Propulsion Airframe Aeroacoustics and Aircraft System Noise Flight Test on the Boeing ecoDemonstrator 2020: Part 1 NASA

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Acoustics Technical Working Group

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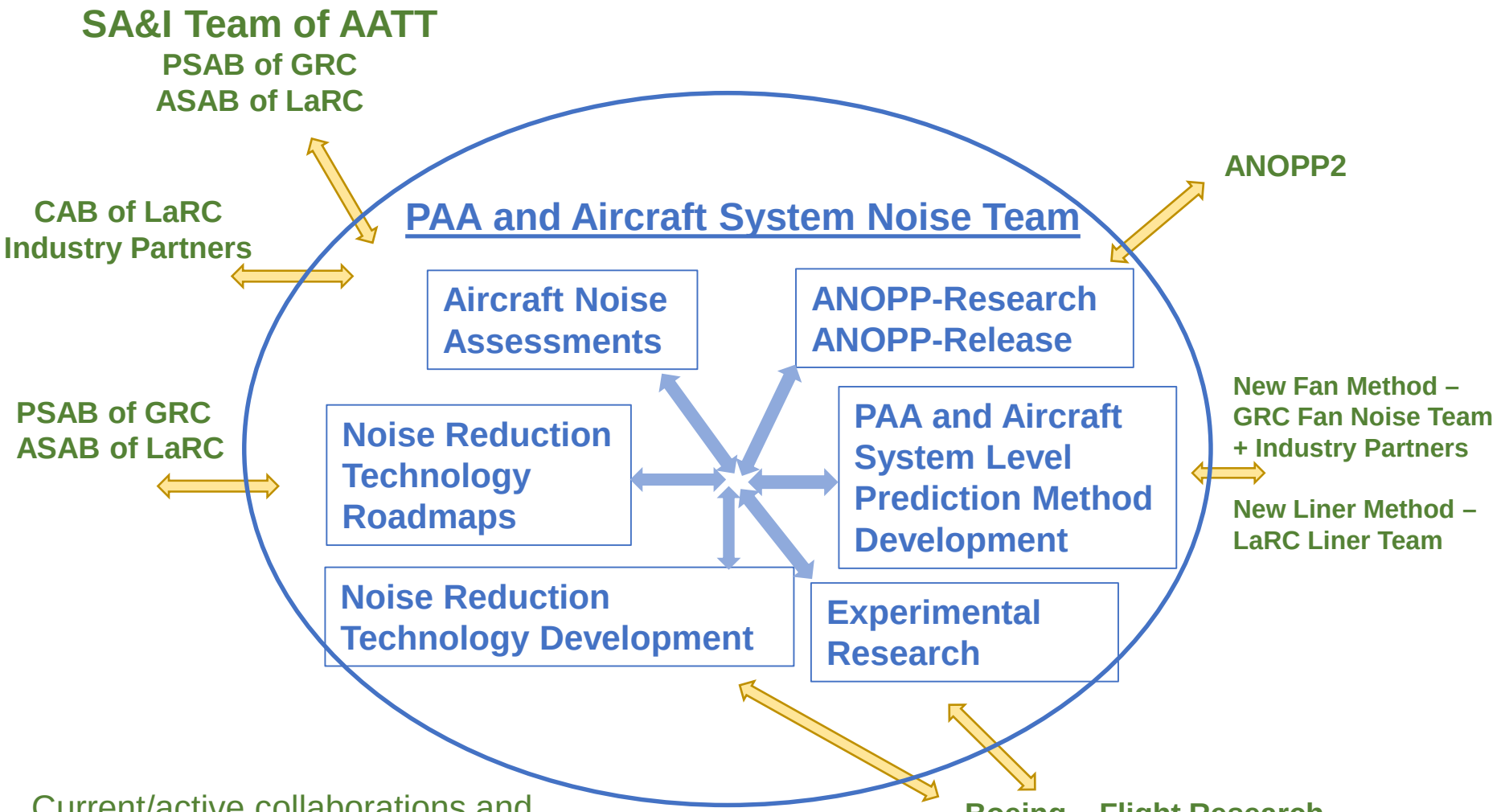
Outline

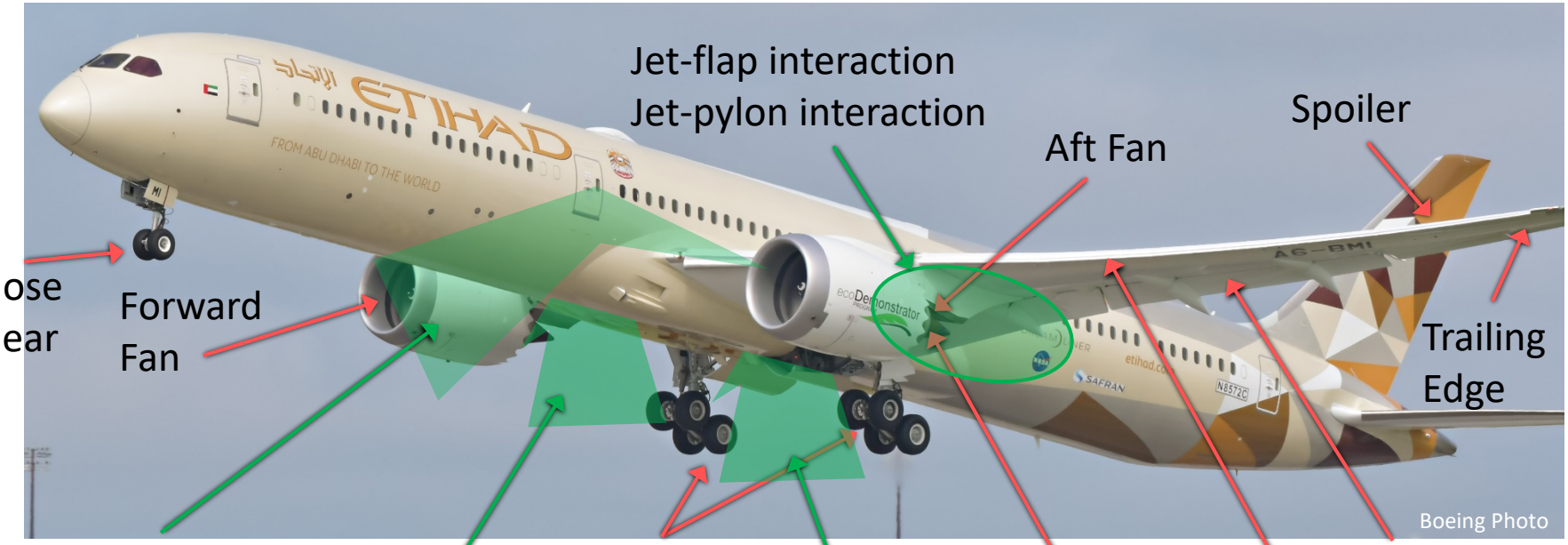
- Context
  - Team Characteristics
  - Importance of Flight Research
  - Research on Future Aircraft Concepts
- Flight Test Timeline
- Key Motivating Ideas
- High Level Objectives
- Pretest Predictions for Test Design
- Flight Research Execution
- Future Directions

Team Technical Strategy Overview and Acknowledgments



Current/active collaborations and connections are indicated but not intended to be exclusive

Aircraft Noise Sources and PAA Effects



Aircraft system prediction methods for assessments, noise reduction approaches, technologies must ultimately be verified and perform confidently for flight conditions.

Current Research is another in Multiyear NASA and Boeing Collaboration

NASA wind-tunnel tests
Advanced propulsion systems and airplane configuration studies

NASA Flight Tests on QTD2 and ecoD 2020
Full scale propulsion airframe aeroacoustics and aircraft system noise

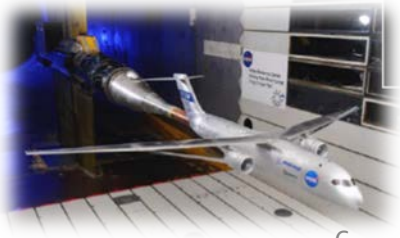
Learnings

Technology experiments, data bases & models

Unique experiments and validation data

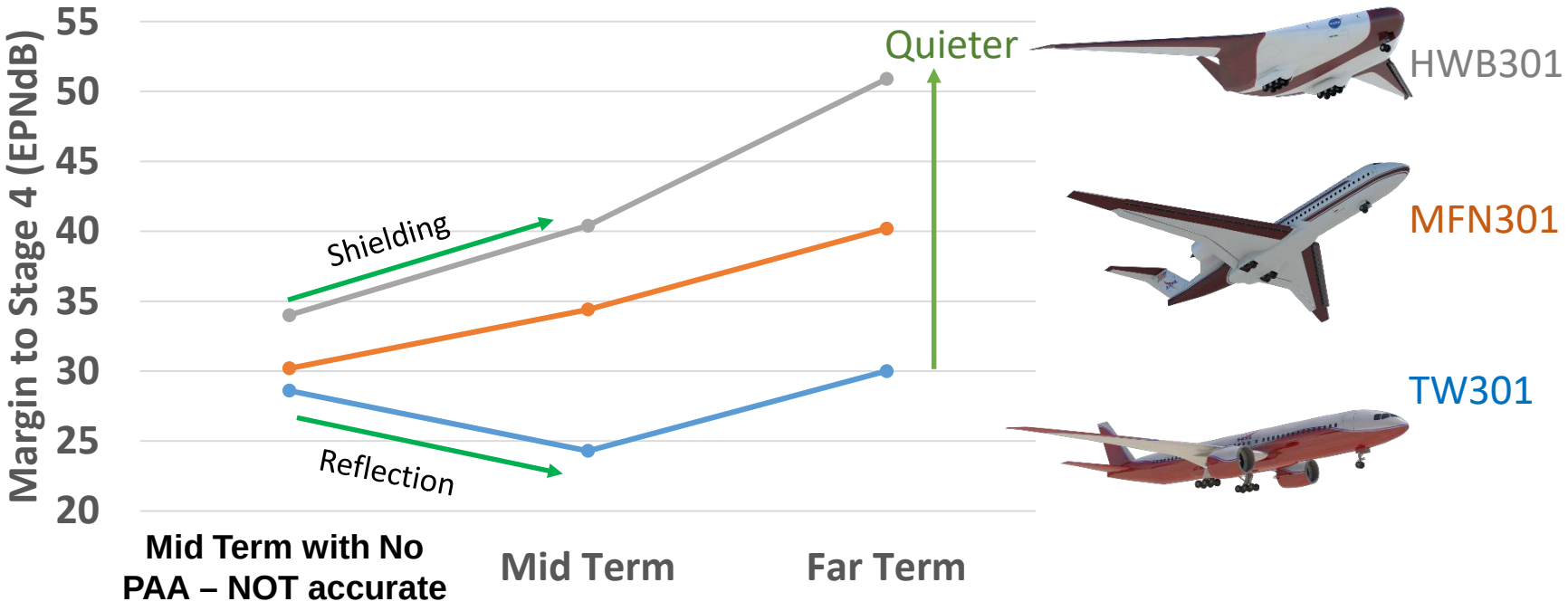
NASA Design Tools – ANOPP-Research

NASA/Boeing Future Designs



Impact of PAA with Configuration Change and Technology Roadmap

Multiyear study on a set of closely matched advanced concepts – the noise reduction value of configuration change.



- PAA largest share of the 16.1 EPNdB difference at Mid Term level.
- Targeted technologies improve PAA effectiveness. Increases difference to 20.9 EPNdB cumulative at Far Term Technology level.

Applicability to New Concepts – TTBW

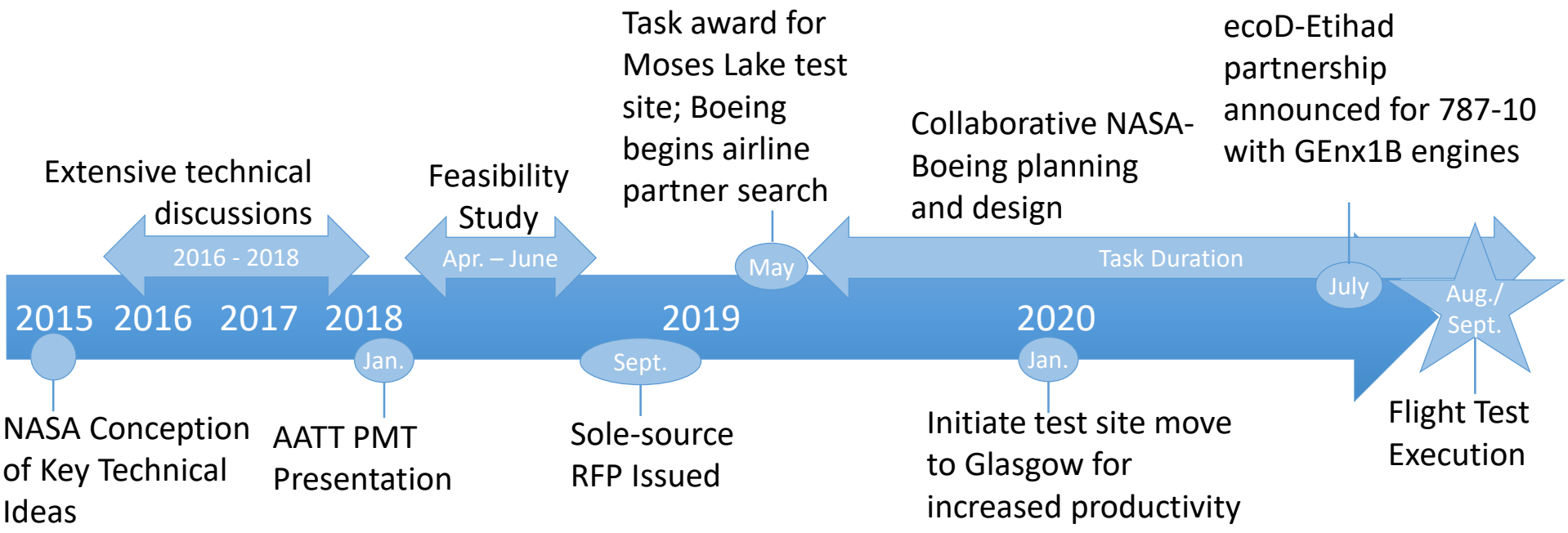
TTBW has **unique acoustic features** that impact aircraft system noise and differentiate the TTBW from an engine-under-wing:

Boeing Image

- **High aspect ratio wings, strut, and junctures** – impacting trailing edge and high lift device noise.
- **PAA of High Wing** – engine noise is:
  - scattered from strut (also a potential shielding surface),
  - reflected (near engine in image) and shielded (far engine) by fuselage and,
  - reflected from wing.
- **Body mounted main gear** – short gear impacted by circulation around strut
- **Leading Edge Device** – full-span variable Krueger flap for enabling drag reduction

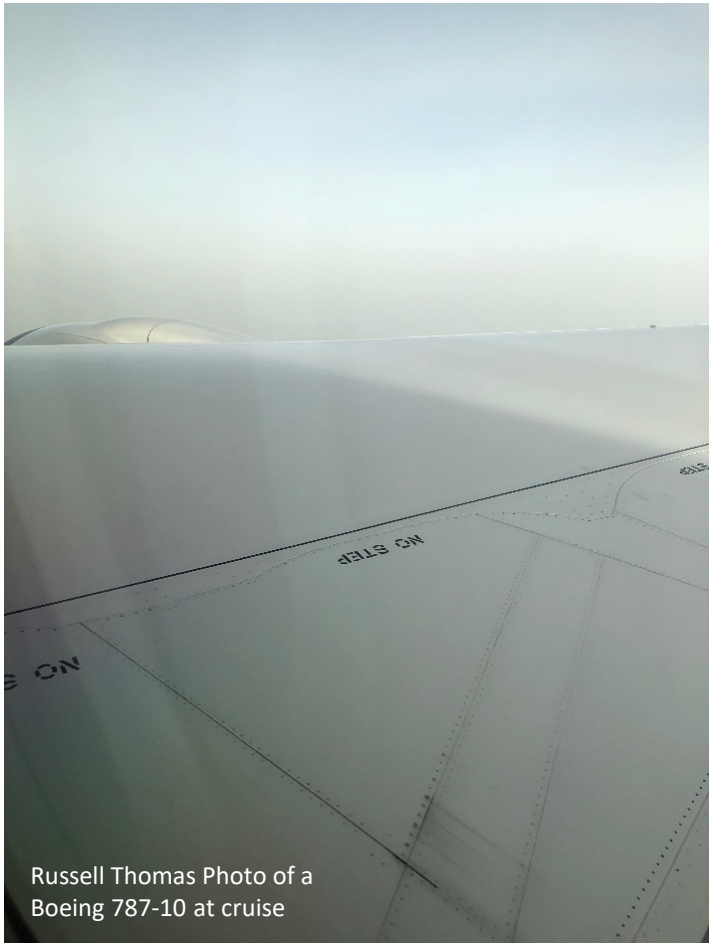
Flight test design and evaluation of ANOPP all contribute to more realistically predicting many aspects of advanced concepts such as the TTBW

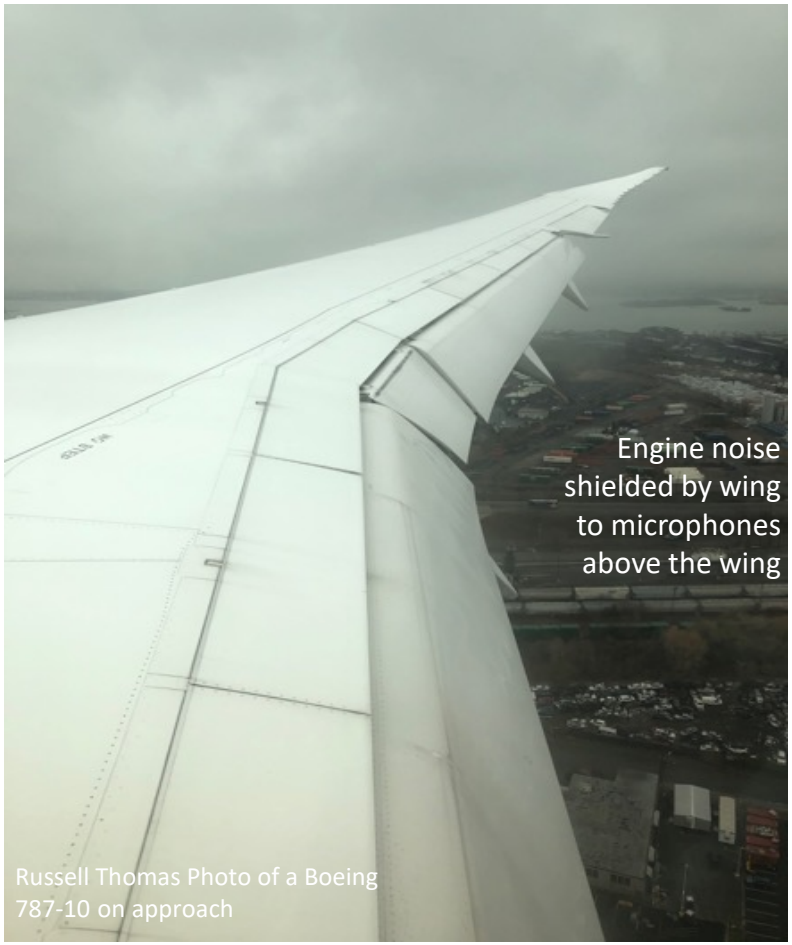
Flight Test Timeline



Dedicated NASA task, developed, and planned over several years in close collaboration between NASA and Boeing combining the unique capabilities and expertise of each organization

Key Idea #1 Using the Wing as a Shield



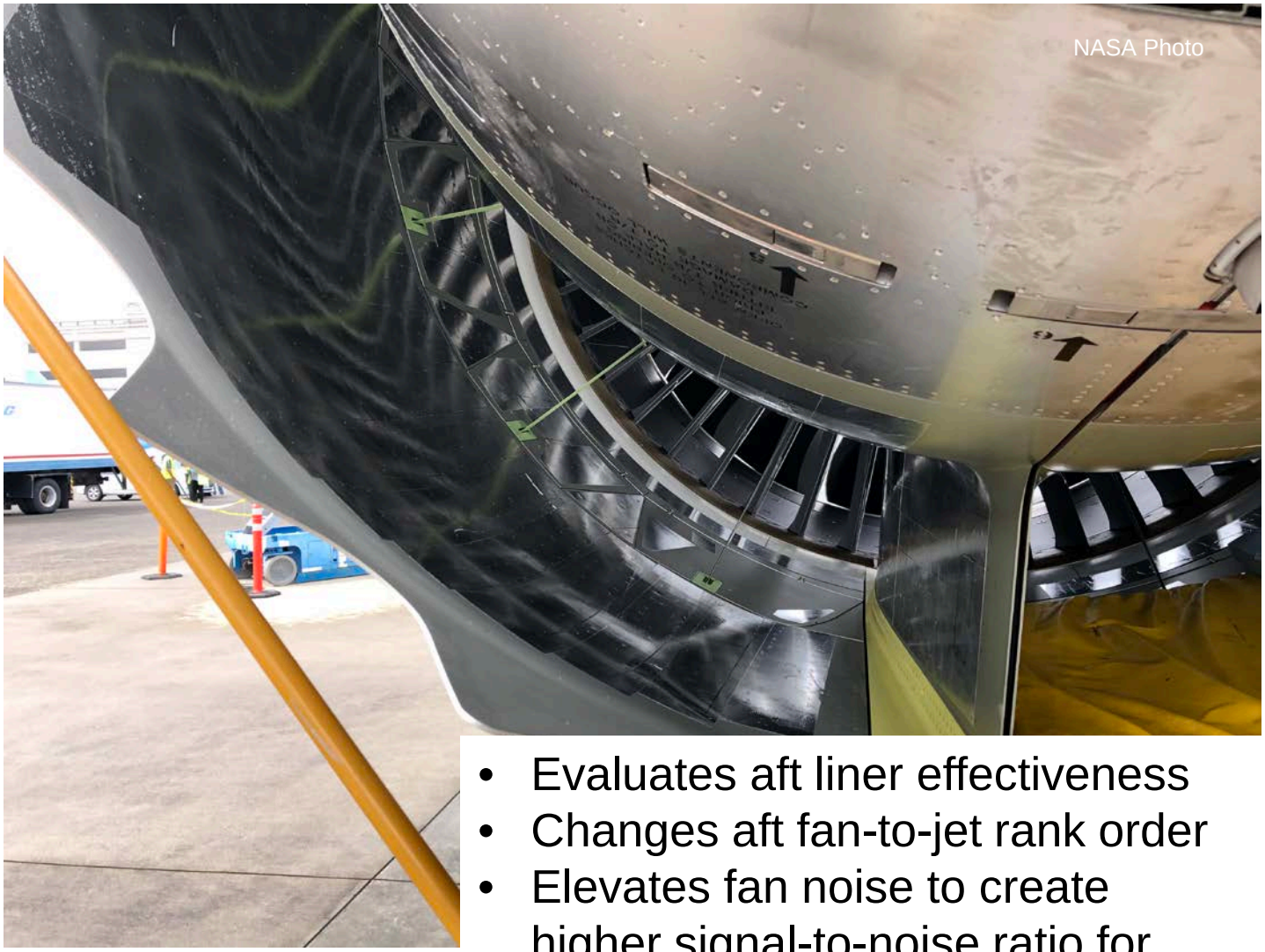


Microphones above the wing are shielded from engine noise below the wing

Key Idea #2 B787 is Best Test Aircraft

Many advanced technologies on the B787 making it most representative of future aircraft

Key Idea #3 Hardwall Taping of Aft Duct



- Evaluates aft liner effectiveness
- Changes aft fan-to-jet rank order
- Elevates fan noise to create higher signal-to-noise ratio for PAA studies

Key Idea #4 PAA Special Operations

Russell Thomas Photo of a Boeing 787-10 banking over New York

Russell Thomas Photo of a Boeing 787-10 with spoilers deployed

- Unique PAA experiments are possible
- Relevant to today's operational noise issues
- Relevant to advanced aircraft

High Level Objectives

- Aircraft System Noise Objective
- PAA Objective

- Supporting objectives:
  - Azimuthal directivity (from PAA effects)
  - Shielding and reflection of engine noise by wing for:
    - engine power and high lift deflection
    - different fan noise characteristics
  - Shielding to the far field by the fuselage with banking of aircraft
  - Engine noise powerline
  - Aft duct liner effectiveness
  - Airframe components and their interactions (e.g., gear-flap)
  - Operational maneuvers
  - Flight effects

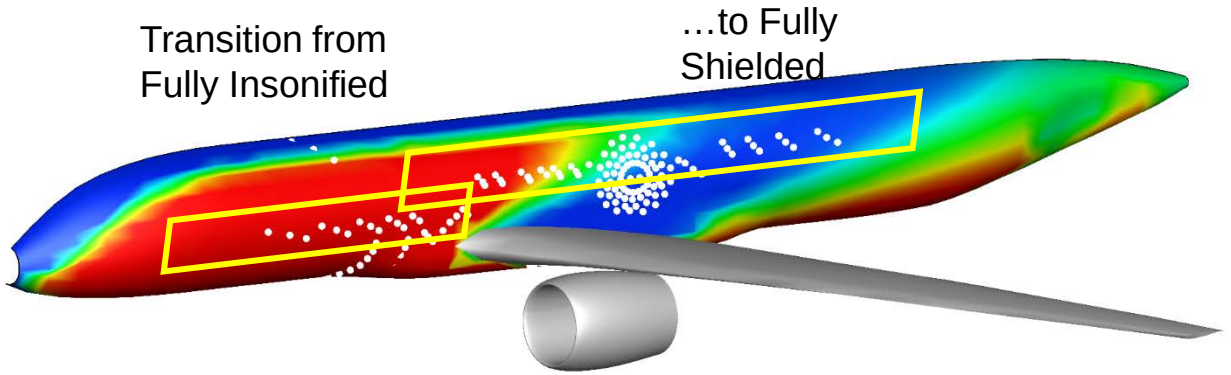
Predictions Supporting Test Design

Prediction work spanned more than a year
Hundreds of charts of results were prepared for the technical interchanges

Predictions by NASA included topics:

- Fuselage acoustic signature from wing shielding of major components
- Shielding by the wing and fuselage to the far field
- Signal-to-noise ratio of major components
- Banking trajectory
- Azimuthal directivity of aft fan noise as function of banking angle, offset flight path, and altitude
- Turbulent boundary layer noise
- Refraction of signal noise through the turbulent boundary layer

Linear Array

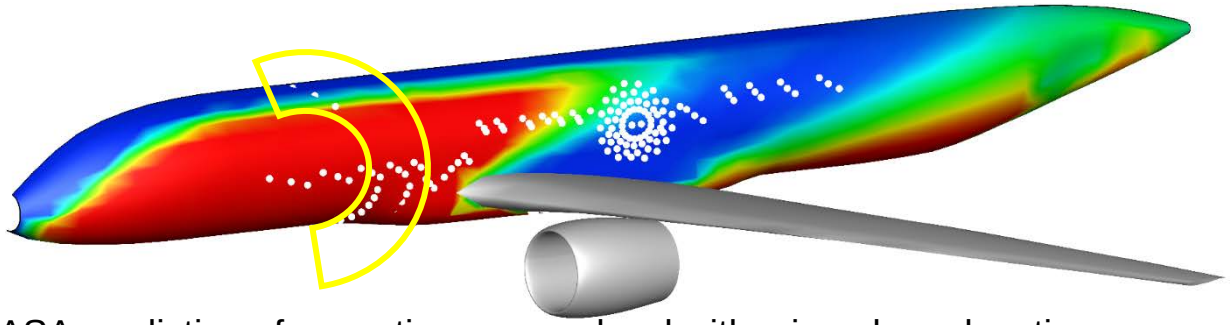


NASA prediction of acoustic pressure level with microphone locations

Variations with engine settings, flap detents, and aircraft speed will provide insight into these dependencies

Circumferential Array

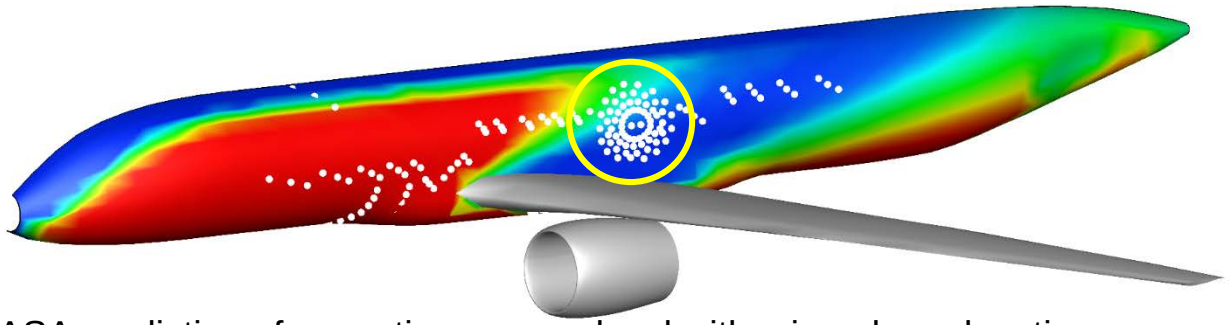
- Azimuthal directivity of the inlet-radiated engine noise
- Propagation around the cylindrical fuselage



NASA prediction of acoustic pressure level with microphone locations

Above-Wing Phased Array

- Elliptical phased array, stretched to improve resolution in axial direction
- Directly measures diffraction (scattering) of engine noise around the wing's leading and trailing edges



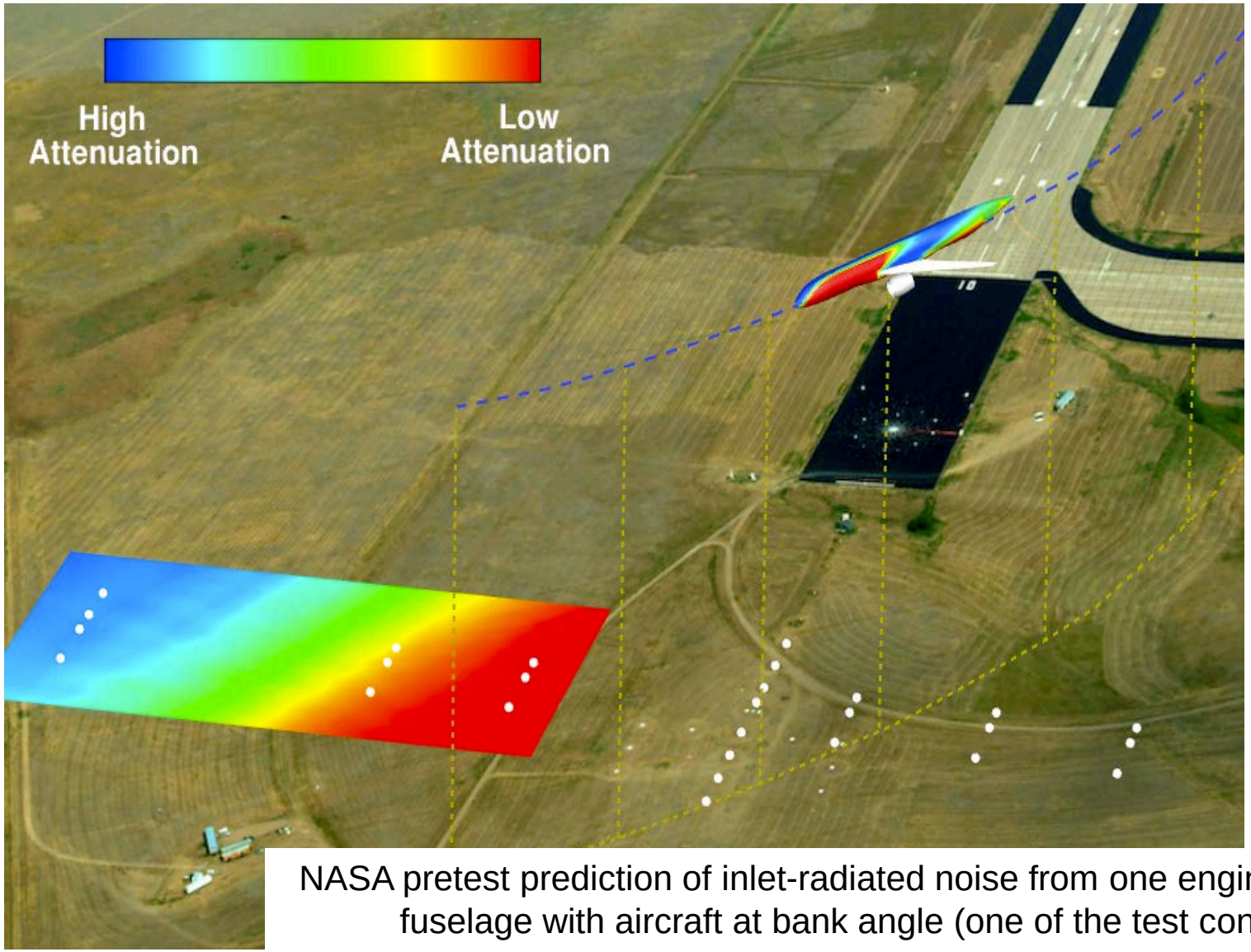
NASA prediction of acoustic pressure level with microphone locations

Boeing Photo

Under-Wing Phased Array

- Provides high-resolution acoustic source definition of the aft fan and jet noise levels and directivity
- Also used as input to shielded data from the other arrays (e.g., above-wing)
- Quantify engine noise reflections from the wing

Banking Design for PAA Objectives



NASA pretest prediction of inlet-radiated noise from one engine shielded by fuselage with aircraft at bank angle (one of the test conditions)

Productivity

All major objectives accomplished for a unique and innovative acoustic flight research campaign

Data collection exceeded success criteria:

- 20 flight hours
- Five flight days out of six from August 25 to September 1
- 50 unique test conditions
- 88 fully successful passes (meeting all tolerances)
- Additional 50 passes that are also expected to be useable

Future Directions

- Joint prediction and comparison
- Joint evaluation of ANOPP and improvement needs and approaches
- Detailed analysis of ground array and on-aircraft array data

Longer term:

- Publication of findings
- Development of improved ANOPP methods
- Stimulate development of noise reduction technologies and approaches


NASA