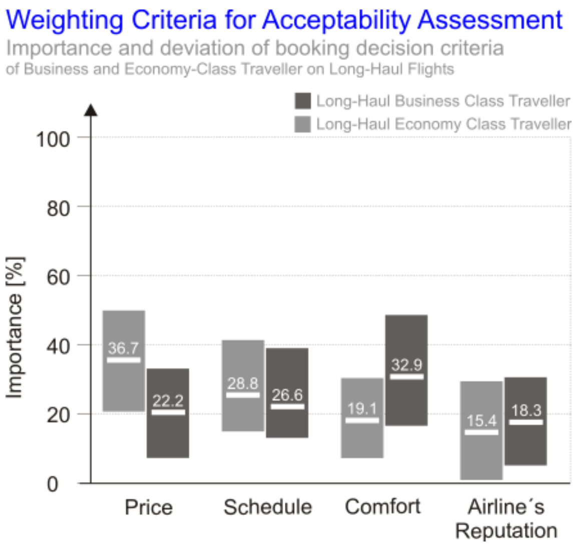

Figure 1 Mean and standard deviation of main booking decision of business and economy class traveller [13]

In this paper, the conducted assessment of future aircraft will only focus on comfort-based criteria, mainly the aircraft cabin.

As shown in equation 2.1, the overall acceptability index $AI_{overall}$ of an aircraft cabin can be calculated as the sum of all individual acceptability indexes AI_i multiplied with the according individual weighting factor Wf_i.

$$AI_{Overall} = \sum_{i=1}^{n} AI_i \cdot Wf_i \qquad 2.1$$

The individual acceptability indexes will be derived out of individual membership functions, as described below. The weighting factors are calculated out of weighting functions regarding different passenger groups.

2.1 Determination of an acceptability index through membership functions

A membership function is a curve that defines how each point in the input space (e.g. seat pitch) is mapped to a membership value (or degree of membership) between 0 and 100 (parameter acceptability index). The input space is sometimes referred to as the universe of discourse.

2.1.1 Deterministic membership functions

Deterministic membership functions are used for measurable, countable and computable evaluation criteria. There are a number of different possible shapes of deterministic membership functions. Figure 2 visualizes a set of possible triangle-like, s-shape, saturating, declining etc. membership functions.

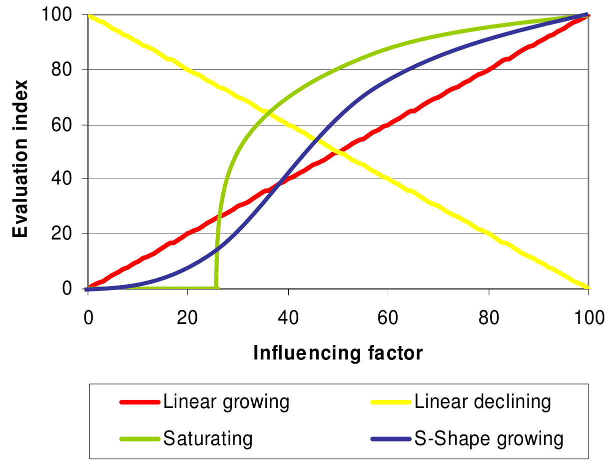

Figure 2 Deterministic membership functions

2.1.2 Probabilistic membership functions

For a probabilistic criterion one may face some statistical data describing this parameter and in order to work with them in the framework of fuzzy sets, it is necessary to convert them into a unique format required by fuzzy set theory. Assume that the relevant statistical data can be represented by their probability (density) functions: Then a relevant probability function can be converted into a membership function which after normalisation of the universe of discourse up to the unit interval can be uniformly treated as a fuzzy set describing the result of evaluation of the parameter (see Figure 3).

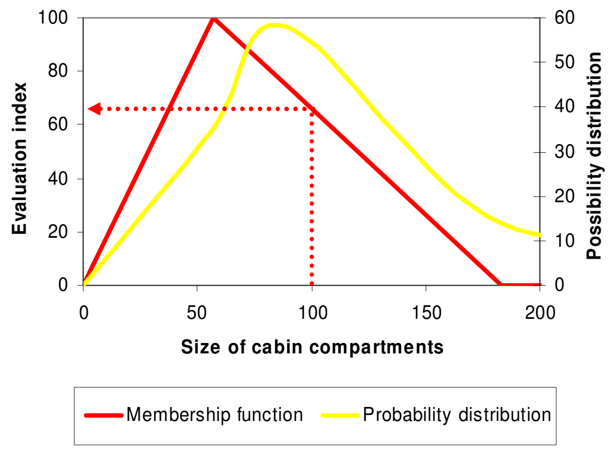

Figure 3 Probabilistic membership functions

Figure 3 exemplifies the conversion of the size of the cabin compartments into an evaluation index for that specific evaluation criterion: assuming a compartment size for 100 passengers the resulting evaluation index is 65.

2.1.3 Modified probabilistic membership function

Modified probabilistic membership functions are used in cases where statistical frequency distribution data is available and the data cannot be transformed into a conventional probabilistic membership function as shown in section 2.1.2. Consequently the evaluation for such kind of criteria is performed using a converted frequency distribution as the evaluation result for that criterion. Figure 4 clarifies this procedure, showing an exemplary distribution over the percentage of cumulative passengers in the final evaluation result.

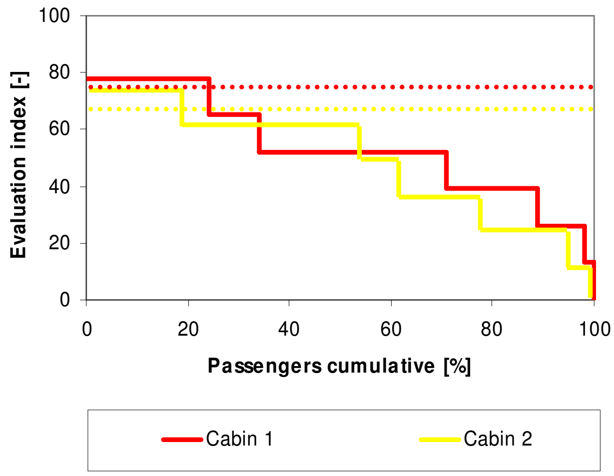

Figure 4 Modified probabilistic membership function

2.2 Determination of an weighting functions through membership functions

The further presented weighting functions have been developed using several surveys. The weighting factors Wf_i have been derived with the help of the analytical hierarchy process method (AHP).

The Analytic Hierarchy Process (AHP) is a mathematical technique for multicriteria decision making, similar to the value benefit

analysis. The AHP method is a compensatory decision methodology because alternatives that are deficient with respect to one or more objectives can compensate by their performance with respect to other objectives. AHP is composed of several previously existing but un-associated concepts and techniques such as hierarchical structuring of complexity, pair wise comparisons, redundant judgments, an eigenvector method for deriving weights, and consistency considerations.
Advantages of the AHP compared to other methods, like the cost-benefit analysis method, are a consistency check and more precise answers because of the pair wise rating combined with matrix multiplication.
Out of the conducted surveys, weighting functions have been derived for different passenger segments. The output of these functions is a weighting factor Wf_i with a value ranging from zero to one. This weighting factor depends on different traveller groups but also on different cabin classes.

3. Passenger Segmentation for Weighting Functions

For the customer-orientated assessment of future cabin designs, it is vital to understand needs and preferences of the customer, precisely the passenger.
As shown in Figure 1 (13), importance of booking decisions varies between passengers travelling mostly in Business or First Class and Economy Class. Especially passenger's attitude towards comfort and ticket price varies tremendously between these classes. For example, passengers in the business class rated comfort issues onboard as the most important criterion (32.9%) followed by schedule properties (26.6%).
Economy Class passengers rated the ticket price as the most important factor for their buying decision (36.7%) followed by schedule properties (28.8%). Therefore, it is necessary to investigate and to understand the passenger needs and preferences especially regarding comfort in more detail.

Different preferences lead to passenger segmentation with passenger groups with similar needs. One main approach for passenger segmentation is a classification by travel purpose. Hereby, travel purpose is divided in the bibliography [3; 4] into two main groups, namely travelling for business and for private/leisure purposes.
Furthermore, these two groups can be subdivided into two subgroups each regarding their travel budget. The amount of spend able travel budget can be limited and nearly unlimited. Determination of an acceptability index through membership functions
Limited travel budget is one of the main reasons for the price-sensitivity of Private Traveller (PT), because flight tickets are paid by this group themselves. The price-sensitivity of this traveller group has been determined by certain price-elasticity studies [8] with a mean value of -1.04 in range of -1.7 and -0.56 for long-haul international leisure traveller.
This applies for business travellers as well: in the last years, a shift towards a price-sensitive booking decision could be observed. Current surveys at Munich Airport identified that in the Economy Class on long-haul flights, 15% of the passengers travelled for business reasons [10]. Therefore, this group can further be called the Price-sensitive Business Traveller or Hard Money Business Traveller [3; 11]
A study led by British Airways identified, that the percentage of business travellers in premium cabins, like Business Class or First Class declined from 60% in 1990 to 40% in 2000 [9] on long-haul flights. In order to close the gap the number of passengers travelling for private/leisure purposes with a booked business class seat had to rise in the same extent. Therefore, this group travels with a nearly unlimited budget and can be called the Premium Traveller in the following. These passengers have a higher demand regarding schedule and service facilities onboard [3,4,12]. One representative of this group is the Double Income No Kids (DINK) passenger group.

The last group for the passenger segmentation is the classical business traveller or Soft Money

Business Traveller [11], who travels for business purposes. The flight ticket is paid by the company without being much price-sensitive. The price-sensitivity of long-haul international business traveller has been determined with a mean value of -0.27 in range of -0.48 and -0.2. [8]

With these four criteria regarding travel purpose and travel budget, four different passenger groups have been identified.

4. Structure of passenger acceptability assessment model regarding cabin design

The structure for the assessment of the passenger acceptability regarding cabin design is categorized in three main cabin parameters for each class (Economy, Business, First):

- *Single seat*
- *Global Cabin*
- *Seat-Cabin Interaction*

For each of these three classes, an acceptability index (AI_{SS}, AI_{GC} and $AI_{S\text{-}C\text{-}I}$) can be calculated. Analogical the according weighting factors Wf_i have to be derived as well.

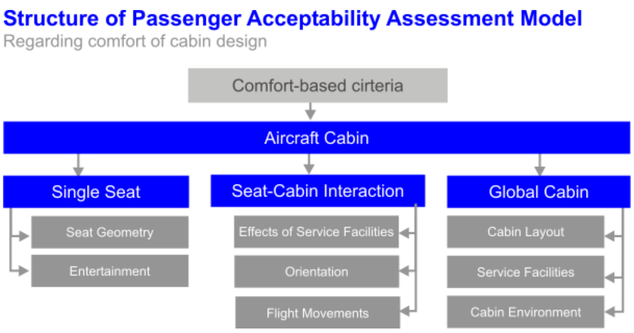

Figure 5 Structure for comfort-based criteria assessment regarding passenger acceptability

4.1 Single Seat Parameters

Single-Seat Parameters include mainly geometrical parameters of a seat (i.e. First Class seat), like seat width, seat pitch or inclination. These geometrical parameters are independent of the geometry of the cabin; therefore these parameters are interchangeable between different cabin layouts. The assessment of the seat's geometry based on membership functions depends on the ergonomic and anthropometric requirements of the passengers. Latter were analysed in different studies focussing on current and expected human dimensions in the next decades.
Furthermore, today's installed entertainment system is part of single seat properties in this methodology as well.

4.2 Global Cabin Parameters

A global cabin can be described with global cabin parameters. In the first level, a global cabin can be divided into following parameters:

- *Cabin layout*
- *Availability and no. of service facilities*
- *Cabin environment*

In the second level this parameter, *cabin layout* can be subdivided into seat layout (seat abreast with number prisoner seats, window seats and aisle seats). Furthermore, cabin height and aisle width are included in the group of *cabin layout parameters*.
The *availability of service facilities* specifies, which additional services are offered inside a cabin/class. These facilities can range from lavatories/galleys, stowage capabilities inside the cabin to a bar or even a conference area. Rather the availability also the number of these facilities is counted among the sub-parameter "*availability and number of service facilities*".

The last sub-parameter of global cabin is the *cabin environment* parameter. This parameter describes effects of habitat's conditions onto passengers. Habitat's conditions inside an aircraft cabin are cabin pressure, cabin humidity/temperature and as well as cabin interior noise and vibration.

4.3 Seat-Cabin Interaction Parameters

Seat-cabin interaction parameters arise because of certain effects of the position of a single seat inside the cabin. Therefore, these parameters are a function of *single seat* and *global cabin parameters*. Three interaction effects can be divided into a second level of parameters like:

- *Effects of service facilities*
- *Orientation*
- *Flight Movement*

The parameter *Effects of service facilities* includes appearance and consequences of noise, odour as well as distances to these service facilities (see 2.2.5).
Especially the unconventional aircraft configuration that is presented in the next chapters, *orientation* not only inside but also an outside-view as well as *flight movements* are one of the main issue. This orientation will be assessed by the existence of windows and/or artificial view properties.

The effects on passenger's well-being of *flight movements* not only generated by rolling or pitching but also by gusts, will be calculated and assessed in the last parameter. Precisely in a cabin with higher length or width compared to current long haul aircraft cabins, flight movements can arise much stronger and will have a stronger impact onto passenger's well-being.

5. Passenger acceptability assessment exemplified on conventional and unconventional aircraft cabin

To present the described methodology as well as single cabin design improvements for future long haul cabins, different aircraft and therefore cabin designs will be presented and assessed. To achieve comparable results, only one class (here Economy Class) will be assessed for both designs.
The first design is an Airbus A340-300 cabin as a representative of a conventional aircraft for typical long haul operations. The presented aircraft cabin has a capacity of 250 seats in a three class version with 8 First Class seats, 54 Business Class seats and 198 Economy Class seats. In that layout, the main galleys for the Economy Class can be found in the rear between rear exits and the bulkhead.

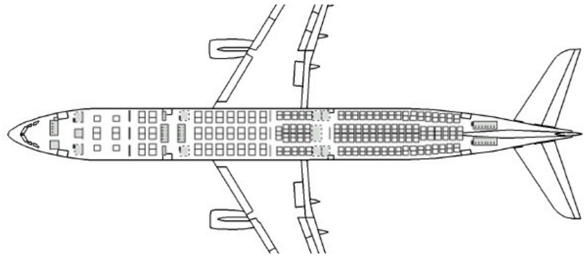

Figure 6 Cabin layout of a conventional long haul aircraft (A340-300)

The second design, as an unconventional aircraft cabin, is a blended wing body configuration as shown below.

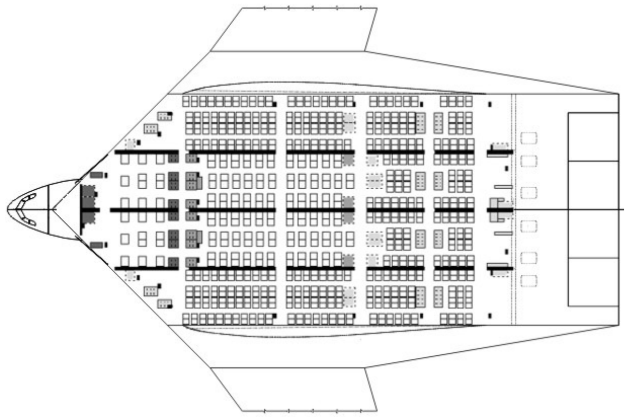

Figure 7 Cabin layout of an unconventional long haul aircraft (BWB) in a three class version [14]

The Blended Wing Body aircraft has a three-class layout with a maximum seat capacity of 750 seats, 22 seats in the first class, 136 seats for the Business Class and 592 seats in the Economy Class.
Going from the front to the rear, classes are arranged in today's aircraft like First Class, Business Class, Premium Economy Class –if installed- and Economy Class.
In the Blended Wing Body design, First and Business Class are situated in the frontal part of the cabin. Due to the wider cabin, these two classes are surrounded by Economy Class. For presenting the methodology, both layouts will

be assessed only regarding their Economy Class.

The main investigations and assessment between these two configurations will be conducted based on effects of *single-seat parameters*, *cabin-seat interactions* and *global cabin parameters*.

The following table listed overall properties of these two configurations:

	A340-300	BWB
No. of seats [-]	248	750
No. of seats FC/BC/EC [-]	10/40/198	22/136/592
Pax seats [%]	4/16/80	3/18/79
Seat pitch EC [inch]	74/48/32	68/46/32
Seat width FC/BC/EC [inch]	28/27/21	28/27/21
Seat's inclination FC/EC/BC [inch]	15/15/5	15/15/5
Cabin attendant seats FC/BC/EC [-]	3/2/5	4/6/18
No. lavatories FC/BC/EC [-]	2/2/5	3/4/16
No. trolleys EC/BC/EC [-]	8/12/16	24/24/36
Stowage	2/4/0	2/2/8

Table 1 Characteristics of the A340-300 and BWB cabin at high-density version

Both cabin configurations are typical representatives of long haul Economy Class layouts [19]. This refers to, that nearly 36% of all long haul aircraft, a cabin layout with three class (FC, BC and EC) is installed. With a three-class layout, 4.7% of all seats belong to the First Class, 15.8 to the Business Class and 79.5 to Economy Class -in average- according to all long-haul aircraft. Furthermore, a seat pitch in the Economy Class of 32 inches can be found in 60% of all long haul aircraft.

6. Assessment of single seat parameters

Differences in the assessment of these two configurations are based on seat's geometry and there mainly seat pitch. Seat pitch is one of the most important comfort criteria in the seat's geometry parameter group. The weighting factor for this parameter was calculated out of the according traveller groups in that class (85% Private Traveller and 15% Price-Sensitive Business Traveller) with 0.29 [13]. As shown in Table 1, both Economy Class layouts have a seat pitch of 32 inches. Nevertheless, due to the location of some seats, some have a higher seat pitch or leg room, if these are located in the first row of an aisle. In the conventional configuration, only two rows with in sum of 16 seats are situated at an emergency exit or in front of a separation wall.

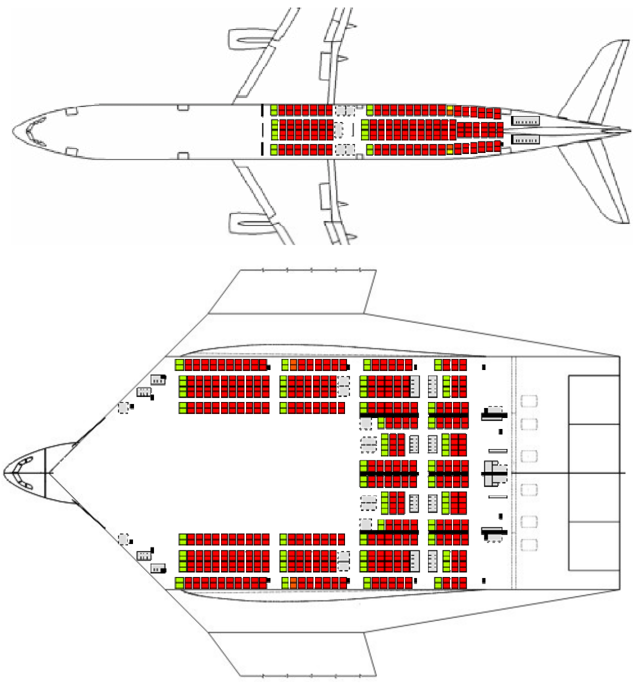

Figure 8 Graphical assessment results of A340-300 and BWB cabin regarding single seat parameter

Because of the tapering rear fuselage, a change from the eight abreast to a seven abreast layout can be observed at row number 29. These two seats have a higher seat pitch than the standard 32 inches (e.g. window seat with 34.5 inch seat pitch). Therefore, window seat is rated with 57.7 and the aisle seat with 50.2.

In this configuration, only 8% of the seats have a higher legroom, which leads to an acceptability index of seats geometry parameter of 48.4 in average (AI_{SG} of 47.3 for standard 32 inch seats, AI_{SG} of emergency exit seats is 63.7)

For the unconventional cabin layout, more aisles have to be provided due to evacuation regulations. Therefore, a higher number of seats are located at lateral aisles. In the presented Blended Wing Body configuration, 96 seats in 12 rows are situated at such an aisle. With 592 seats in the Economy Class, more than 16% of installed seats have a higher legroom. Therefore, the single seat acceptability index of the BWB is 50.4 in average (AI_{SS} of 47.8 for standard 32 inch seats, AI_{SS} of emergency exit seats is 64.2). For acceptability index determination, weighting factor is equivalent to the A340-300 passenger distribution.

7. Assessment of global cabin parameters

Cabin layout

The acceptability index of cabin layout parameter has been determined with 69.5 for the A340-300 cabin and 70.23 for the BWB cabin. In the BWB cabin as well as in the A340-300 cabin, an eight-abreast seating configuration can be found, which leads to an equal acceptability index. The same refers to the cabin height.

One main difference between these two configurations is the compartment size. Studies [17,18] identified that bigger compartments enhance the occurrence of phobias, like fear of flying, claustrophobia or agoraphobia. In the same time, tendencies can be observed that passengers tend to more privacy, even in the Economy Class [13]. Therefore, the acceptability index regarding compartment size is 11 for the A340-300 and for the BWB 46. The index for the A340-300 is derived out of two compartments with 64 seats in the forward and 94 seats in rear compartment, separated by installed lavatories in the middle of that class.

In the BWB cabin, the acceptability index is much higher, due to separations by galleys, lavatories and linings. The cabin can be divided into 10 different compartments, the biggest compartment can accommodate 158 passengers, the smallest compartment only 32 passengers. The higher number of smaller compartments (32 to 52 seats) is responsible for the much higher acceptability index of the BWB cabin configuration.

Availability and no. of service facilities

One indication for service quality is the number of cabin attendants. For the assessment of this parameter, the number of cabin crew for service has been set to five for the A340-300 Economy Class and 18 for the BWB cabin.

Hence, the BWB has a higher ratio of cabin attendant per passenger (*0.030*) compare to a ratio of 0.025 for A340-300 cabin. The higher number of cabin attendants for the Blended Wing Body configuration is required due to safety regulations. Nevertheless, the acceptability index is rather low (*1.9* for the BWB and 0 for the A340-300). Higher indexes are achieved in the Business Class and First Class for both configurations ($FC_{BWB}=100$;, $FC_{A340}=100$; $BC_{BWB}=22$; $BC_{A340}=16$) whereas these passenger groups in these classes rated the importance of service much higher than the determined passenger groups in the Economy Class.

Beside the number of cabin attendants, the number of installed galleys, precisely number of trolleys with their dimensions, is another indication for service quality. In the A340-300 Economy Class, one main galley is installed in the rear of the fuselage. With a capacity of each eight full size trolleys, the ratio of 12.375 passengers per trolley leads to an acceptability index of 34.1 for the A340-300 Economy Class. 16 full size trolleys and 40 half size trolleys with a total capacity of 36 trolleys are installed in the BWB configuration. Hence, the ratio of passengers and trolleys is for the unconventional cabin 16.444, which is slightly higher than for the conventional cabin.

One other indication for service onboard is the number of installed lavatories per class per passenger. In the A340-300, five lavatories are installed in the middle of that class, whereas 16 lavatories can be found in the blended wing body configuration. The ratio of passengers per lavatories is for the A340-300 is slightly higher compare to the BWB (A340: 40 pax/lav; BWB: 37 pax/lav) and leads to an acceptability index of 9.8 for the BWB and 6.2 for the A340-300. In almost the same manner, higher acceptability indexes are achieved in higher classes, due to lower number of passengers sharing theoretically one lavatory. ($FC_{A340}=100$; $BC_{A340}=56.6$).

8. Assessment of seat-cabin interaction parameters

As mentioned in chapter 4.3, seat-cabin interaction parameters can be derived from the effects between a single seat and the installed cabin items. The values are dependent on the relative location of seat and cabin item (e.g. lavatories).

For the A340-300 cabin, a seat-cabin interaction parameter of 76.2 has been determined. The BWB cabin was rated slightly lower with a parameter value of 73.3. Both graphical assessments are shown below:

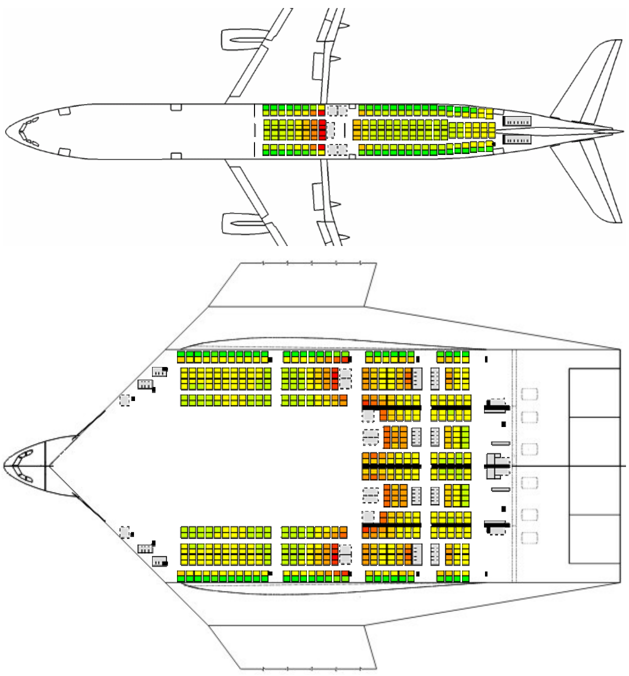

Figure 9 Graphical assessment results of A340-300 and BWB cabin regarding seat-cabin interaction parameter

Effects of service facilities

In the previous subchapter, it was referenced to the high number of installed cabin items inside the BWB cabin. These installations have mainly a negative effect onto the acceptability assessment. Seats located close (one to two seat rows) to cabin items (e.g. lavatories) are rated mainly more negative than other seats [20,21]. This refers to a restriction on seat's inclination angle, occurrence of noise, odour and movements.

According to the number of installed cabin items, the more seats are affected by these disturbances in the BWB cabin compare to the Airbus 340-300 cabin. Therefore, the acceptability index for odours can be determined for the A340-300 design with 88.2 and is slightly lower for the BWB cabin configuration with a value of 82.8. Nevertheless, the acceptability index with a value higher than 80 indicates that odours or noise disturbances are local phenomena. Close to the lavatories, the index drops down to values below 35.

Other investigations regarding passenger movement behaviour on long haul flights have identified that even with the high capacity of the BWB, cabin width, higher number of aisles and location of galleys and lavatories reduces the negative effect of disturbances due to haunting lavatories or galleys. In a conventional aircraft, the fuselage geometry has a tubing effect with concentrating movement activities at the installed cabin items [10].

Orientation

For the assessment of orientation parameter, both cabin designs have windows plus artificial view at every seat because of a forecasted entry into service in the year 2020.

In the BWB cabin design, only the outer seat rows have window access. Therefore, the percentage of window seats to no-window seats is much higher in the BWB configuration supported by the wider cabin. Studies identified, that artificial view can substitute to some extent real windows [17]. Therefore, the acceptability index of the BWB is slightly less than for the A340 cabin (A340-300:51, BWB:48)

Flight Movement
According to the unconventional shape of the BWB cabin, *flight movements* can occur stronger compare to conventional aircraft and might arise phobias, like fear of flying.
Due to the geometry of the BWB cabin, numbers of seats are situated more far away from the axis of rotation. The acceptability index is derived out of the probability changes in occurrence of motion sickness due to flight movements. According to the two configurations, the A340-300 cabin has an acceptability index of 100, whereas the index is 97.5 for the BWB design. The slight decrease of acceptability index refers to a less probability increase of occurrence of motion sickness, even if flight movements are more distinctive.

9. Consolidated view on different cabin configurations

The overall assessment of comfort-based criteria regarding different aircraft designs is carried out through summation of each parameter group and weighting factor. The determination of the acceptability index of an aircraft cabin is based on single-seat, global cabin and seat cabin interaction acceptability indexes.
The results for the conventional and unconventional aircraft are shown in Figure 10:

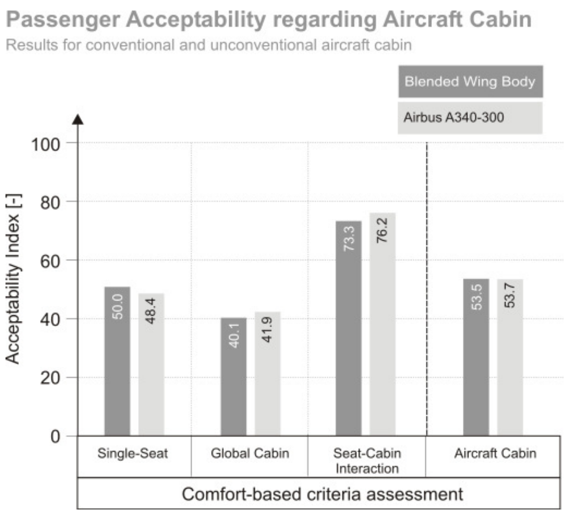

Figure 10 Assessment result of acceptability indexes for aircraft cabin for A340-300 and BWB

As described in the previous subchapters, only slight differences can be observed between a conventional and unconventional aircraft cabin configuration.
With an aircraft cabin acceptability index of 53.4, the A340-300 has marginal higher values than the BWB cabin with an acceptability value of 53.7. From the external shape, a BWB configuration is a representative of an unconventional aircraft, but the inside cabin design and layout is similar to a conventional approach. Instead of new innovative cabin layouts, the assessment of these two configurations is more or less based on geometrical effects of cabin width and number of passengers.
Nevertheless in Figure 10, strengths and improvements potentials for both cabin designs can be derived. For example, the wider cabin has a positive effect on the single seat parameter due to lateral aisles which benefits seats with more legroom. On the other side, cabin items like lavatories, being installed like in the BWB, have a more negative effect onto passenger well being through occurring noise and odours
An installation in the lower deck - like in today’s A340-600 - might be an option to reduce the negative effect of service facilities for both configurations for the future.
Furthermore, other effects of both configurations have not been assessed. Amongst them are processes onboard like boarding/deplaning or service procedures (catering).
Nevertheless, this assessment shows that geometrical properties of a BWB have slight effects onto the overall acceptability of such an aircraft compared to today’s conventional long haul aircraft.

10. Conclusion

For the assessment of aircraft cabin concepts, the presented methodology is applicable to both existing and future aircraft and can be used to evaluate, design, and make decisions regarding the interior of passenger aircraft. The interior is mainly assessed by dimensions and locations.

Cabin properties like illumination, colour schemes or haptical issues have not been taken into the assessment methodology because purpose of this methodology for decision making during preliminary design phase.
The strengths of the presented methodology are its extension ability including schedule-based or ticket-based criteria as explained before.
In case of this paper's assessment between conventional and unconventional cabin design, small differences in the acceptability can be observed. This refers to the former design approach of two conventional cabin designs in two different aircraft configurations. Therefore, new opportunities of unconventional aircraft regarding comfort-based criterion have not been fully implemented. Higher potentials are given by more usable space for cabin comfort with the result of higher acceptability indexes especially for the unconventional long haul configuration.

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