

Latest research on the reduction of aircraft noise at the source

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Knowledge for Tomorrow



Outline

- sources of aircraft noise
- low noise technology for current aircraft
- conclusions



sources of aircraft noise



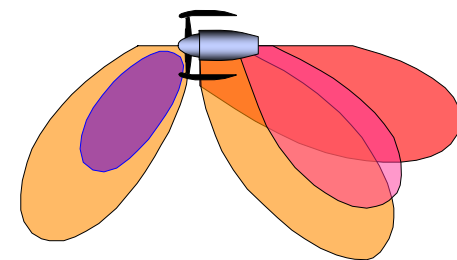
Sources of exterior noise at transport aircraft



➤ Take-off:

engine noise

- jet
- fan tonal (+ broadband)
- (compressor)



➤ Approach:

engine noise

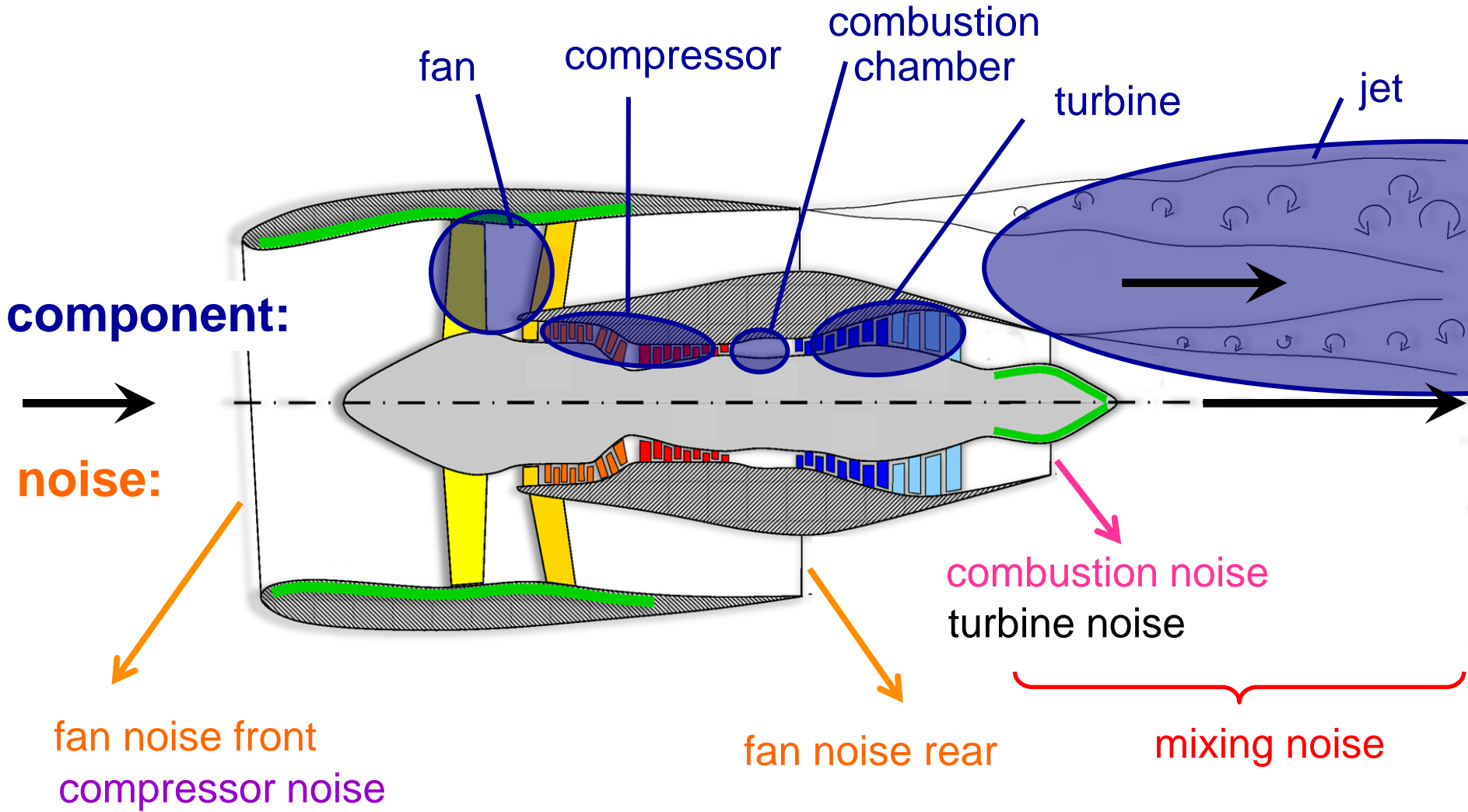
- jet
- fan broadband (+ tonal)
- combustion + turbine

airframe noise

- high lift devices
- landing gears
- installation related sources

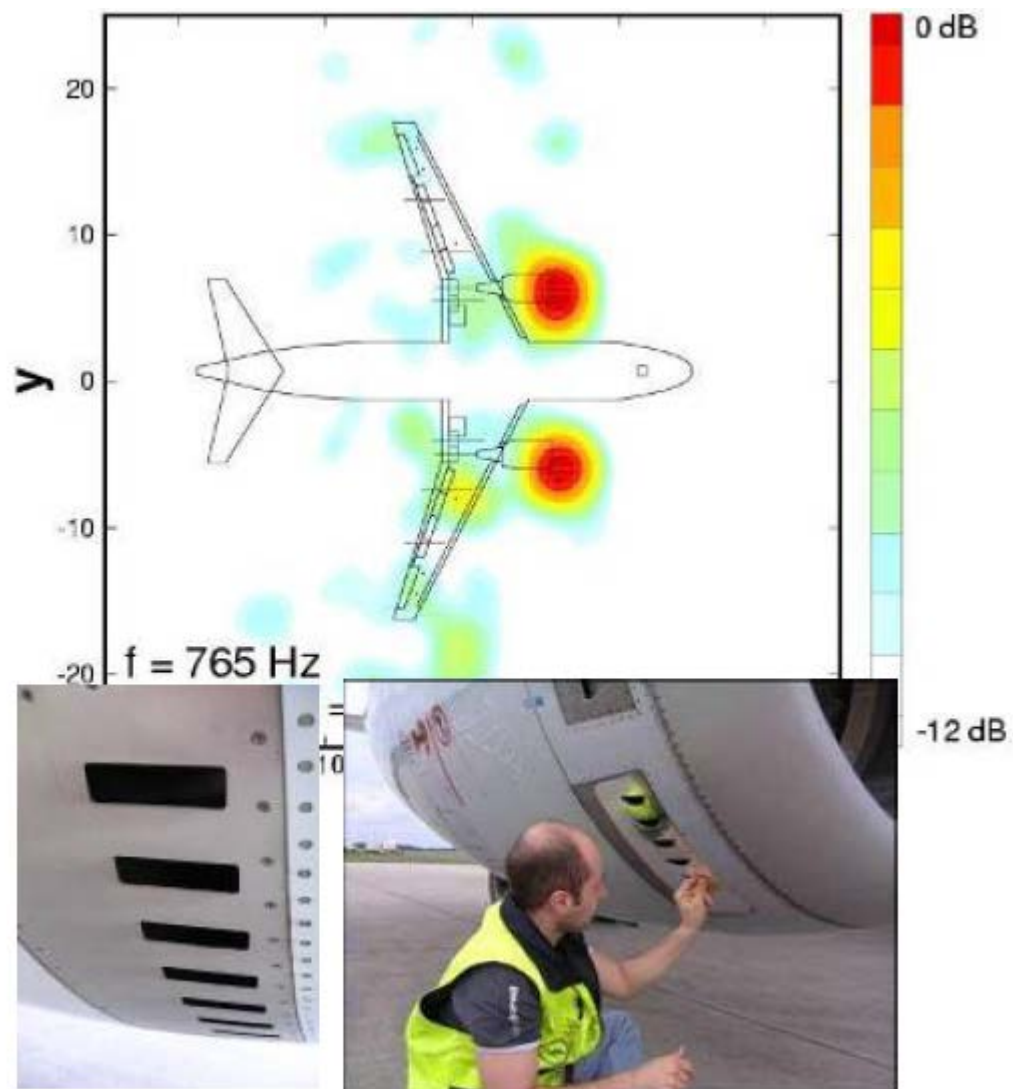


Sources of turbofan engine noise

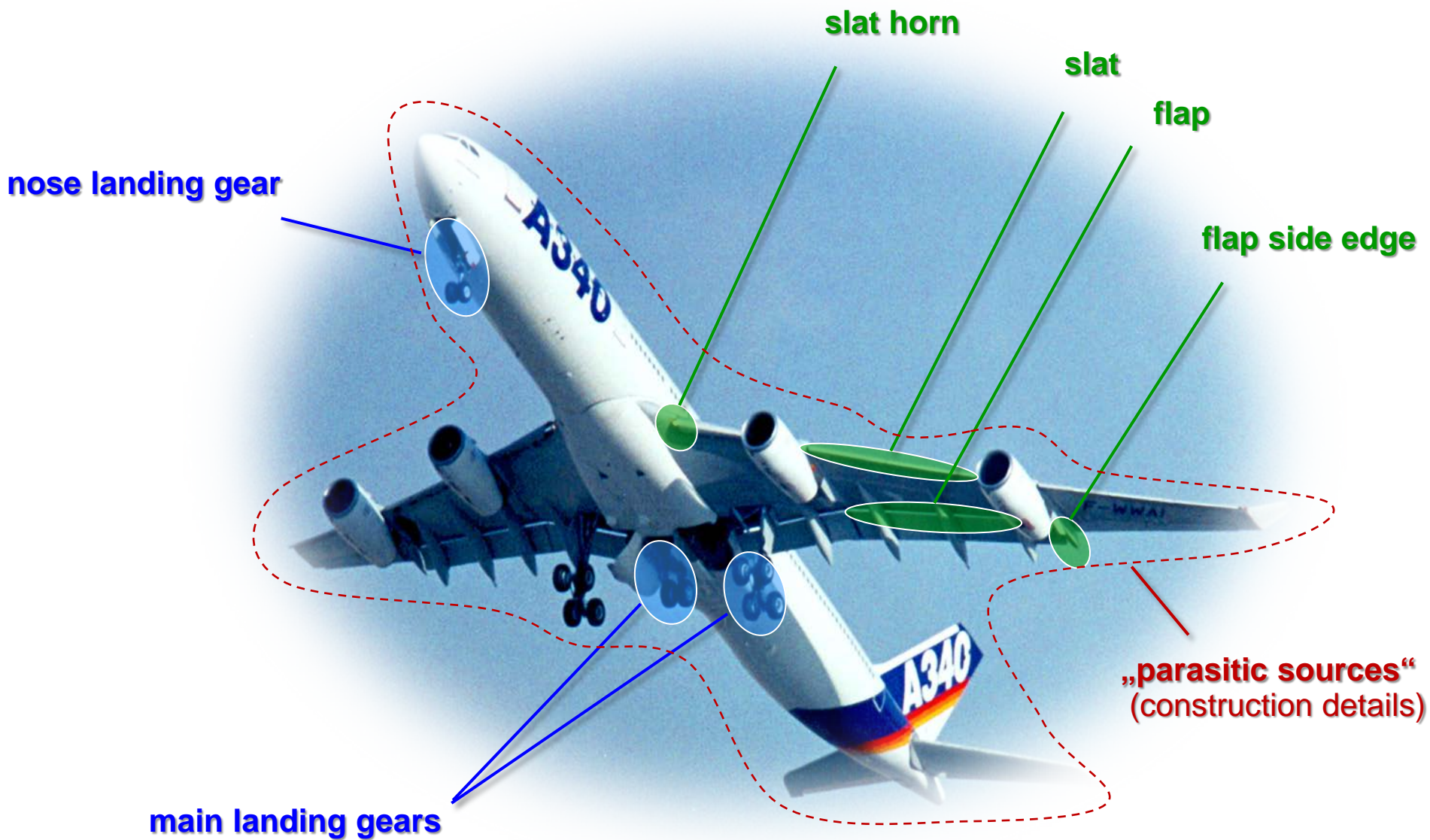


Parasitic tones at engines

Nacelle de-icing air outlets

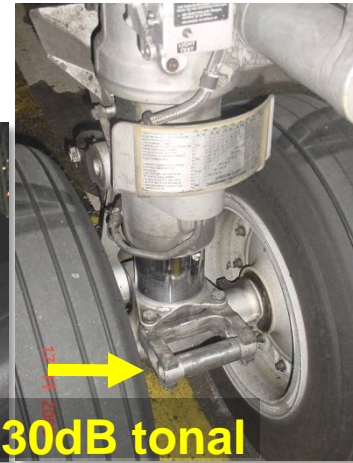
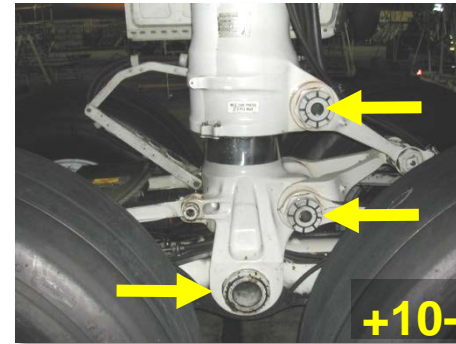


Sources of airframe noise at aircraft



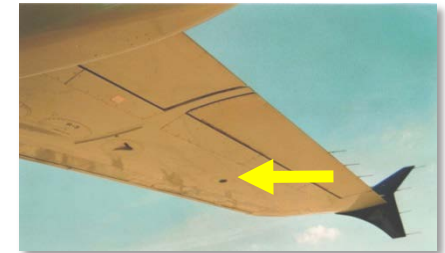
Parasitic sources at real a/c airframes

- tone noise from pin-holes in landing gear pins/bolts (hollow for weight reasons)



+10-30dB tonal

- tone noise from pressure release openings



- broadband excess noise from slat/flap tracks



+2-3dB broadband

- broadband excess noise from recessed geometries

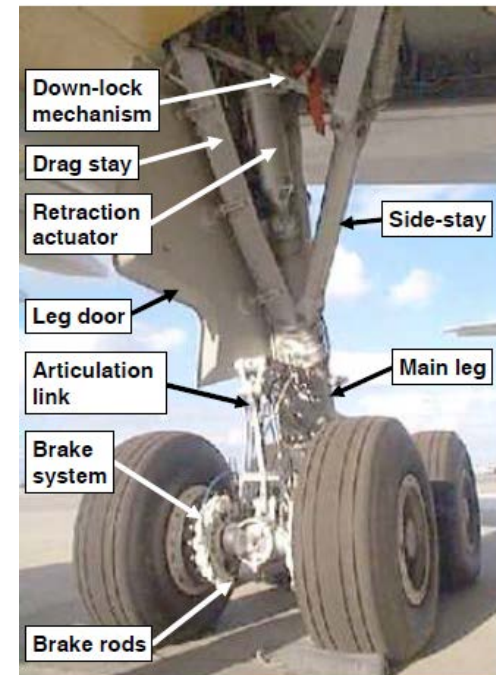


+2-4dB broadband



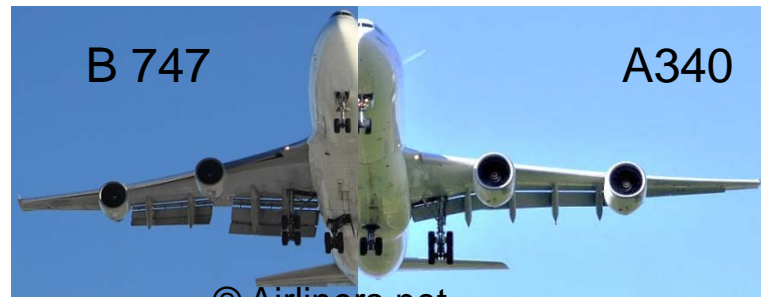
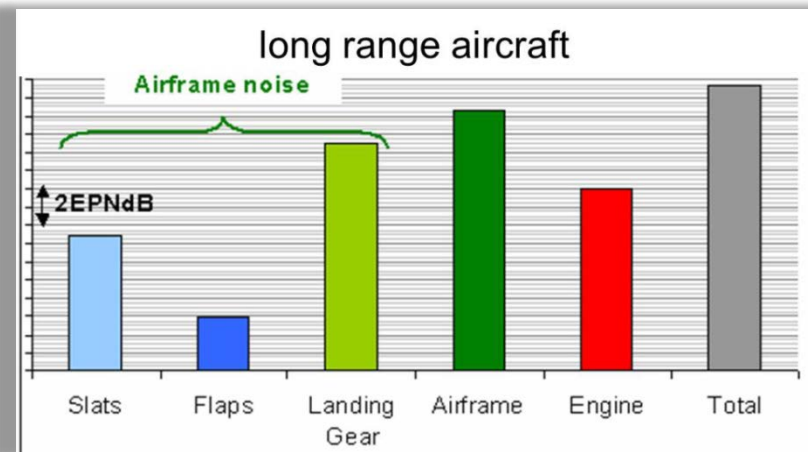
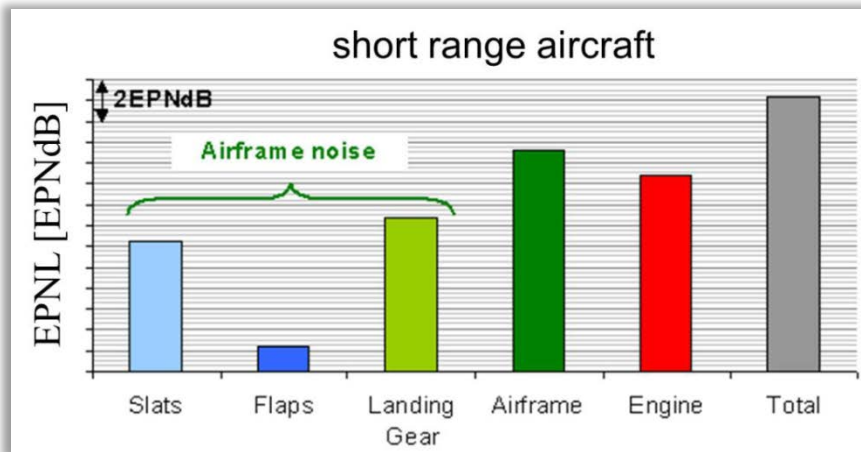
Landing gear noise

- considerable experimental research during past 15 years in EU and USA
- most important source of airframe noise (at certification point)
- very broadband in character (slow roll-off of spectrum)
- size^2 scaling of intensity for similar geometry
- speed^6 scaling of intensity (compact source components)
- no pronounced directivity due to complex cluster of compact sources

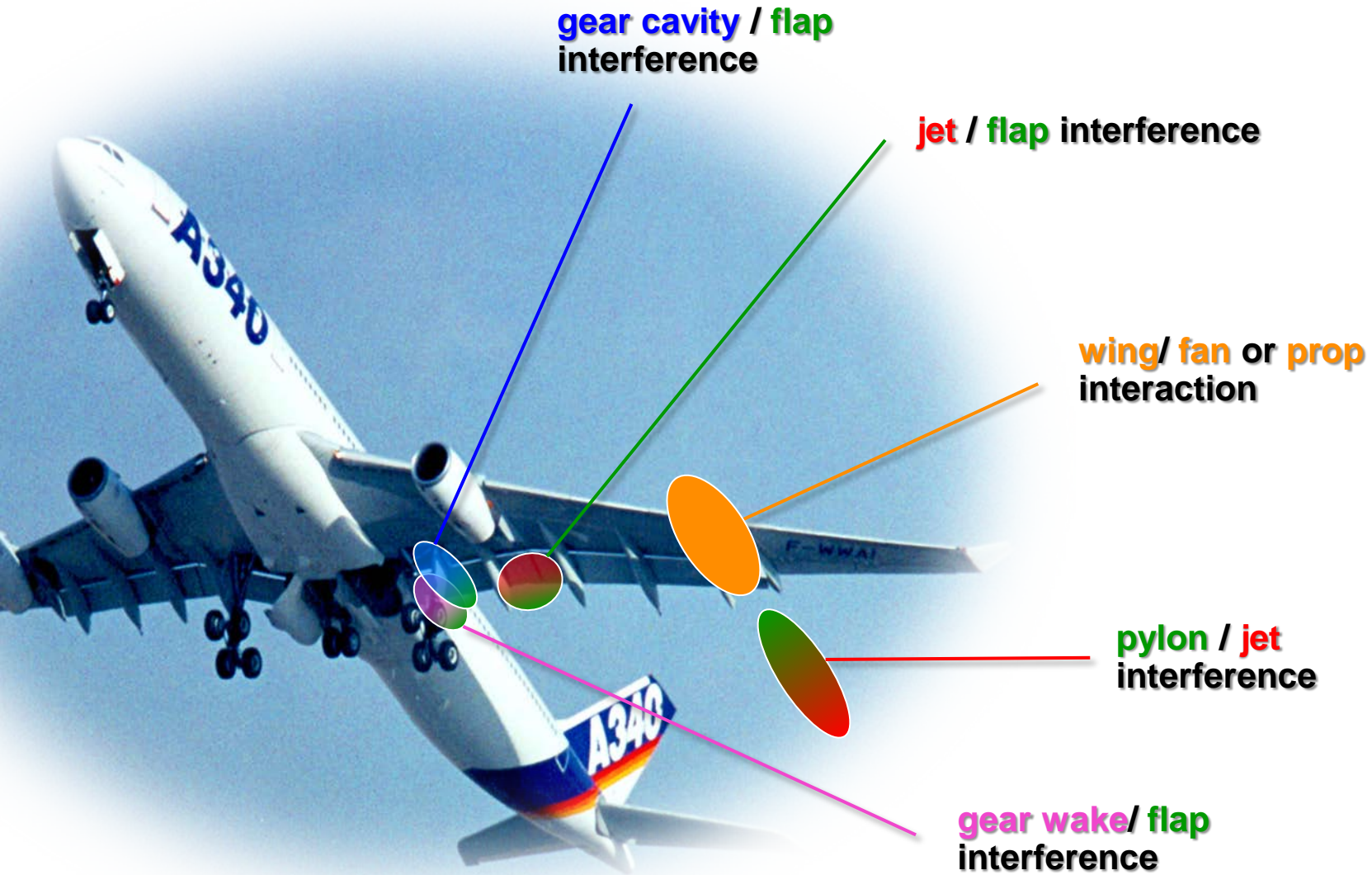


Typical rank ordering of sources at approach

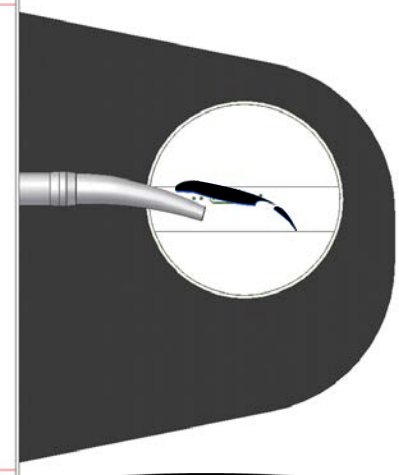
Source: Airbus



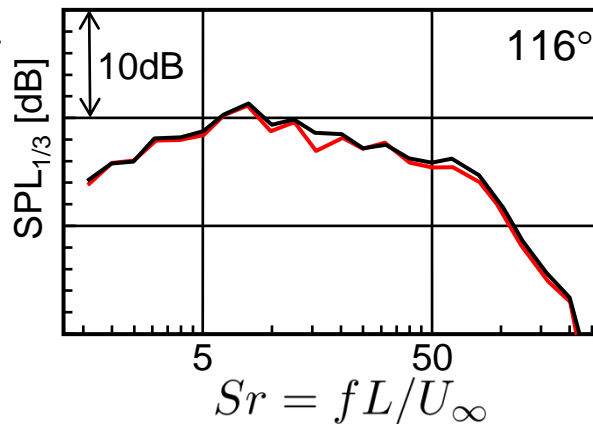
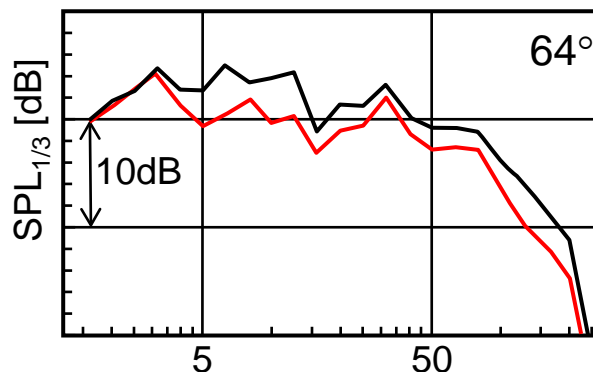
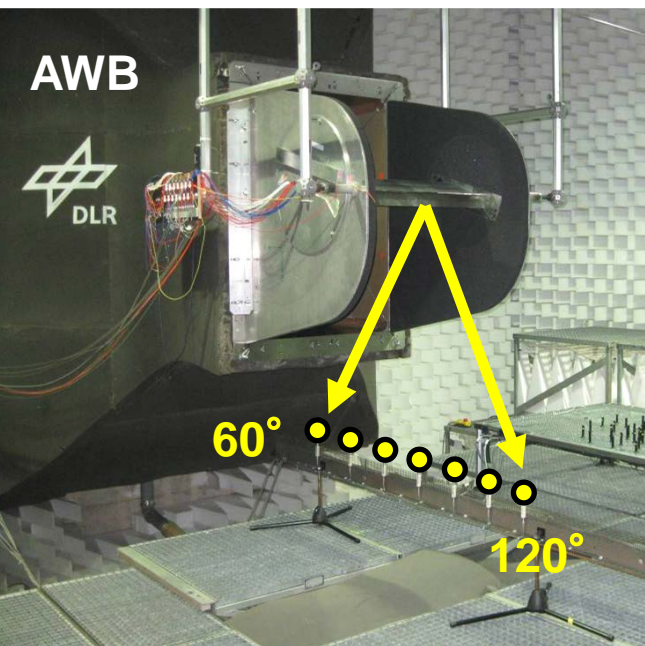
Installation sources of exterior noise at aircraft



Jet flap interference (JFI)

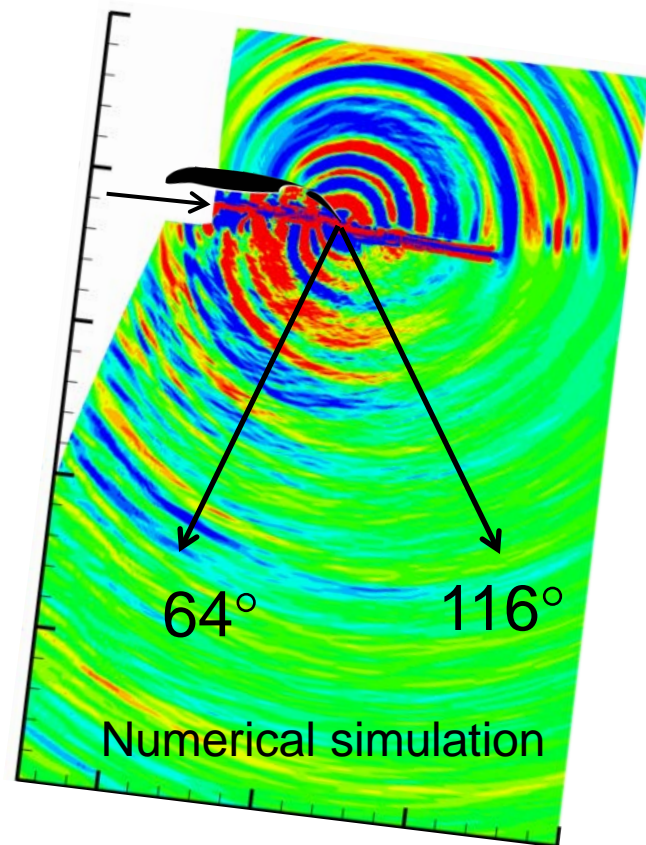


F16 with droop nose



- total
- sum jet + flap (each isolated)

Flight speed $U_{\infty} = 60$ m/s
 Jet speed $U_{jet} = 185$ m/s
 (cold single stream jet)



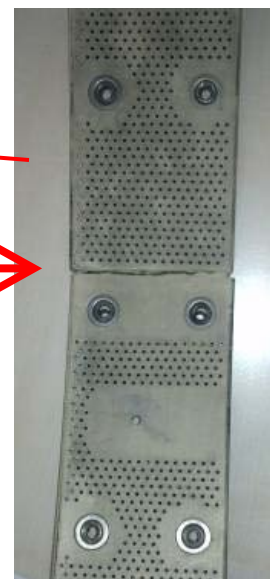
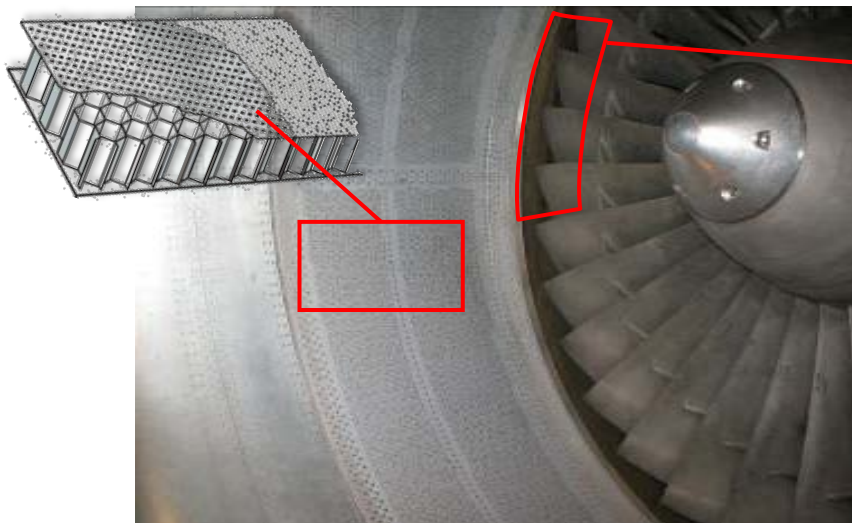
Low noise technologies for current aircraft



Engine noise reduction

fan noise

- lined ducts
- splice-less casing
- nacelle lip-liner
- swept rotor leading edge, swept stator
- cut-off design
- increased diameter



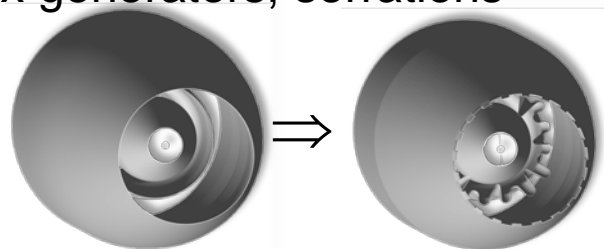
CFM56 C3 fan-forward casing liner

jet noise

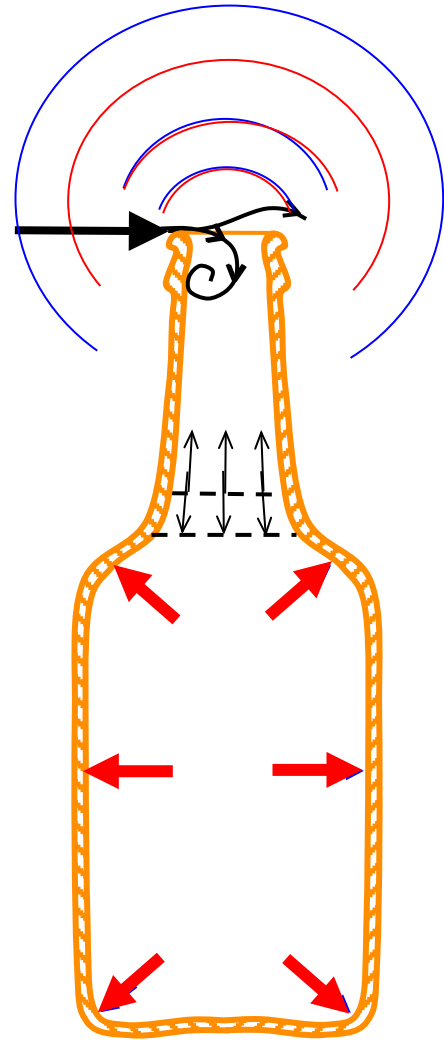
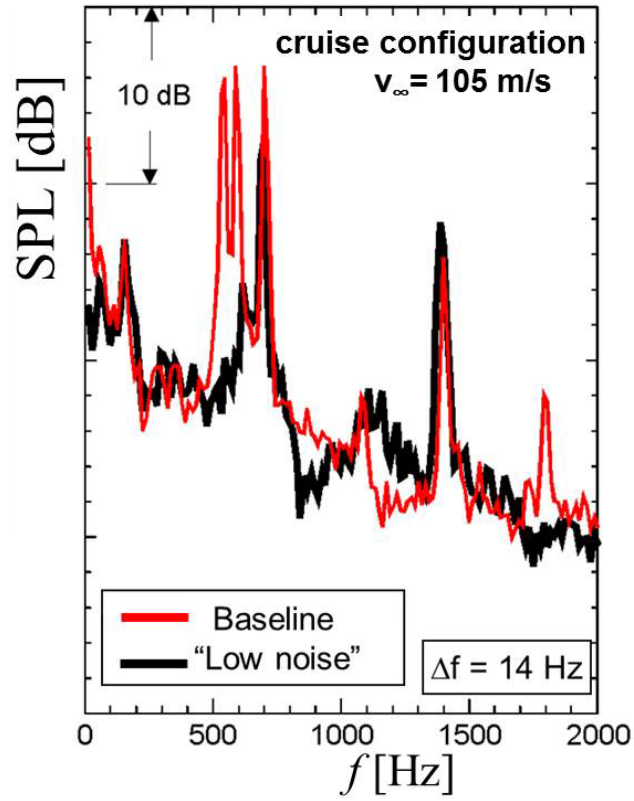
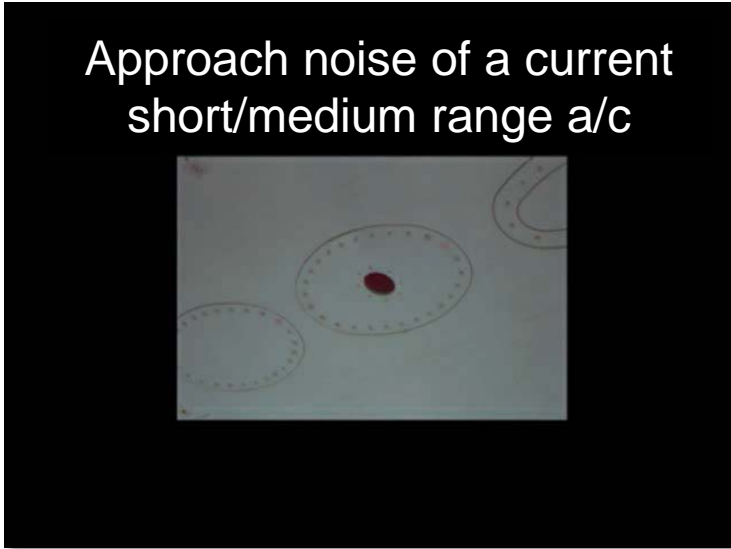
- increased diameter
- internal mixer and/or
- vortex generators, serrations



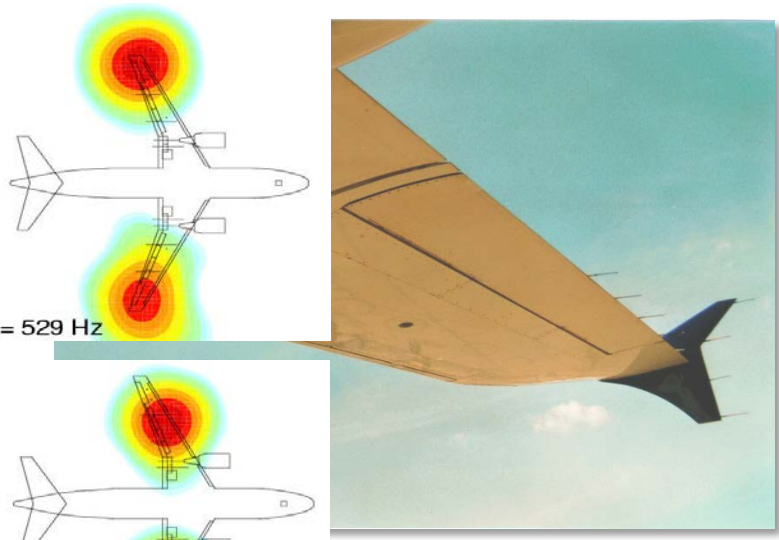
Source: Boeing



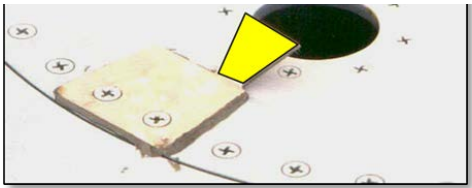
Elimination of parasitic tones at wings



Helmholtz resonator



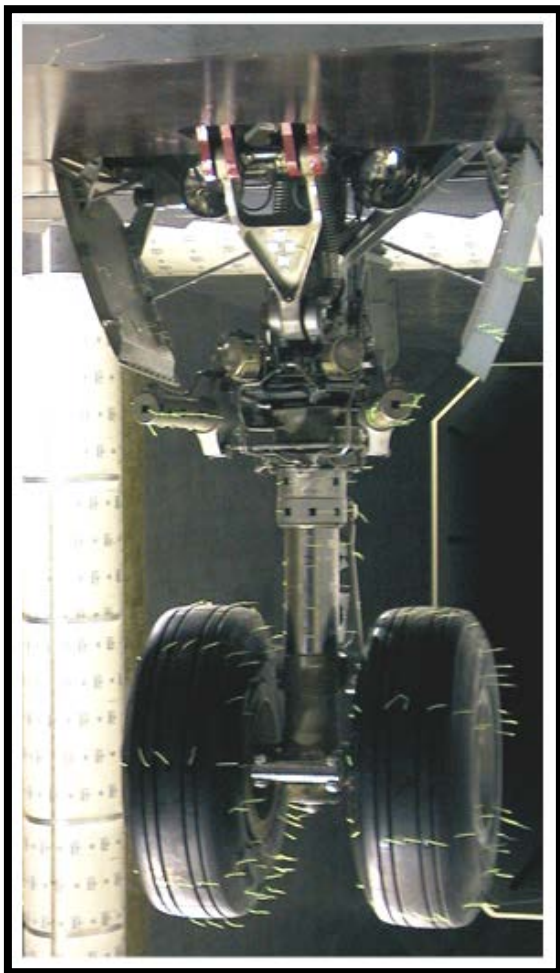
Michel, DLR



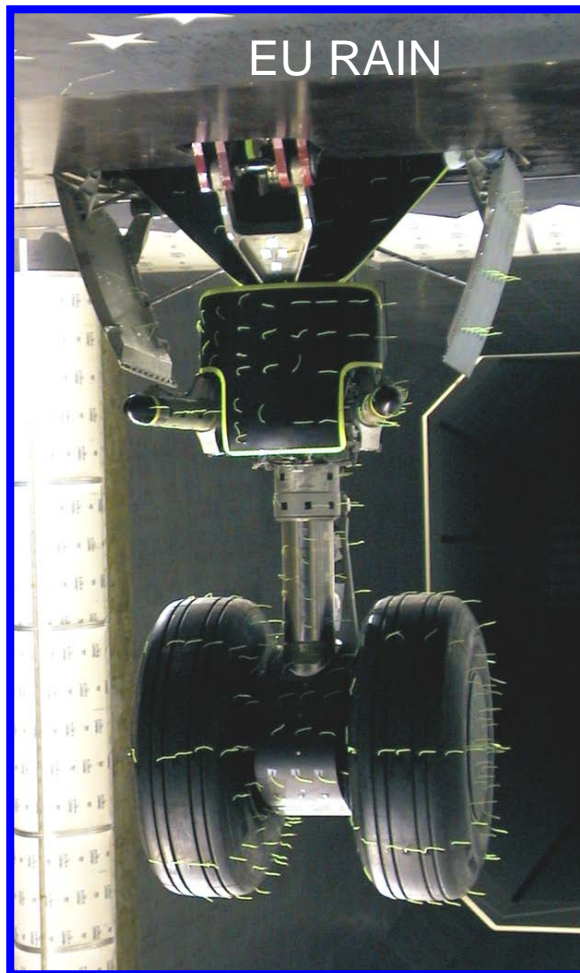
M. Pott-Pollenske et al. 2002



Low noise nose landing gear



A340 nose landing gear



retro-fitted
~ 2.6 dB reduction



low noise NLG
~ 6.3 dB reduction

Low noise main landing gear



A340 main landing gear

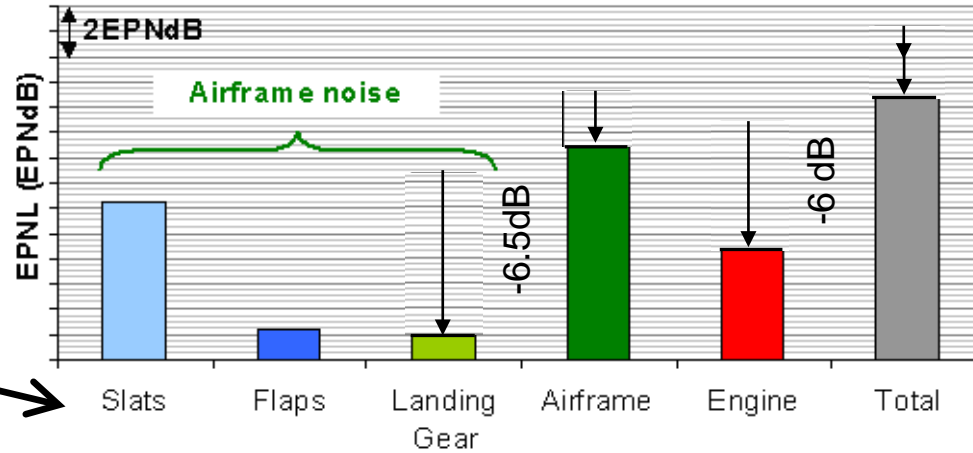


retro fitted
~ 2.5 dB reduction



low noise
8 dB(A) reduction

Significance of high lift devices for airframe noise

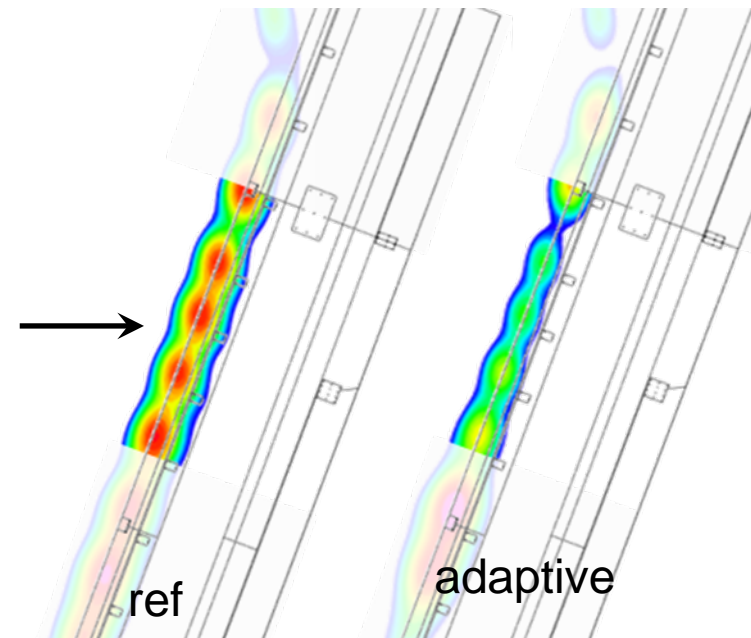
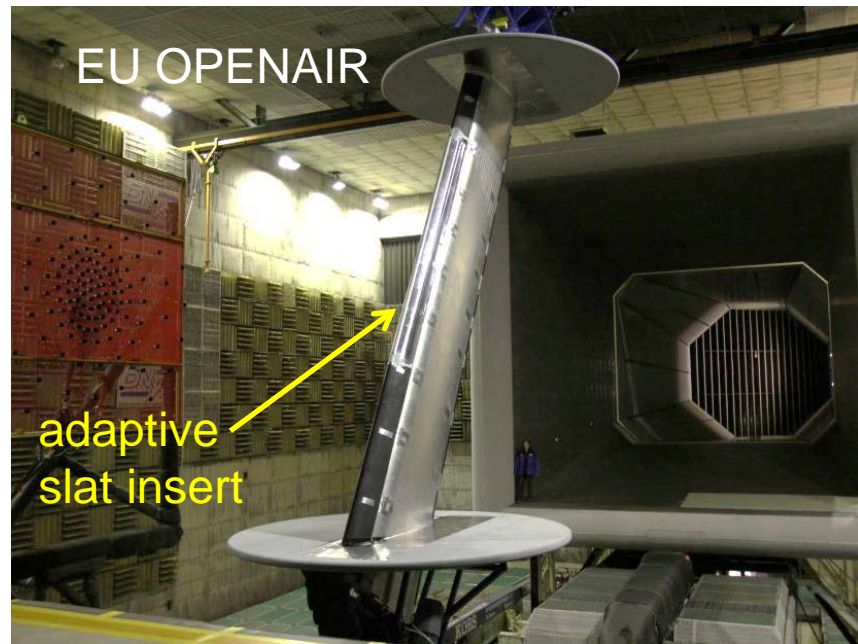
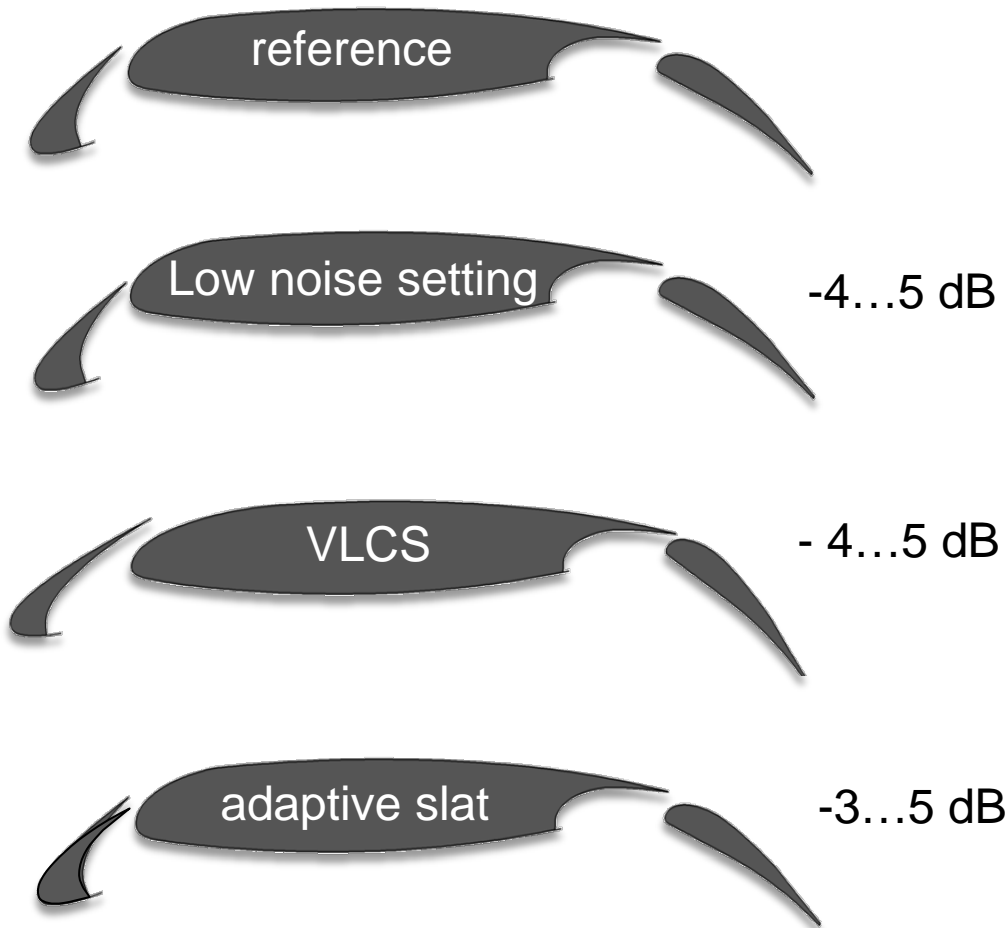


⇒ Noise reduction at landing gear of limited effect for a/c if High Lift Devices unaltered

- But: much more difficult to improve, since aerodynamically highly optimized component
- Significance discovered by DLR (Dobrzynski), 1998



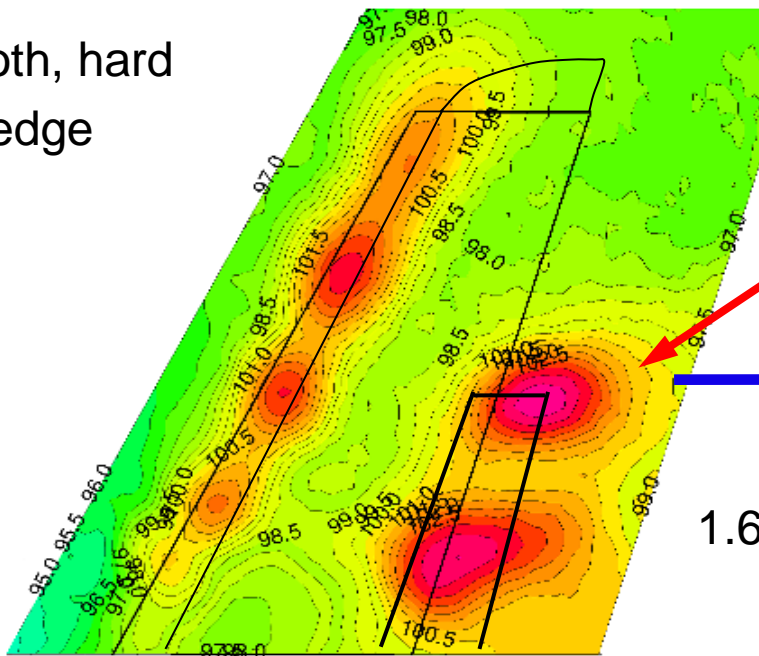
Low noise slat



Noise reduction on flap side edges

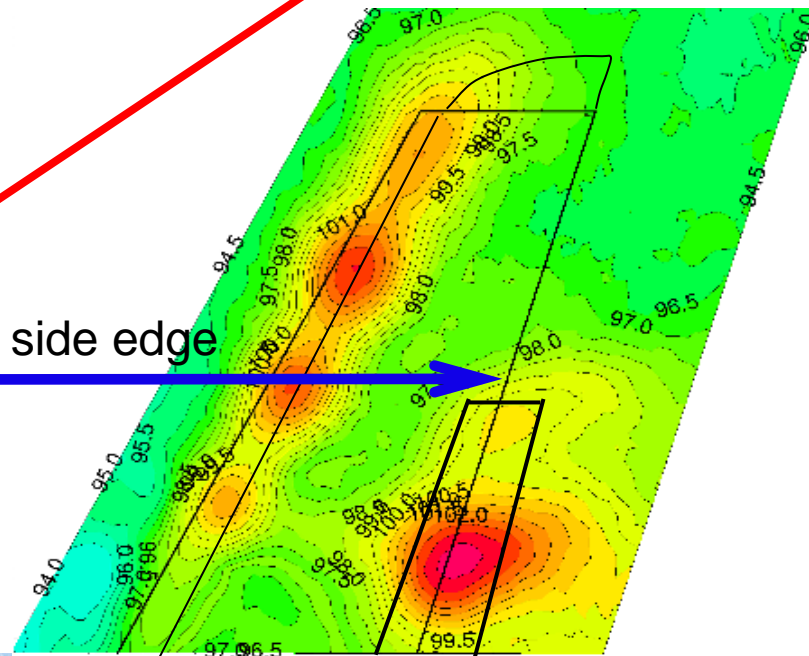


Smooth, hard
side edge



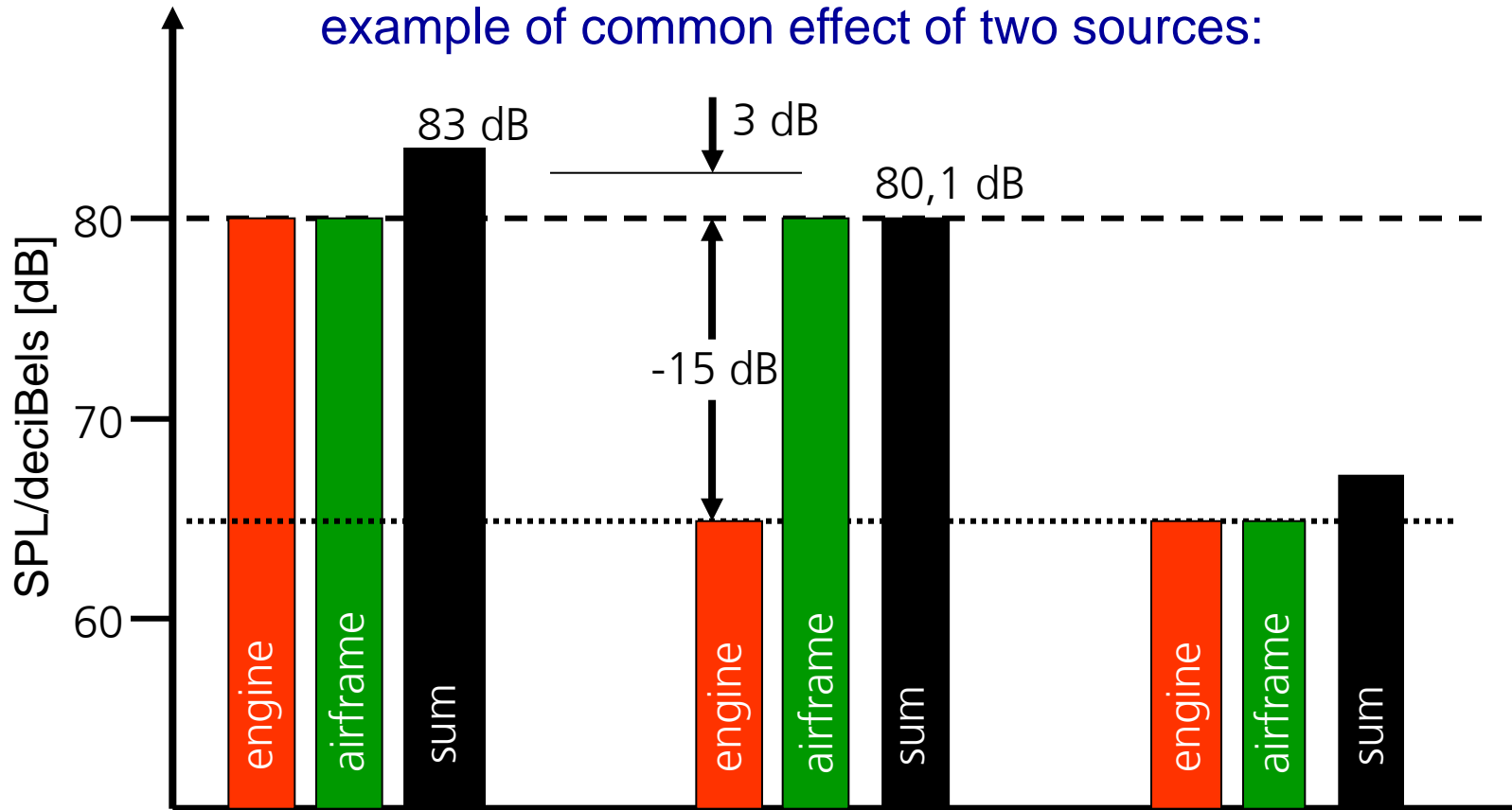
Brush side edge

1.6 kHz



Source noise reduction at complete aircraft

example of common effect of two sources:



For more silent aircraft sources of about equal strength have to be reduced altogether!



Conclusions

- All, engine, airframe, and installation sources important
- considerable progress made in engine low noise technology in the past (most important jet + fan)
- highly effective flyable low noise landing gear technology developed
- high lift system is THE challenge for approach noise
- parasitic sources easily removable
- only partial application of low noise technology will have very limited effect
- next generation transport a/c will be dominated by installation sources
- noise driven a/c architectures? High potential of noise shielding.

