National Aeronautics and Space Administration

Advanced Air Transport Technology Project

Acoustic Considerations for PAI

(formerly: Ultimate Performance for Podded Propulsors UP^3)

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Acknowledgement to Dr. Russ Thomas and team

www.nasa.gov

The Premise:

Noise is an aircraft system level issue.

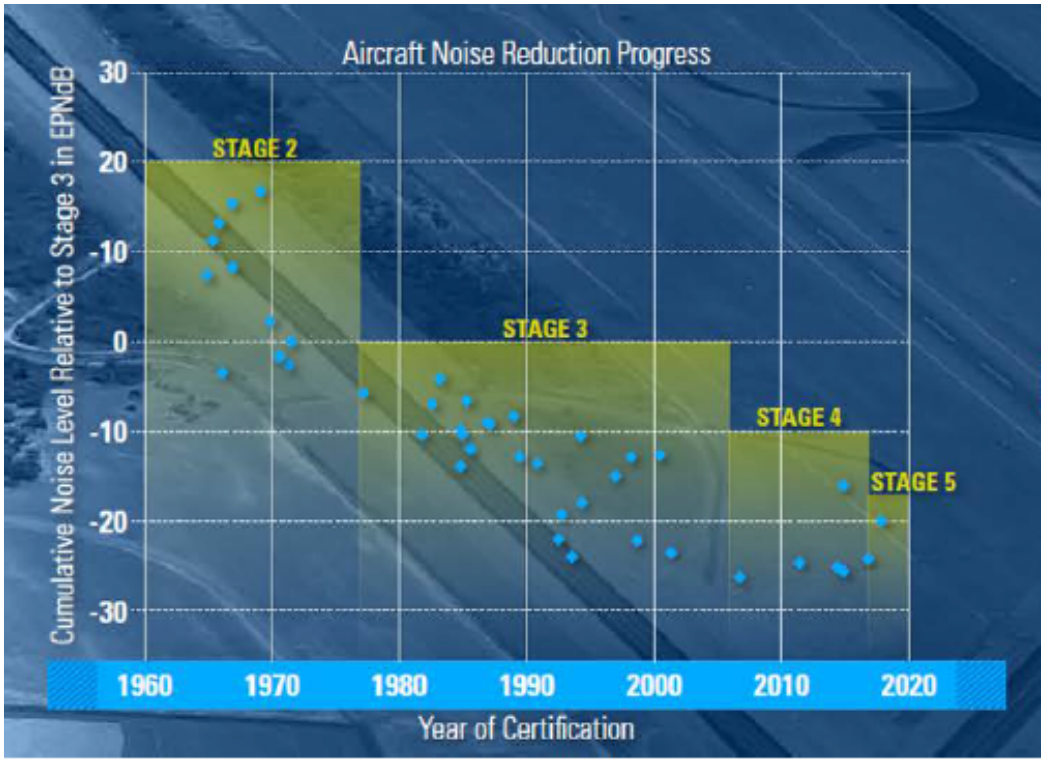
- **The propulsion system noise is influenced by the local aerodynamic environment. (it's easy to make a quiet propulsor noisy with a bad installation)**

- **The presence of aircraft structures near the propulsion system will impact the noise produced and how it radiates to observers (you have to understand the aerodynamics first before you can understand the acoustics)**

Ergo, propulsion airframe integration will have significant influence on the acoustics of the final aircraft system design.

Background

- FAA current noise certification standards for airplanes certificated in the US (known as Stage 5) entered into effect in January 2018 and represents an increase in stringency of 7 EPNdB (cumulative) relative to Stage 4 levels.



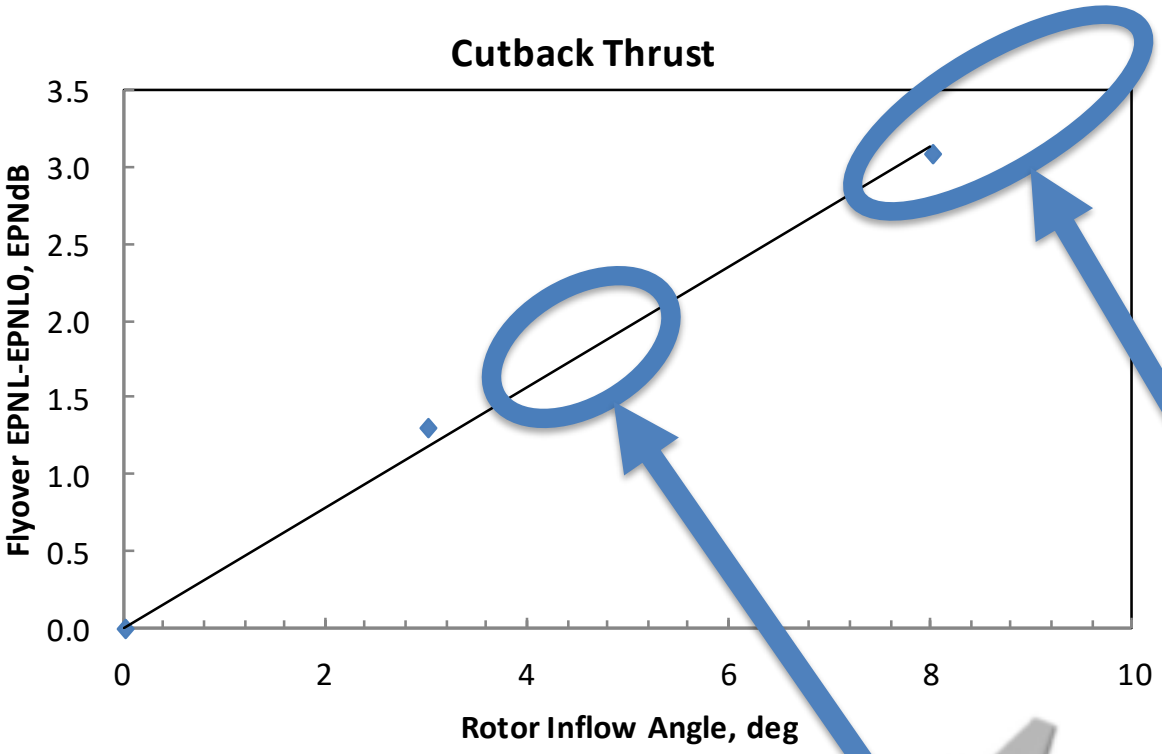
"Despite advances in noise reduction technologies, aviation noise is still the greatest constraint to capacity/growth at airports."

-- Sandy Lancaster, Environmental Program Manager at Dallas-Fort Worth International Airport, during the Acoustics Technical Working Group held at LaRC on April 10, 2018

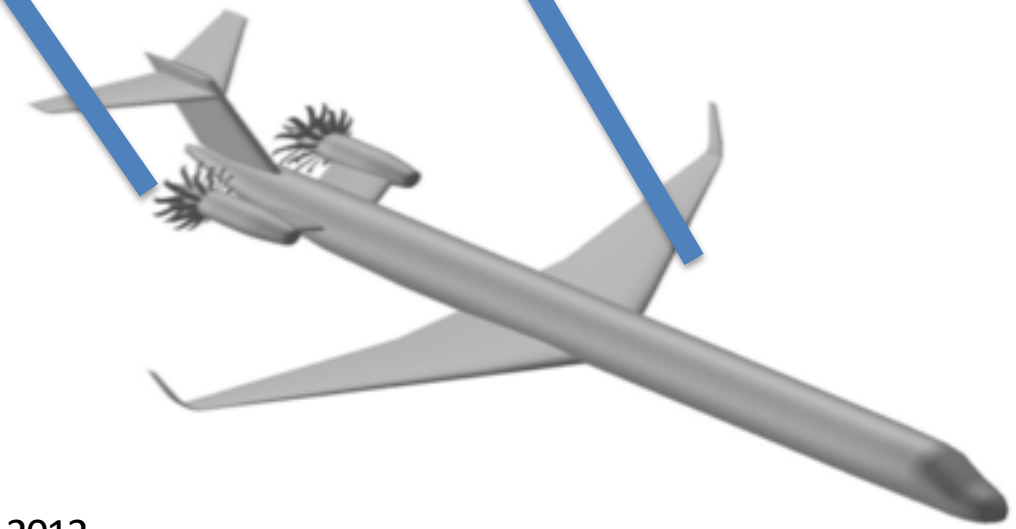
- **By 2030 it is expected that regulations for noise will be much stricter than current Stage 5. At least 2 new stages for regulations might be expected.**

Source: Acoustics Technical Working Group, NASA Langley, April 2018.

Example: PAI impact on noise for Open Rotors

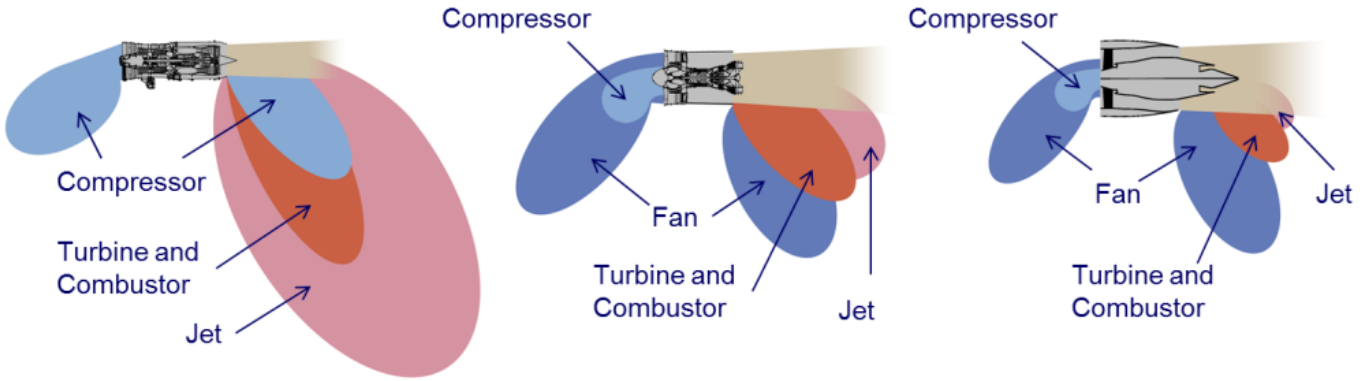


Acoustic installation penalty due to the local flow environment.



Presentation to ICAO Independent Expert Panel, Feb 2012.

Engine noise source character



1960s engine
1:1 BPR

1990s engine
6~8:1 BPR

2015 engine
12:1 BPR

Image: Epstein, 2015

The configuration and cycle characteristics of the new engines will influence the effect of the propulsion system installation on total system noise.

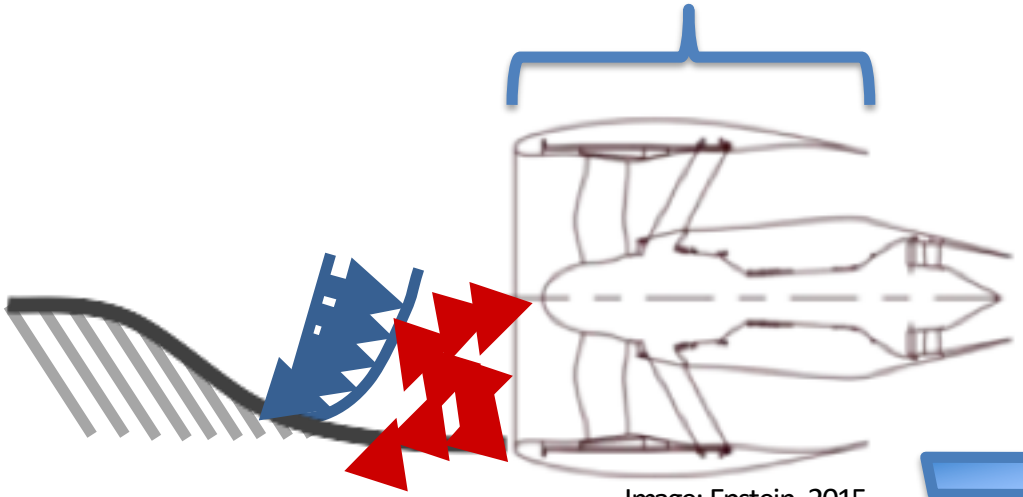
Noise challenges with low FPR engine configurations

Slim/low drag nacelle

Short inlet – large diameter fan

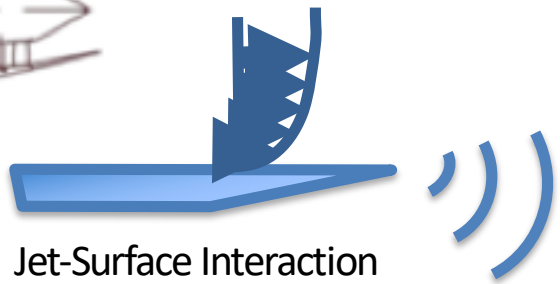
Close rotor-OGV spacing

High PR core with lean-lean combustor

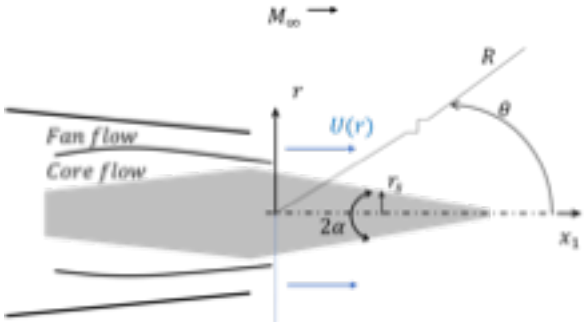


Distortion Induced Noise

Image: Epstein, 2015



Jet-Surface Interaction
Trailing Edge Noise



Fan Exhaust Noise Propagation

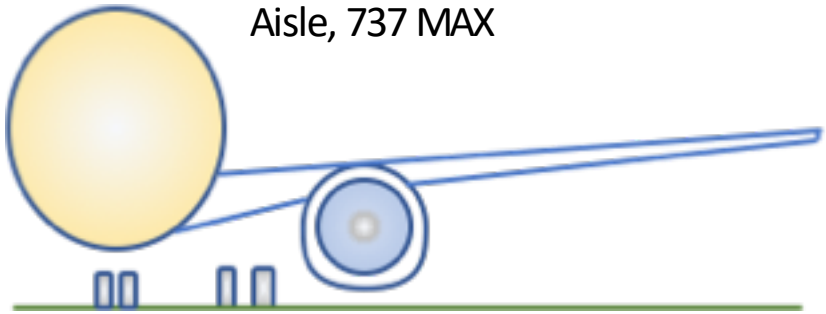
Low FPR engine configuration changes are beneficial, and necessary, for reducing fuel burn, however, but may be detrimental for noise. The inlet and outlet 'boundary conditions' for the engine will influence the overall system noise.

Potential Future Airframes:

What are the acoustics considerations of engine installation on these configurations?

Images: NASA

Installation effects: Reflection and Shielding

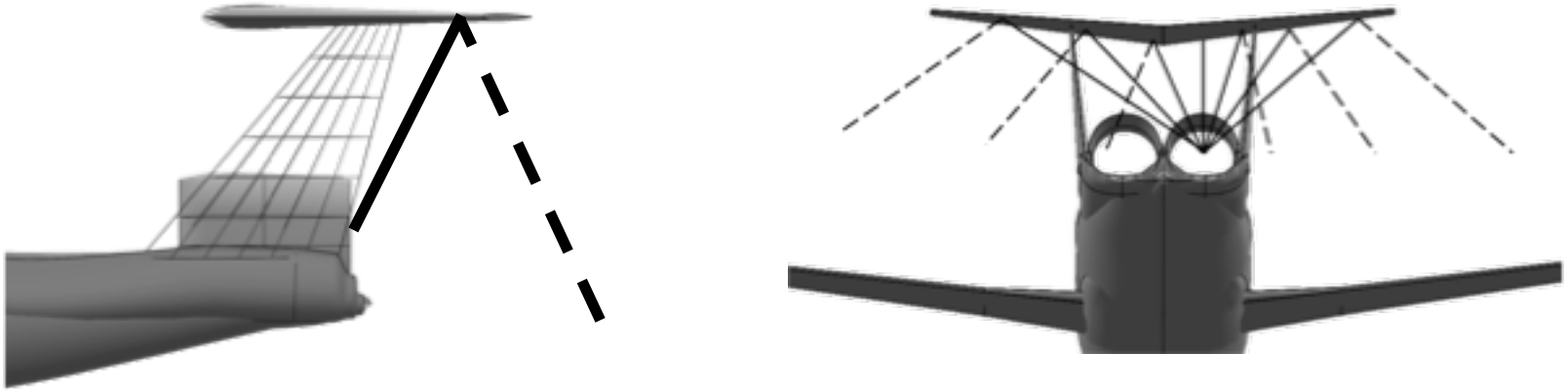


NASA Boeing PAA Chevron Nozzle in 2005

Large diameter engines must be 'tucked in' tighter to the wing underside leading to increased scrubbing noise and reflection.

Installation effects: Reflection and Shielding

The NASA D8 engine and tail configuration

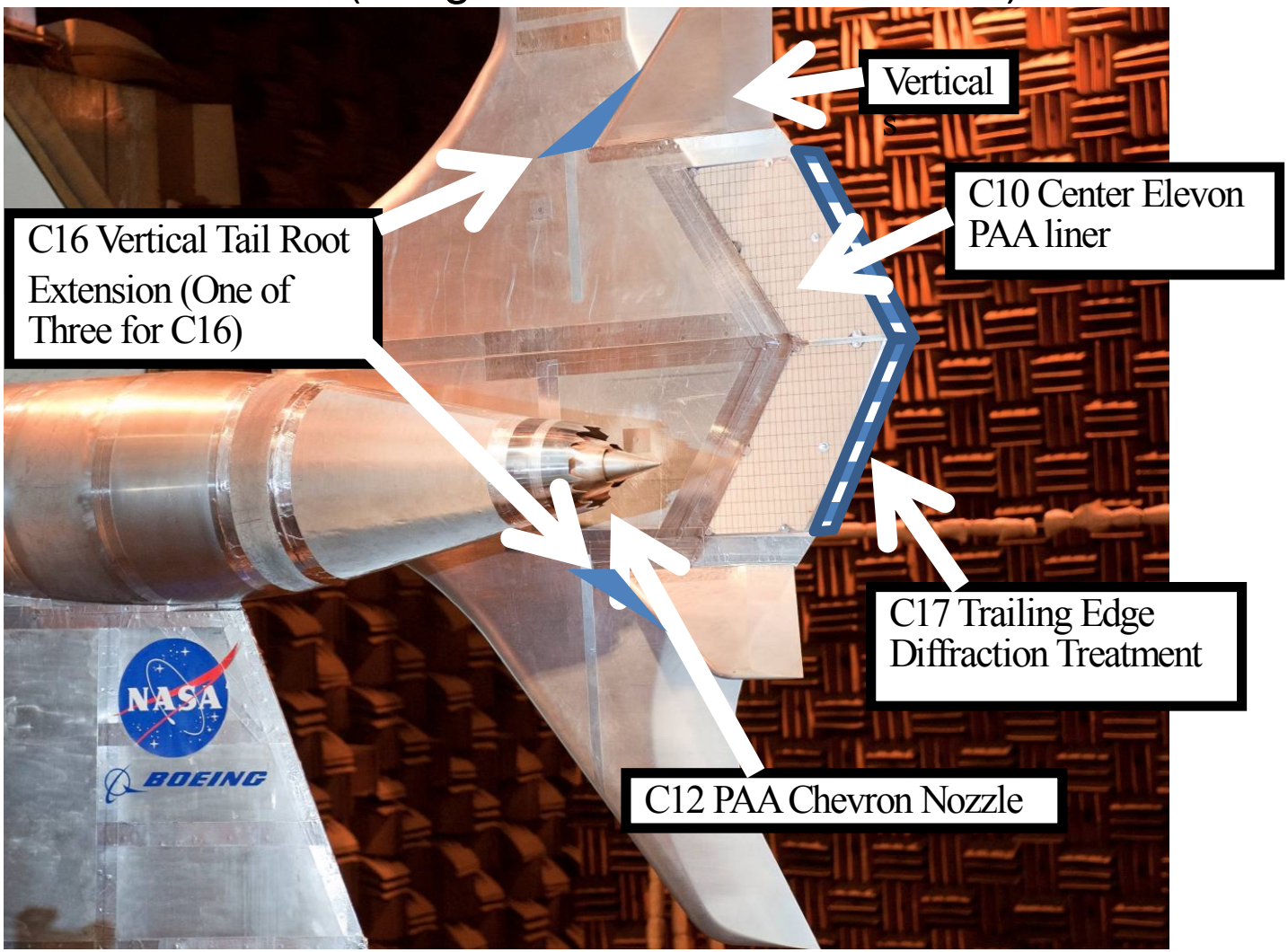


Accurate noise estimates for the D8 will require validated distortion induced propulsion noise models as well as trailing edge, reflection and shielding models.

From: Clark, I. A., Thomas, R. H., and Guo, Y., "Aircraft System Noise Assessment of the NASA D8 Subsonic Transport Concept," 24th AIAA/CEAS Aeroacoustics Conference, Atlanta, Georgia, 2018.

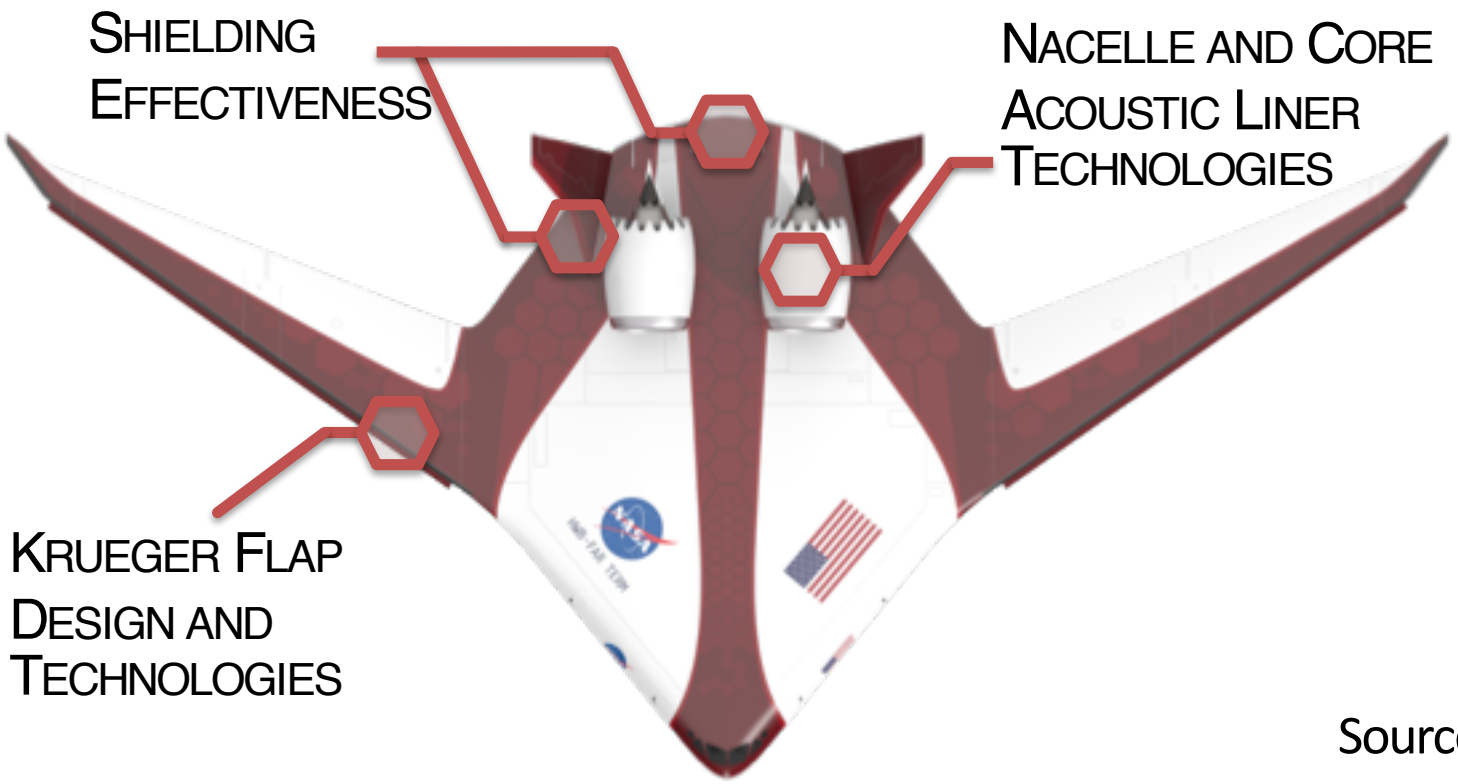
Non-traditional use of acoustic liners

NASA / Boeing Series of PAA Experiments 2004-2012
(image from AIAA-2013-0541)



Application of external liners might be possible for under wing mounted engines also.

What if noise regulations force a configuration change?



Source: NASA image
AIAA-2017-3193

An aircraft configuration change is necessary to achieve the long term NASA noise goal. Engine placement is one of the factors in producing ultra quiet configurations.

Summary

Noise regulations for future transport aircraft may require greater attention to the engine installation impact on the aircraft acoustic signature.

New engine cycles/configurations and aircraft configurations will require validation data to support accurate noise estimates in the design process:

For example:
distortion induced noise
surfaces near the propulsion system

Airframe and engine development have often progressed as parallel but separate activities. Going forward, PAI/PAA specific tests (with accurate propulsion simulation) may be necessary, therefore, test methods for airframes and propulsors must be harmonized.