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Personal Overhead Stowage Bins To Ease Flight Boarding And Disembarking And Enhance Passenger Experience

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Abstract

The research lays emphasis on the total elimination of aisle interference and boarding/disembarking delays for airlines. This will drastically let the airline save in terms of turnaround time and hence a lot of money and carbon footprint. After analysing the major concern i.e. airline economy and passenger comfort, this research became a bridge between the two.
Development of personal stowage bins with a sinusoidal wave-like configuration running across the length of the cabin is proposed. Promodel simulations for different boarding techniques were done resulting in an enhanced passenger experience, lesser turnaround time and better economy for airlines, less carbon footprint, easier and low-cost maintenance, a fresh look to the aircraft cabin, a comfortable passenger seating and easy cabin baggage handling.

1. Introduction

Overhead bins are stowage bins which are attached to ceilings in the passenger cabins of the aircraft. The items a passenger carries on-board in airplanes can be stowed in overhead bins or under the seats. Overhead stowage bins were never designed to replace the check-in baggage for transport in the cargo of the airplane. They only provide easy access to baggage to the passengers. Stowage capacities have been increased to accommodate better different sizes and shapes of bags. Also, these extra spaces can sometimes come with prices.

Currently, there are three types of overhead stowage bins: shelf, pivoted, and translating bins. In shelf bins the door opens outward and up. Shelf stowage bins were use in older interior designed aircrafts. While the pivoted and translating bins, designs offers a controlled rate of opening. But they provide better visibility during opening and closing because the door opens out and down. Stowage bin capacities have increased, and the designs have evolved for better accommodation of carry-on baggage

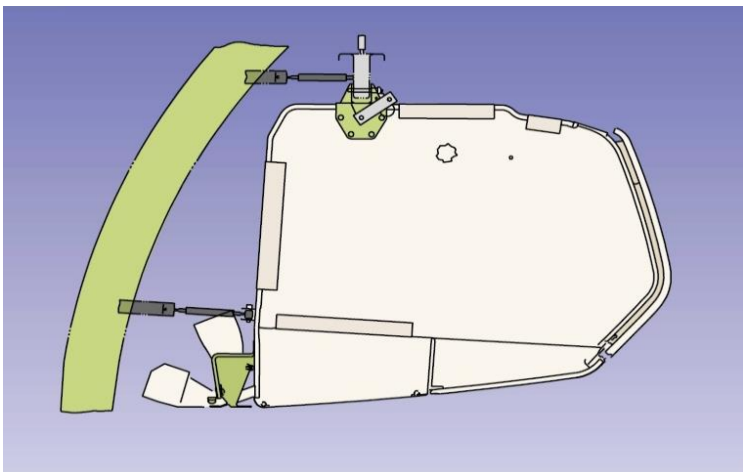

Figure 1: Outboard overhead shelf bin in closed position

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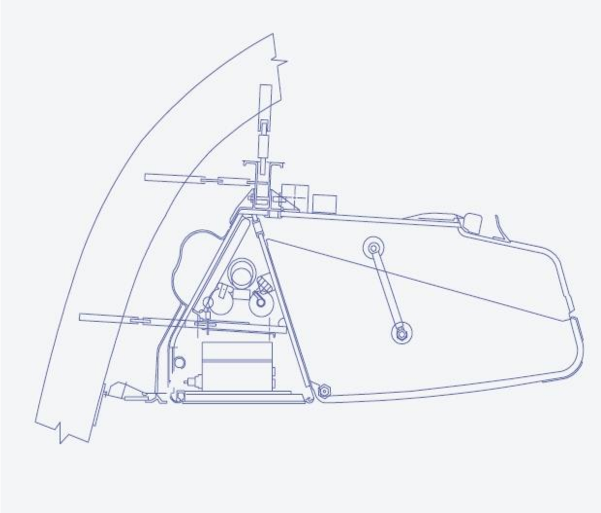

Figure 2:Outboard overhead pivot bin in closed position

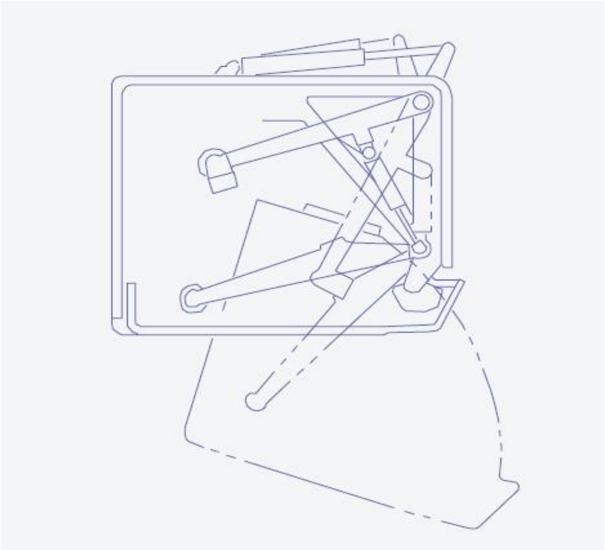

Figure 3:Center overhead translating bin in open position

Throughout the boarding process, assuming that all passengers access their seats altogether, a number of conflicts and interferences will take place. The major interferences that cause the major delay in boarding are Aisle interference and Row interference. Aisle interference is a conflict when a person 2Atrying to access his/her seat, is hampered by another person 2B (As show in the fig 4) in the passenger cabin corridor. Passenger 2A has to wait till the other one releases the path so that he/she can access their seat. As for loading and unloading baggage into the stowage bins, the passenger has to stand in the cabin corridor or aisle. The current way of utilisation of overhead bins involves a system in which passengers can stow their baggage anywhere in overhead bins. Therefore, people tend to rush in the aircraft to stuff their baggage's in order to get maximum space for themselves. This in turn generates a series of conflicts creating interference and hence, leading to potential delays in boarding and disembarking process. Row interference is the interference caused in between passengers of the same row illustrated in fig 4 . Passenger 1A cannot access his/her seat until and unless Passengers 1B and 1C moves out or gives way to Passenger 1A.

In order to eliminate these interferences to a slight amount several passenger boarding patterns are used by the airline industries in effort to swiftly load passengers and their luggage's onto an airplane. Since the boarding and disembarking time often takes longer than refuelling and restocking the airplane its reduction could constitute a significant savings to a particular carrier, especially for airplanes which make several trips in a day. Boarding patterns such as 'Back to front', 'WILMA', 'Random', 'Block' and 'Check-in order' are studied and compared to provide the minimum level of interference offering much faster boarding process. (references)

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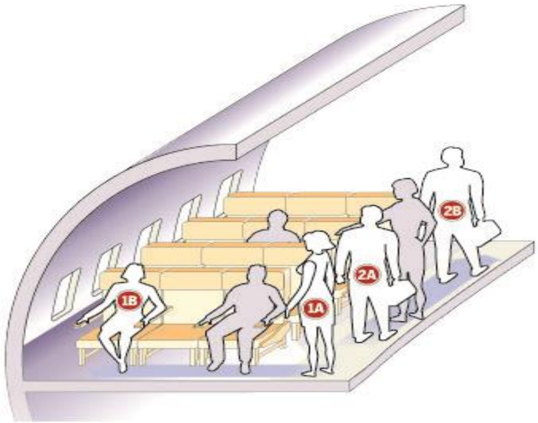


Figure 4: Aisle and Row interferences

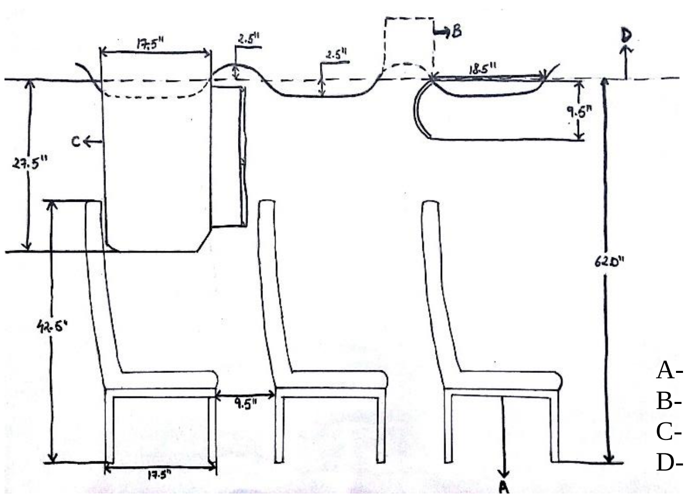
Our idea inspired from attic stairs or ceiling drawers articulates the approach of personalized overhead bins installed directly above the respective seat of a passenger. This will ensure that passengers move directly to their seat first rather than blocking the aisle trying to manage their luggage from conventional bins. This in turn will eliminate aisle interference to 90% offering less turnaround time for airliners.

2. Design

The proposed design is a total makeover of the conventional overhead stowage bin layout. It has been inspired by the basic model of ceiling drawers. This new layout utilizes most of the available cabin ceiling space in creating an entirely new cabin experience for the passenger, ensuring more space, comfort and easy access to baggage.
The overall design of the luggage stowage section of the aircraft cabin is divided into three main sections, viz. the supporting frame, luggage bins and the secondary bins for oxygen masks.

2.1 Supporting Frame

The supporting frame as depicted in fig5 runs longitudinally throughout the aircraft cabin in columns, separated by space above the aisle. It is made in cut sections, with each section containing bins for a single row. Every cut section is given a curved lower and upper surface that looks like crests and troughs of a sinusoidal wave. This sinusoidal wave configuration has troughs directly above the passenger seat and crests above the available legroom in front of the passenger seat. The troughs contain the personal luggage stowage bins and the PSUs, and the crests contains emergency equipment such as oxygen masks. The crests and troughs are displaced approximately 2.5” above and below the surface of the conventional overhead bins respectively. The inner structure is well explained in fig 5.



A- Passenger Seat
B- Secondary bin
C- Luggage bin
D- Conventional

Figure 5: Side view of our personalised bins

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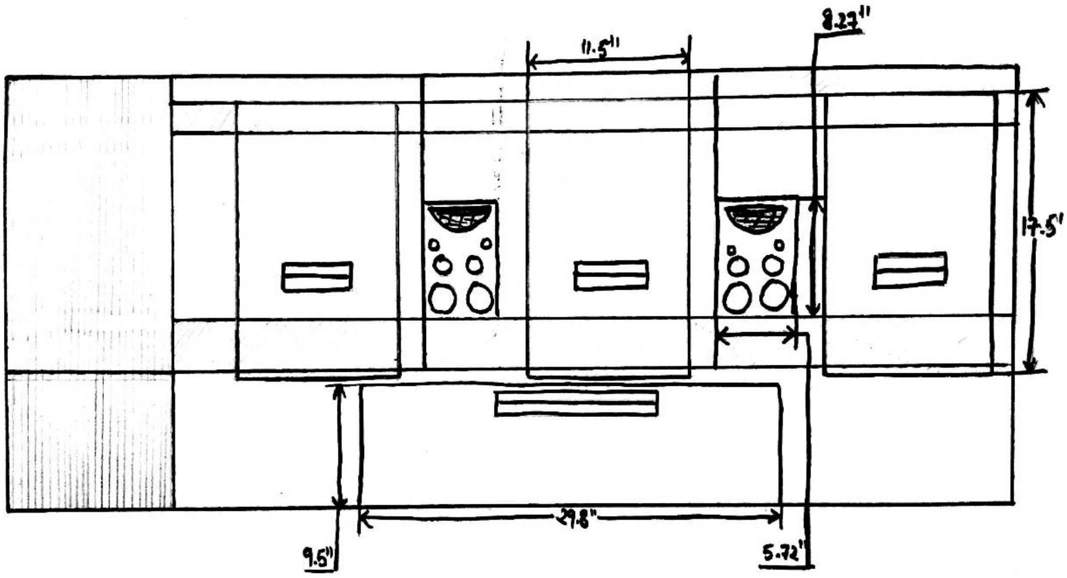

Figure 6: Bottom view of the personalised overhead bins which shows the positions of PSUs and Luggage bins

2.2. Luggage Bins

The design as shown in figure 6 consists of overhead bins placed inside the troughs right above the passenger seats. Each bin will open directly above the seat in a vertically linear motion. The bin is proposed to be in a cuboidal shape covered from all sides, along with a frontal lid opening in the direction of motion of the aircraft. This suggests that when a passenger is to board his/her seat, he will face the opening of the bin while he standing in front of his seat and facing towards the rear end of the cabin. The retraction of the bins is suggested by the use of roller-slider mechanism mounted on its opposite faces (both adjacent to the opening of the bin). The roller tray is hinged from one point on the inner surface of the layer covering all the bins and the slider is attached to the surface of the bin. Also, a small roller assembly is mounted on the top edge of the bin to ensure easy traverse. The movement of the bin assembly is such that the bin is placed in a tilted position while it is closed and takes a curved path to come linearly down in the open position and vice versa. The hinge assembly will mainly contribute to this curvature in the travel of the bin.

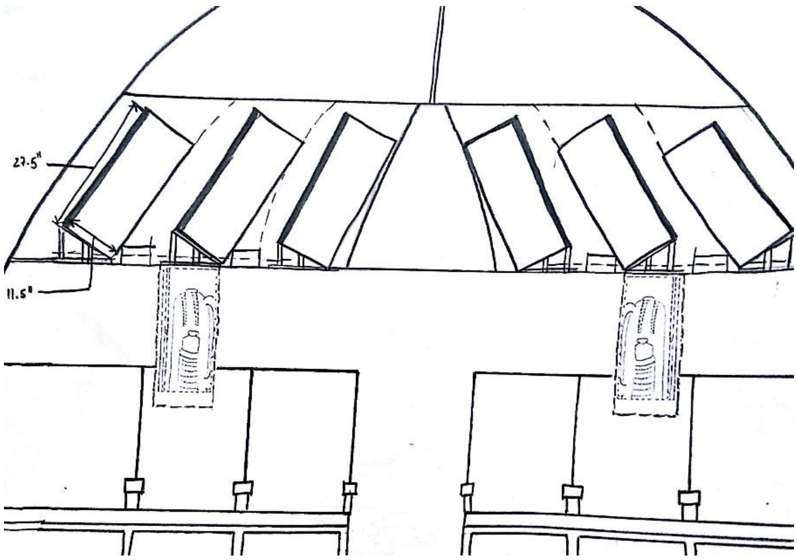

Figure 7: Cut-section of an aircraft showing the placement of bins and opening of bins

2.3. Secondary Bins

The secondary bins are placed inside the crests and have openings at the bottom, in the supporting frame's skin. These bins are much smaller in volume as compared to luggage stowage bins and don't require a roller-slider mechanism. In case of emergency, the lid will open downwards hence making the emergency equipment accessible to the passengers.

3. Design Analysis

Airplane turn time -- the time required to unload an airplane after its arrival at the gate and to prepare it for departure again -- has increased since the mid-1970s. Computer simulations can help airlines reduce one of the key elements of turn time: passenger boarding (enplaning and deplaning). Decreasing passenger boarding time may significantly lower the amount of time between revenue flights, and so increase profitability to airlines. We developed a simulation to see different scenarios of boarding's for our personalised bins to analyse the difference in turnaround time in conventional bins v/s personalised bins. The focus is to assign each passenger boarding the airplane the best seat so that there is the least amount of interference. The objective function includes aisle interference and row interference during the boarding. Each of these interferences are assigned a certain negative value, and sum of these values will tell us the boarding time and total interferences in different boarding techniques. The constraints guarantee that every seat is assigned to a particular passenger and cannot be interchanged within passengers.

The average boarding velocity was observed to be around 20 passengers per minute. However, over the last 30 years, that rate has decreased to a figure close to nine passengers per minute (Marelli et al., 1998). This 55% decline in boarding process efficiency can be attributed to ''increased passenger carry-on luggage, more emphasis on passenger convenience, passenger demographics, airline service strategies, and airplane flight distance.''

Triangular distribution

Triangular distributions are used because we had only very few data points. We were unable to fit a distribution to our observed luggage speeds so that we could easily calculate the min, max, and mean. Below is a small condition used in our simulation model. Here T(3.2,7.1,38.7) represents the minimum, mean and maximum values respectively.

```
if rand(1) < 0.4 then
        lugage_speed = 0
else
        lugage_speed = T(3.2,7.1,38.7)
```

Boarding techniques

Boarding techniques are different ways in which passengers can board the aircraft. Several passenger boarding techniques are used by the airline industry in order to quickly board passengers and their luggage onto an airplane. Since the passenger boarding time often takes longer than refuelling and loading the luggage's in the airplane, its reduction could result in a significant savings to airline companies, especially for airplanes which make several trips in a day. Examples of boarding techniques- 'Back to front', 'WILMA', 'Random', 'Block' and 'Check-in order' etc. After choosing the distribution pattern we chose four different boarding techniques such as Random, By Seat, Outside - In, Back to Front. We performed two different sets of simulations in each technique to analyse different results of interferences and turnaround time. One was with the conventional pivoted overhead stowage bins and other was for the personalised bins. We took 100 simulations for each of the four boarding techniques and graphed the turnaround time v/s check in time graphs for all. We have assumed that the first class always board first.

As our personalised bins involves going directly to your assigned seat, there in negligible aisle interference. On assuming only 10% of aisle interference is left from the conventional interferences, we assigned the simulation model that aisle interference will decrease by 90%. After comparing the simulations done using conventional bins and simulations using our personalised bins we were able to clearly say that due to reduction in overall aisle interference the turnaround time will be decreased. For each boarding technique our bins will save equal to more than 2 mins of boarding time. That is minimum of 4 mins of turnaround time including boarding and disembarking, which will save millions of dollars per annum.
Several luggage management techniques are also adopted in order to minimise the turnaround time such as Self-tagged kiosks and bag-drops.

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3.1. Back to Front

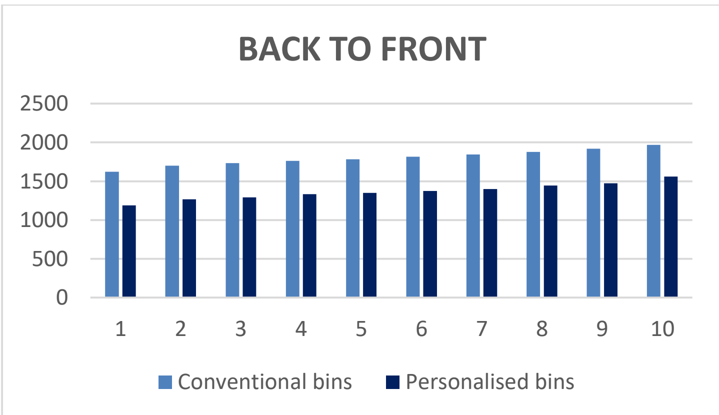
In Back to Front boarding techniques as the name describes, the passenger starts filling the seats from the rear part of the airplane and the front. The logic behind this boarding procedure was that freeing the passengers making the journey to the back of the airplane from aisle obstacles would minimize congestion in the aircraft aisle.
Since it is not easy to sort passengers in the boarding gate queue according to the row in which they have been assigned, the back-to-front boarding strategy is usually simplified by aggregating rows of seats in blocks.

			6	6	6	6	5	5	5	5	4	4	4	4	4	3	3	3	3	3	2	2	2	2	2
1	1	1	6	6	6	6	5	5	5	5	4	4	4	4	4	3	3	3	3	3	2	2	2	2	2
1	1	1	6	6	6	6	5	5	5	5	4	4	4	4	4	3	3	3	3	3	2	2	2	2	2
1	1	1	6	6	6	6	5	5	5	5	4	4	4	4	4	3	3	3	3	3	2	2	2	2	2
1	1	1	6	6	6	6	5	5	5	5	4	4	4	4	4	3	3	3	3	3	2	2	2	2	2
			6	6	6	6	5	5	5	5	4	4	4	4	4	3	3	3	3	3	2	2	2	2	2

Figure 8: Back to Front boarding scheme

Table 1: Boarding time in back to front boarding techniques with conventional bins and personalised bins

CHECK IN TIME	BACK TO FRONT Conventional bins	Personalised bins
1	1621.908	1189.842
2	1700.97	1267.764
3	1732.668	1292.046
4	1760.964	1333.098
5	1784.838	1351.434
6	1814.634	1373.142
7	1847.028	1401.408
8	1879.296	1445.928
9	1920.786	1474.62
10	1969.164	1560.45
AVG	1803.2256	1368.9732



Graph 1: Check in time v/s Boarding time for back to front strategy

The average difference in turnaround time was 434.2524 secs i.e 7 mins and 20 secs.

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3.2. Outside in (WILMA)

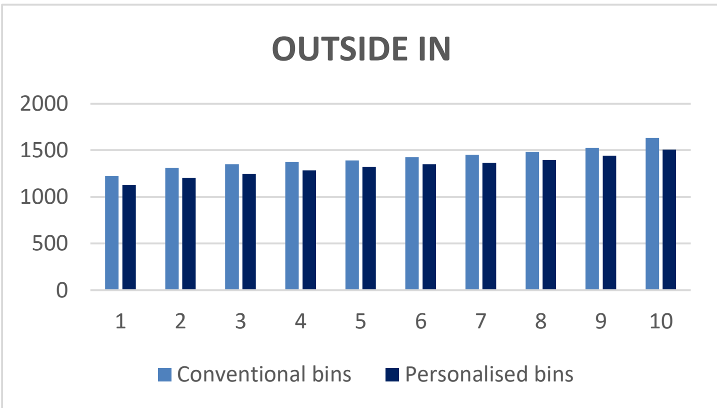
In outside in boarding techniques, the passengers are made to board first the window seats, then the middle and lastly the aisle seat.The goal of the WILMA (windows, middle, aisle) boarding strategy, or “outside-in”, is to reduce the seat conflicts caused among passengers assigned to the same aircraft row. In order to achieve this, passengers are assigned to the boarding groups according to their assigned seats, and then access the aircraft in thefollowing order.

			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Figure 9: WILMA boarding scheme

Table 2:Boarding time in Outside-In boarding techniques with conventional bins and personalised bins

	OUTSIDE IN	
Check In Time	**Conventional bins**	**Personalised bins**
1	1221.108	1126.278
2	1311.798	1204.53
3	1349.496	1246.986
4	1373.826	1283.07
5	1390.536	1322.568
6	1423.062	1348.872
7	1451.82	1366.5
8	1481.604	1393.476
9	1523.874	1442.904
10	1630.188	1506.84
AVG	1415.7312	1324.2024



Graph 2:Check in time v/s Boarding time for Outside-In strategy

The average difference in turnaround time was 434.2524 secs i.e. 1 minute 52 seconds.

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3.3. Random

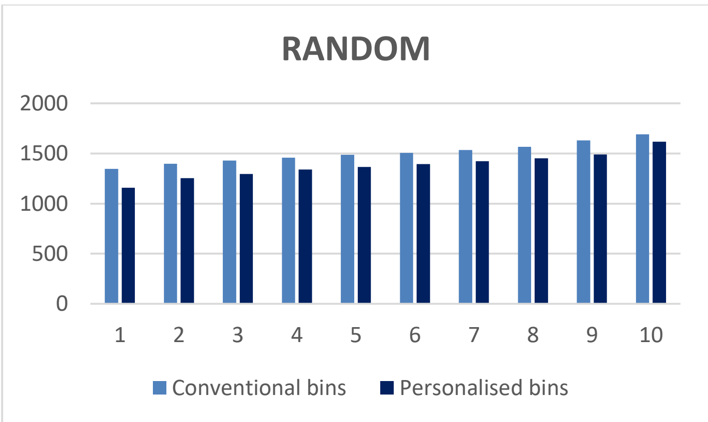
It is based on managing a uniformly random method to handle the boarding process. Which means that passengers can access to the aircraft cabin, to lodge the seats which they have been assigned, in the order they waiting at the boarding gate queue.

			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Figure 10: Random boarding scheme

Table 3:Boarding time in Random boarding techniques with conventional bins and personalised bins

	RANDOM	
Check In Time	**Conventional bins**	**Personalised bins**
1	1346.874	1159.416
2	1398.318	1252.842
3	1428.72	1294.146
4	1457.61	1339.032
5	1485.396	1365.528
6	1507.302	1392.72
7	1534.188	1422.102
8	1567.398	1452.048
9	1628.844	1491.234
10	1691.592	1616.316
AVG	1504.6242	1378.5384



Graph 3: Check in time v/s Boarding time for Random strategy

The average difference in turnaround time was 126.0858 secs i.e. 2 mins and 1 sec.

3.4. By Seat

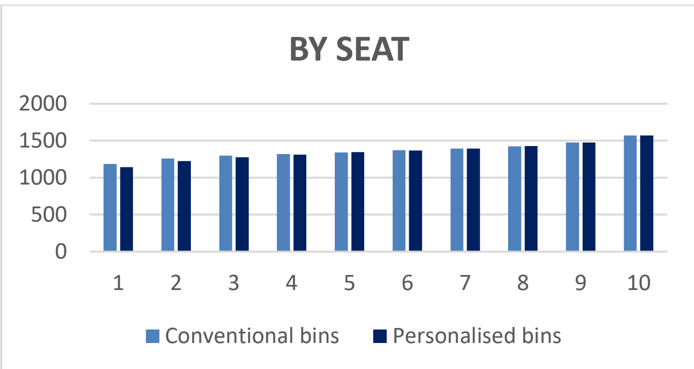
As the name refers, in By Seat boarding techniques the passengers are made to load the airplane in the order of their seats. Firstly, the first class board the plane and after that the boarding starts of economy class. In the economy class the boarding is started from the window seats so as to minimize the left row interference. By Seat offers the minimum interferences but the maximum boarding time.

			24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2
1	1	1	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48
1	1	1	116	115	114	113	112	111	110	109	108	107	106	105	104	103	102	101	100	99	98	97	96	95	94
1	1	1	139	138	137	136	135	134	133	132	131	130	129	128	127	126	125	124	123	122	121	120	119	118	117
1	1	1	93	92	91	90	89	88	87	86	85	84	83	82	81	80	79	78	77	76	75	74	73	72	71
			47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25

Figure 9: By Seat boarding scheme

Table 4:Boarding time in By Seat boarding techniques with conventional bins and personalised bins

	BY SEAT	
Check In Time	**Conventional bins**	**Personalised bins**
1	1186.152	1143.66
2	1259.28	1223.742
3	1296.882	1273.788
4	1319.322	1309.296
5	1342.86	1344.768
6	1371.438	1368.864
7	1392.618	1394.922
8	1424.514	1427.682
9	1474.086	1475.1
10	1570.998	1568.856
AVG	1363.815	1353.0678



Graph 4:Check in time v/s Boarding time for By Seat strategy

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The average difference in turnaround time was 10.7472 secs i.e. 10 sec.

4. Economic factors

Economic factors have always been of a major concern to the airline companies. Recently Nyquist and McFadden (2008) found that the average cost to an airline company for each minute of time spent at the terminal is roughly $30. Thus, each minute saved in the turnaround time of a flight has the potential to generate over $20,000,000 in annual savings assuming 2000 flights per day.

Our personalized bins claim that there will be an overall decreased turnaround time. As the passengers have to go directly to their respective seats to stow their luggage. This method eliminates aisle interferences while allowing multiple passengers to stow their luggage simultaneously. Thus, we test this in Promodel simulations to get the difference in boarding time when there are conventional bins and when there are personalized bins.

Table 5 explains the results produced during the simulations of all the four boarding techniques. From the difference in boarding time we can get the overall money that each airline can save from our personalised bins.

Table 5: Boarding time, aisle interference and row interference for different boarding techniques

Name	Back to Front	Outside In	Random	By Seat
Average boarding time	1368.3822	1344.4128	1354.2684	1353.0678
nr passes	1.54	0.16	2.44	0.08
nr seat interferences	71.42	2.9	72.2	2.97
nr aisle interferences	24.63	2.15	25.61	0.99
Total interference	96.05	5.05	97.81	3.96

Table 6: Overall money saved by airlines per annum if 10 flights fly per day

Boarding techniques	Time saved	Money saved per annum (for 10 fights per day)
Back to front	7 minutes 20 secs	**799350 $**
Outside – In	1 min 52 sec	**219000 $**
Random	2 min 1 sec	**219000 $**
By Seat	10 sec	**17799.9 $**

5. Advantages

5.1. Less maintenance and production cost

The personalized luggage bins are made in different parts. The supporting frame and luggage bins. The supporting frame is a fixed component but the luggage bins are separable parts. The personalised bins will require less maintenance as they will be produced by flexible manufacturing technique. This technique will although increase the implementation costs but will help to save money in future. They will reduce the costs of operation because their ability to adapt to changes helps to prevent defective products as well as wasted time and resources. This in turn will require less skilled labours as the assembly of the parts is easier.
If any parts get damaged, only that particular part will be replaced. This will ensure less production cost as the whole bin is not manufactured again. And also, will lead to faster production.

5.2.Air Flow

To provide an aircraft interior arrangement in which the space for baggage is enlarged without limiting the comfort of the passenger. Preferably this arrangement will favour more fluid boarding of the passengers. Advantageously it will also be original and agreeable from the aesthetic viewpoint. Finally, it will permit good air circulation in the cabin to provide an aircraft interior arrangement in which the space for baggage is enlarged without limiting the comfort of the passenger. Preferably this arrangement will favour more fluid boarding of the passengers. Advantageously it will also be original and agreeable from the aesthetic viewpoint. Finally, it will permit good air circulation in the cabin

In such an aircraft cabin segment, the alignment of baggage compartments is advantageously interrupted above a longitudinal aisle in such a manner that it does not obstruct the movement of passengers and personnel navigating in this aisle.

5.3. Height

Personalised overhead bins are located just above the passenger seat, due to the sinusoidal configuration of the supporting frame, it will provide more headspace to the passengers having more height. This will eliminate the disadvantage that the conventional bins have that is the stowage bin compartments are located above the seats and are disposed parallel to the aisle in such a way that when a passenger stands up he risks bumping his head on the baggage compartment situated above him.
Also, now there is no need for short passengers to wait for the crew members or fellow passengers to stow their luggage. Just like attic stairs our bins will be pulled perpendicularly down from skin so that passenger can load baggage and easily push the bin back. (fig 5). This will help the short passengers to load the luggage easily.
Also, as the luggage's are sometimes heavy

5.4. Easy Access and Safety/ Passenger Comfort

With the all new aircraft cabins and personalized bins, all the passengers will overall experience a comfort which cannot match the conventional bins. The problem of waiting for fellow passengers to adjust to get your luggage will now be totally vanished. Also, due to personalized cabins, the cabin baggage's will be safer than before. Personalized bins also offer easy access to PSUs because of the sinusoidal configuration.

6. Conclusions

The simulations done in Promodel presented great results for our research and hence suggest that the proposed bins will be saving a lot in terms of money and carbon emissions for every airline across the globe. Due to less turnaround time, less amount of external supply will have to be given to the airplanes in order to keep the electricals running while the airplane is being boarded or de-boarded, which in turn will result in less carbon consumption. Also, less turnaround time will result in more available airport and runway space for aircrafts circling around busy aircrafts which in turn will again result in saving fuel. These bins will not only be airline friendly but also passenger friendly, since every passenger will now have easy and safe access to their luggage. Short and long passengers, both will be benefitted by the sinusoidal configuration given to them. Along with these, many more benefits come bundled with these bins. There is further research going on to make these bins more efficient and user friendly which will be presented in the near future.

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7. Appendix

7.1. List of Tables:

7.2. List of Figures:

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