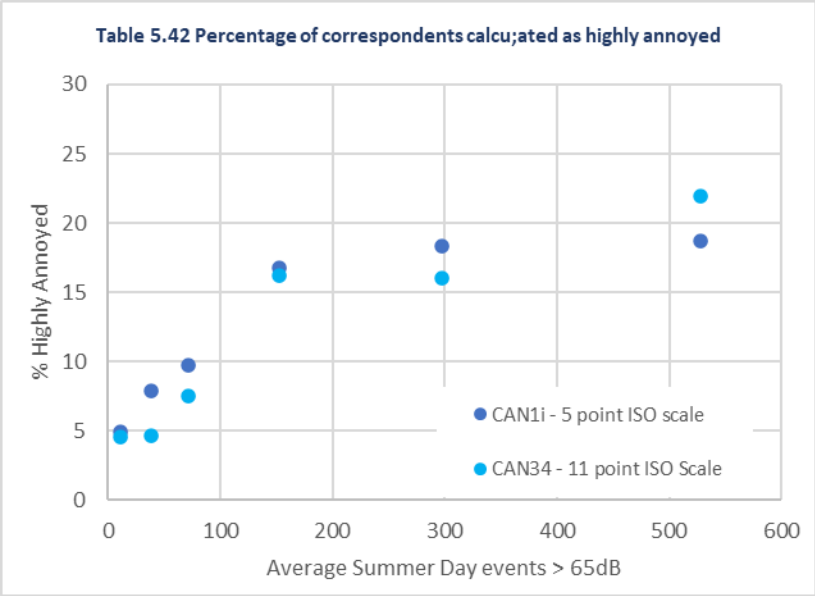
Objective (from Heathrow Community Noise Group)

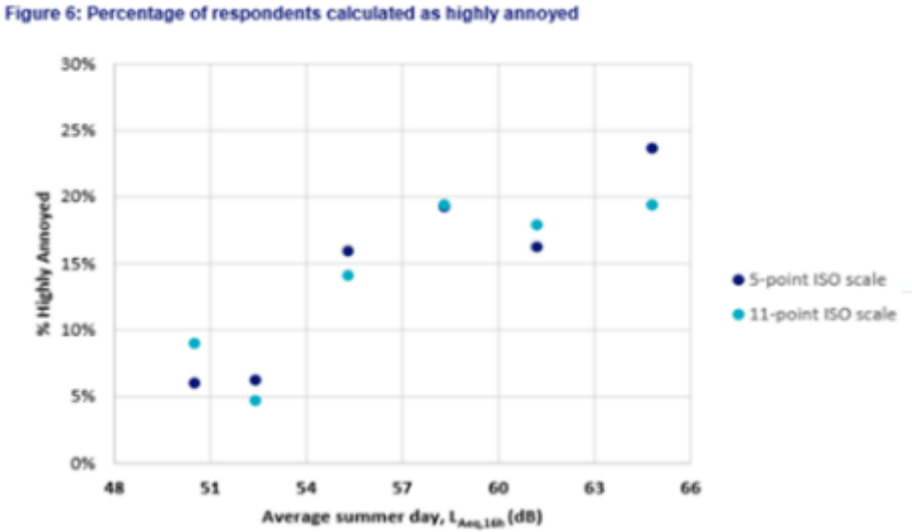
Objective

Reduce departure noise based on LAmax as much as possible for the largest population (and SELs where possible), while minimising negative effects including increased noise (e.g. sideways or close in), NO_X and fuel burn.

Rational for Objective – based on annoyance relationships



Note only presented as a Table in SoNA 2014 report



SoNA 2014	Average Numbers of N>65dB Events			
LAeq 16hr	1-25	25-50	50-100	>100
48-51	75%	16%	9%	
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54-57		6%	28%	66%
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60-63				100%
66-69				100%
69-72				100%

No Logical relationship <54dB LAeq (note few hundred responses per data point below 54dB), <54dB includes departures

In addition important to understand i) airline considerations – fuel burn and engine wear and ii) environmental concerns NO_X and CO_2 to hold a balanced discussion

Departure noise optimisation

Preliminary results

Kjeld Vinkx

Objective & results

Loudness of noise event

Total noise exposure of noise event, includes duration

Objective

Reduce departure noise based on LAmax as much as possible for the largest population (and SELs where possible), while minimising negative effects including increased noise, NO_X and fuel burn.

Results

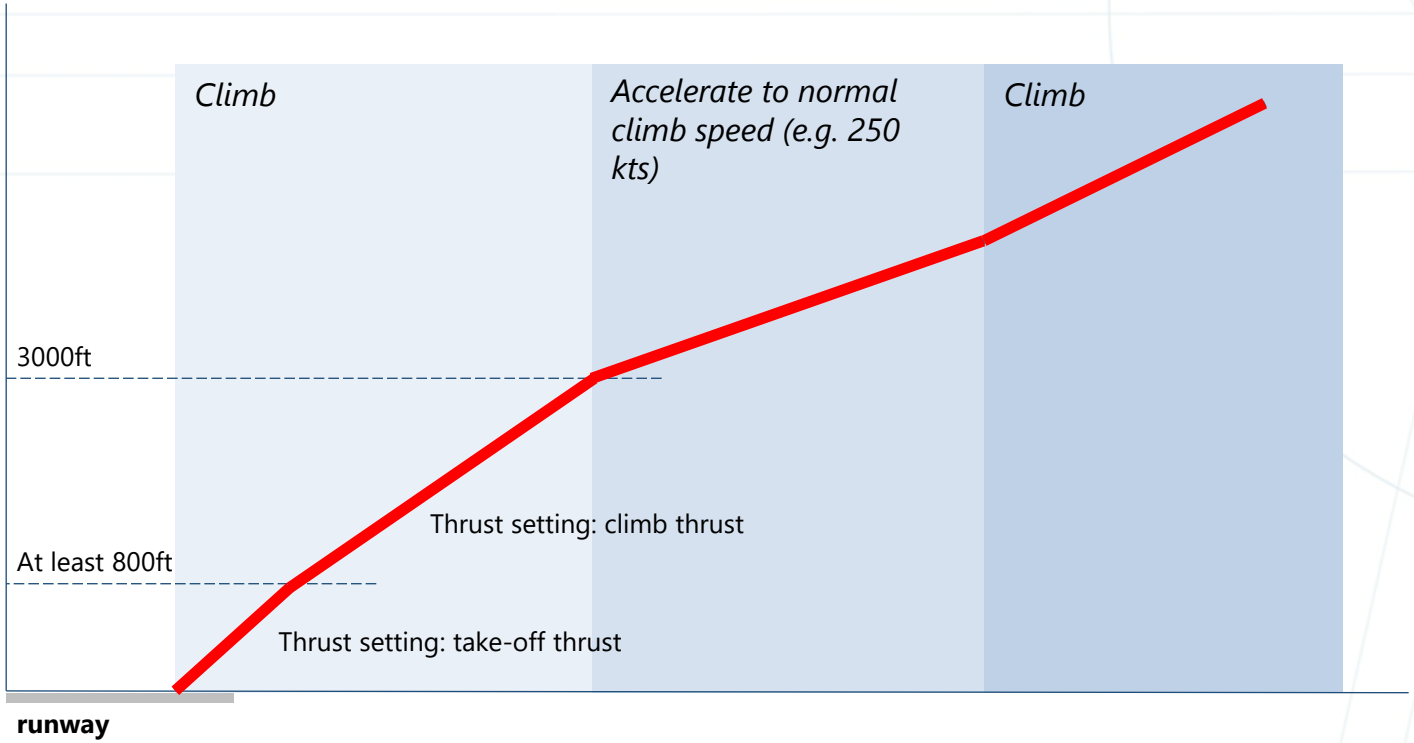
Significant potential to reduce departure noise for A320 aircraft based on both LAmax and SELs for 60+ dB area:

- Change from NADP 2 to NADP 1
- Preferably, increase acceleration height

Further reductions in noise possible by increasing T/O thrust

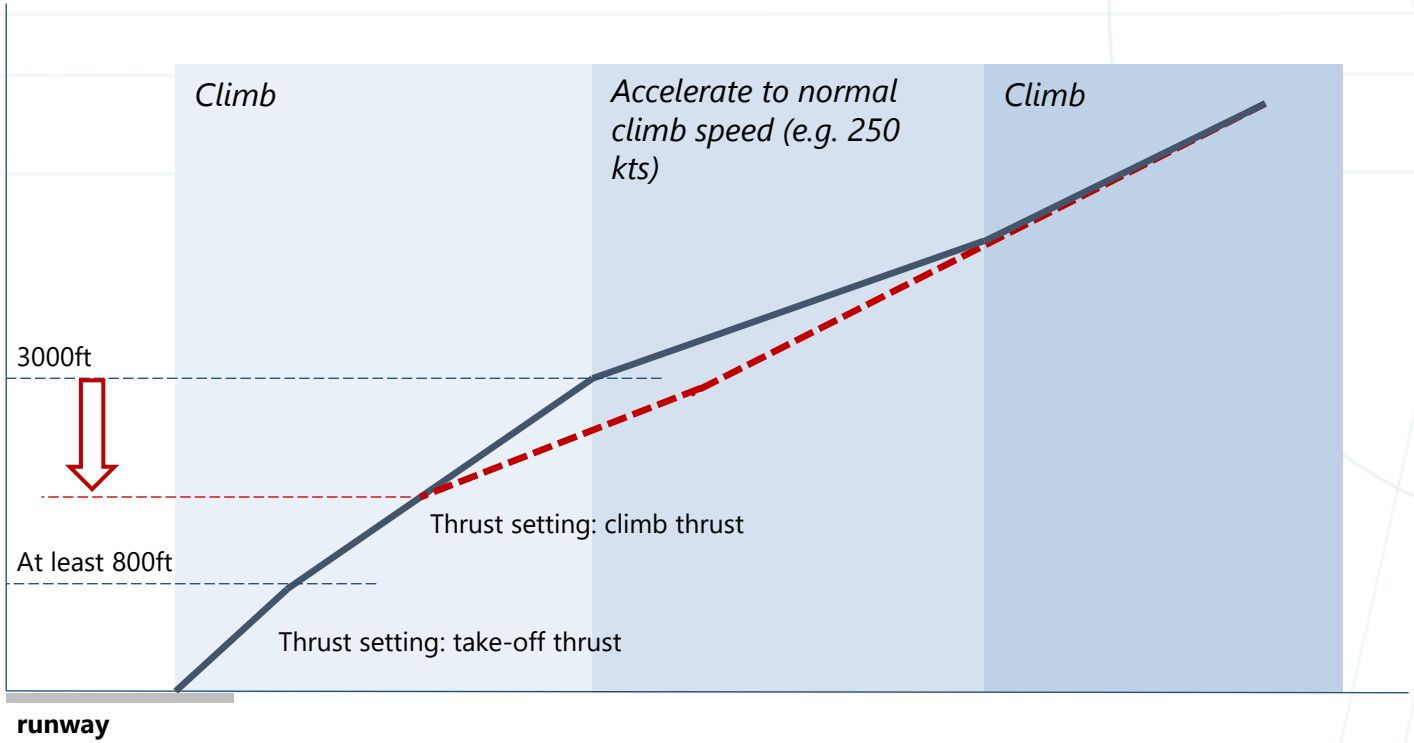
What is a departure procedure?

Example: Noise Abatement Departure Procedure 1 (NADP1)
(defined by international guidelines)



What is a departure procedure?

NADP2: start acceleration below 3.000ft



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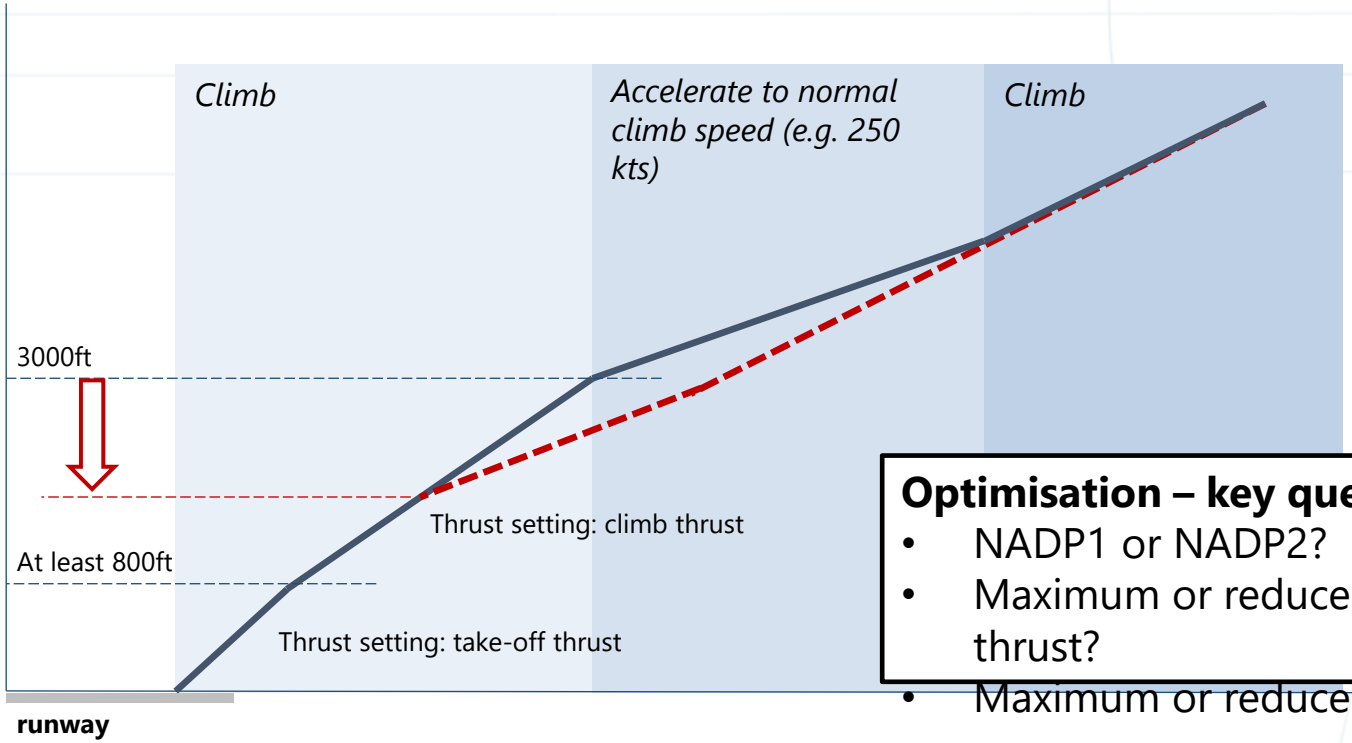


Optimisation – key questions:

- NADP1 or NADP2?
- Maximum or reduced take-off thrust?
- Maximum or reduced climb thrust?

Some background

International regulations: ICAO doc8168

- An airline shall develop no more than two noise abatement procedures for each aircraft type
- Two examples: NADP1 and NADP2

In practice

- NADP1 and NADP2 procedures are standard operating procedures worldwide
- NADP2 is the most standard procedure for noise and fuel optimisation, as most airports are not situated next to dense populations

London Heathrow

- The AIP does not provide an advised procedure, however Noise Abatement Procedure requires *'Aircraft to be operated in a manner calculated to cause the least disturbance practicable in areas surrounding the airport'*

Research: explore the environmental impact of different departures

Selected aircraft: type A320 (medium size aircraft)

- Most common aircraft at LHR: share 18.5% (see table)
- Along with similar aircraft types: A319, A321, A32N, A32A, A32Q make 55% of aircraft movements

Different departure profiles have been created

- NADP1 and NADP2 departures
- For NADP1: a) flaps retraction at 3.000 ft, and b) delayed (at 4.500ft)
- Different thrust settings for take-off thrust (80 – 100%) and climb thrust (70 – 100%)

Noise impact studied for DETLING departures runway 09R.

95% of traffic movements at LHR:

Aircraft type	Share 2019
320	18.50%
319	15.27%
321	7.76%
32N	6.58%
77W	6.55%
789	6.27%
772	5.67%
32A	4.24%
744	3.72%
788	3.60%
388	3.00%
333	2.99%
DH4	2.18%
32Q	1.93%
76W	1.71%
332	1.57%
359	1.11%
73H	1.03%
346	0.74%
CS3	0.69%

Research approach

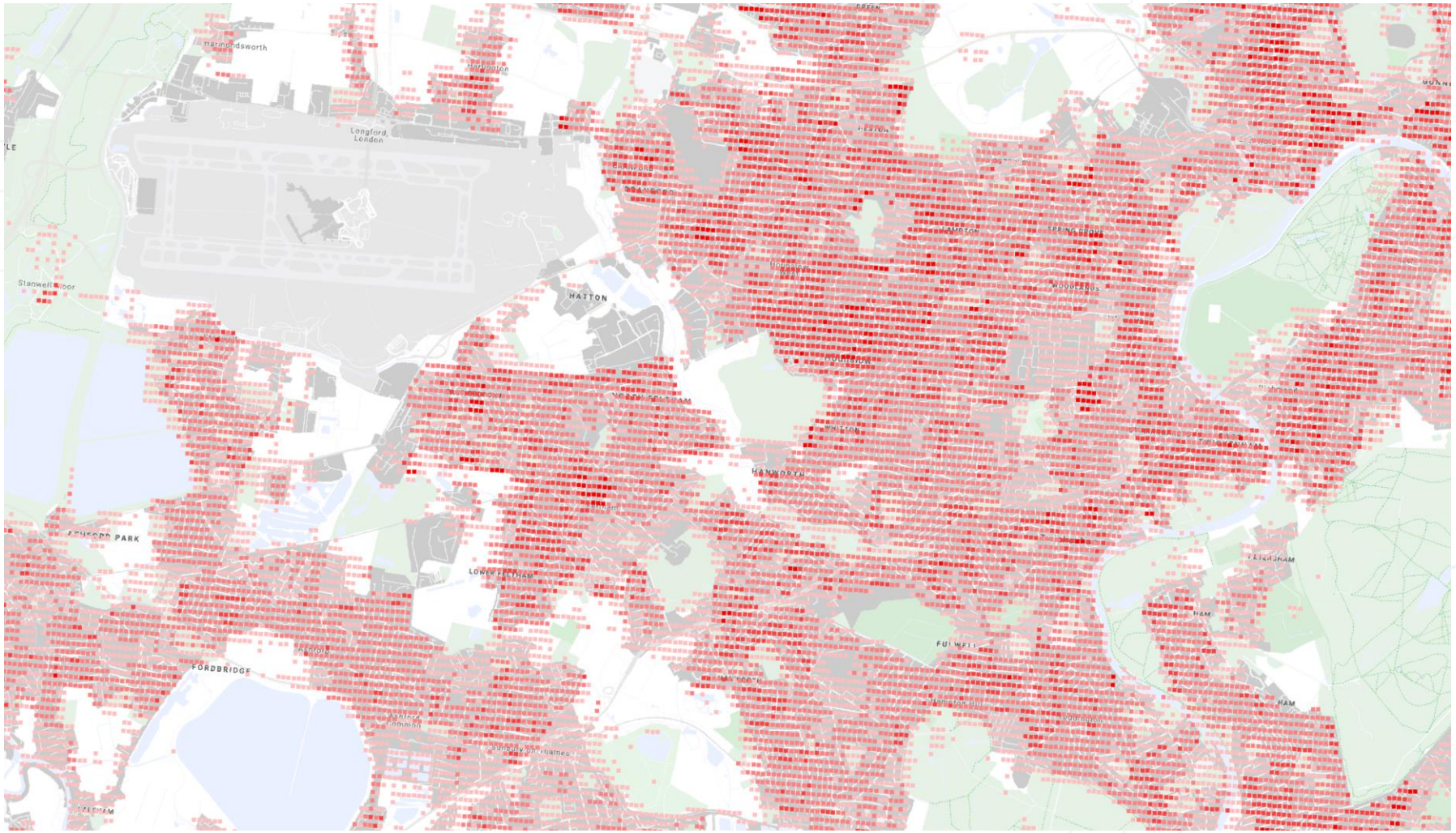
- Reference procedure: NADP2 with reduced take-off and climb thrust

- Selected aircraft type: **A320-211**
- Selected flight distance class: 2 (500 nm – 1000 nm)
- NADP1 acceleration height: a) 3000ft, and b) delayed, at 4500ft
- NADP2 acceleration height: 1500ft

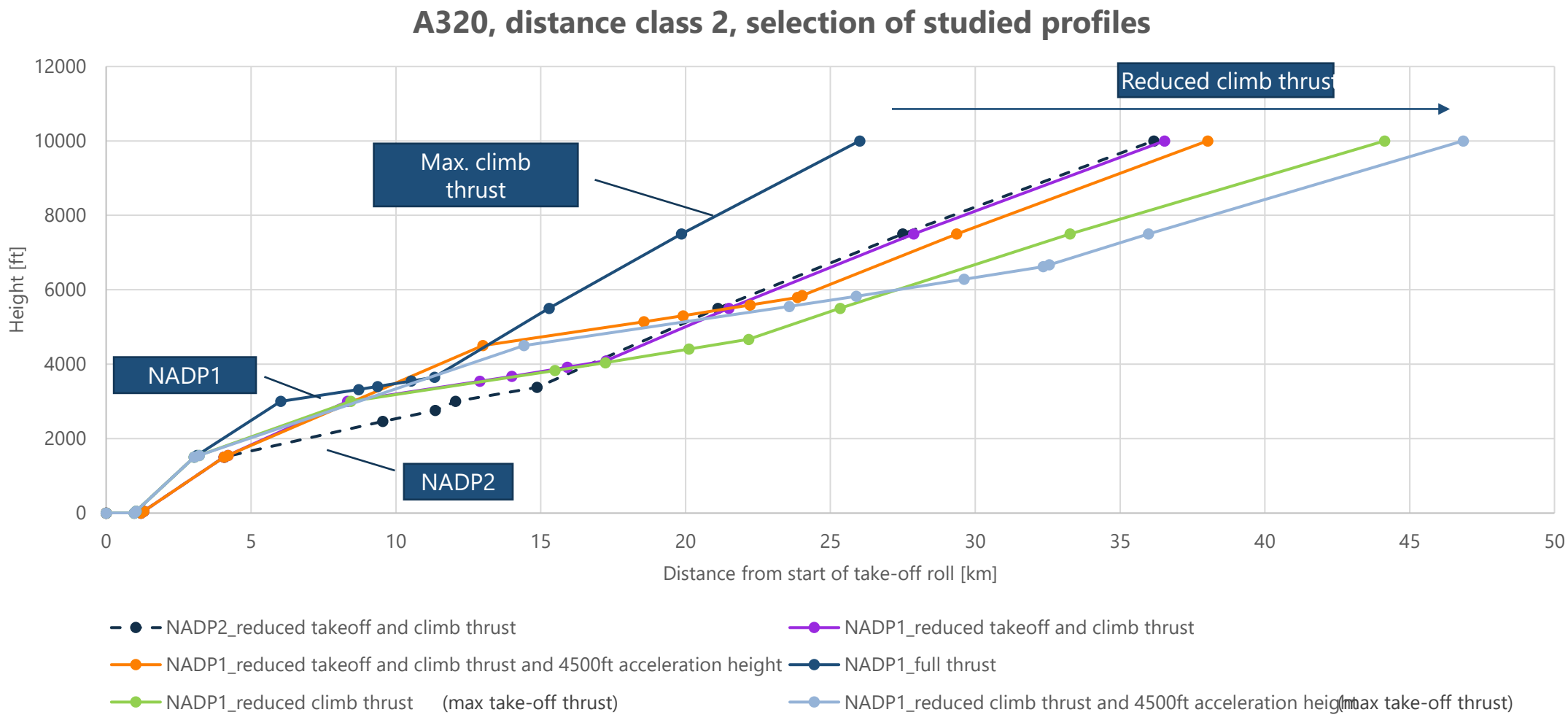
- Noise calculations: INM (~doc29, European standard)
- Noise indicators noise: Focus on LAmax (loudness) but also SEL (includes the duration of event)

- Population 2018: 100x100 grid cells (source: https://www.worldpop.org/)

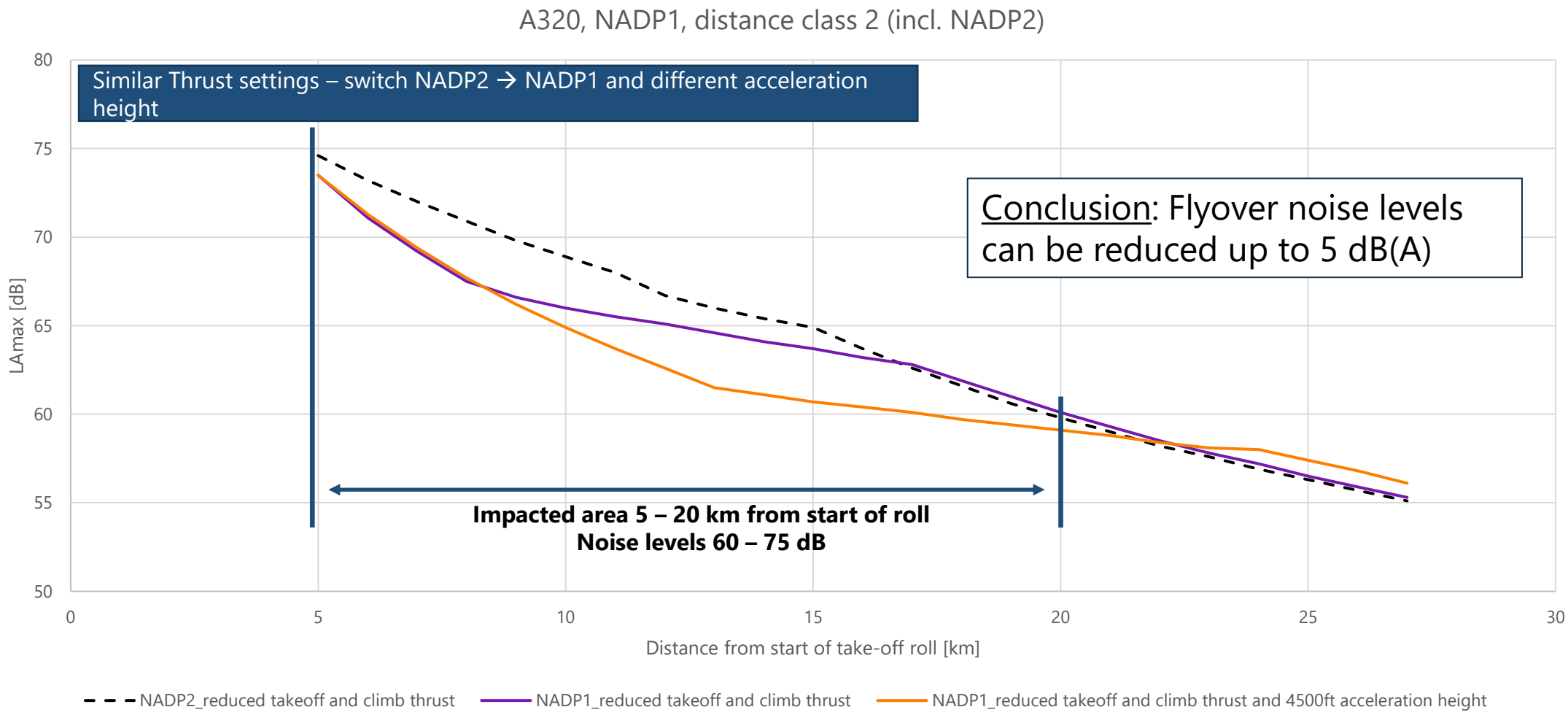
Population 2018



Airbus A320 – distance class 2, height profiles



Airbus A320 – loudness flight path



Airbus A320 – Affected Population per 5 dB LAmax

Population 2018 (x 1,000):

LAmax	NADP2 reduced thrust (80%)	NADP1 reduced thrust (80%)	NADP1 reduced thrust (80%) start of acceleration at 4.500ft	NADP1 max. thrust	NADP1 max. T/O thrust reduced climb thrust (70%)	NADP1 Max. T/O thrust reduced climb thrust (70%) acceleration at 4.500ft
60 dB	148	147	121	188	127	107
65 dB	66	44	35	82	24	26
70 dB	8.8	2.9	3.0	4.0	3.4	3.4

NADP1

Start acceleration at 4.500ft

Max. thrust

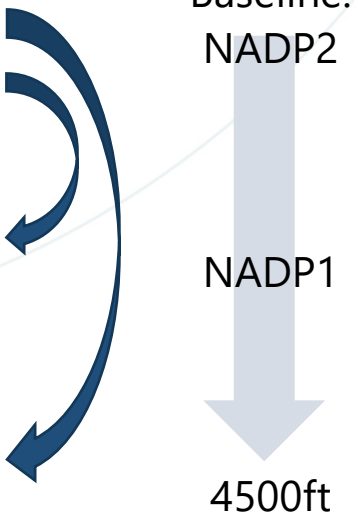
Airbus A320 – impact of NADP1 and acceleration height

Impact on affected population, per 5 dB

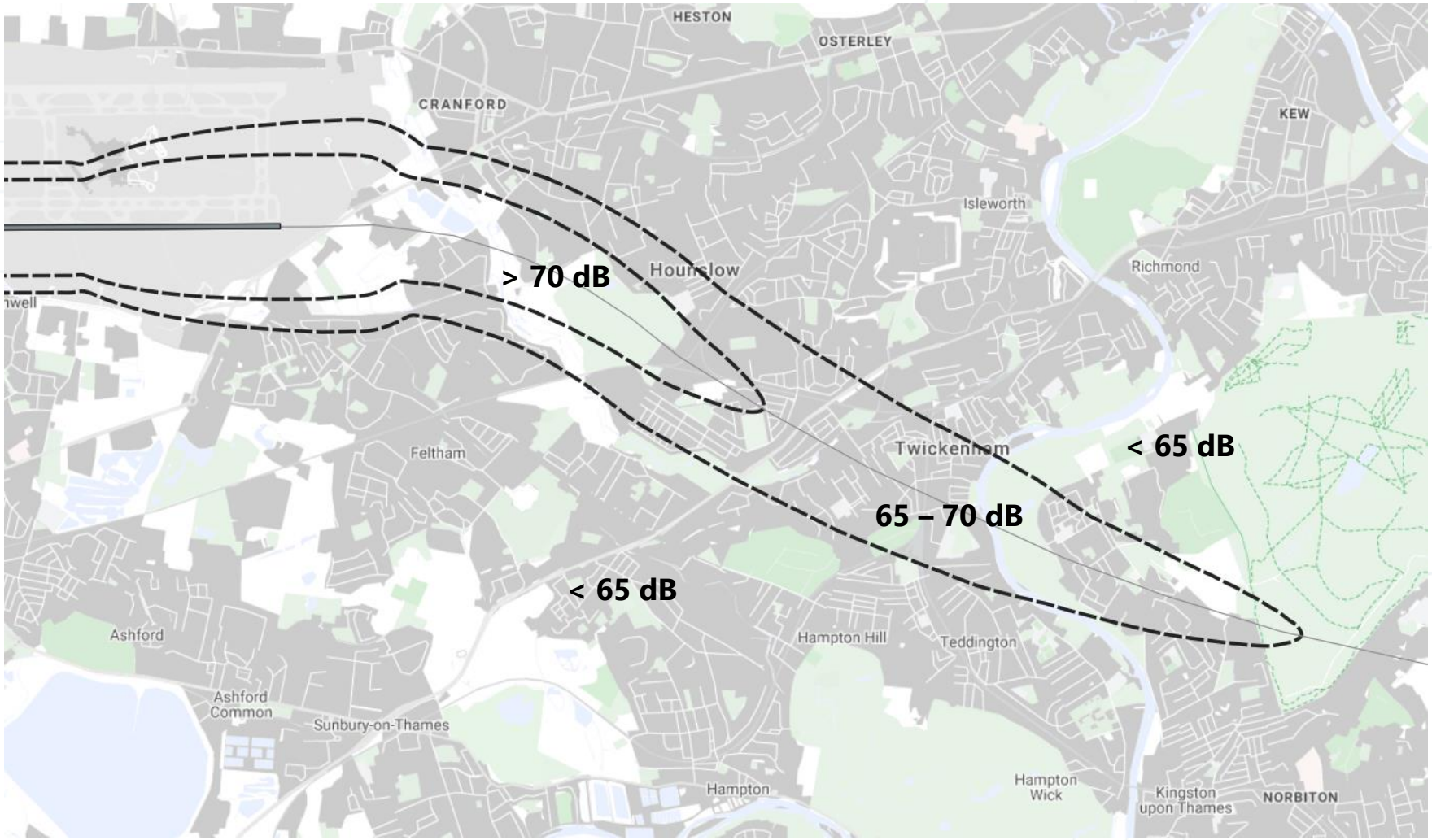
- Reference: NADP2 departure; distance class 2
- Note: cell colored relative to reference

Key - Take-off thrust %_Climb-Thrust %

	A100%	100%_80%	100%_70%	90%_80%	90%_70%	80%_100%	80%_80%	80%_70%
60 dB	182.4	145.9	131.8	145.1	131.7	181.5	147.5	135.8
65 dB	85.0	64.3	45.2	64.3	44.9	89.0	66.4	47.8
70 dB	15.3	5.1	3.7	6.2	3.0	22.8	8.8	3.0
60 dB	3%	-2%	-3%	-1%	-3%	3%	0%	-2%
65 dB	-3%	-39%	-46%	-37%	-45%	-4%	-34%	-39%
70 dB	-74%	-31%	-8%	-55%	-13%	-79%	-67%	-17%
60 dB	-2%	-17%	-19%	-17%	-20%	0%	-18%	-22%
65 dB	-48%	-55%	-44%	-53%	-41%	-39%	-47%	-36%
70 dB	-73%	-31%	-8%	-55%	-13%	-78%	-66%	-13%



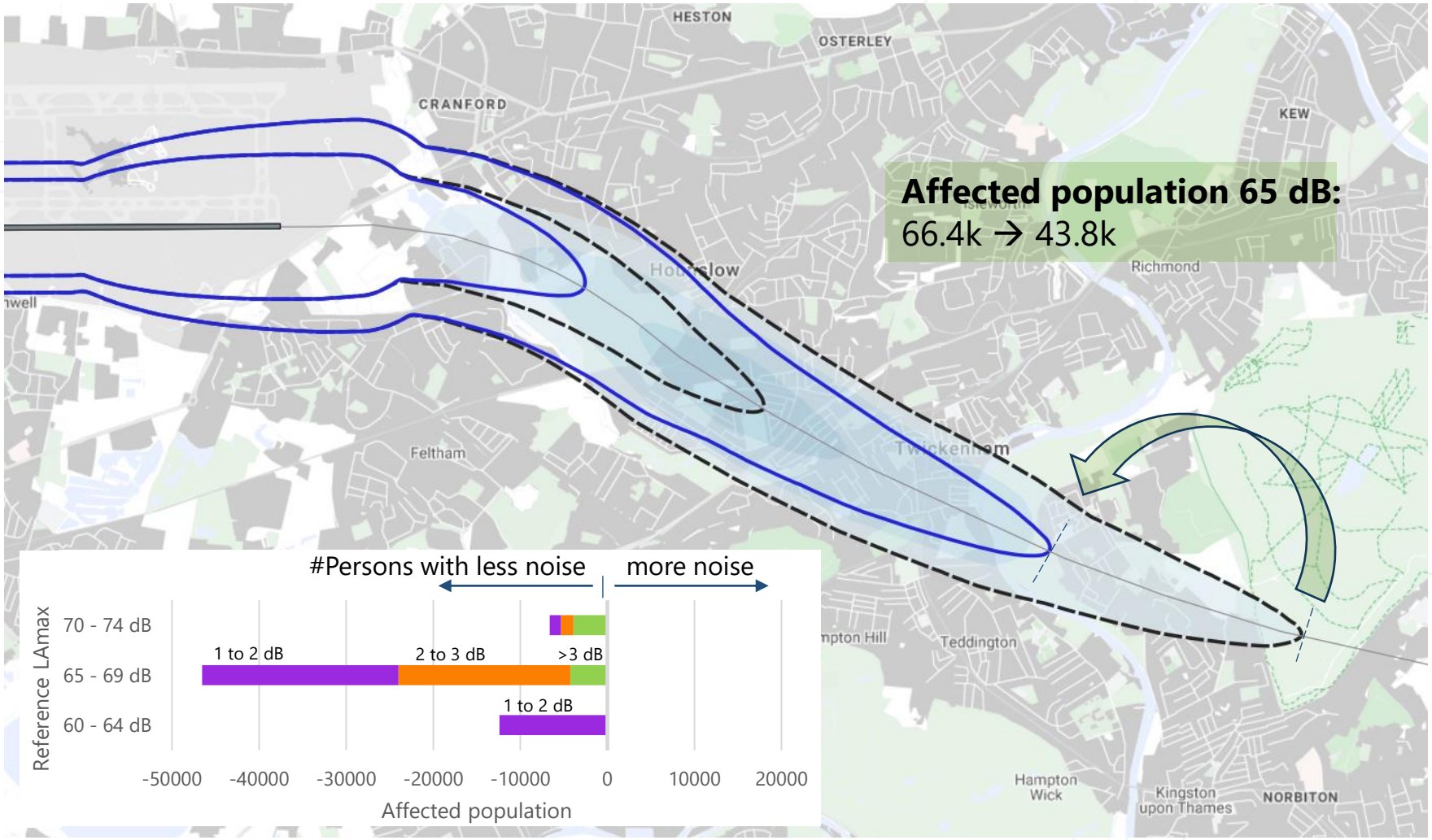
Airbus A320 – 65 and 70 dB LAmax contours



Reference:

- **NADP2**
- **Reduced take-off thrust**
- **Reduced climb thrust**

Airbus A320 – 65 and 70 dB LAmax contours



Reference: NADP2
- **Reduced take-off thrust**
- **Reduced climb thrust**

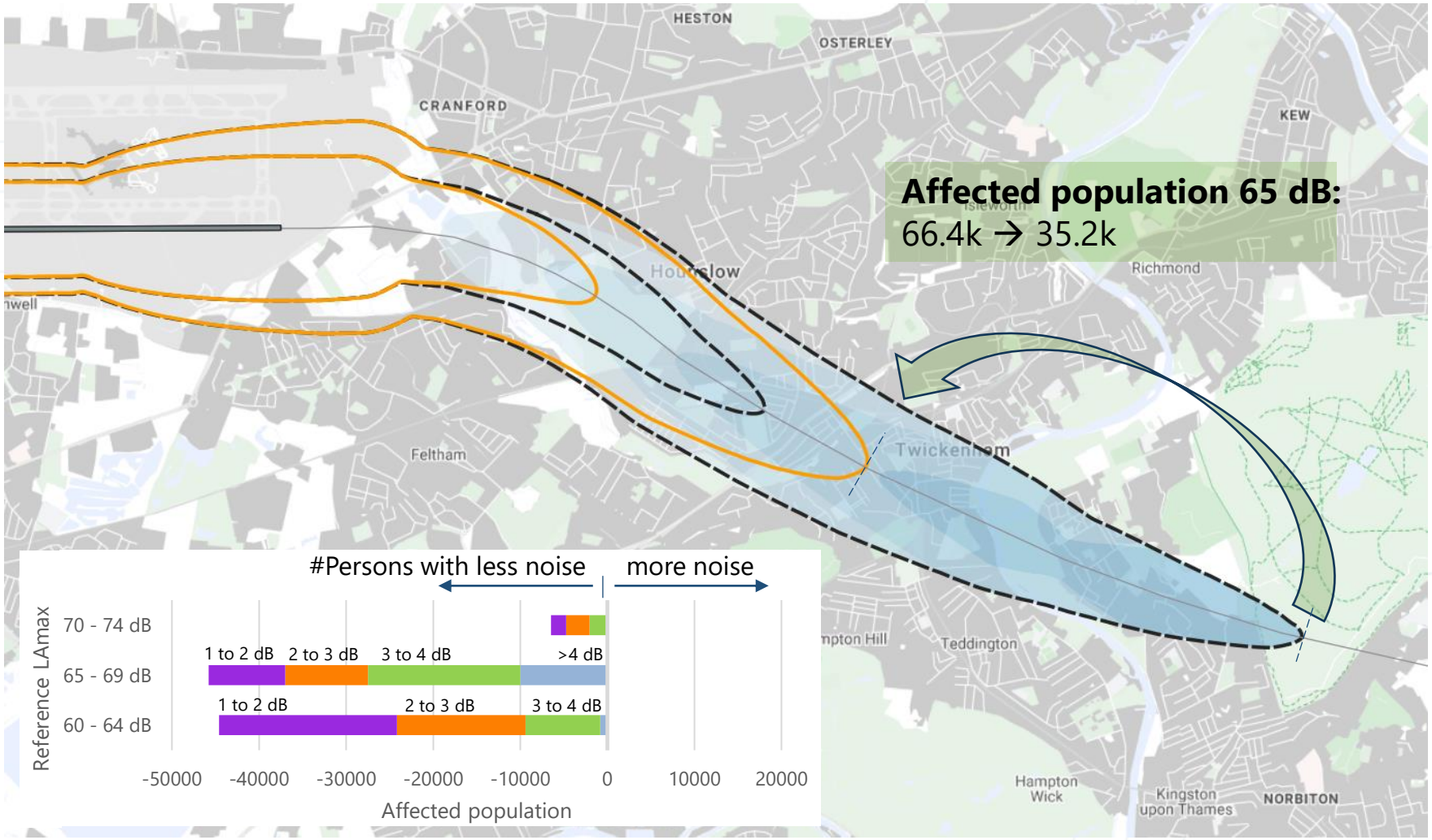
NADP1
- **Reduced take-off thrust**
- **Reduced climb thrust**

No area sees higher loudness

noise decrease (>1 dB)

noise increase (>1 dB)

Airbus A320 – 65 and 70 dB LAmax contours



Reference: NADP2
- **Reduced take-off thrust**
- **Reduced climb thrust**

NADP1
- **Reduced take-off thrust**
- **Reduced climb thrust**
- **Acceleration at 4.500ft**

No area sees higher loudness

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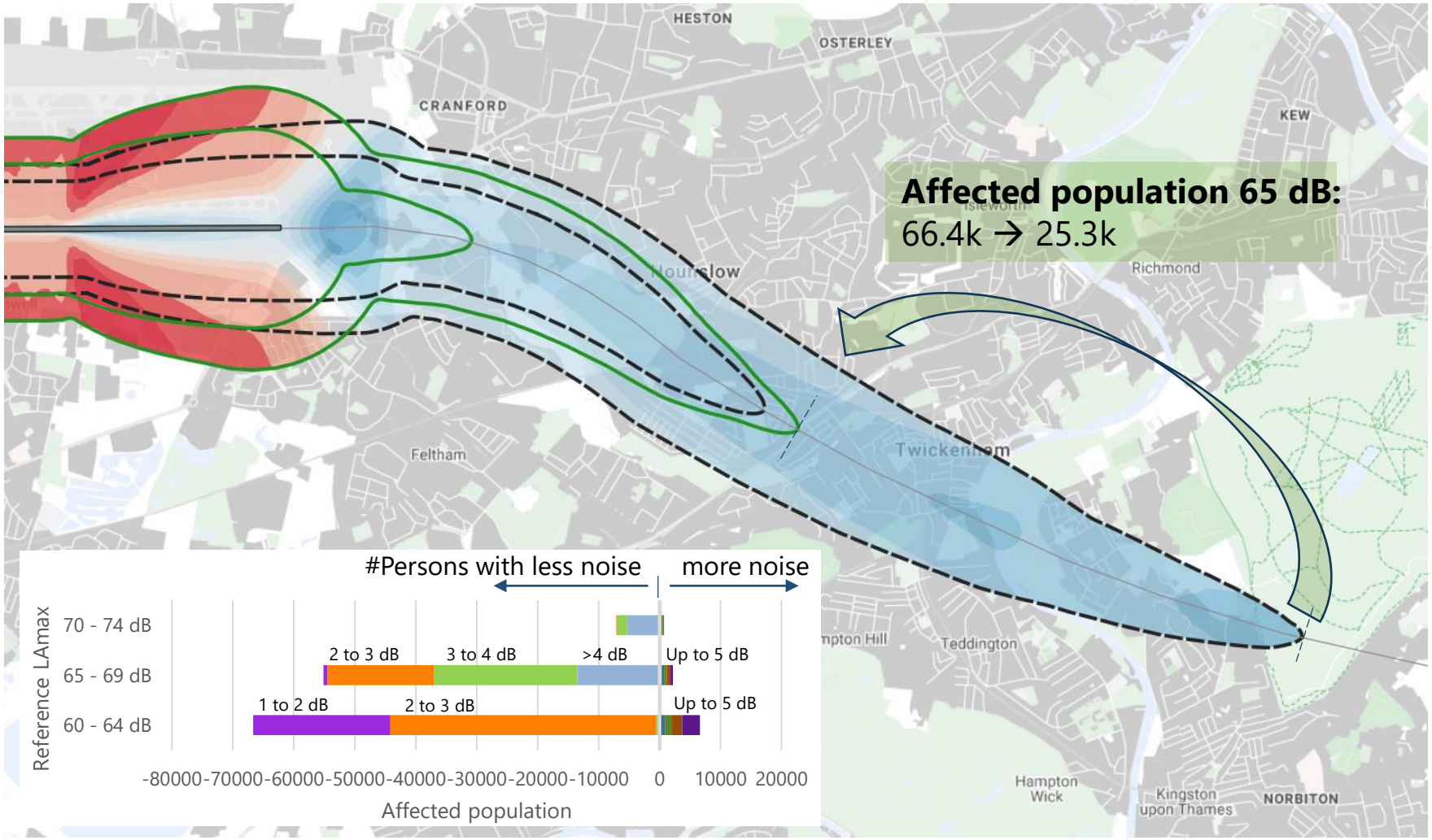
Airbus A320 – 65 and 70 dB LAmax contours



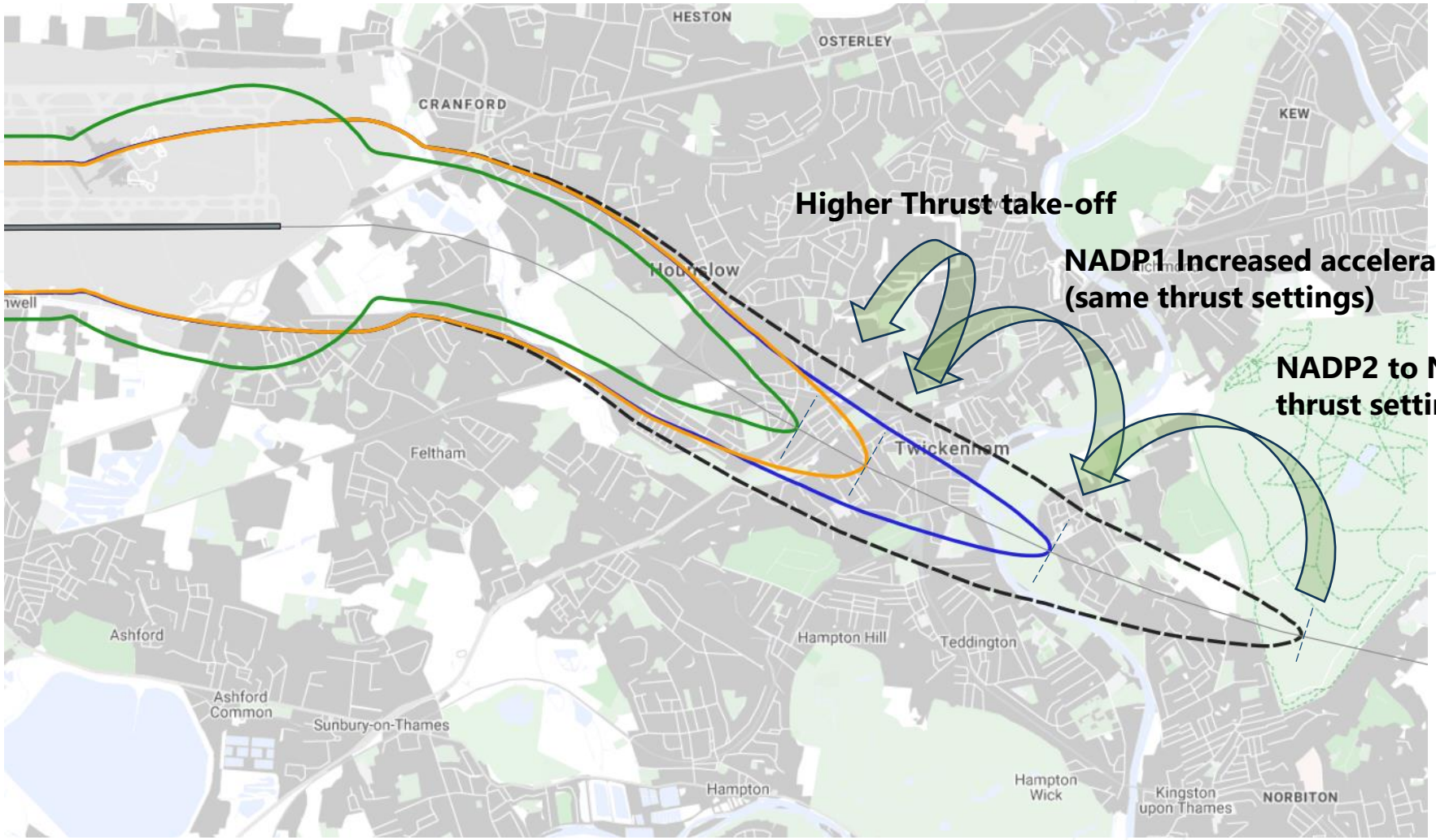
Reference: NADP2
- **Reduced take-off thrust**
- **Reduced climb thrust**

NADP1
- **Max take-off thrust**
- **Low climb thrust**
- **Acceleration at 4.500ft**

noise decrease (>1 dB)

noise increase (>1 dB)

Airbus A320 – 65 dB LAmax contour



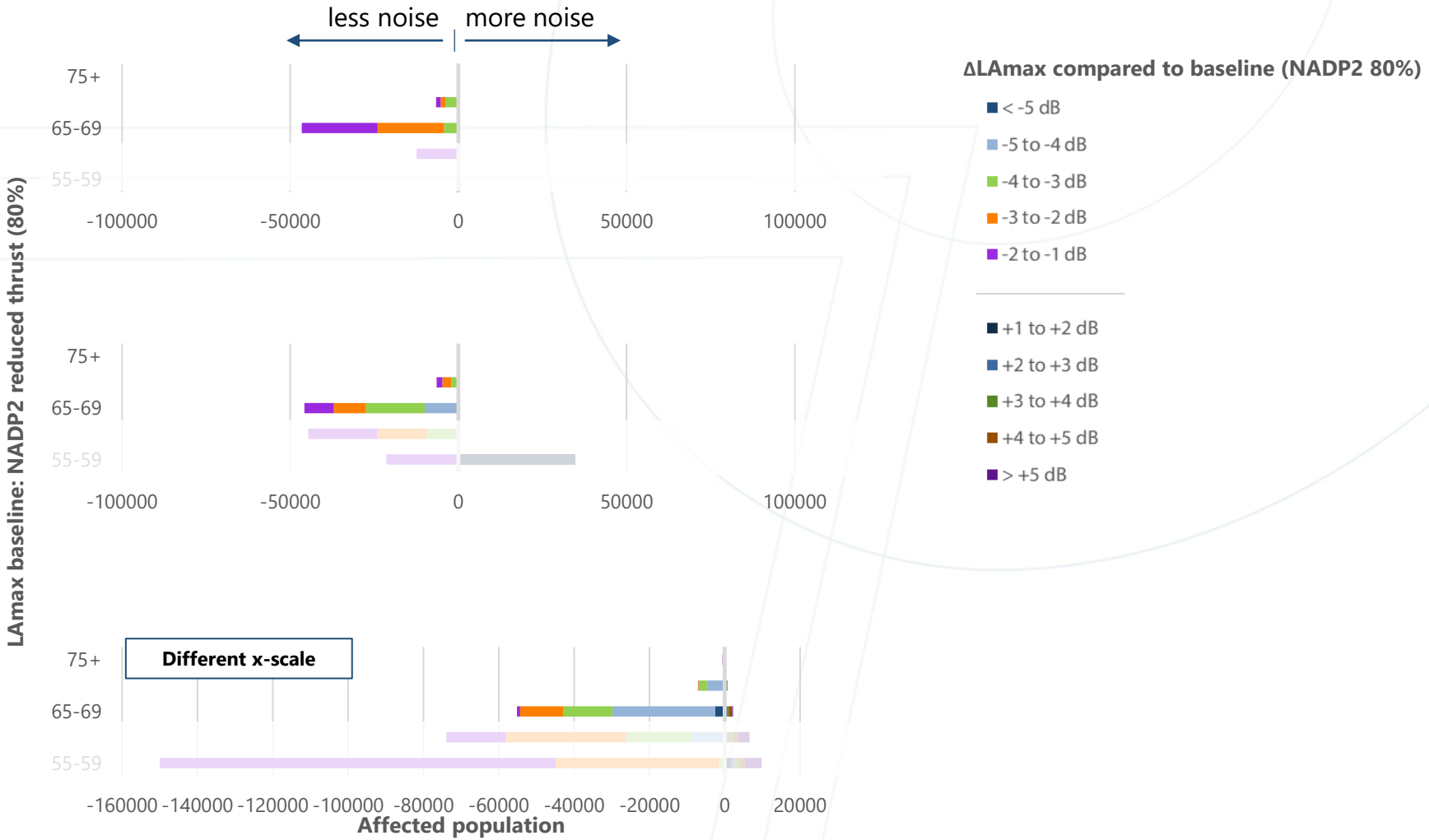
Airbus 320 Affected population, compared to NADP2 – LA_{max}

Focus on daytime noise: 65+ dB(A) LA_{max}

NADP1
80% T/O and climb thrust

NADP1
80% T/O and climb thrust
acceleration at 4.500ft

NADP1;
Max. T/O thrust
reduced climb thrust (70%)
acceleration at 4.500ft



Airbus 320 Affected population, compared to NADP2 – SEL

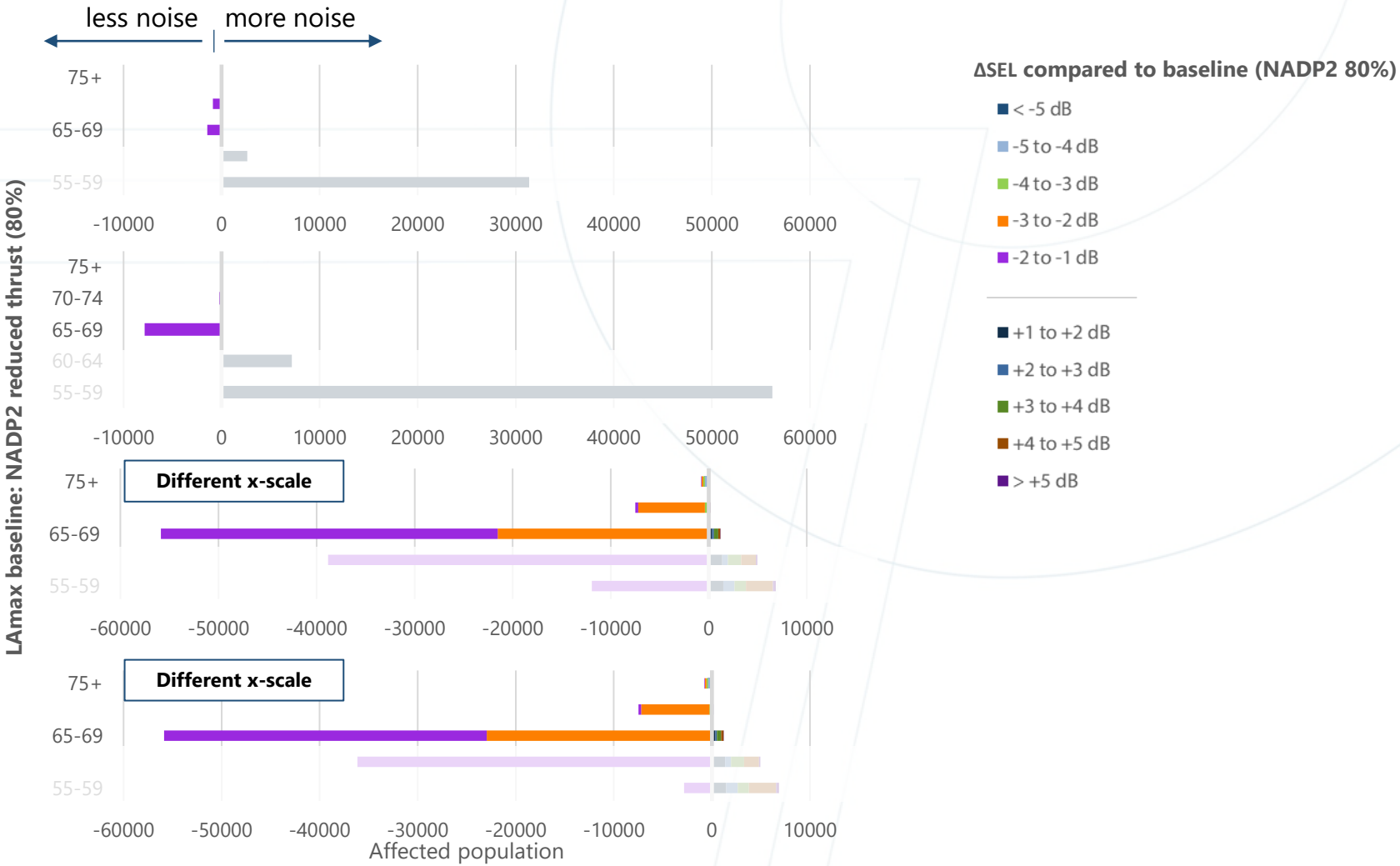
Focus on daytime noise: 65+ dB(A) LA_{max}

NADP1
80% T/O and climb thrust

NADP1
80% T/O and climb thrust
acceleration at 4.500ft

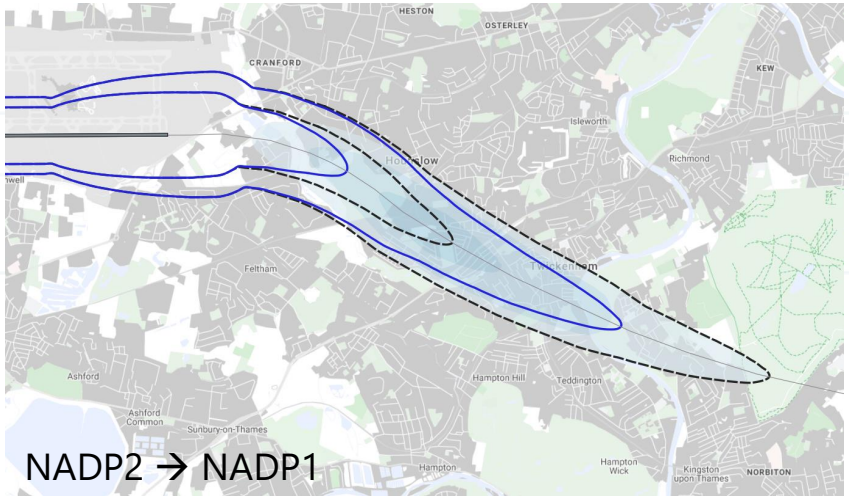
NADP1
max. T/O thrust
reduced climb thrust (70%)

NADP1;
Max. T/O thrust
reduced climb thrust (70%)
acceleration at 4.500ft

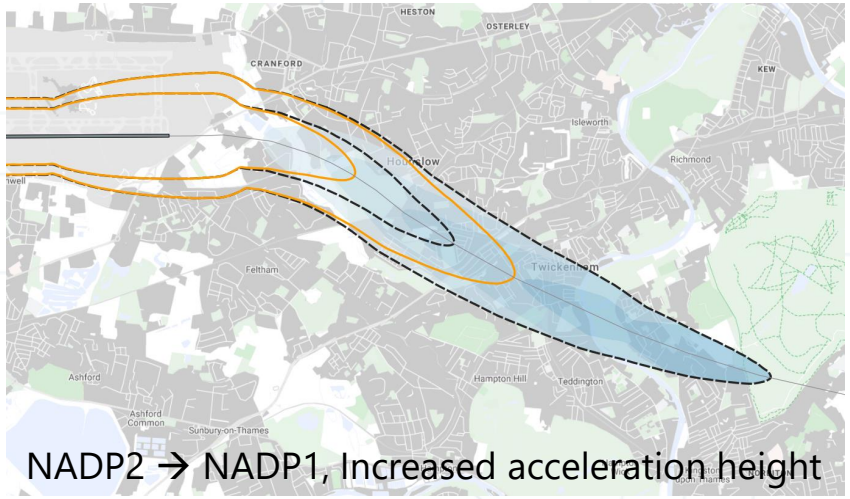


Airbus 320 Affected population, compared to NADP2 – SEL

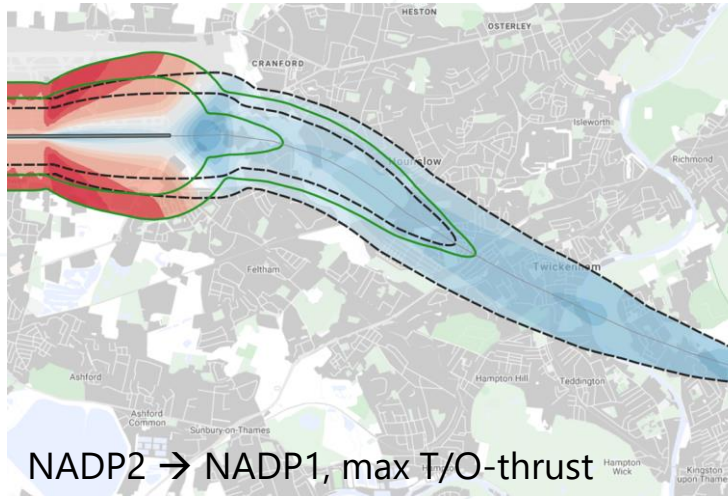
Changes in LA max: loudness



NADP2 → NADP1

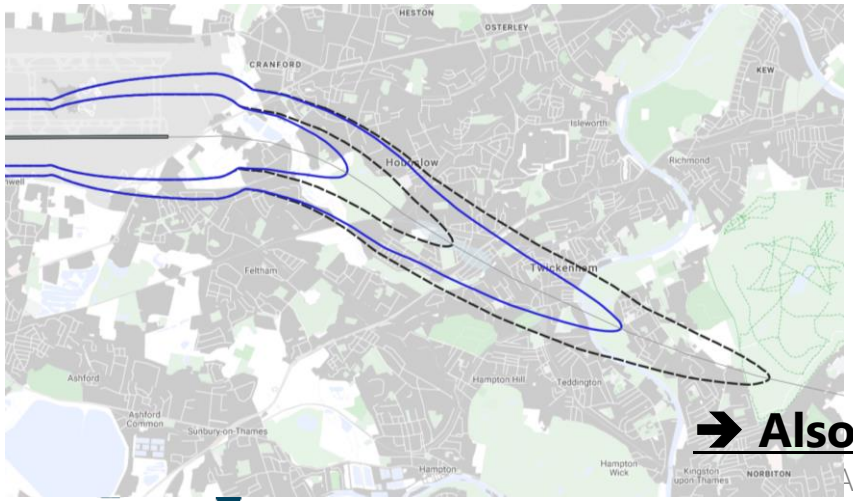


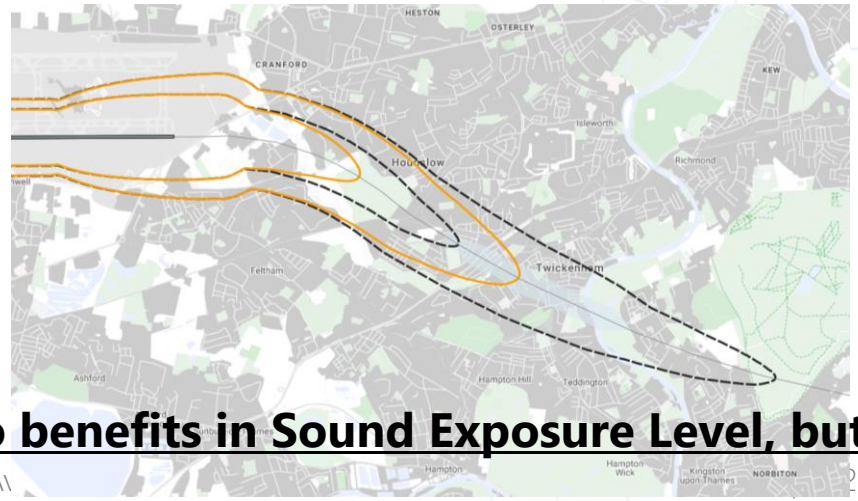
NADP2 → NADP1, Increased acceleration height

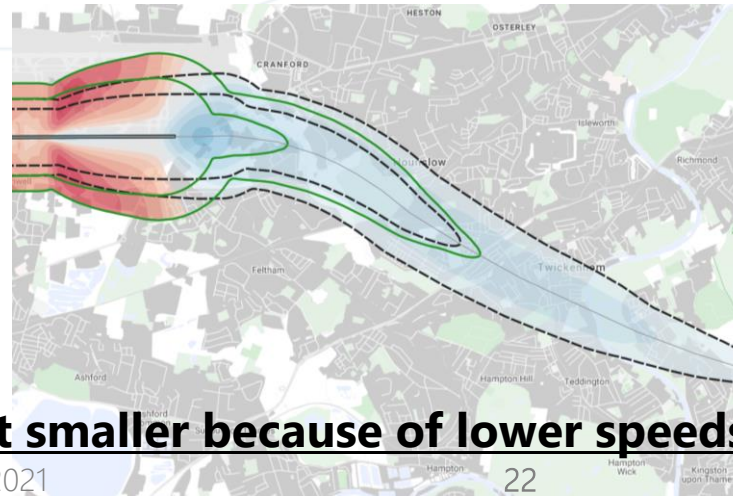


NADP2 → NADP1, max T/O-thrust

Changes in SEL (within 65 LAmax area) – includes duration of noise event







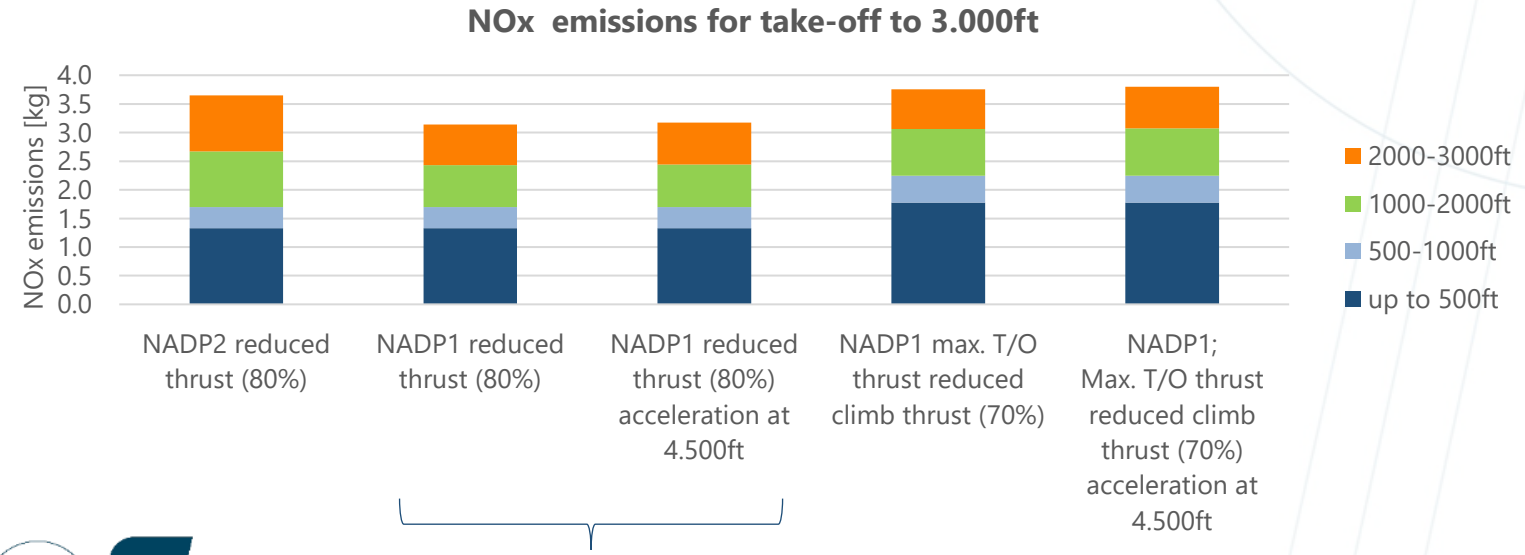
➔ Also benefits in Sound Exposure Level, but smaller because of lower speeds

Fuel burn and NOx

Additional fuel burn and NOx increase per flight with NADP1 and reduced thrust settings.

Fuel burn	NADP2 reduced thrust (80%)	NADP1 reduced thrust (80%)	NADP1 reduced thrust (80%) acceleration at 4.500ft	NADP1 max. T/O thrust reduced climb thrust (70%)	NADP1 max. T/O thrust reduced climb thrust (70%) acceleration at 4.500ft
Additional fuel burn [kg] (% total flight, 4.750 kg)	-	25 (0,5%)	25 (0,5%)	46 (1,0%)	103 (2,2%)
Additional cost of fuel	-	€ 14	€ 14	€ 25	€ 57

Increased thrusts also means increased engine wear



Pollution reduced in mixing zone to 3000ft

Objective & results

Objective

Reduce departure noise based on LAmax as much as possible for the largest population (and SELs where possible), while minimising negative effects including increased noise, NO_X and fuel burn.

Results

Significant potential to reduce departure noise for A320 aircraft based on both LAmax and SELs for 60+ dB area:

- Change from NADP 2 to NADP 1
- Preferably, increase acceleration height

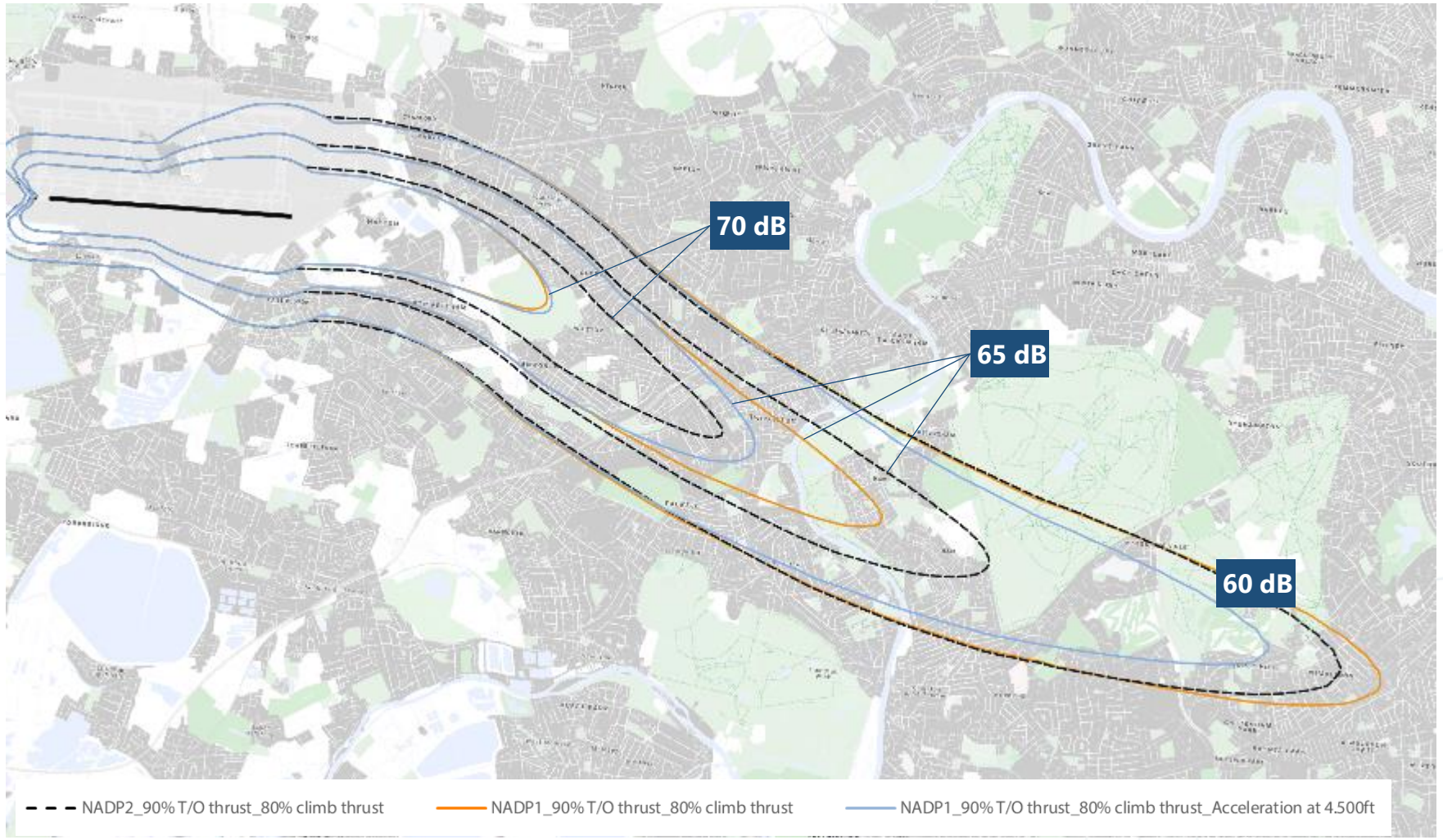
Further reductions in noise possible by increasing T/O thrust

Departure noise optimisation

Preliminary results

Boeing 787-8 – 60, 65 and 70 dB LAmax contours

Distance Class 5 (2500-3000nm)



Recommendation

- **To comply with AIP at London Heathrow**

'Aircraft to be operated in a manner calculated to cause the least disturbance practicable in areas surrounding the airport'

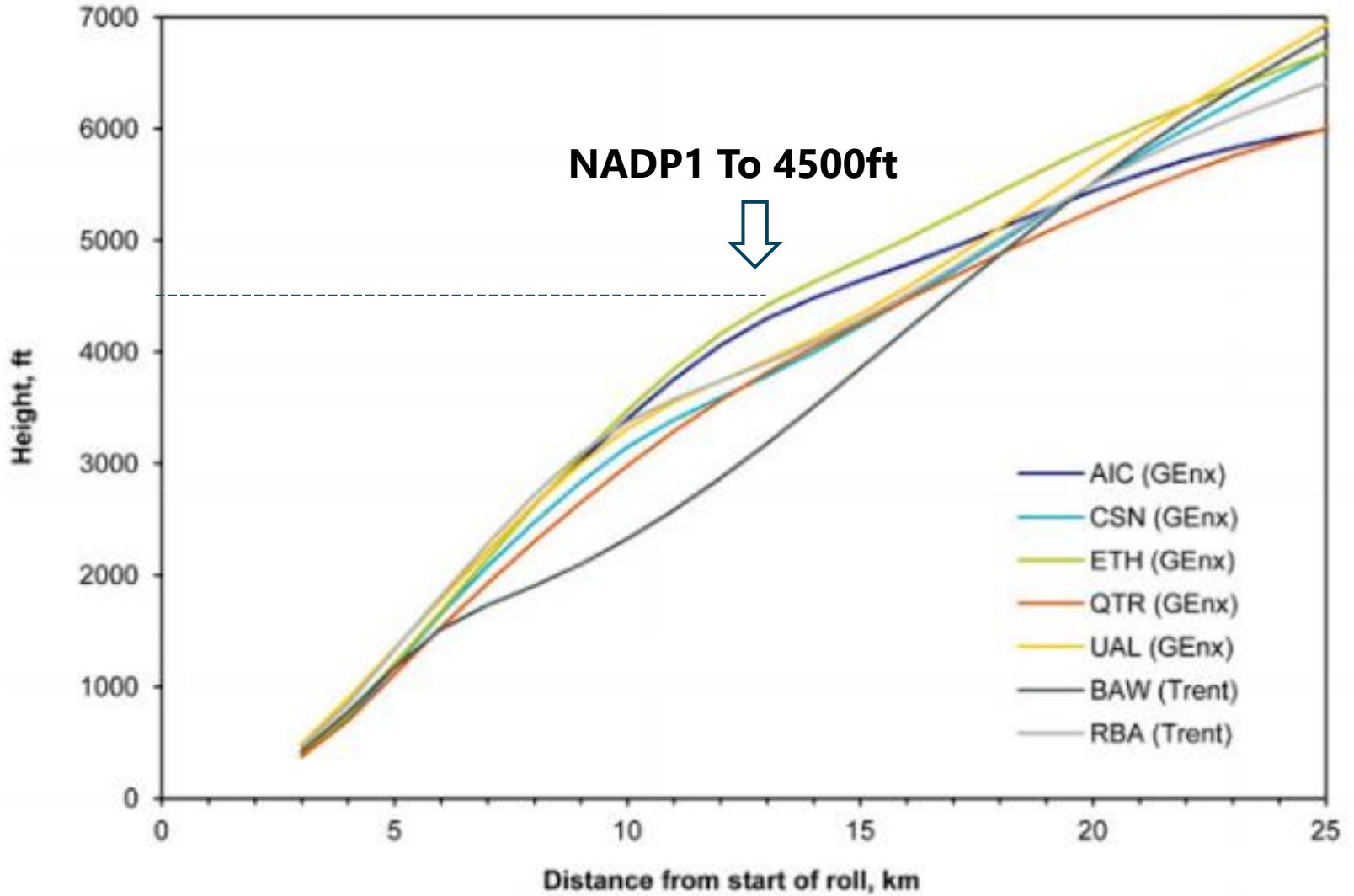
- **Heathrow to advise all pilots to use NADP1 to 4500ft**

- Monitor performance of pilots using this procedure

Note it is standard practise to use NADP1 at airports with dense populations close by

Profiles from CAA/ERCD report CAP1911 July 2014

Figure 9 Comparison of average 787 departure height profiles by airline



Airbus 320 Affected population, compared to NADP2

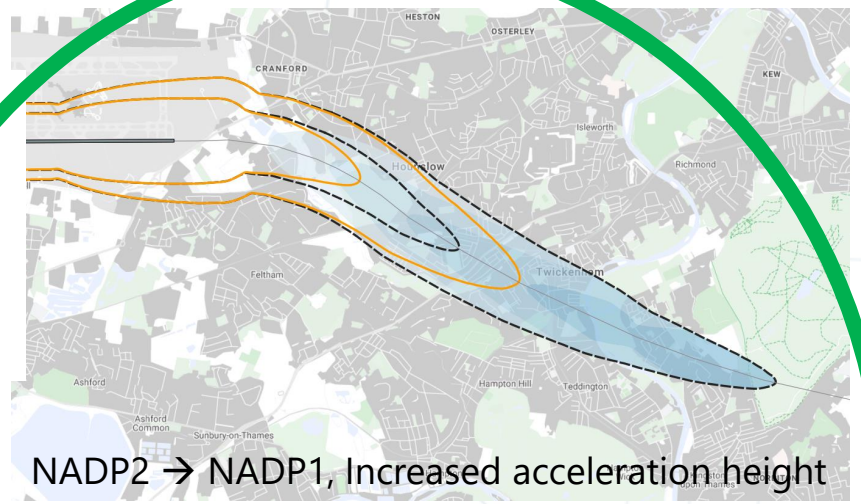
Changes in LA max: loudness

Clear Recommendation for Heathrow

- NADP1 to 4500ft

- Already practised

NADP2 → NADP1



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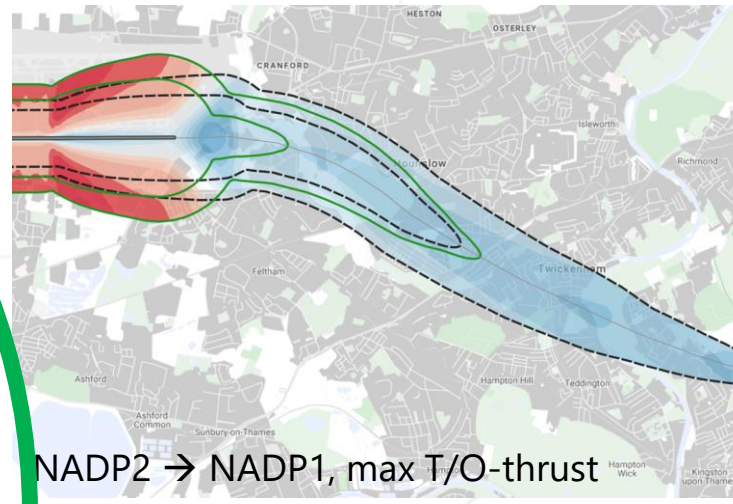

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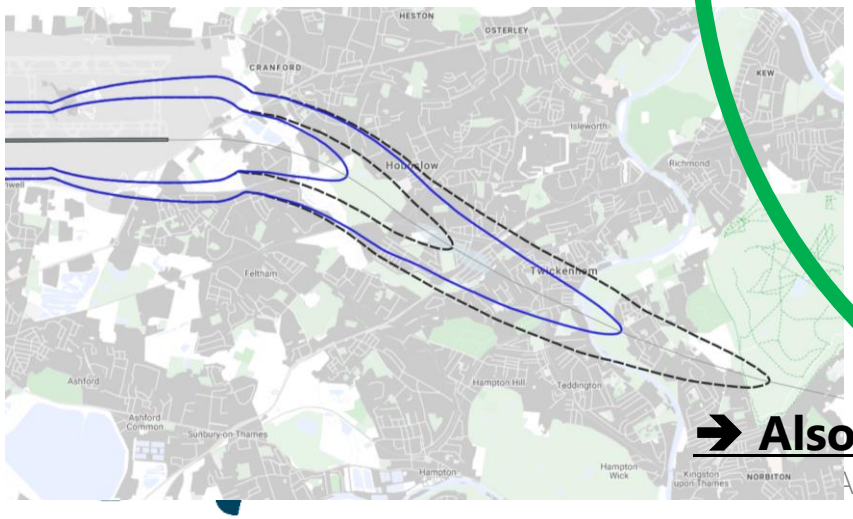
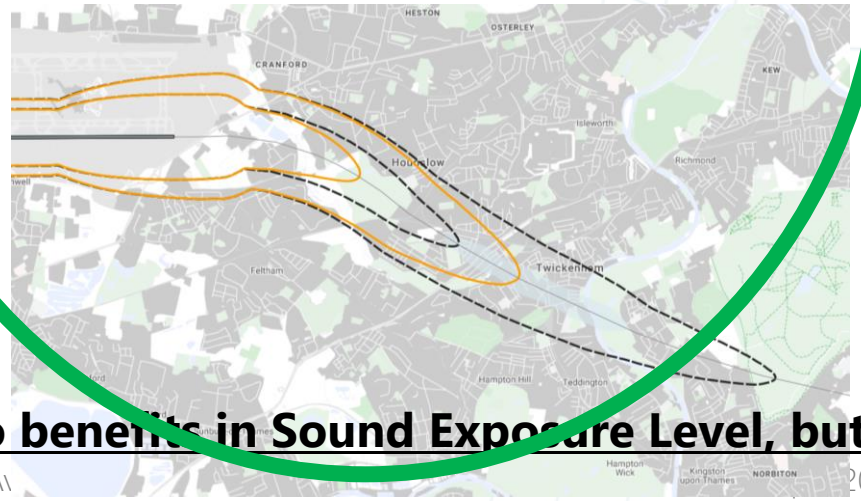
Changes in SEL (within 65 LAmax area) – includes duration of noise event





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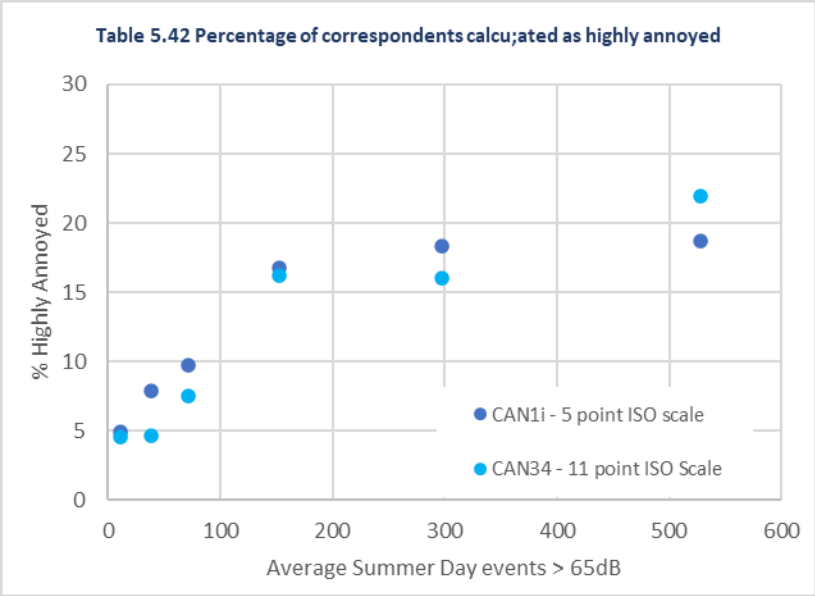
Rational for Objective – based on annoyance relationships

Although National Metric uses LAeq – for departures LAmax shows best route to reduce % highly annoyed



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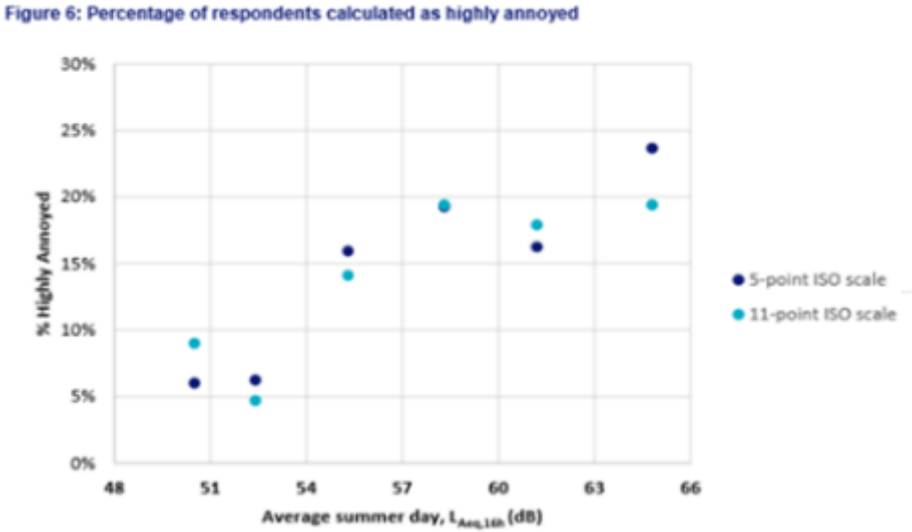

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