Sideways Noise Modelling

NACF 7th February

Dave Gilbert for Heathrow Community Noise Groups (HCNG)

NADP1 vs NADP2 study is running very late

- Has given us the opportunity to study sideways noise modelling

Background

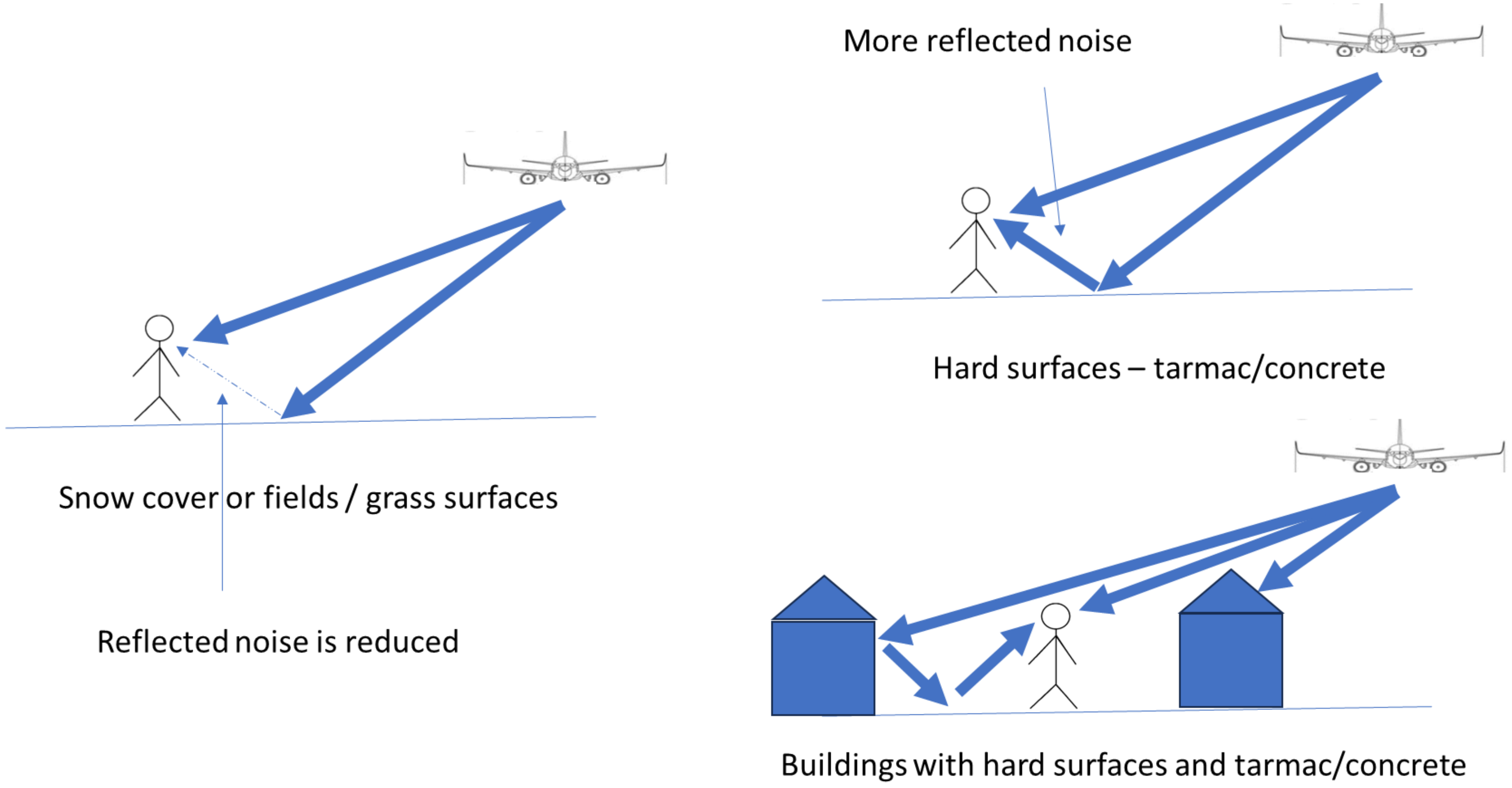
- 2015 Heathrow Community Noise Forum created after PBN trials – one of the core requests was for planes to fly higher
- Multiple mini studies by CAA/ERCD for several years. Chair (Matt Gorman) asked for more progress.
- 2020 External Independent Consultant with clear ToR over 6 months showed 60% of planes using Heathrow could be flown more quietly (LAmax = ‘ loudness’ & Sound energy levels - SEL) using NADP1 to 1.5km (4500ft)
- Covid
- Post Covid 2022 - Further study proposed by Heathrow to consider entire fleet as concern that significant levels of sound energy could be spread sideways - as Heathrow want to give simple instruction to all users of airport
- Communities proposed using external consultant to resolve quickly but CAA/ERCD used - result has been slow progress. Work still ongoing
- Study expected to be reported at May 2024 Heathrow Noise forum

Sideways Noise Modelling – why is it important?

- Most 'outer contours' are at the side of flight paths
- Noise generally follows a simple distance squared rule
- However sideways noise from planes is observed to be attenuated (reduced) more than this simple rule depending on the angle of the observer
- A standard has been developed to apply this 'attenuation correction' in a systematic way by industry experts – SAE 'AIR-5662' behind a paywall costing $140
- A5662 states *'The methods for calculating the lateral attenuation of the sound apply to: propagation over ground surfaces that may be considered to be "acoustically soft" such as lawn or field grass'* (as most airports surrounded by fields)
- However - Heathrow surroundings are often urban, with hard and sound reflective surfaces such as tarmac, bricks and concrete

SAE – Society of Automotive Engineers

What is the effect of surfaces?



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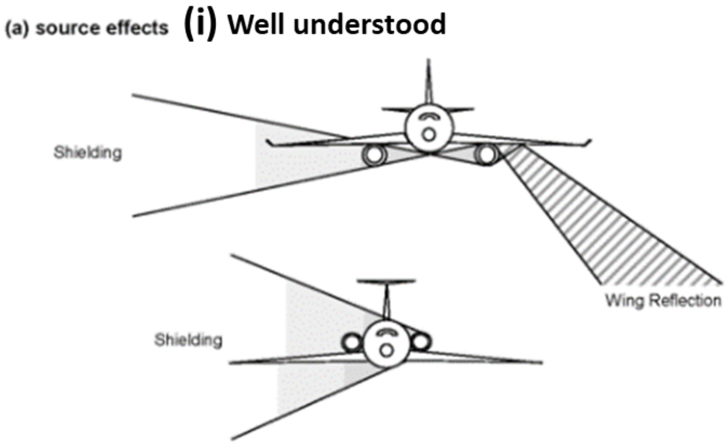
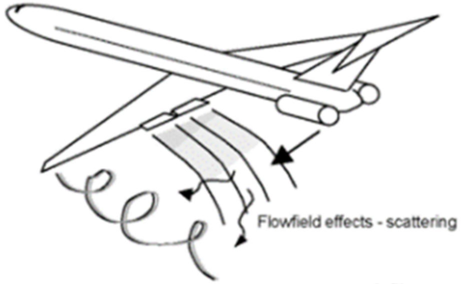
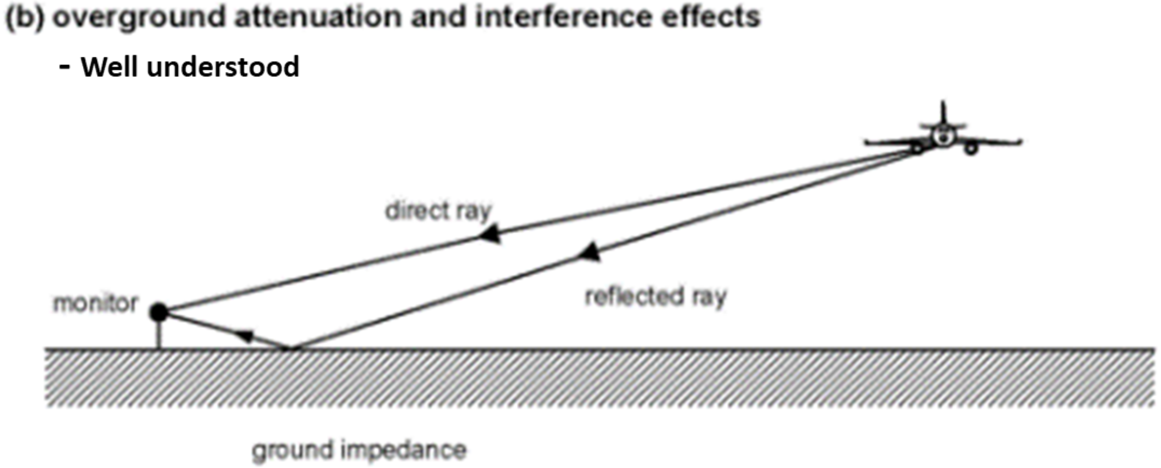
What are the other causes of sideways attenuation (sideways noise reduction)?



a) Source Affects (ii)
- difficult to model





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From SAE-AIR-5662

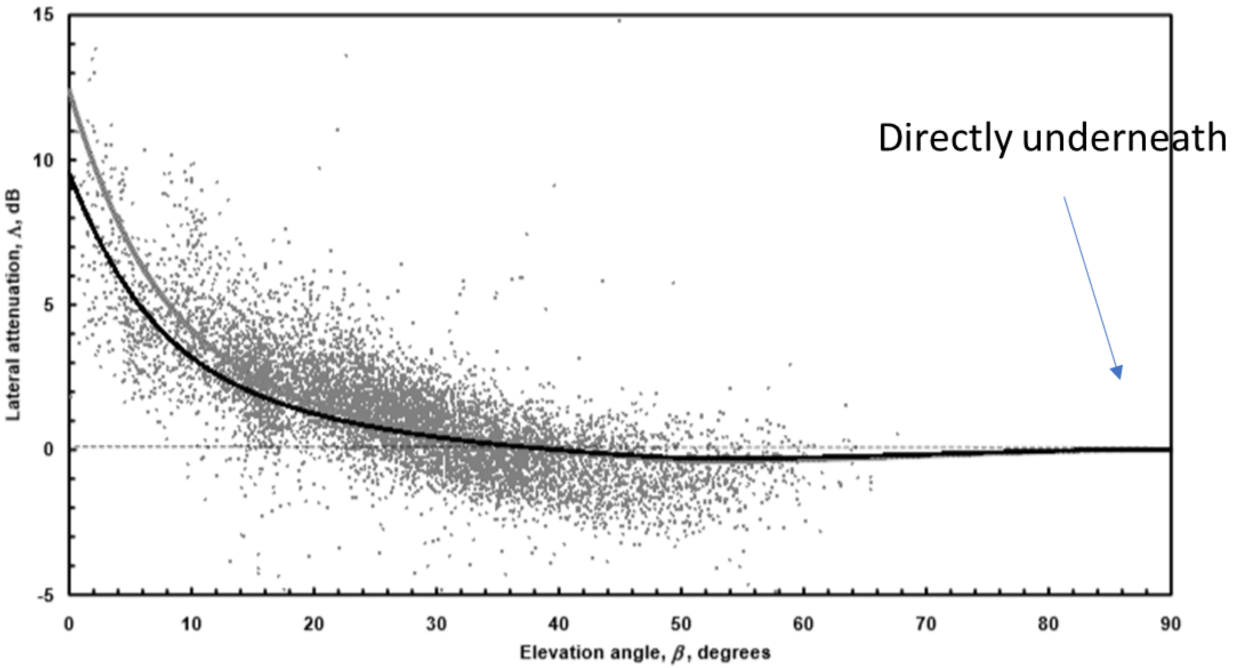
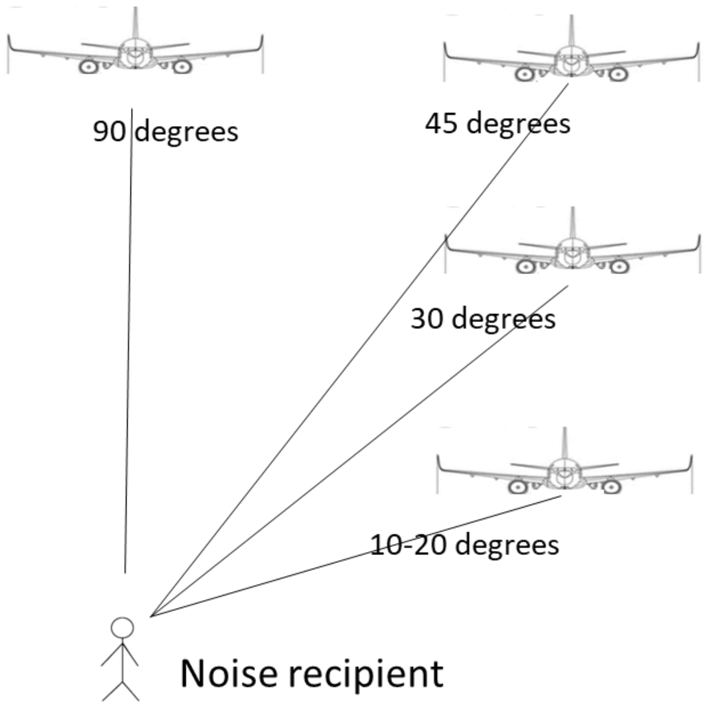


FIGURE E3 - PREDICTED LATERAL ATTENUATION FOR LATERAL DISTANCES OF 450 M (LOWER SOLID LINE) AND 1500 M (UPPER SOLID LINE) AND LATERAL ATTENUATIONS MEASURED FOR AIRPLANES WITH WING-MOUNTED ENGINES OPERATING FROM LONDON GATWICK

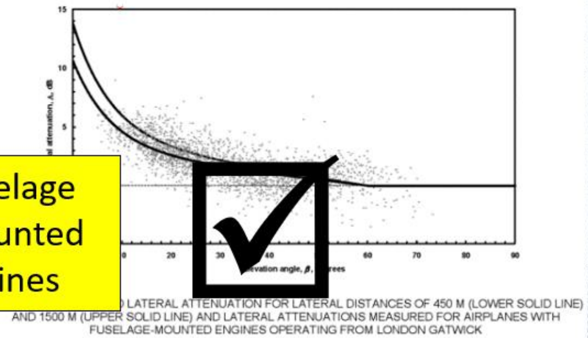


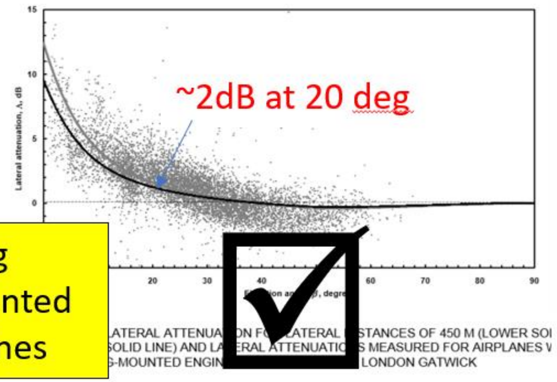
Schematics not to scale

- Sideways attenuation (noise reduction) is shown in several datasets
- This is data from ‘soft’ ground (fields around Gatwick) and for under wing mounted engines

Comparison of Engine Type & Ground conditions

- Present attenuation assumptions work on soft surfaces but not on intermediate & hard surfaces





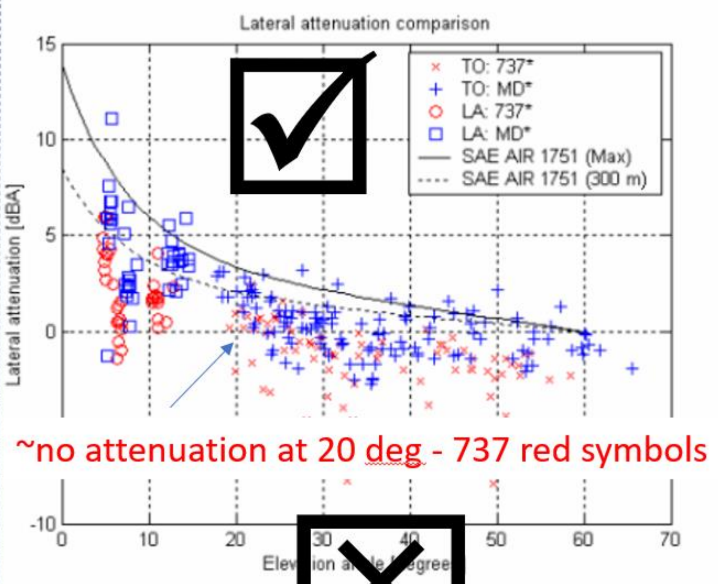


Figure 4.7 Measured lateral attenuation versus elevation angle.

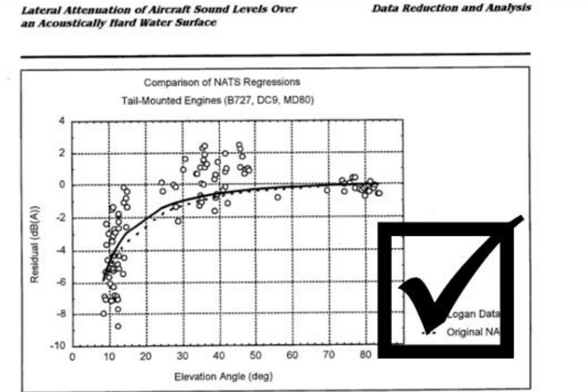


Figure 16. Comparison of NATS Regressions with Original and New Coefficients, Tail-Mounted Engines

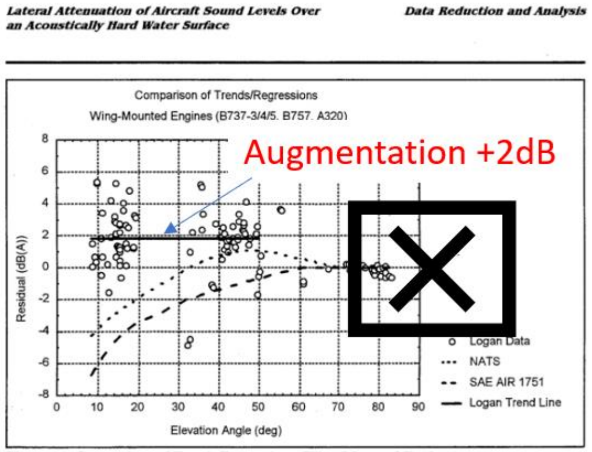


Figure 21. Comparison of Trends/Regressions, Wing-Mounted Engines

Source / Ground conditions	Gatwick - Soft Ground. CAA	Oslo Gardemoen – Intermediate acoustic surface Sand and Scrub. SINTEF	Logan – Hard acoustic surface - water NASA (note reversed vertical axis)

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Data suggests Impact of different Surfaces – for wing mounted engines

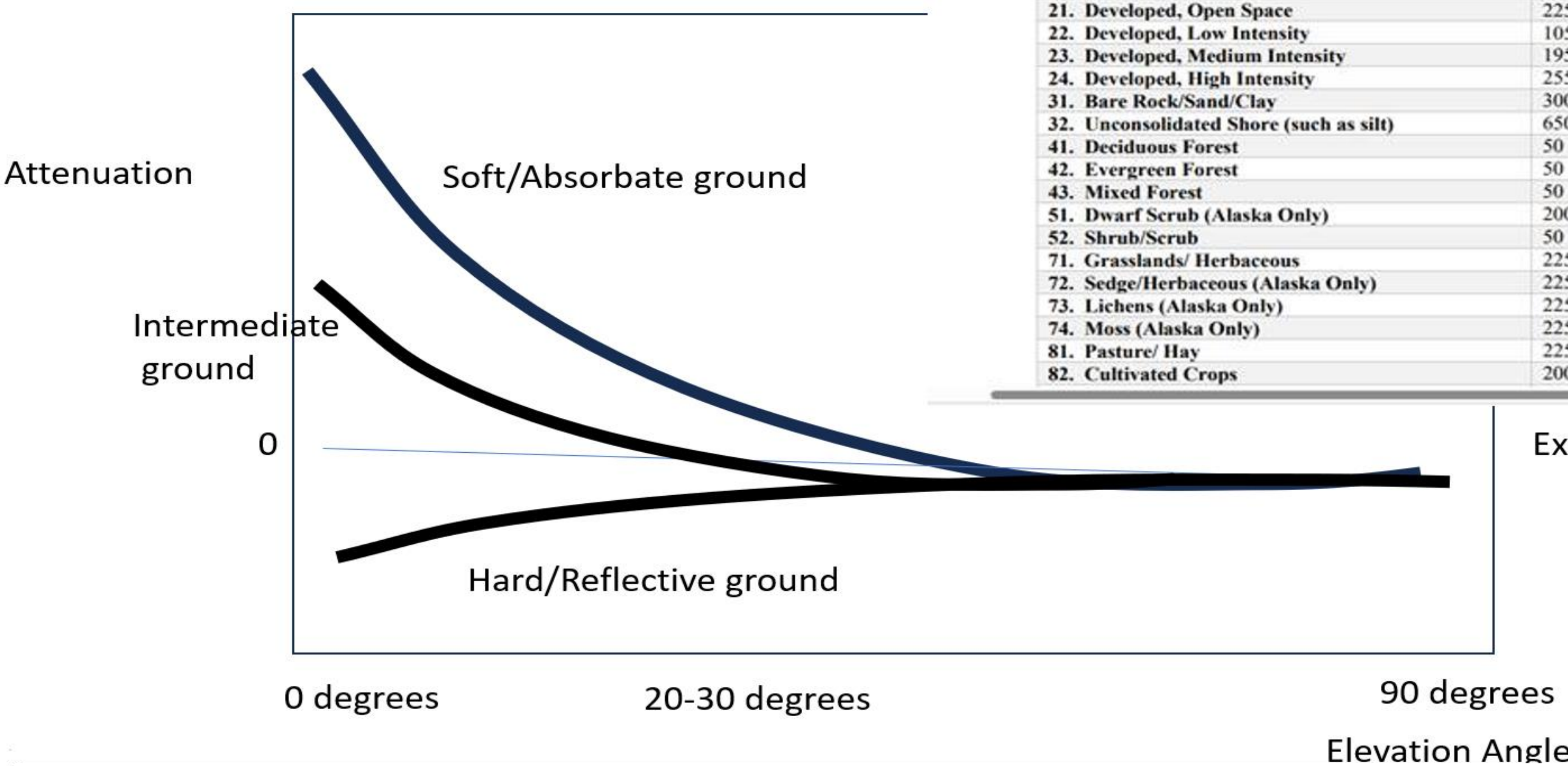


TABLE 5 National Land Cover Database Ground Cover Classifications and Associated BASEOPS Flow Resistivity Estimates

NLCD2011 Land Cover Classifications	Estimated Flow Resistivity (kPa s/m^2)
11. Water	100000
12. Perennial Ice Snow	20000
21. Developed, Open Space	225
22. Developed, Low Intensity	10500
23. Developed, Medium Intensity	19500
24. Developed, High Intensity	25500
31. Bare Rock/Sand/Clay	3000
32. Unconsolidated Shore (such as silt)	650
41. Deciduous Forest	50
42. Evergreen Forest	50
43. Mixed Forest	50
51. Dwarf Scrub (Alaska Only)	200
52. Shrub/Scrub	50
71. Grasslands/ Herbaceous	225
72. Sedge/Herbaceous (Alaska Only)	225
73. Lichens (Alaska Only)	225
74. Moss (Alaska Only)	225
81. Pasture/ Hay	225
82. Cultivated Crops	200

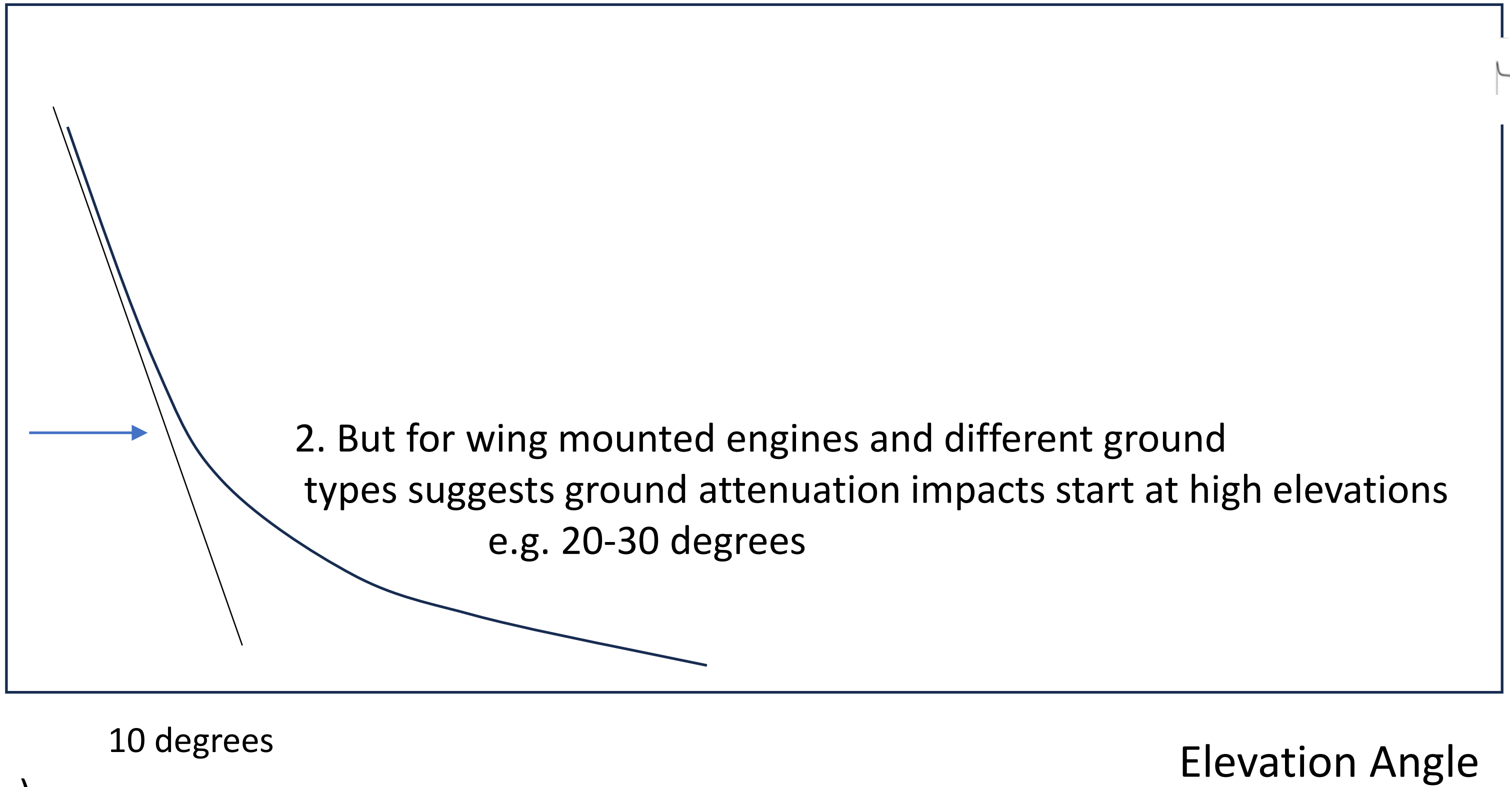
4-5x

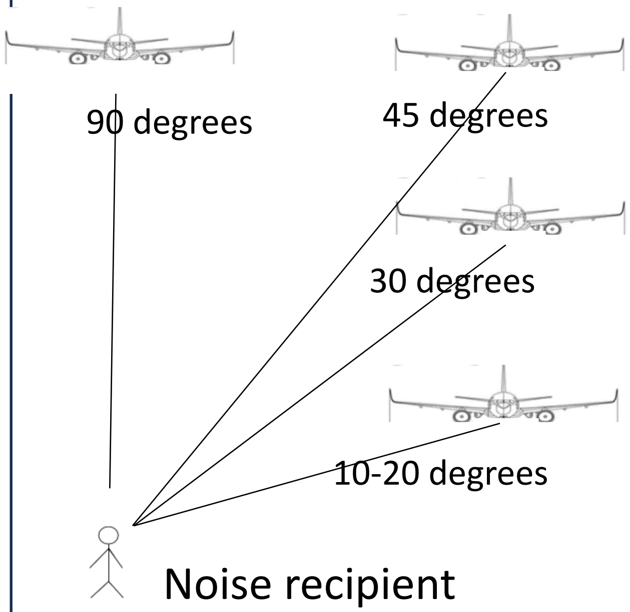
100x

Example from FAA report

SAE AIR 5662 – Does not consider different Ground surfaces

Attenuation





1. Based on soft ground SAE AIR 5662 suggests ground Attenuation Impacts below 10 degrees (for fuselage mounted engines impacts hidden by Scattering & refraction)

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What is the effect if we take surfaces impacts into account?

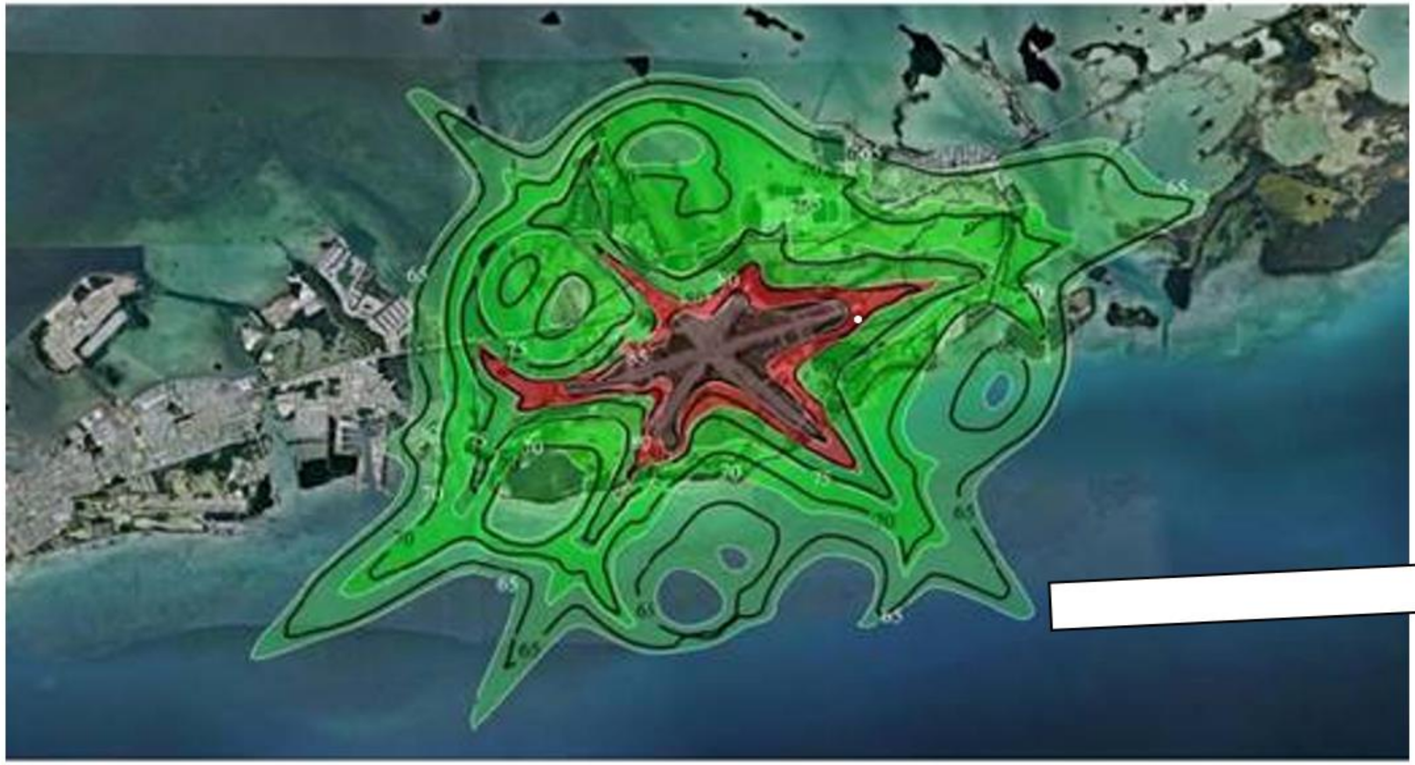

FIGURE 25. Contours of Ldn calculated with the entire area as soft (dark lines) and hard for water/soft for land (light gray contours with shading).

Example from FAA report

Contour is extended by 2-3 dB
at side and directly under flight path

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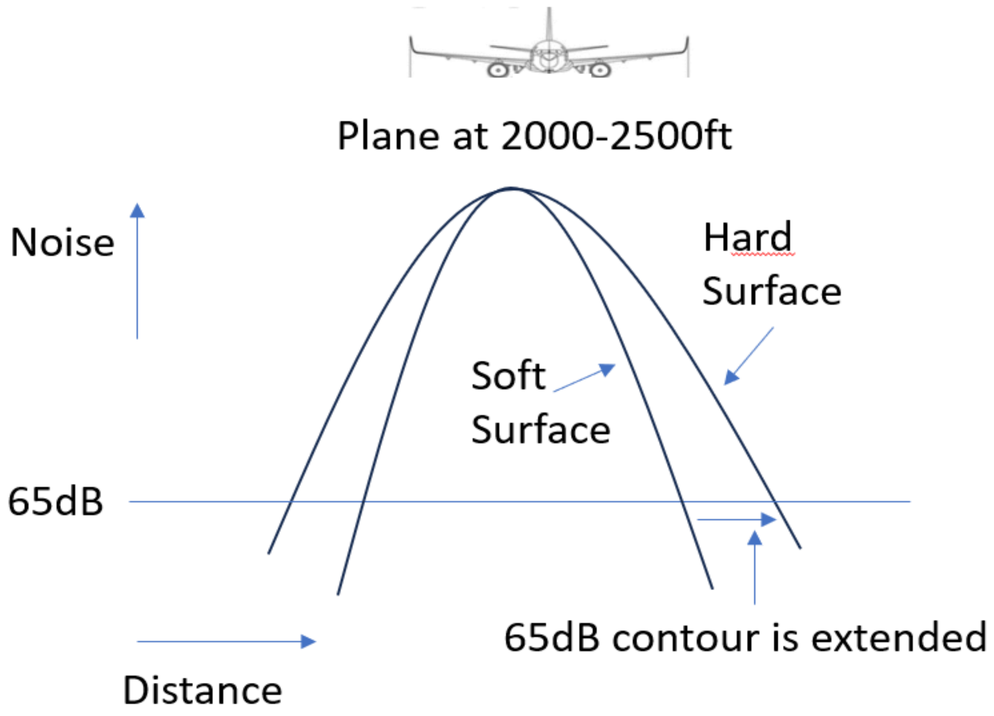
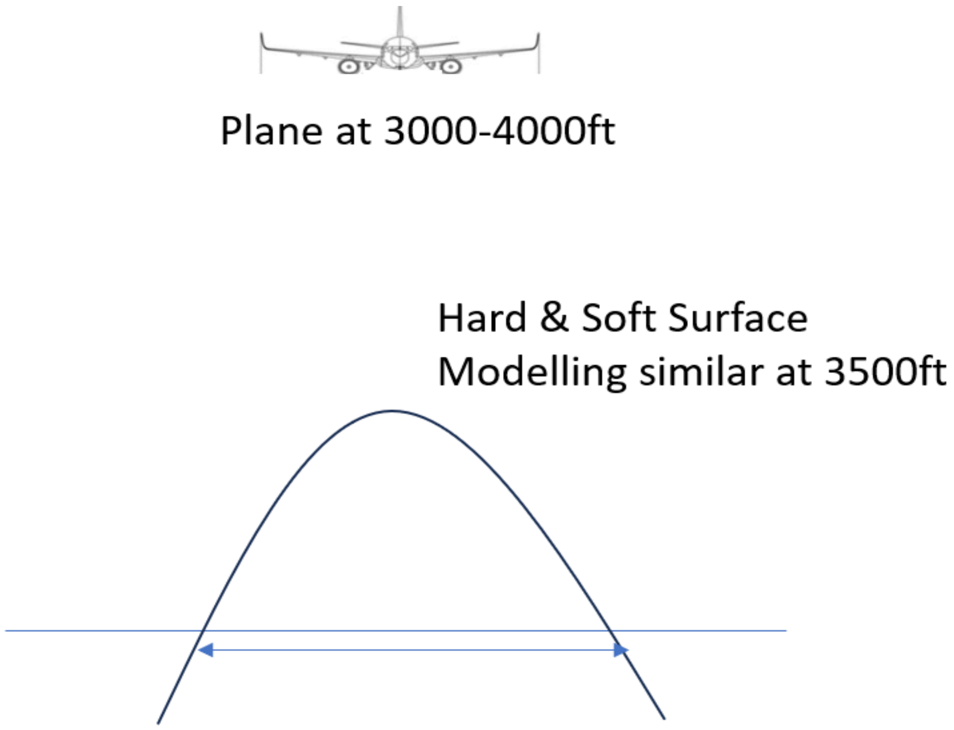
Noise Modelling is impacted at lower heights (lower elevation angles) – using a soft surface assumption makes contours smaller





These differences of 1-2dB are important if you are comparing NADP2 at 2500ft to NADP1 at 3500ft

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FAA have sponsored work on ground effects which has been reported in 2017

(Detailed 154 page report)

Improving AEDT Noise Modeling of Mixed Ground Surfaces (2017)

DETAILS

0 pages | 8.5 x 11 | PAPERBACK
ISBN 978-0-309-46217-4 | DOI 10.17226/24822

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CONTRIBUTORS

Christopher M Hobbs, Yuriy A Gurovich, Eric Boeker, Aaron Hasting, Amanda Rapoza, Juliet Page, and John A Volpe; Airport Cooperative Research Program; Transportation Research Board; National Academies of Sciences, Engineering, and Medicine

SUGGESTED CITATION

National Academies of Sciences, Engineering, and Medicine 2017. *Improving AEDT Noise Modeling of Mixed Ground Surfaces*. Washington, DC: The National Academies Press. https://doi.org/10.17226/24822.

This document presents a critical review of relevant acoustic theory, a review of practical applications implementing this theory, a synthesis of available airport data that support this project, an analysis and validation of the theory with measurement data, and recommendations on improving modeling of noise propagating over hard, soft and mixed ground surfaces in AEDT.

The recommended methods for modeling ground effects in AEDT were evaluated using data from SFO, OAK, and PDX. The research concluded that:

- Using the single-parameter model of ground impedance based upon flow resistivity estimates of categories in the National Land Cover Database along with straight ray theory as presented here accurately calculated the average lateral attenuation of aircraft operations to within 1 dB of measurements.
- The methods presented here can be incorporated into AEDT's architecture with minimal changes. In addition to decreasing segment lengths of input tracks and importing the additional terrain properties necessary for estimating ground impedance, one can make use of the existing framework of AEDT to add this capability.

5.2.4.5 Ground Cover

The following ground cover options are displayed when any noise metric is selected (Figure 4). Select the appropriate option:

- *Calculate mixed ground impedance effects*: When selected, AEDT uses the new mixed ground impedance effects method to supplement the default, soft-ground-only lateral attenuation adjustment (based on SAE-AIR-5662). If not selected, AEDT computes airplane-to-observer noise propagation over a default soft ground, based solely on the lateral attenuation adjustment. When selected, two ground cover definition options are made available:
  - *Uniform ground cover*: If selected, AEDT uses a uniform, user-supplied ground cover value (estimated flow resistivity in kPa*m/s²) in the noise calculations.
  - *Geospatially referenced ground cover data*: If selected, AEDT uses the ground cover data specified in the *Definitions* tab in noise calculations. See Section 9.7 for more information.
    - If selected, AEDT computes the noise propagation from an airplane to a ground-based observer using ground cover data from one or more ground cover files. This is used for the mixed ground impedance adjustment for noise, which supplements the lateral attenuation adjustment (see Section 5.2.4.3).
    - *Fill ground cover (kPa*s/m²)*: If desired, enter estimated flow resistivity value in kPa*s/m² to be used to fill gaps in the ground cover data.

To produce noise results when using geospatially referenced ground cover data, the ground cover data must cover the same areas as the receptor set used for the noise metric result.

When *Calculate mixed ground impedance effects* is selected, the *Use hard ground attenuation for helicopters and propeller aircraft* option is disabled.

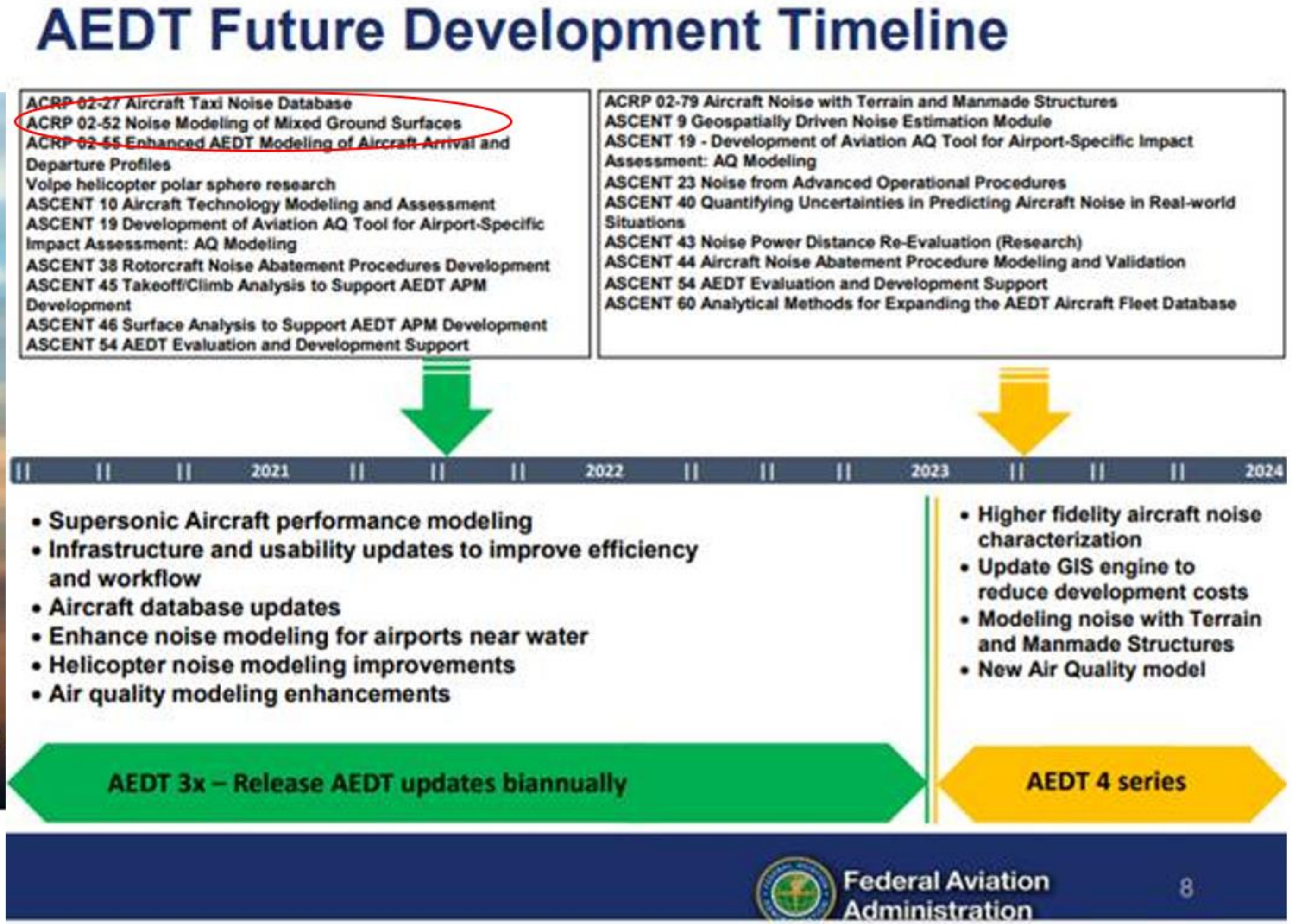
FIGURE 78. Recommended new section to AEDT 2c sp1 User's Guide (Section 5.2.4.5) to account for ground cover effects Processing Options for noise propagation modeling

- Worked to point where it can be implemented in noise modelling

AEDT - Aviation Environmental Design Tool

Implementation

- AEDT continuously being refined and modelling updated



- Planned for 2021. Covid looks to have delayed implementation

Conclusions and Questions

- Heathrow's unique position close to urban areas means sideways noise is higher than modelled
- Issues recognised by FAA and AEDT noise model refinements are in progress
- 1-2dB of difference are likely at sides of contours around Heathrow – important for NADP1/2 analysis and needs to recognised in any results

- Is DfT aware that noise modelling around Heathrow assumes London urban environment behaves like grassy fields?
- Is there a workplan in CAA/ERCD to update the CAA/ANCON noise model?

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