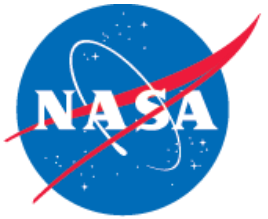

Noise Reduction Approaches for the NASA D8 Subsonic Transport Concept

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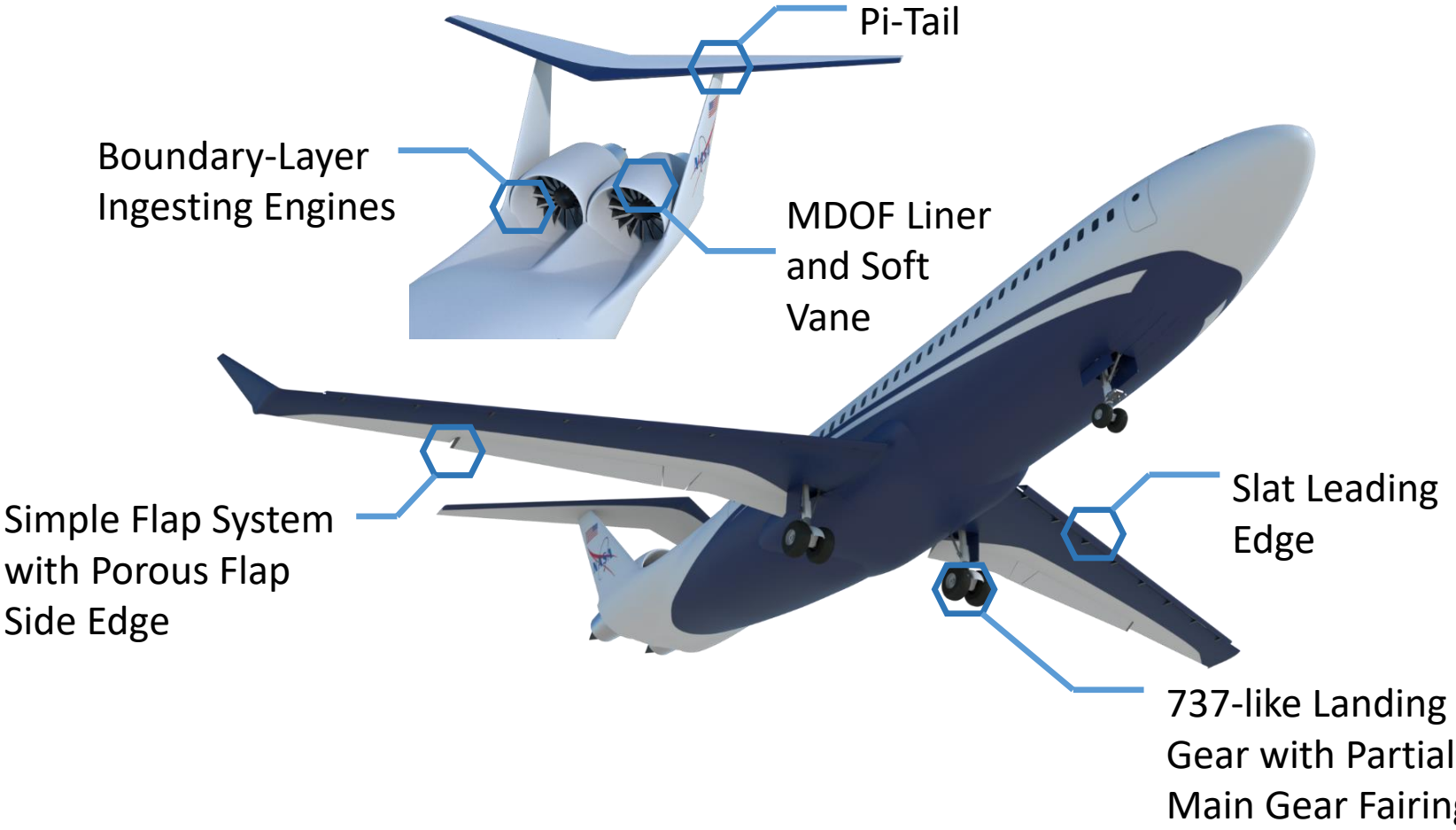
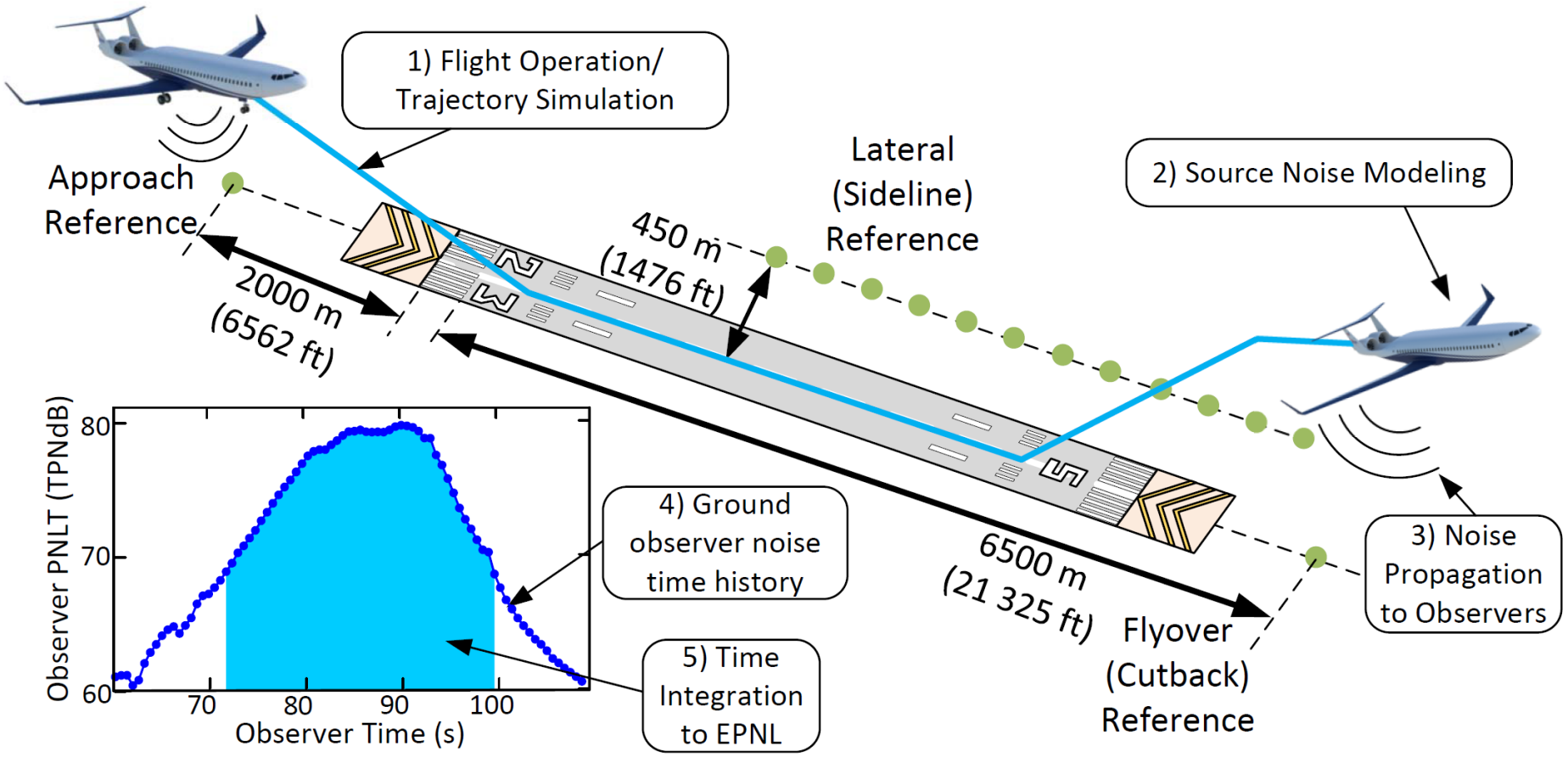
- Jason June, John Rawls, and Stuart Pope for their contributions to the Aircraft System Noise and Propulsion Airframe Aeroacoustics Team.
- The Advanced Concepts Laboratory, Analytical Mechanics Associates, for providing the artist renderings of the vehicle and technologies.

Background

- System noise of the NASA D8 aircraft concept predicted and presented at Aviation 2018 (AIAA-2018-3124).

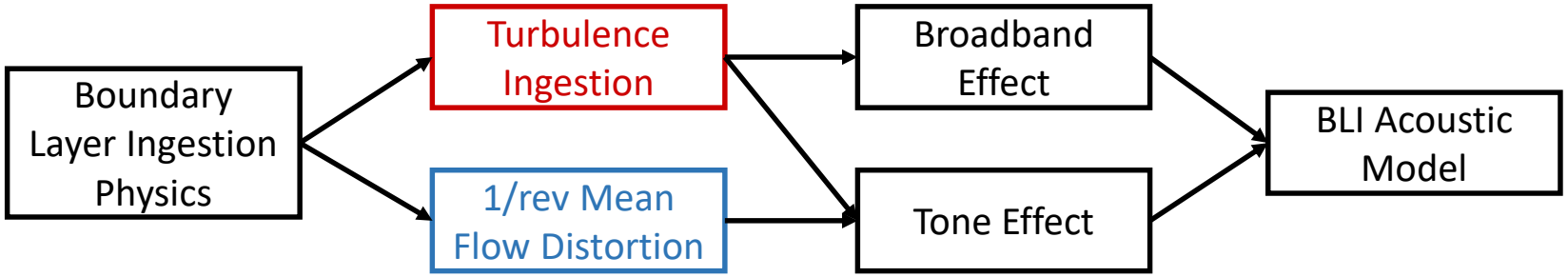


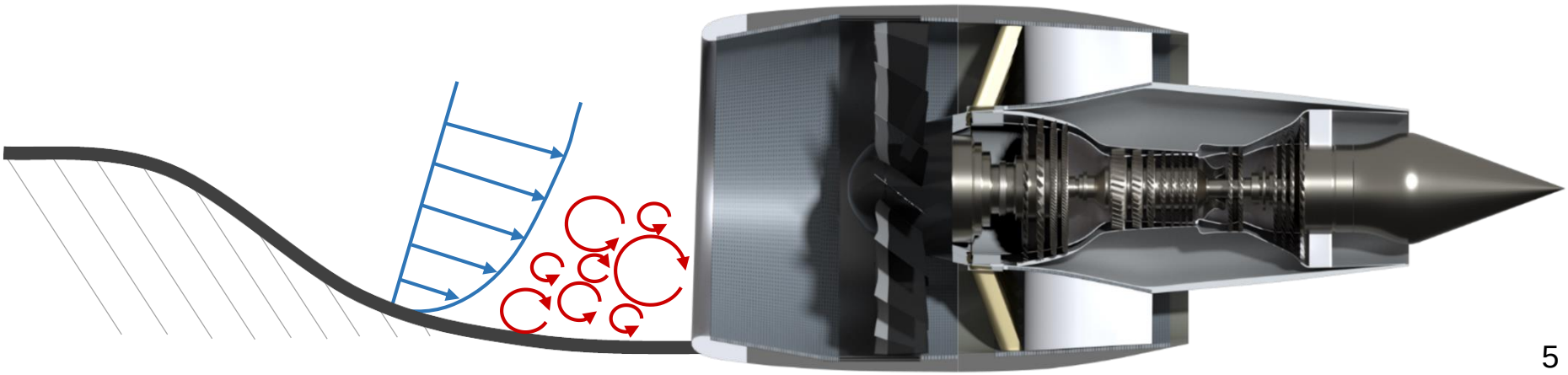
Noise Prediction Framework



Boundary Layer Ingestion Noise

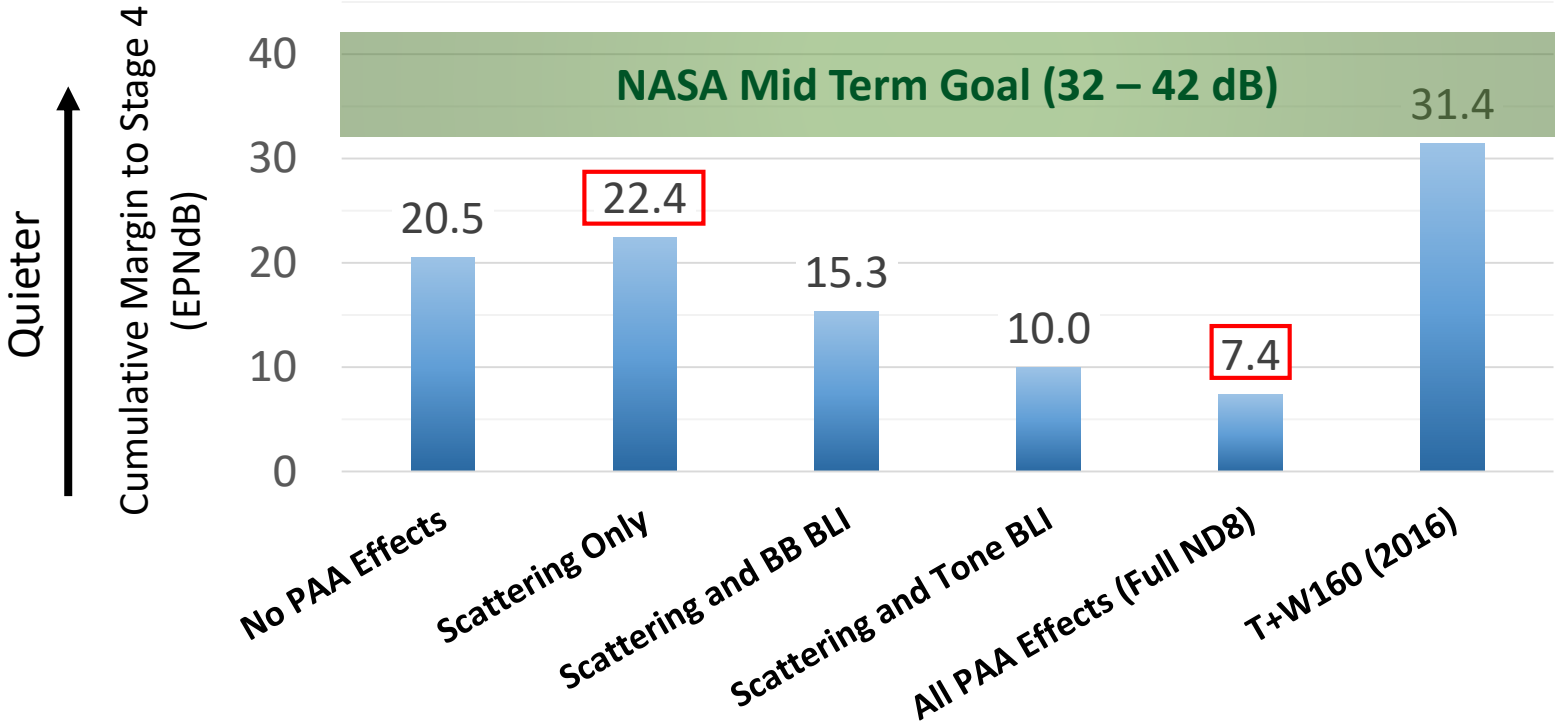
- Boundary layer ingestion (BLI) identified as key noise mechanism, limiting the ND8's potential as a low noise aircraft.





Results of Initial System Study

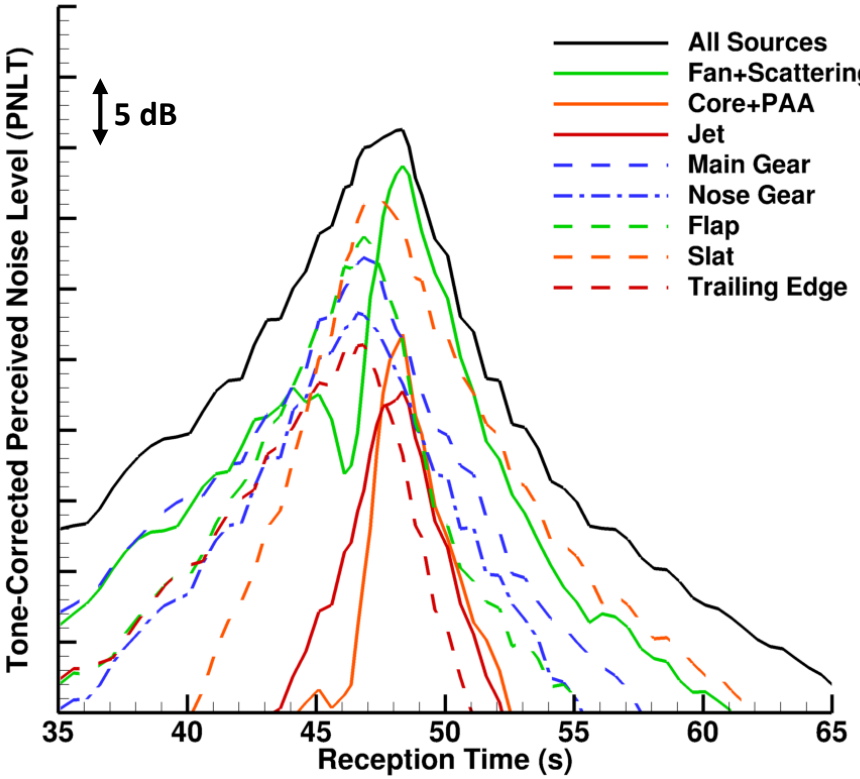
- Reflections from the pi-tail add to the unshielded aft-radiated noise from the fan, which is limited in bypass ratio by the pi-tail.



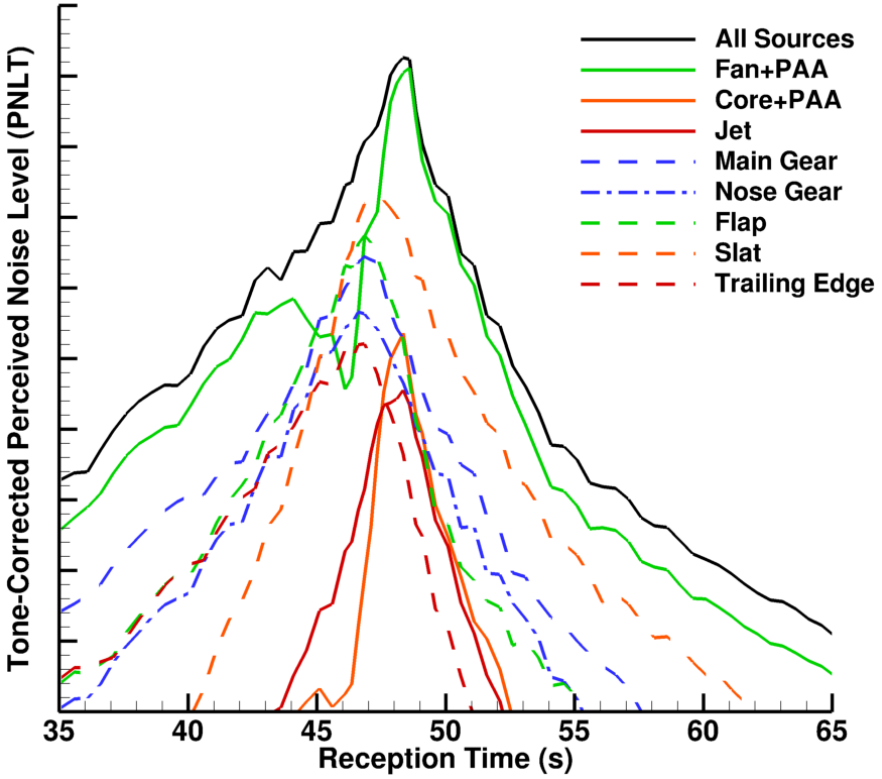
	Approach	Sideline	Cutback	Total
BLI Penalty (EPNdB)	**2.8**	**6.5**	**5.7**	**15.0**

ND8 PNLT - Approach

BLI Suppressed:

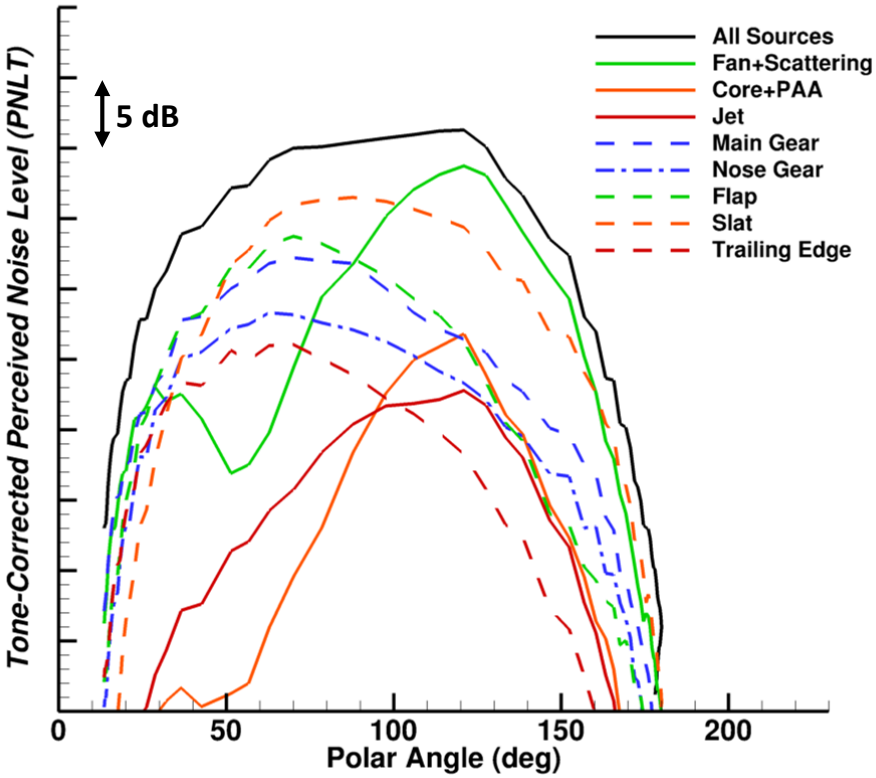


BLI Present:



ND8 PNLT - Approach

BLI Suppressed:



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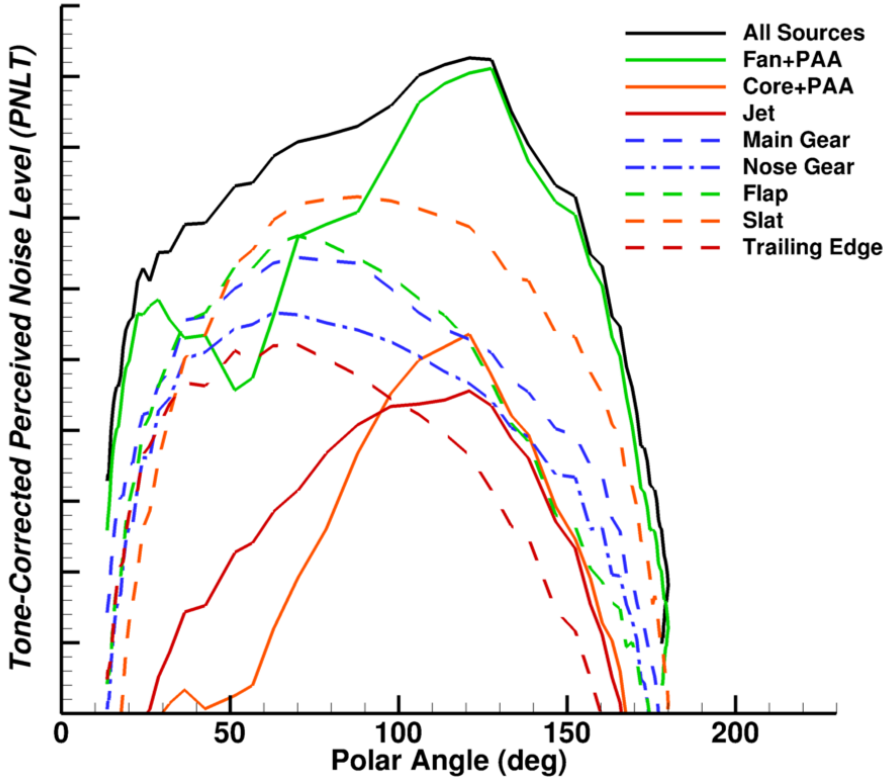
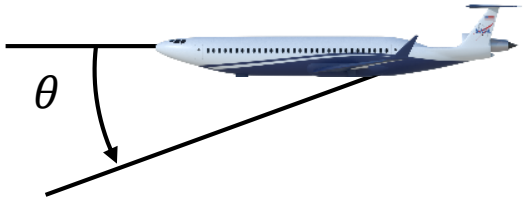
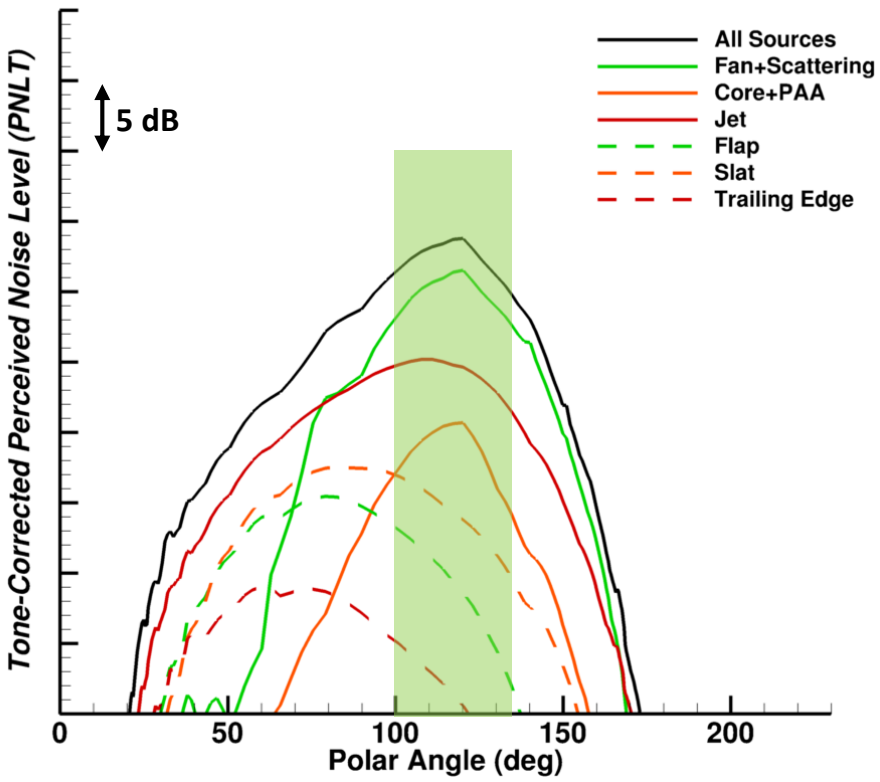


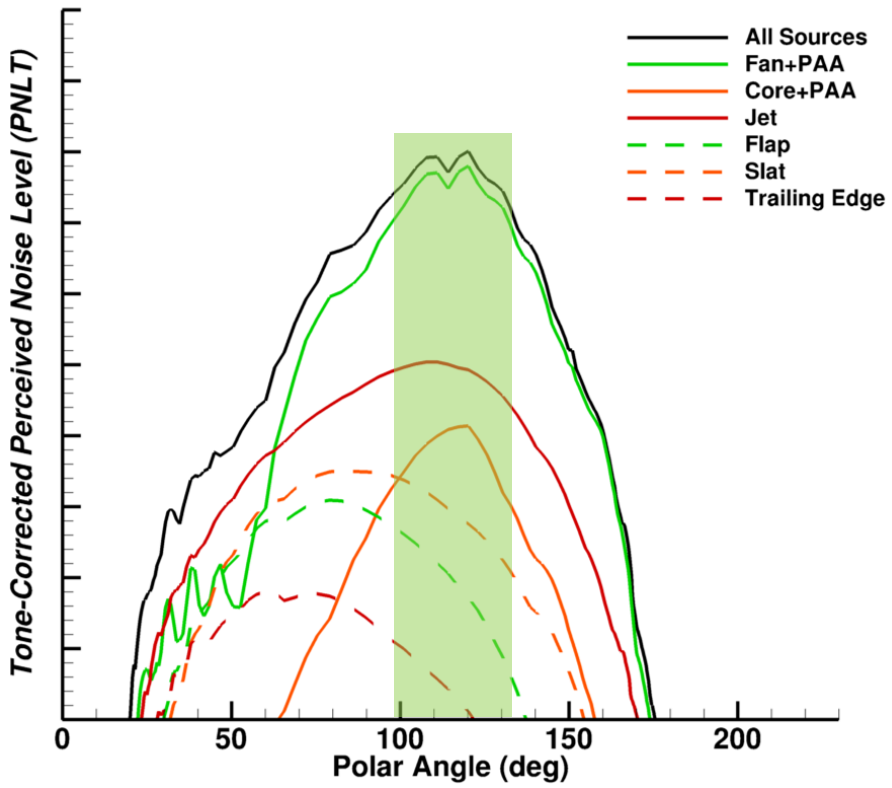


ND8 PNLT - Cutback

BLI Suppressed:



BLI Present:



Target aft-radiated fan noise for maximum system noise reduction.

Objectives

- Incorporate far term technologies to reduce fan noise (the dominant source) of the ND8:
  - Bifurcation liners
  - Over-the-rotor treatment[1]
  - PAA liner on tail[2,3]
  - Scarfed fan nozzle
- Evaluate the effect of a tail reconfiguration to eliminate reflections
- Quantify BLI effect with far term technologies included
- Identify further strategies for noise reduction

[1]Sutliff, D. L., Jones, M. G. and Hartley, T. C., "Attenuation of FJ44 Turbofan Engine Noise with a Foam-Metal Liner Installed Over-the-Rotor," *15th AIAA/CEAS Aeroacoustics Conference*, Miami, Florida, 2009. AIAA Paper 2009-3141.

[2]Czech, M. J. and Thomas, R. H., "Open Rotor Aeroacoustic Installation Effects for Conventional and Unconventional Airframes," 19th AIAA/CEAS Aeroacoustics Conference, Berlin, Germany, 2013. AIAA Paper 2013-2185.

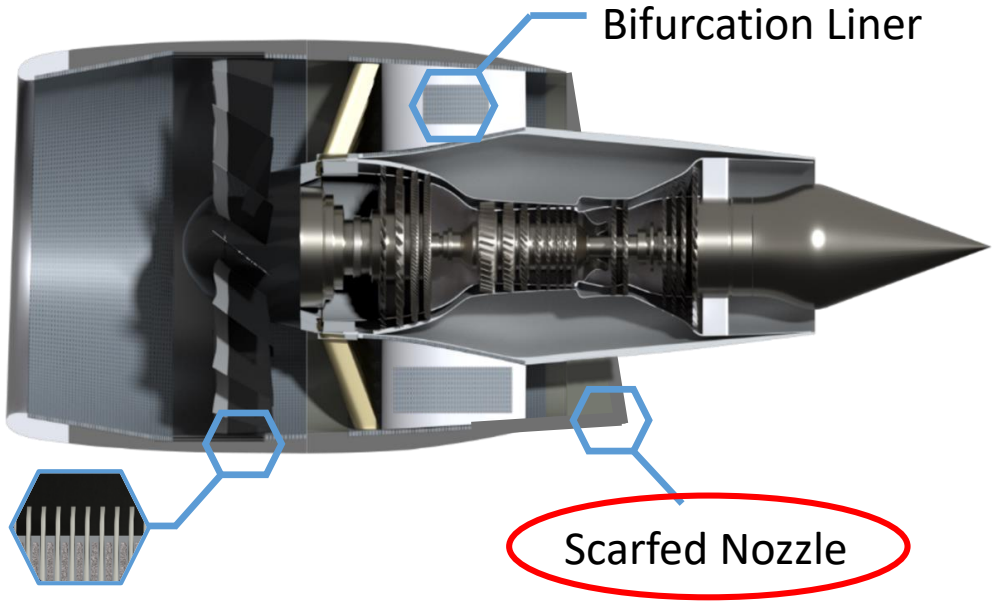
[3]Howerton, B. M. and Jones, M. G., "Acoustic Liner Drag: Measurements on Novel Facesheet Perforate Geometries," 22nd AIAA/CEAS Aeroacoustics Conference, Lyon, France, 2016. AIAA Paper 2016-2979.

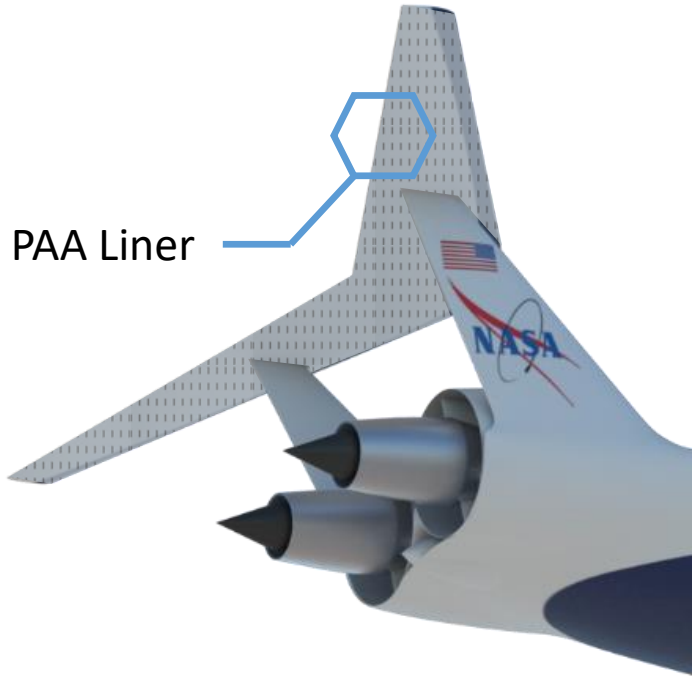
Far Term Technologies

- Explore the impact of far-term noise reduction technologies on the total system noise of the ND8.
- Incorporated previously on the Hybrid Wing Body* (HWB) and Mid-Fuselage Nacelle** (MFN) aircraft.

*AIAA-2017-3193

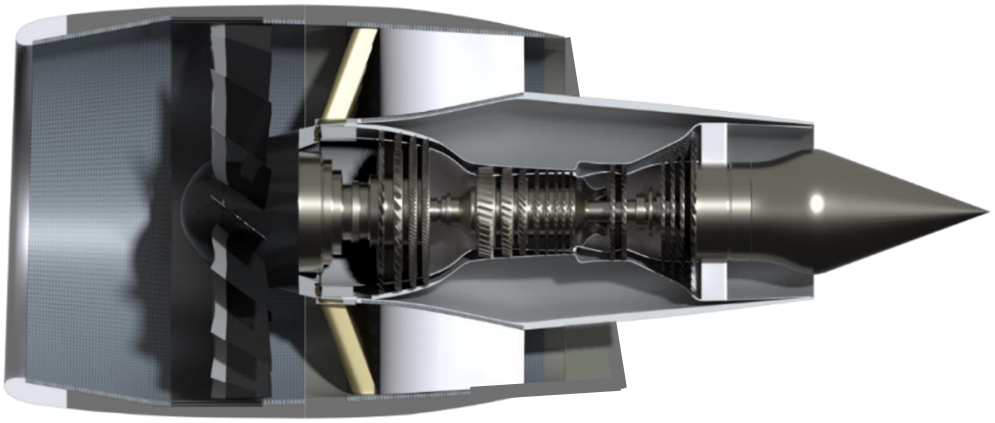
**AIAA-2014-0257
AIAA-2018-3126

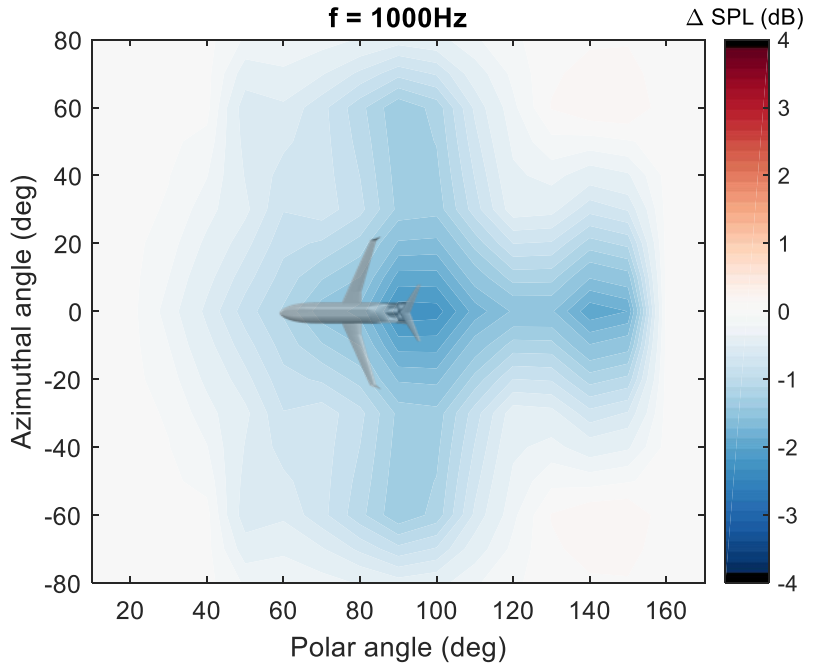




Scarfed Nozzle

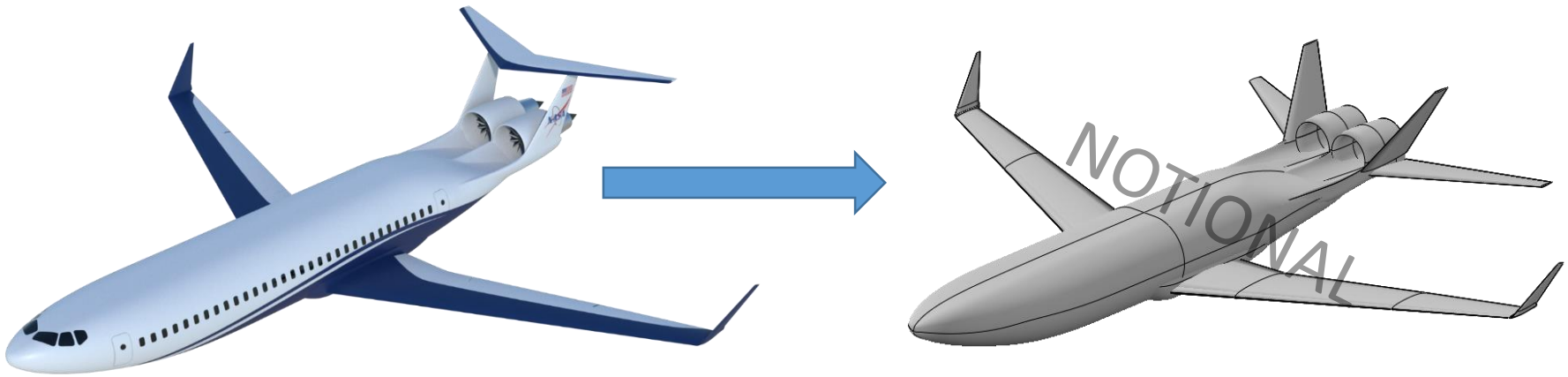
- Acoustic data collected in Boeing LSAF for a range of polar and azimuthal angles.
- Isolated nozzle with and without scarf used to quantify noise suppression.



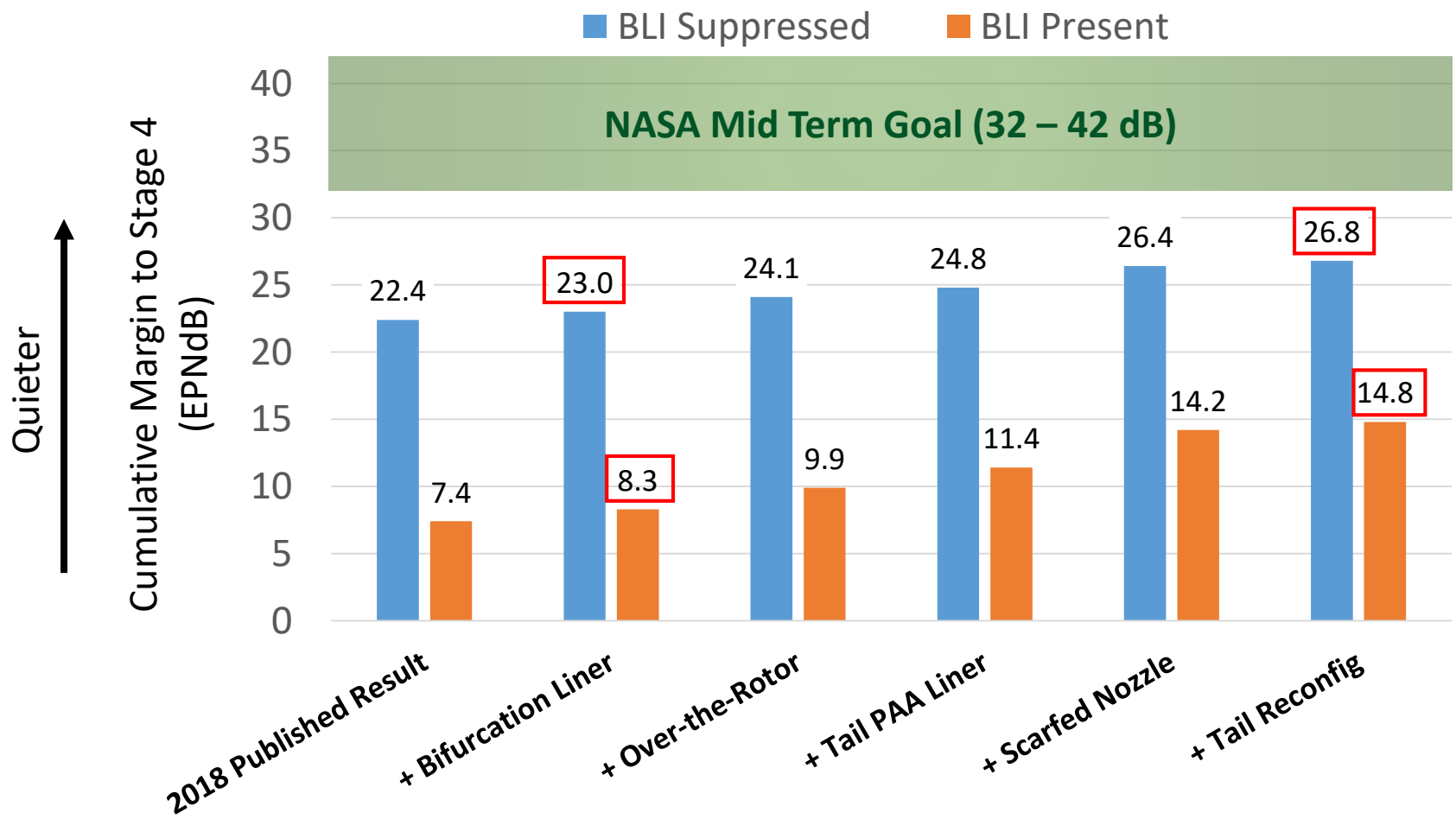


Configuration Change

- The PAA liner can be expected to reduce reflections over a certain frequency range.
- Reconfiguring the tail would eliminate reflections entirely.
- Further design work is necessary to ensure a feasible configuration.
- Reconfiguring the tail may also allow for higher-bypass ratio engines, but **this is not considered here.**



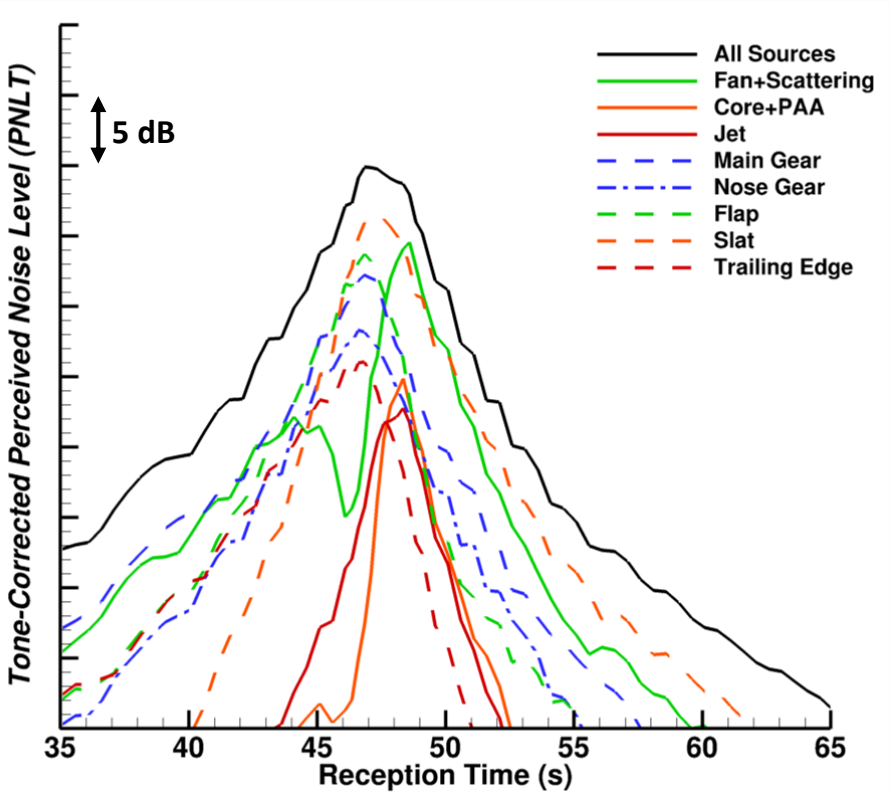
System-Level Certification Results



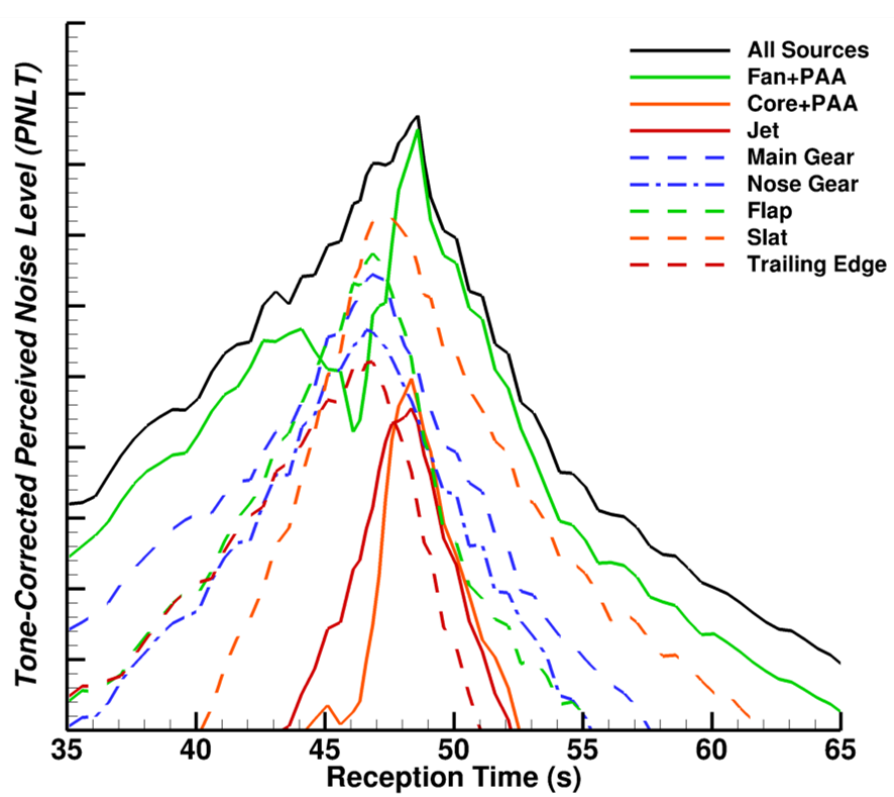
	Approach	Sideline	Cutback	Total
Previous System BLI Penalty (EPNdB)	2.8	6.5	5.7	15.0
New System BLI Penalty (EPNdB)	1.8	5.6	4.6	12.0

PNLT w/ All Technologies - Approach

BLI Suppressed:

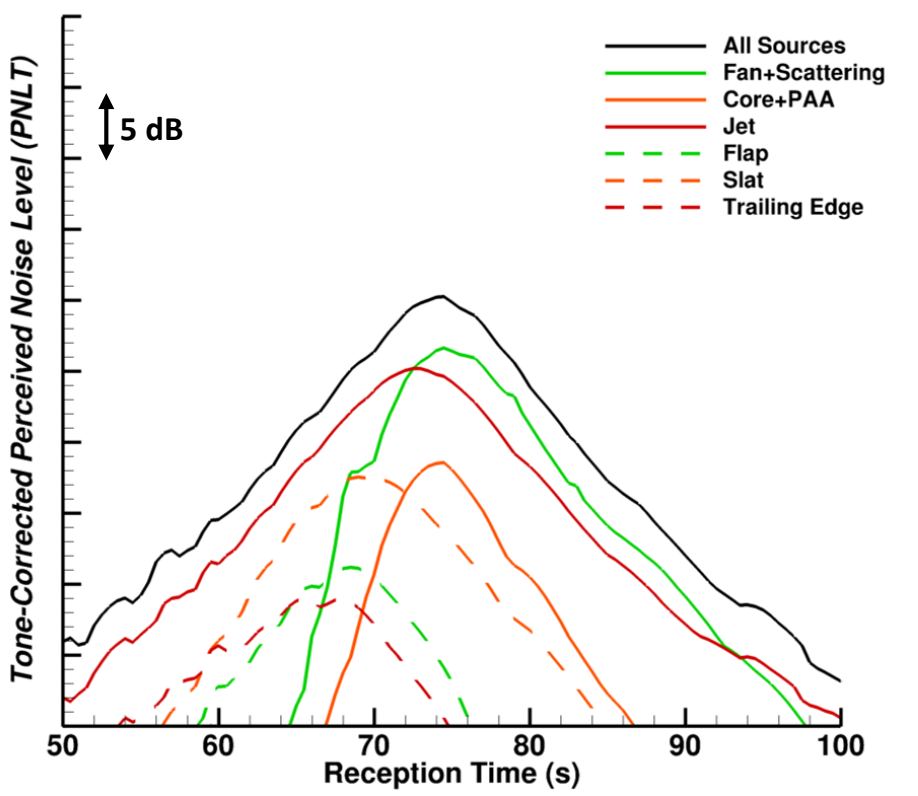


BLI Present:

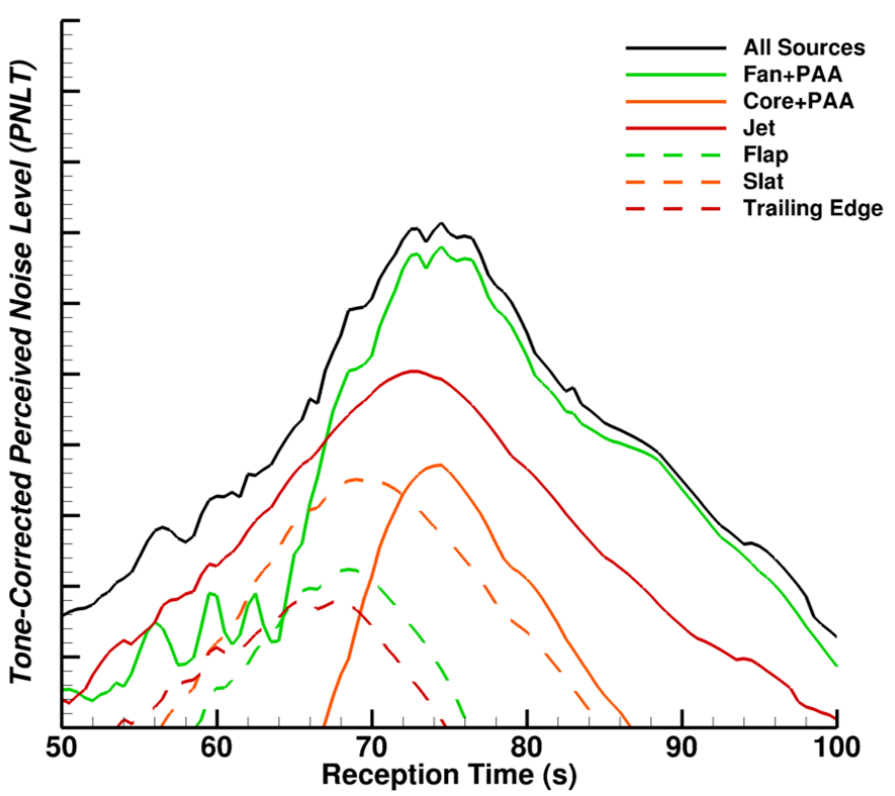


PNLT w/ All Technologies - Cutback

BLI Suppressed:



BLI Present:



Conclusions

- Far term technologies are effective at reducing fan and system noise of the ND8, but the resulting aircraft still does not meet NASA Mid Term noise goals. Two options moving forward:
  - Continue to add technologies and attain incremental noise reductions.
  - Pursue more aggressive reconfiguration (step 1 is tail reconfiguration, allowing for higher bypass ratio).
- If BLI noise **is not suppressed**, system-level BLI penalty is 12 EPNdB, compared to 15 EPNdB without technologies.
  - Aft-radiated fan noise is still the dominant noise source that dictates the overall system noise.
  - Active flow control or BL diverter to suppress BLI at community noise conditions could be seen as the most important technology for the ND8.
- If BLI noise **is suppressed**, slat noise becomes dominant at approach, while jet noise is significant at both sideline and cutback.
  - Noise reduction roadmap should focus on slat and jet noise to achieve further noise reduction.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