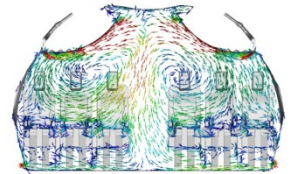


HAW Hamburg in cooperation with the DGLR, RAeS, ZAL and VDI invites to a lecture



# Aircraft Cabin Ventilation in the Corona Pandemic – Legend and Truth



Flow visualization in a cabin cross section with CFD. Boeing: <https://perma.cc/S5VV-UNS2>.

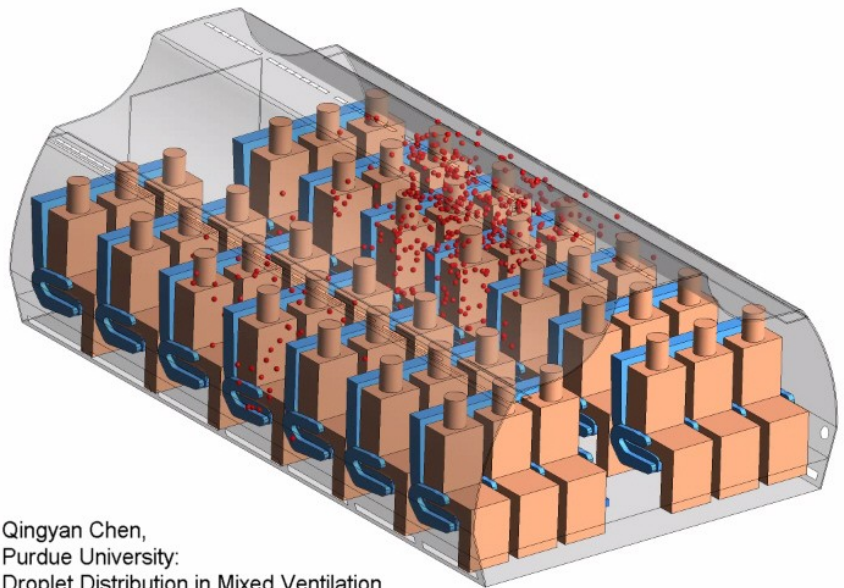
Prof. Dr.-Ing. Dieter Scholz, MSME, HAW Hamburg

Date: Thursday, 24 June 2021, 18:00 CEST

Online: <http://purl.org/ProfScholz/zoom/2021-06-24>



We are hopefully coming to the end of the coronavirus pandemic and are approaching a summer with a holiday perspective including air travel. As such, it is time to present a **wrap-up of the discussion** from the last 15 month. The lecture starts with a brief explanation of passenger aircraft **air conditioning systems**. This is followed by an introduction to **aircraft cabin ventilation theory**. Seven legends are famous; three of them have been used extensively by the aviation industry. With an aeronautical sciences perspective, we try to find out how much **truth** is in these seven **legends**. More details on the second page of this PDF poster.



Qingyan Chen, Purdue University: Droplet Distribution in Mixed Ventilation

Read about the fundamentals of cabin ventilation: <https://doi.org/10.31224/osf.io/ac6p8>

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## Aircraft Cabin Ventilation in the Corona Pandemic – Legend and Truth

There are 3 main **legends about aircraft cabin ventilation** used by the aviation industry again and again during the Corona pandemic to lobby for special conditions in operation (Legend 1 to 3). More legends were made up (Legend 4 to 7), but have not been used as extensively.

Legend 1: The air in the cabin has the quality of a hospital because high-performance filters (HEPA filters) are in use. (Figure 1)

Legend 2: The air in the cabin is (fully) renewed every two to three minutes. (Figure 2)

Legend 3: The air in the cabin flows down from the ceiling and is extracted from the cabin at floor level. Hence, there is no horizontal airflow neither sideways nor length the cabin aisle. (Figure 3a and 3b)

Legend 4: The seats provide a barrier for transmission to the front and rear of the cabin.

Legend 5: The passengers look forward and have little facial contact.

Legend 6: 6 feet physical distancing minimum without a mask (CDC recommendation) is equivalent to 1 foot distance onboard the aircraft with a mask. (Figure 4)

Legend 7: The risk of getting infected with the virus during a flight is extremely low: "The risk of contracting the virus on board appears to be in the same category as being struck by lightning," said Alexandre de Juniac, IATA's Director General and CEO in 2020.

**The truth about aircraft cabin ventilation** is this:

1. Even if the HEPA filters would filter out 100% of the viruses in the SUPPLIED air, the AIR IN THE CABIN is still NOT virus free, because the viruses are in the cabin in the first place. What is possible is this: The virus concentration in the cabin can be halved (with 50% recirculation) if, in addition, recirculation with a 100% effective HEPA filter is used. Please also note: There are no binding requirements for the use of HEPA filters in aircraft. Therefore no information can be given about their quality in practice.
2. Without ventilation, various substances would accumulate in the cabin air (CO<sub>2</sub>, viruses, ...). The decisive factor is the concentration of these substances, which can be easily calculated in the steady state from  $C = S / Q$ . S is the strength of the source strength of the substance in question - for example kg CO<sub>2</sub> per hour and per person. Q is the ventilation strength - for example m<sup>3</sup> of fresh air per hour per person. S / Q then gives the concentration C in kg per m<sup>3</sup>. According to the certification regulations (CS-25.831), the cabin must be ventilated with 0.25 kg per minute and person. The air exchange rate indicates how many cabin volumes of air are pumped into the cabin for ventilation per hour. The formula is  $n = Q / V$ . V is the volume that is available to each person (about 2 m<sup>3</sup> on an airplane). The air change rate is only important for dynamic processes (not relevant here!). The air change rate in the aircraft is only so high because the volume V per passenger is so small. For 0.25 kg of air per minute and person, a cabin volume of fresh air must flow into the cabin at least every 6.7 minutes. With optimal mixed ventilation (which is never the

case in practice), the concentration of a substance is reduced to 37% of the original value after one air change. Only after 5 air changes does the concentration drop below 1%.

3. In the cross-section of the cabin, the ventilation causes vortices, which mix the air within several rows of seats (Figure 5). Turbulence and diffusion also mix the air along the cabin (forwards and backwards).

More details will be given in the presentation to refute legends 1 to 3 further. Also legends 4 to 7 will be dealt with in the presentation.



Figure 1: Aircraft Cabin Ventilation Legend 1 (<https://perma.cc/686X-X9AZ?type=image>)



Figure 2: Aircraft Cabin Ventilation Legend 2 (<https://perma.cc/686X-X9AZ?type=image>)

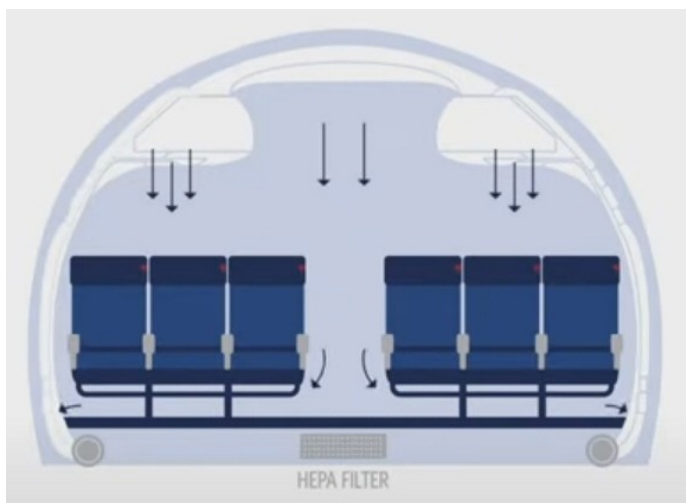
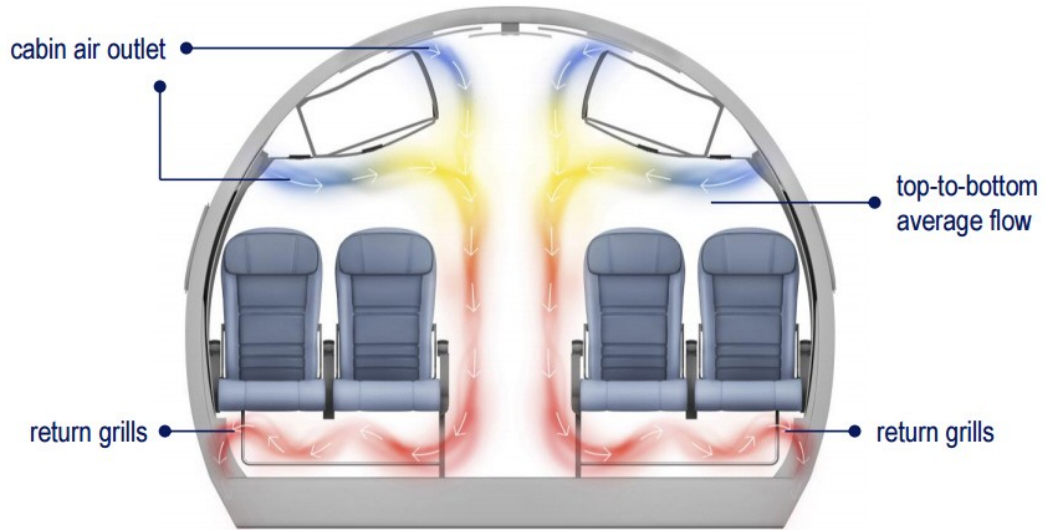


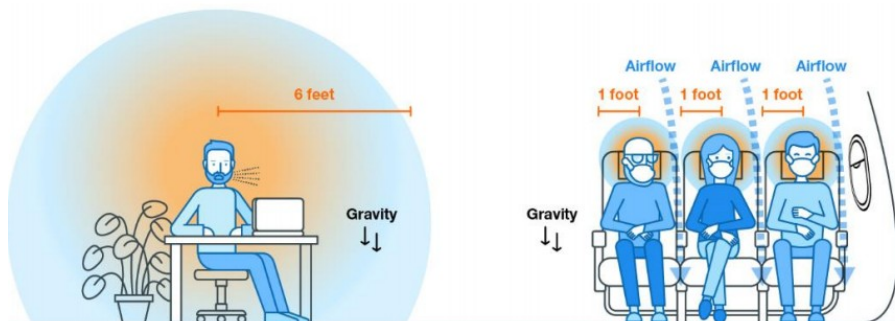
Figure 3a: Aircraft Cabin Ventilation Legend 3 (Delta: [https://youtu.be/Il-4LUfcr\\_s](https://youtu.be/Il-4LUfcr_s))

# Clean air designed to cycle from top to bottom minimizing cross-cabin flow



**Figure 3b:** Aircraft Cabin Ventilation Legend 3 (Embraer: <https://perma.cc/J8W2-8R9C>)

## Physical distance in both worlds



**Potential exposure is very low**

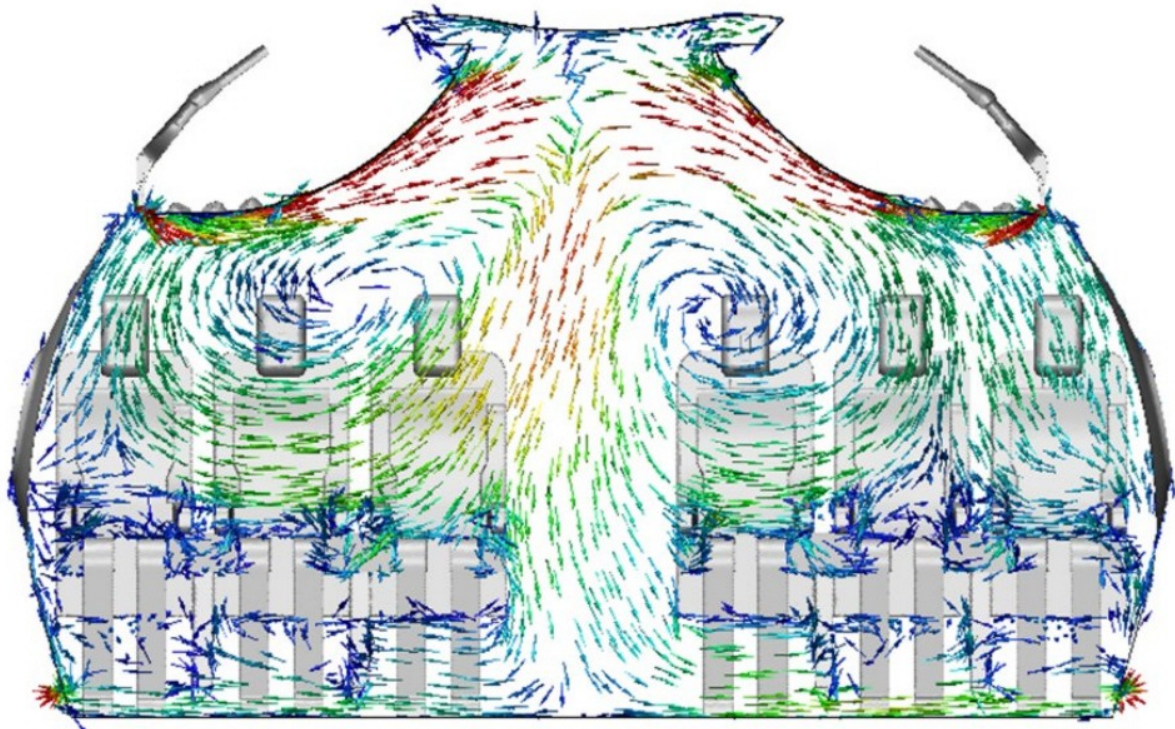
...even with ALL seats occupied

Based on the CDC\* recommendation of 6 feet physical distancing minimum without a mask  
 =  
 1 foot distance onboard the aircraft with a mask

\*CDC = Center for Disease Control

**AIRBUS**

**Figure 4:** Based on the Center for Disease Control (CDC) recommendation of 6 feet physical distancing minimum without a mask = 1 foot distance onboard the aircraft with a mask (<https://perma.cc/NE83-9GS9>).



**Figure5:** Flow in a cabin cross section. CFD snapshot. Ventilation causes vortices or rotors on both sides of the aisle with substantial flow from one passenger to another sitting in one row. No mention of this in the Boeing document (Boeing: <https://perma.cc/S5VV-UNS2>).

24.06.2021, 18:00 CEST

### **Aircraft Cabin Ventilation in the Corona Pandemic – Legend and Truth**

Prof. Dr.-Ing. Dieter Scholz, MSME

Lecture given in the frame of Hamburg Aerospace Lecture Series (Aerolectures)

(<http://AeroLectures.de>)

This abstract supplements the lecture announcement, <http://purl.org/aerolectures/2021-06-24> (PDF).

For more information please go to <http://corona.ProfScholz.de>.

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