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Noise Reduction Techniques in Commercial Aircraft Cabins

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Noise Reduction Techniques in Commercial Aircraft Cabins

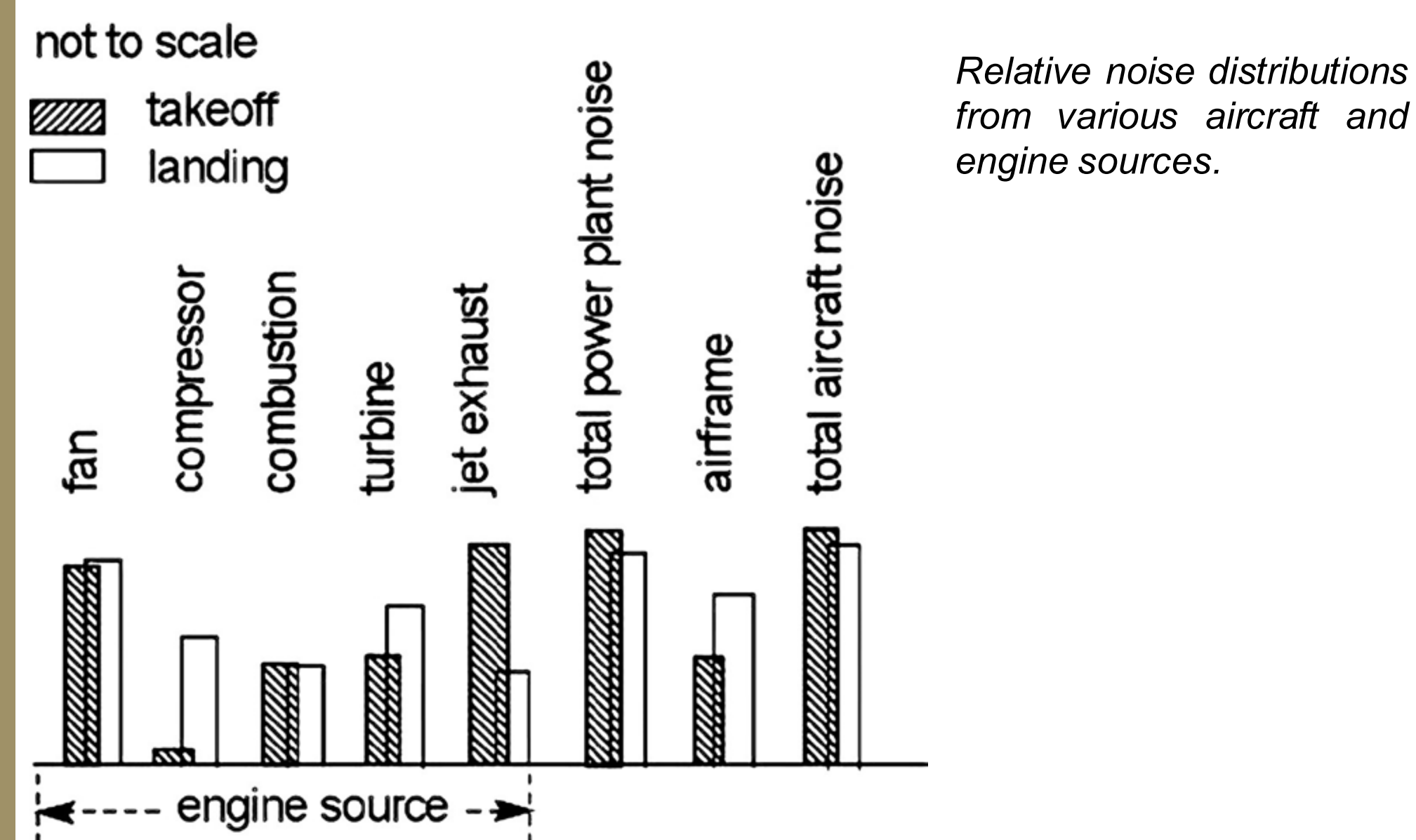
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BACKGROUND

Main sources of noise heard inside an aircraft cabin:

- Engines.
- Airframe & control surfaces.
- Window vibrations.
- Passenger announcements & activities.

Relative volume & frequency proportions vary depending on flight phase.



Noise is a matter of human perception.

- Noise increases annoyance & awareness of other discomfort factors.
- Amplitude + Exposure time → Effective perceived noise level (EPNL).
- Passengers on U.S. flights spend 72% of their flight time exposed to noise > 80 dBA.
- Passengers perceive noises to be 1.5 dB louder as exposure time doubles.

OBJECTIVE

No noise regulations currently govern noise exposure on-board flights.

- National & international governing bodies traditionally focussed on noise control to people on the ground.
- ICAO's Balanced Approach to Aircraft Noise Management:

- Reduction of noise at source.
- Land-use planning & management.
- Noise abatement operational procedures.
- Operating restrictions.

Principal elements do not specifically/directly target the cabin as an area for noise reduction.

AIM: Devise a new & unique solution that reduces noise inside aircraft cabins.

LITERATURE REVIEW

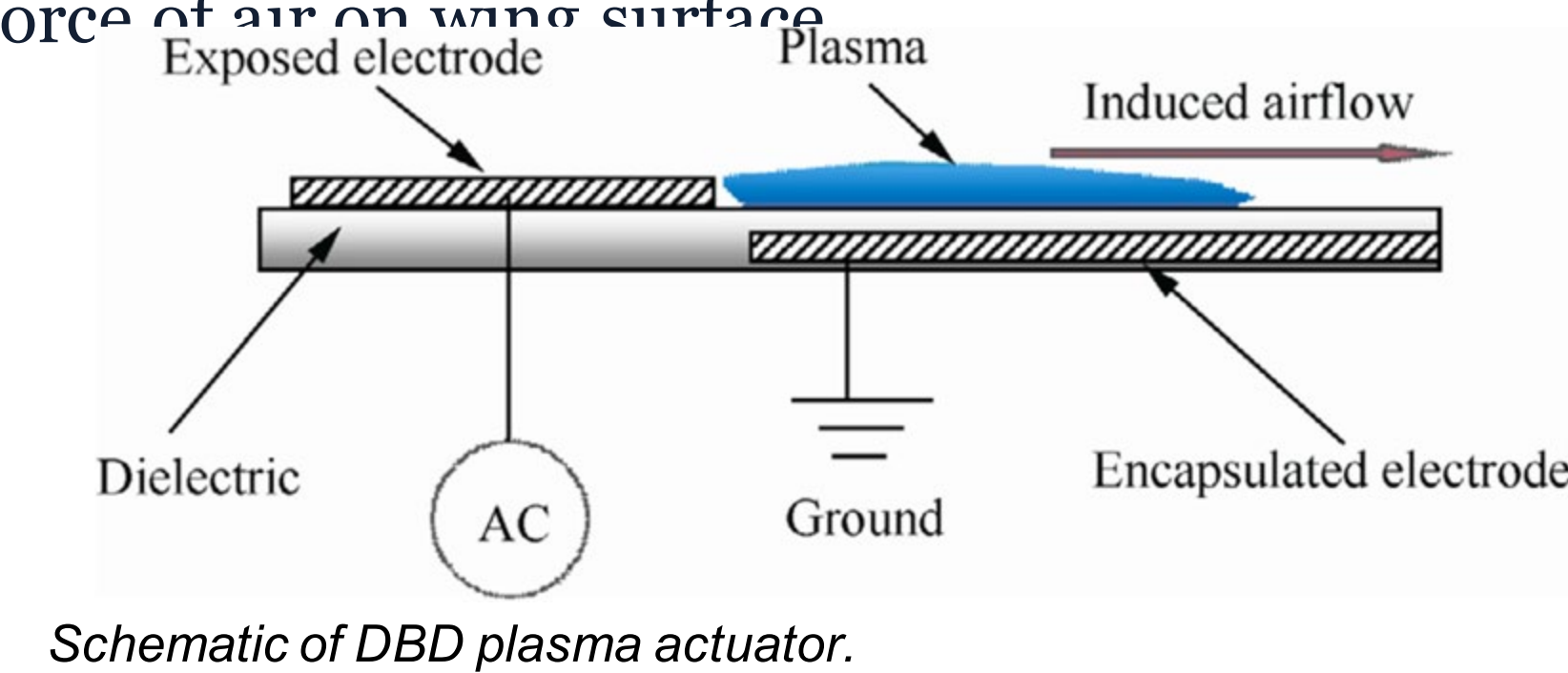
Existing cabin noise-reduction techniques:

Heating Ventilation and Cooling: Boiler silencer linings reduce its noise by an average 7.2 dBA at 100% power.

Fuselage liners: Acoustic field sensors; used in ATR 42, ATR 72, & DHC-8 Q400 liners; estimate Sound Pressure Level based on their vibrations.

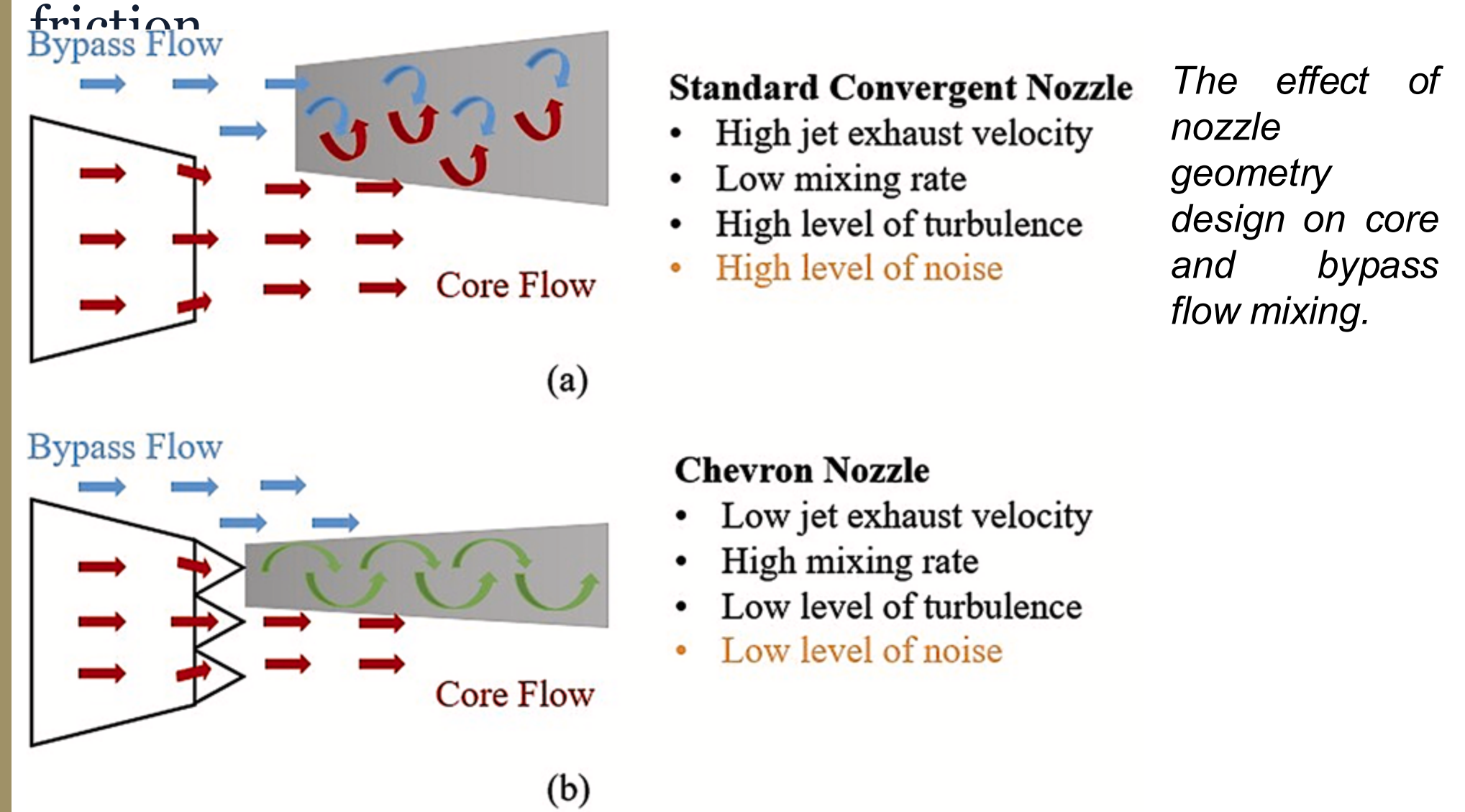
Airframe:

- Passive slat & leading edge liners reduce noise by ~ 4 dB across the 1/3 octave band.
- Dielectric barrier discharge (DBD) plasma actuators create an electric field gradient that reduces resultant force of air on wing surface.

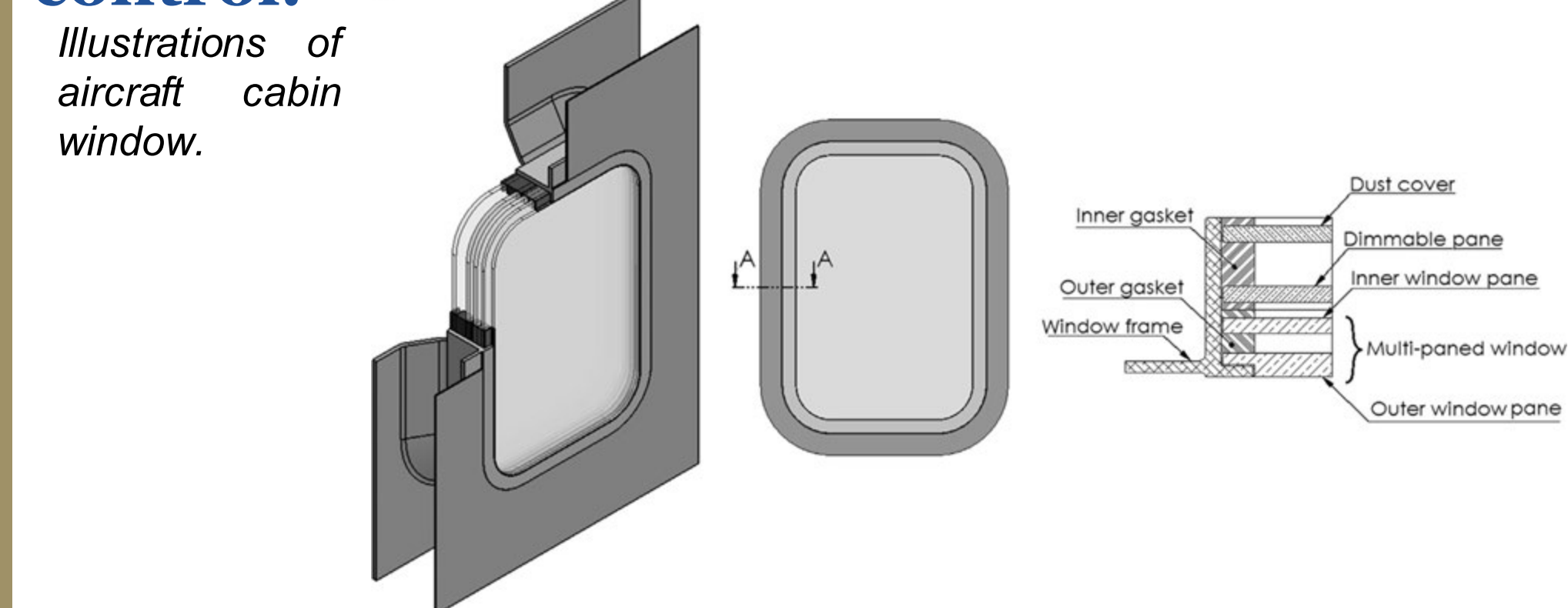


High bypass ratio: Ultra-high bypass ratio (17%) engines are 20 dB quieter than conventional bypass ratio (5%) engines above 200Hz.

Chevron nozzles: Enhanced mixing between hot exhaust gases & cooler ambient air reduces turbulent shearing friction.



Aircraft windows not yet addressed for noise control.



Ineffective window noise control → ineffective fuselage noise control.

DATA ANALYSIS

Critical analysis of cabin window noise reduction techniques:

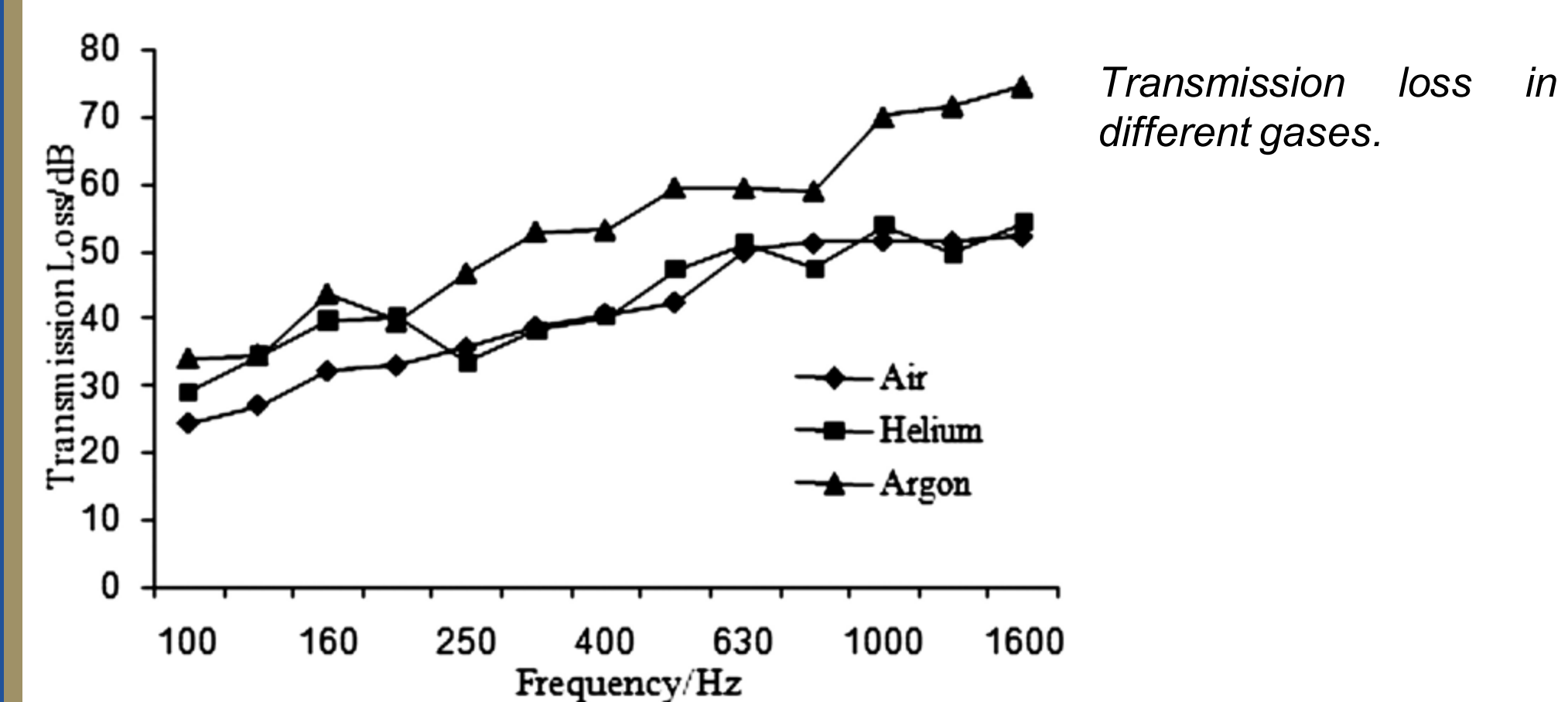
Recommendation selection parameters:

- New & unique within the aviation industry.
- Effective at noise reduction.
- Feasible weight, construction, & maintenance.

Argon window cavities: Replacement of air with argon in window cavities.

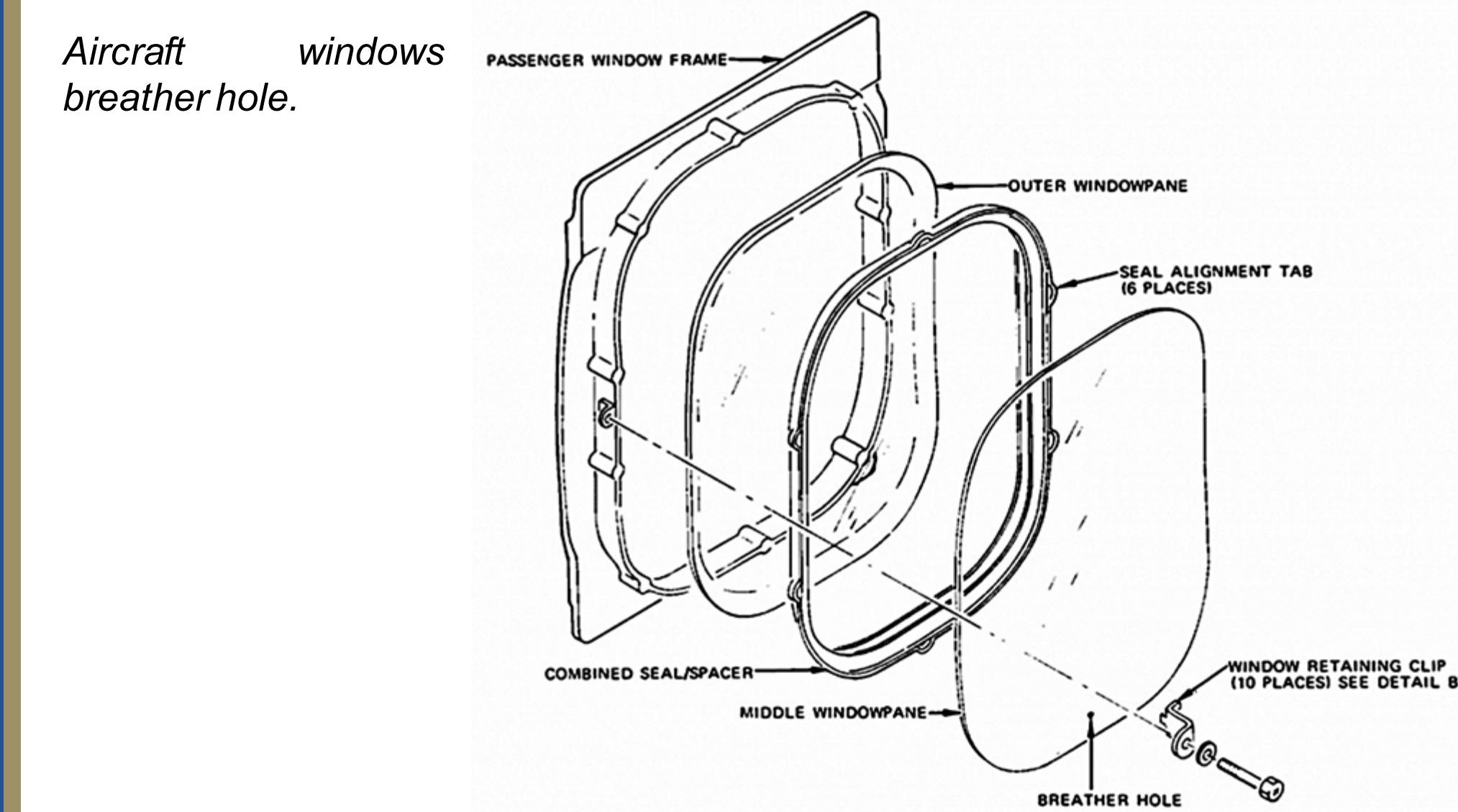
Advantages:

- Minimal change to window construction.
- Argon is a gas → lightweight solution.
- Proven application in homes & high-speed trains.



Disadvantages:

- Current argon applications limited to uniform pressure environments.
- Argon has a larger density & specific heat ratio than air.
- Aircraft bleed holes limit extent of their application.



Active structural acoustics: Piezoelectric actuators vibrate window panels at their resonant frequencies.

Advantages:

- Active noise control → specifically targets cabin noise frequencies.
- Piezoelectric actuators a lightweight solution.
- Applicable on all aircraft types.

Disadvantages:

- Active window vibration not "new & unique"
- Prolonged gasket vibration could increase fatigue rate.
- Uniform vibration induces constructive interference.

RECOMMENDATION

Both proposed solutions are new & unique.

Metric	Argon	Acoustics
Effectiveness	Passive, ~20 dB.	Active, attenuation not guaranteed.
Application	Limited application.	Versatile application.
Construction & maintenance	Minimal construction changes, maintenance concerns.	Minimal construction changes, potential fatigue concern.
Lightweight	Yes.	Yes.

Proposed Recommendation: Argon window cavities.

- No additional scientific research to prove effectiveness.
- Minimal construction & maintenance changes attractive to aviation industry stakeholders.
- Solution remains applicable to 1,072 current and 648 future Boeing 787 aircraft.

CONCLUSION

Further research:

- Cost-effectiveness of argon & its supply chain.
- Volume of argon that can be placed in window cavities.

