Noise-Reduction Benefits Analyzed for Over-the-Wing-Mounted Advanced Turbofan Engines

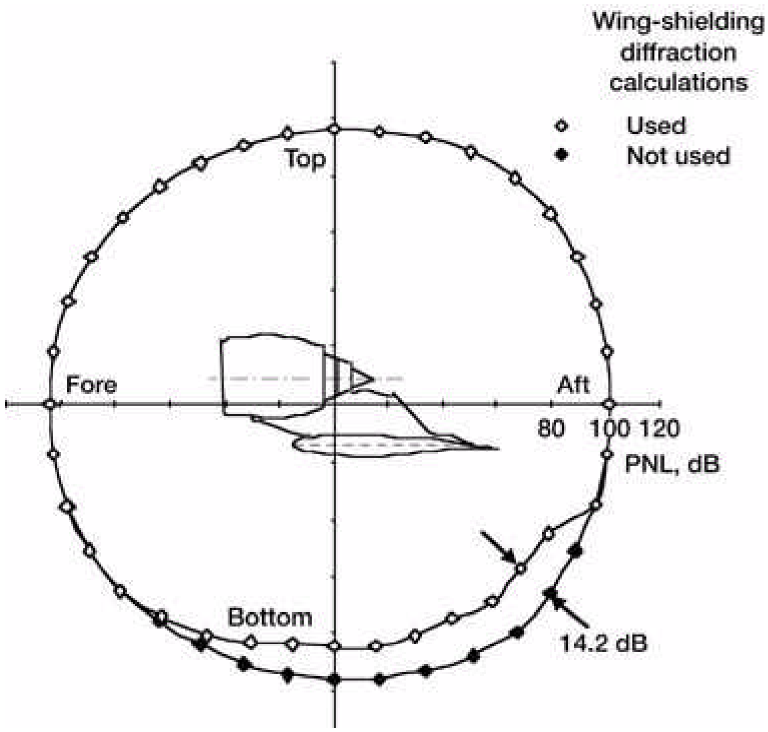
As we look to the future, increasingly stringent civilian aviation noise regulations will require the design and manufacture of extremely quiet commercial aircraft. Also, the large fan diameters of modern engines with increasingly higher bypass ratios pose significant packaging and aircraft installation challenges. One design approach that addresses both of these challenges is to mount the engines above the wing. In addition to allowing the performance trend towards large diameters and high bypass ratio cycles to continue, this approach allows the wing to shield much of the engine noise from people on the ground.

With older technology engines, jet noise was prominent and fan inlet noise was high. Investigations with such engines showed limited noise-reduction benefits from mounting engines above the wing. Experimental wing shielding tests in the 1970's demonstrated reductions of less than 3 dB because the wing chord was not sufficiently large to shield both ends of the engine. Jet noise was particularly difficult to shield efficiently because it is a distributed source downstream of the wing. However, the overall noise signature of advanced turbofan engines with highly loaded, wide-chord fan blades will be dominated by fan discharge noise that can be effectively shielded by the wing. Also, modern, high-pressure cores and high bypass ratio cycles extract significant energy from the core airflow, which tends to reduce primary jet noise. Consequently, designers anticipate that, with fan discharge noise dominating modern turbofans and with jet noise becoming less prominent, wing shielding will be much more effective than it was in the past. Mounting the engines above the wing will also allow designers to install increasingly larger diameter engines more easily and will allow the performance trend toward high bypass ratio cycles to continue.

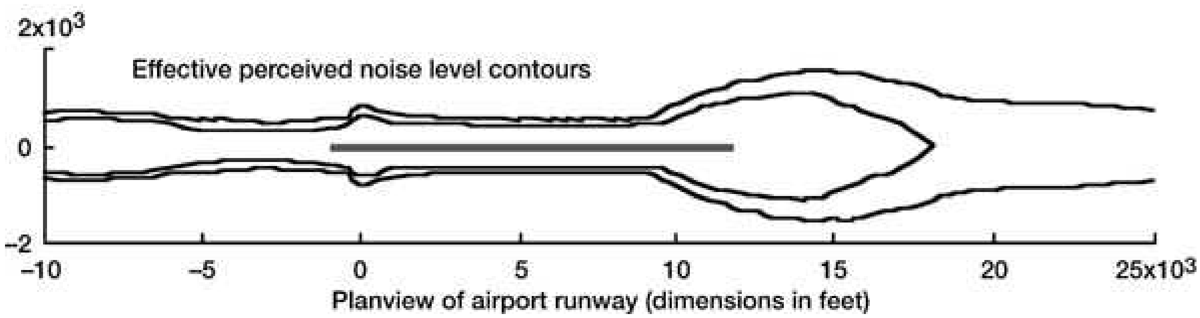
The Propulsion Systems Analysis Office at the NASA Glenn Research Center at Lewis Field conducted independent analytical research to estimate the noise reduction potential of mounting advanced turbofan engines above the wing. Certification noise predictions were made for a notional long-haul commercial quadjet transport. A large quad was chosen because, even under current regulations, such aircraft sometimes experience difficulty in complying with certification noise requirements with a substantial margin. Also, because of its long wing chords, a large airplane would receive the greatest advantage of any noise-shielding benefit.

Fan inlet and discharge source noises were predicted using actual experimental acoustic data measured from fan rig tests conducted at Glenn's 9- by 15-Foot Low-Speed Wind Tunnel. Then, existing analytical models were used to calculate jet, core, and airframe noise sources and propagation effects. A classic partial-barrier diffraction analysis was used to predict the apparent attenuation of the source noise due to wing shielding.

Effective perceived noise levels were calculated for listening points on the ground. In certification parlance, the airplane in this study is 45 cumulative dB below current regulations, 10 cumulative dB of which may be attributed to wing barrier shielding. This compares favorably with the certification noise levels of current large quadjets, which are only approximately 10 cumulative dB below current regulations.



Perceived noise level (PNL) variation in pitch angle with respect to an engine/wing assembly.



Reduction in airport noise "footprint" area resulting from wing shielding. Shown are the 90-dB effective perceived noise level contours around the airport runway, with and without wing shielding diffraction calculations.

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