Project 41
Identification of noise acceptance onset for noise certification standards of supersonic airplanes

Motivation

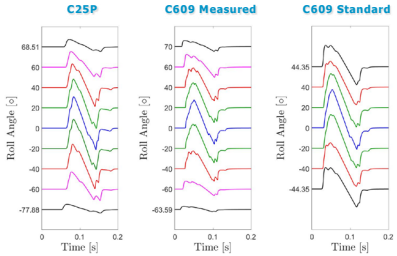
- Formulating a new civil, supersonic aircraft sonic boom (noise) certification standard
- Working toward potential approval of supersonic flight over land for low boom aircraft

Objectives

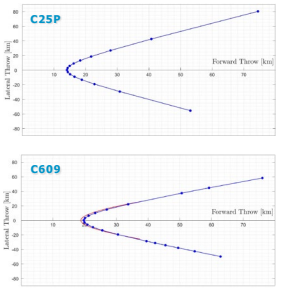
- Study the change in boom level induced by fluctuations in atmospheric variables such as ambient pressure, temperature, relative humidity, and wind
- Recreate the secondary sonic boom predictions of Rickley & Pierce using PCBoom modeling software.

Sonic Boom Prediction Workshop 2020

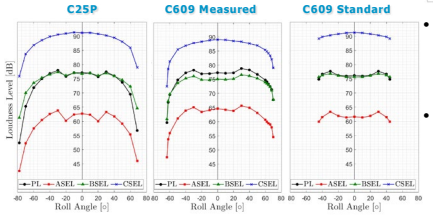
Ground Signatures



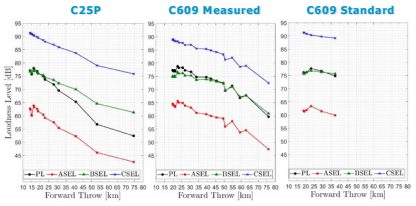
Ground Intersections



Loudness vs. Roll Angle

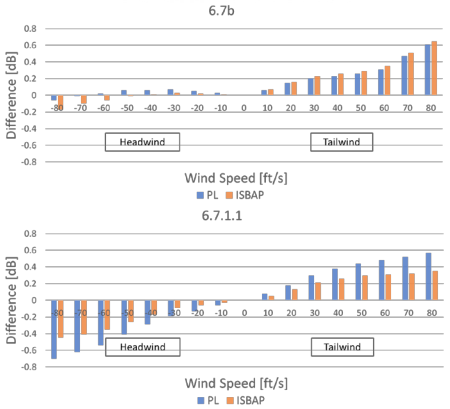


Loudness vs. Distance



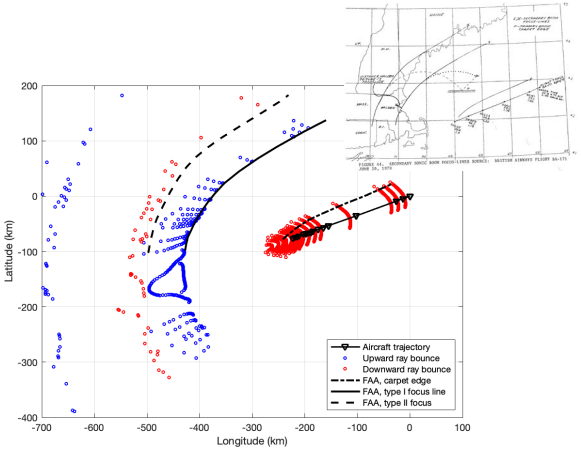
- Project 41 participated in the 3rd AIAA Sonic Boom Prediction Workshop, Orlando, FL, in 1/2020.
- C609 source has lower peak amplitudes at all azimuthal angles relative to the standard atmosphere due to added refraction from wind and temperature gradients.
- C609 source has strong asymmetry in ground footprint due to wind.
- 75 PLdB nominal cruise boom for X-59 (C609) is not unreasonable, though levels were typically higher (sometimes up to 4 dB).

Task 1: Effect of Wind on Sonic Boom Loudness



- PCBoom 6.7b failed to invariably increase boom level with increasing tailwind
- PCBoom 6.7.1.1 properly implemented wind effects, recovering expected trend

Task 2: Recreation of 1980 Concorde Work



Lead investigator: Victor Sparrow, Penn State
Project manager: Sandy Liu, FAA

March 31, 2020

Results and Discussion

- Changes in atmosphere have a dramatic effect on the propagation of C609 signatures
- For larger or nonuniformly sampled cases, PCBoom's Thomas mode is more reliable than Cylinder mode
- Task 1 has determined potential variability in sonic boom PL/ISBAP due to various atmospheric perturbations which may provide useful sonic boom noise certification of supersonic aircraft
- Task 2 has successfully recreated the simulations performed by Rickley and Pierce in 1980 using the PCBoom modeling software

Next Steps

Task 1: Obtaining Confidence in Signatures, Assessing Metrics Sensitivity, and Adjusting for Reference Day Conditions

- Carry out further work on the study of atmospheric perturbations, including studying more realistic profiles, crosswinds, and statistical analysis of boom level variability due to changes in the atmosphere

Task 2: Assessing Secondary Sonic Boom Propagation

- Investigate influence of upper atmospheric winds on the distribution of secondary sonic booms
- Predict pressure signatures of received secondary booms
- Examine different aircraft weights to observe differences in the received secondary sonic boom levels

Research Team:
University Investigators: Victor Sparrow
University Graduate Assistants: Luke Wade, Joshua Kapcsos
Post-Doctoral Scholar: Trevor Stout
Queensborough Community College: Kimberly Riegel
FAA: Sandy Liu, Project Manager
Volpe: Juliet Page

Cost Share Partners:
Boom Supersonic: Marshall Gusman, *et al.*
Gulfstream: Robbie Cowart, Joe Salamone, *et al.*

References:

[1] L. Wade, V. Sparrow, "Effects of perturbing a reference atmosphere on sonic boom propagation and metrics," J. Acoust. Soc. Am., **145** (3, Pt. 2) 1903 (2019). 13-17 May 2019 ASA presentation, Louisville, KY, USA.
[2] D. Maglieri, *et al.*, *Sonic Boom: Six Decades of Research* (NASA SP-2014-622, 2014).
[3] J.B. Lonzaga, "Recent Enhancements to NASA's PCBoom Sonic Boom Propagation Code," AIAA 2019-3386, AIAA Aviation Forum, Dallas, Texas, USA (2019).
[4] K. Plotkin, J. Page, E. Haering, "Extension of PCBoom to over-the-top booms, ellipsoidal earth, and full 3-D ray tracing," AIAA 2007-3677, 13th AIAA/CEAS Aeroacoustics Conf. (2007).
[5] E. Rickley and A. Pierce, "Detection and assessment of secondary sonic booms in New England," FAA-AEE-80-22, May 1980, accessible as ADA088160.

This work was funded by the US Federal Aviation Administration (FAA) Office of Environment and Energy as a part of ASCENT Project 41 under FAA Award Number: 13-C-AJFE-PSU. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the FAA or other ASCENT Sponsors.