Noise Abatement Departure Procedures Study

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Introduction

- CAA/ERCD commissioned by Heathrow to investigate the effects of choosing NADP 1 over NADP 2, or vice versa.
- Effects:
  - Noise: changes in average summer day LAeq16h, Number of events above 65 dB LAmax and 70 dB LAmax, and Time Above 65 65 dB LAmax and 70 dB LAmax
  - Emissions: changes in NOx emissions below 1,000 feet and 3,000 feet
  - Greenhouse Gas emissions: changes in CO_2
  - Monetised noise and emissions impacts using DfT's Transport Appraisal Guidance
  - Potential effects on departure separation

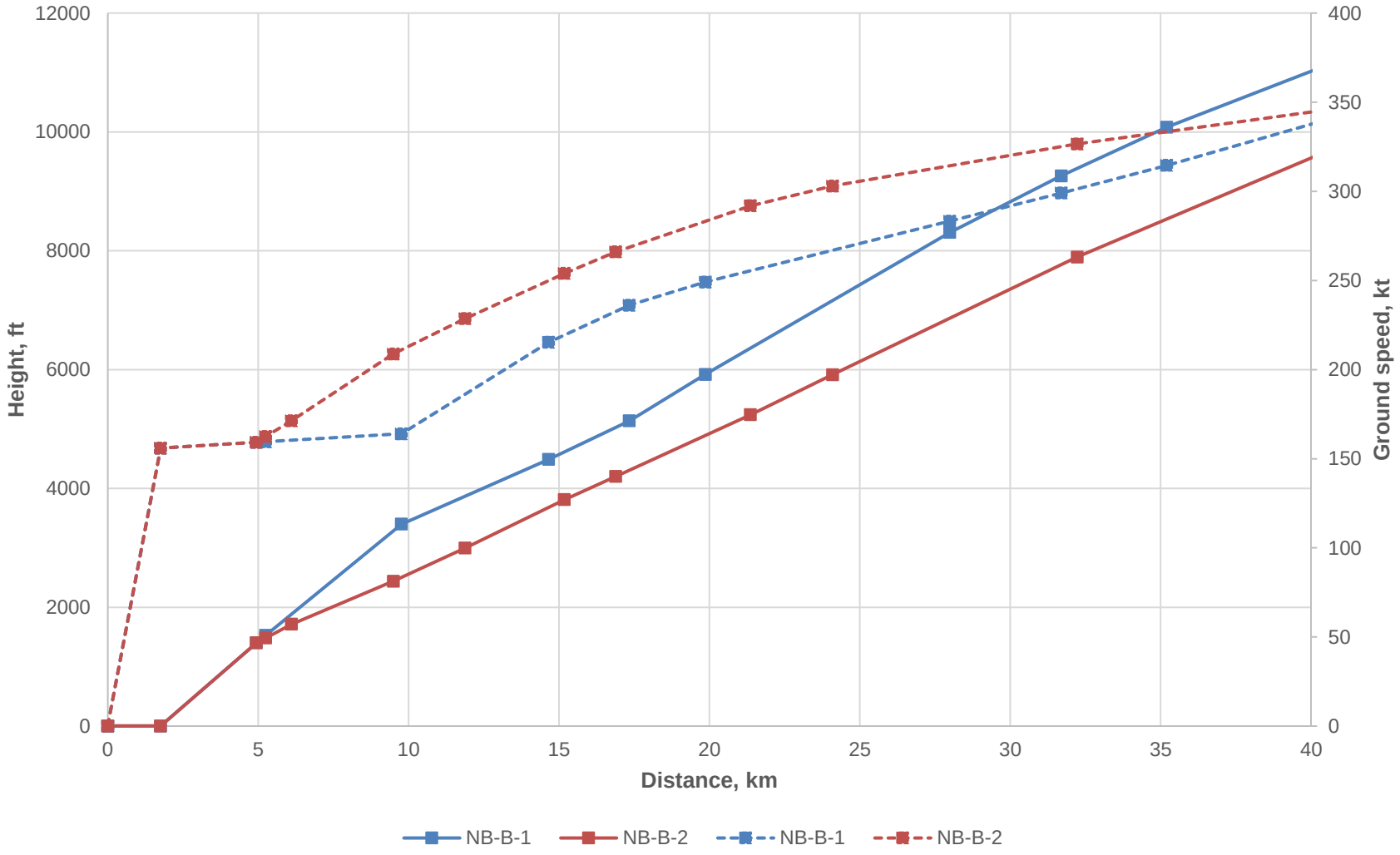
Noise Abatement Departure Procedures

- Noise Abatement Departure Procedures (NADPs) is a regulated area governed by safety and desire for standardisation and harmonisation
- ICAO guidance recommends two families of procedures, NADP 1 and NADP 2
  - NADP 1 engine thrust is reduced at height 1, followed by acceleration at height 2
  - NADP 2 acceleration is initiated at height 1, followed by engine thrust reduction at height 2
    - The most common application of NADP 2 uses the same height for both acceleration and thrust reduction
  - For either procedure the minimum safe height for the first action is 800 feet, with the noise abatement procedure to be completed by 3,000 feet
- Implemented into law through UK Air Ops/EU Ops 1 regulations

Noise Abatement Departure Profiles

Civil Aviation Authority

NB-B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Height, ft
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Ground speed, kt
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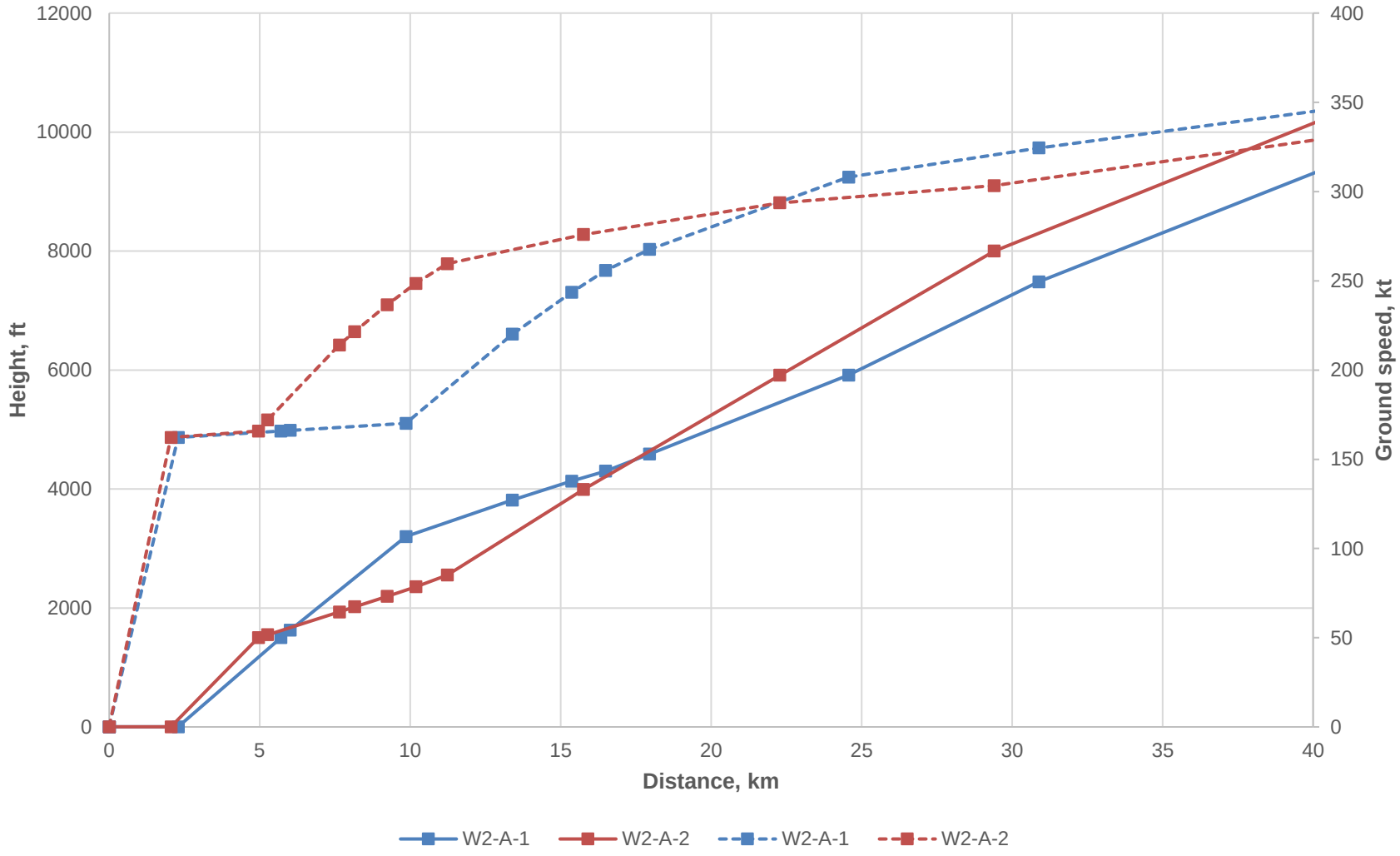
Distance, km
NB-B-1
NB-B-2
NB-B-1
NB-B-2

W2-A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Height, ft
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Ground speed, kt
0
5
10
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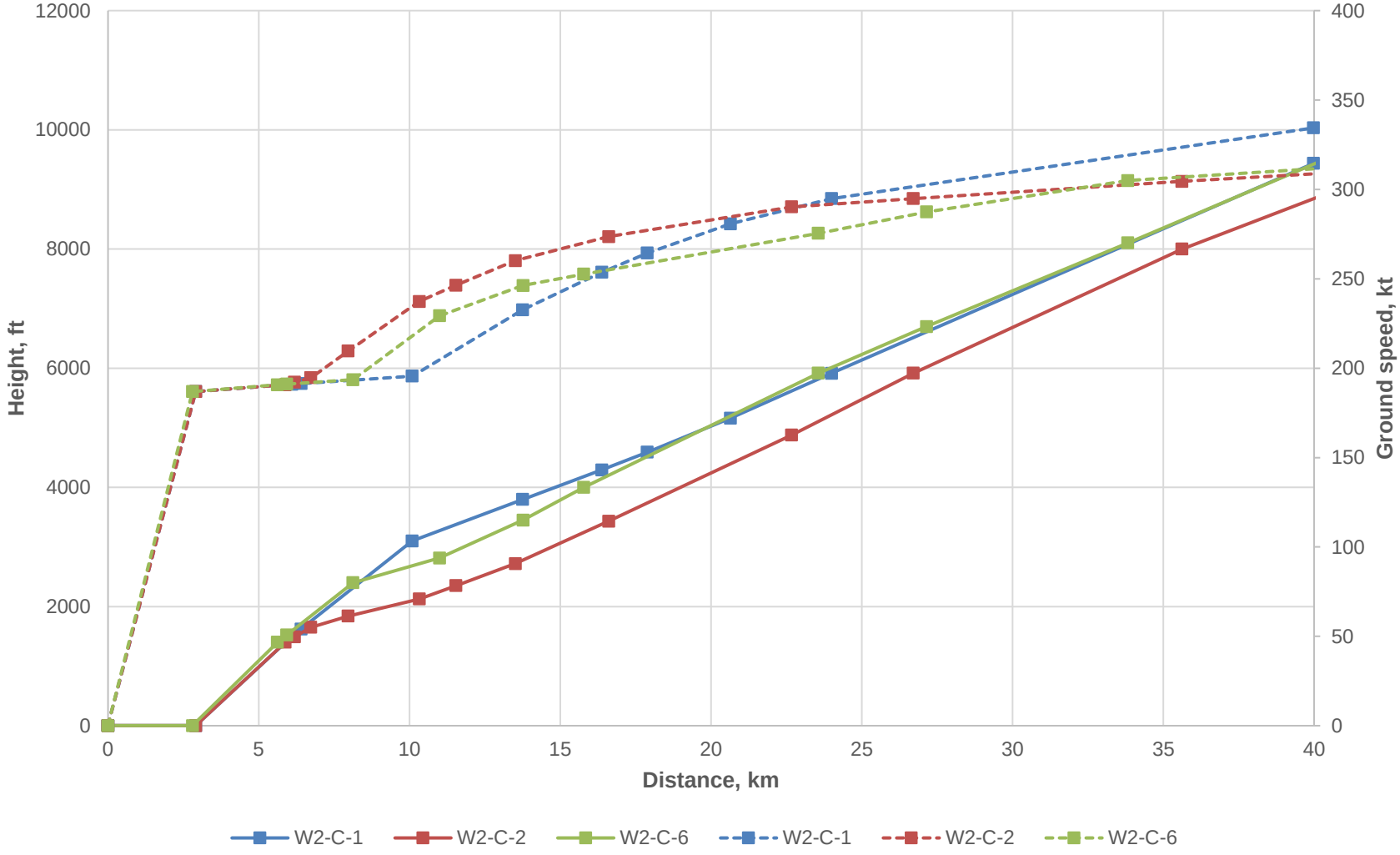
Distance, km
W2-A-1
W2-A-2
W2-A-1
W2-A-2

W2-C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Ground speed, kt
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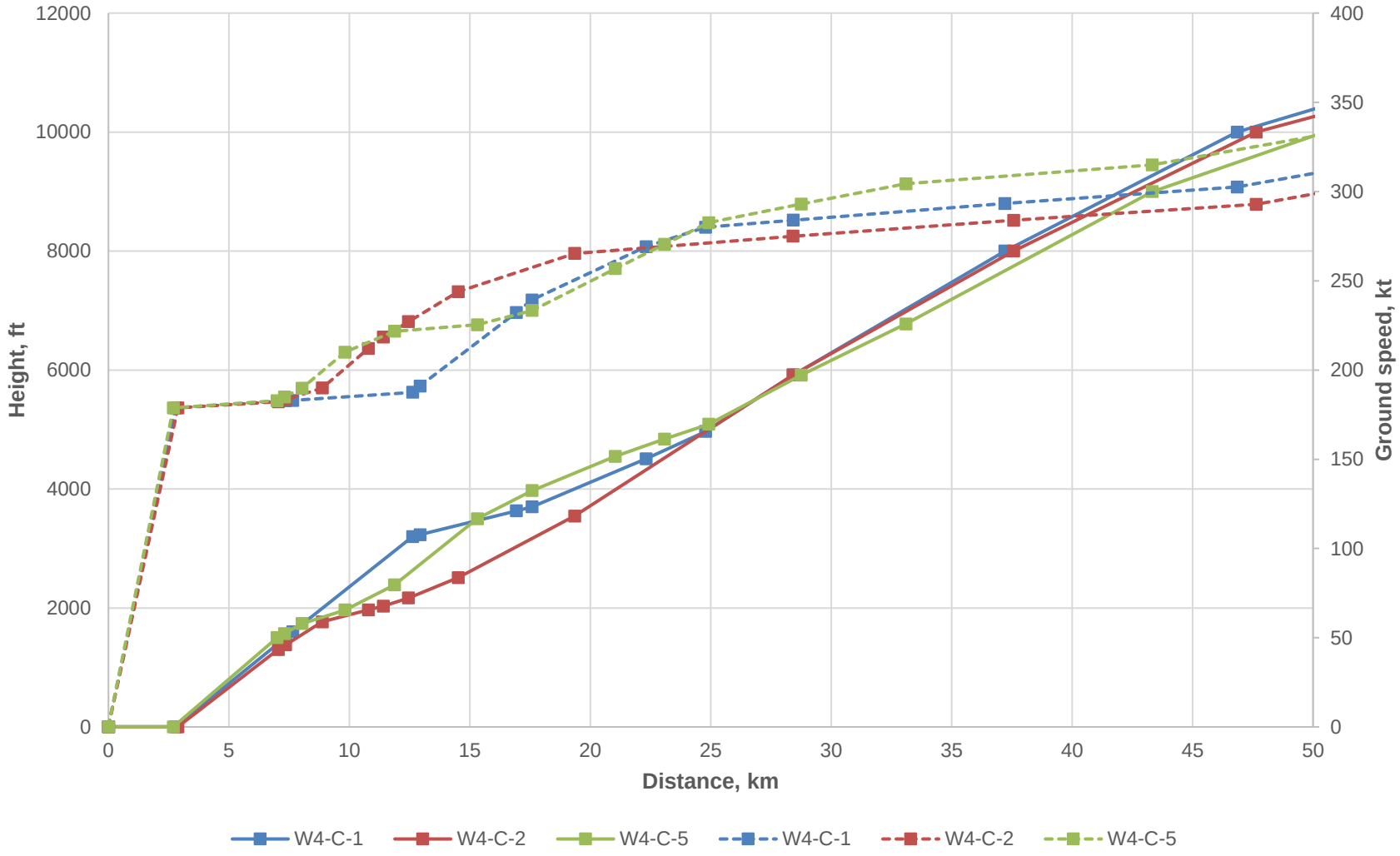
Distance, km
W2-C-1
W2-C-2
W2-C-6
W2-C-1
W2-C-2
W2-C-6

W4-C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10000
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2000
0
Height, ft
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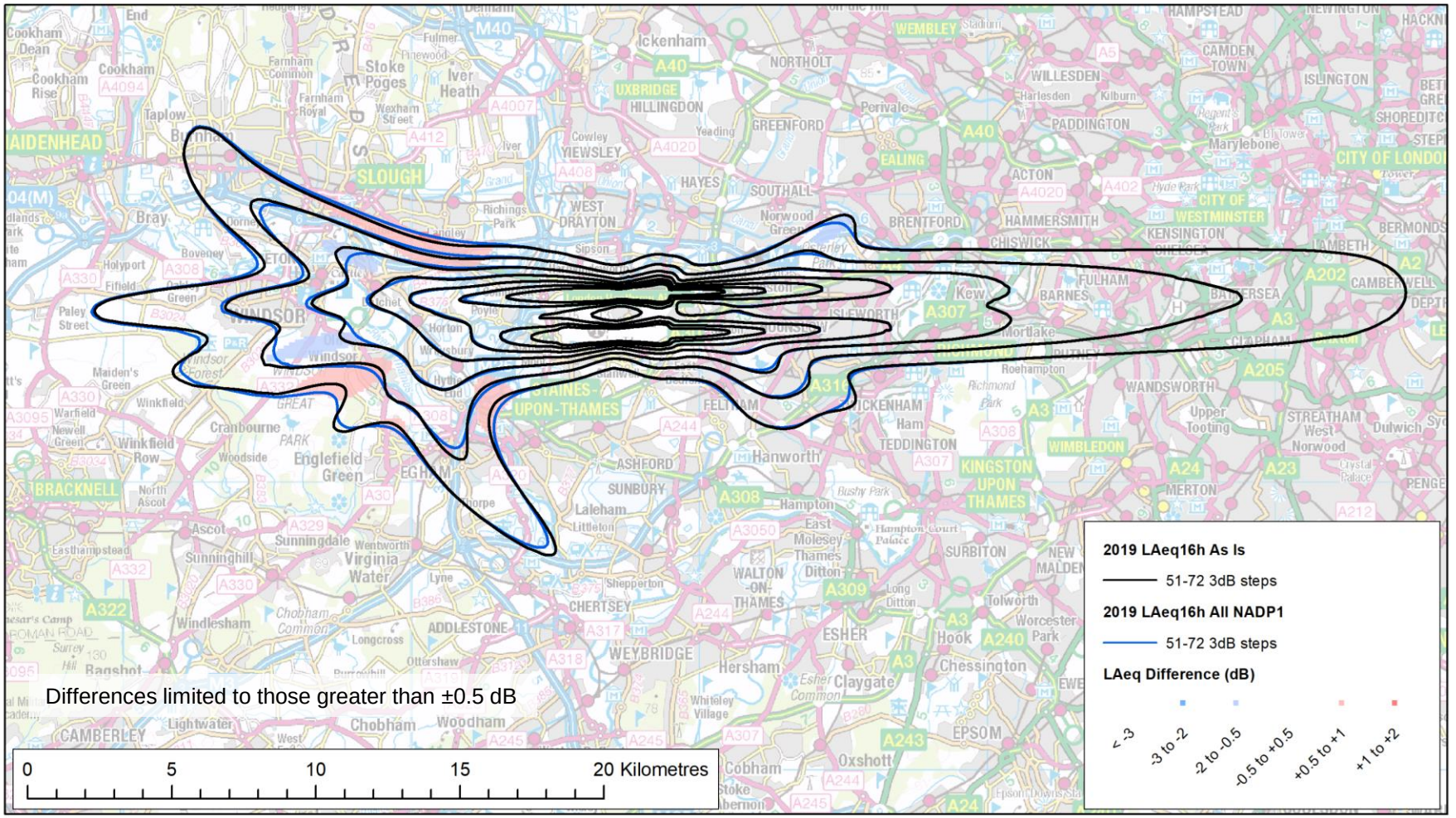
350
300
250
200
150
100
50
0
Ground speed, kt
0
5
10
15
20
25
30
35
40
45
50
Distance, km
W4-C-1
W4-C-2
W4-C-5
W4-C-1
W4-C-2
W4-C-5

Learnings from the profiles

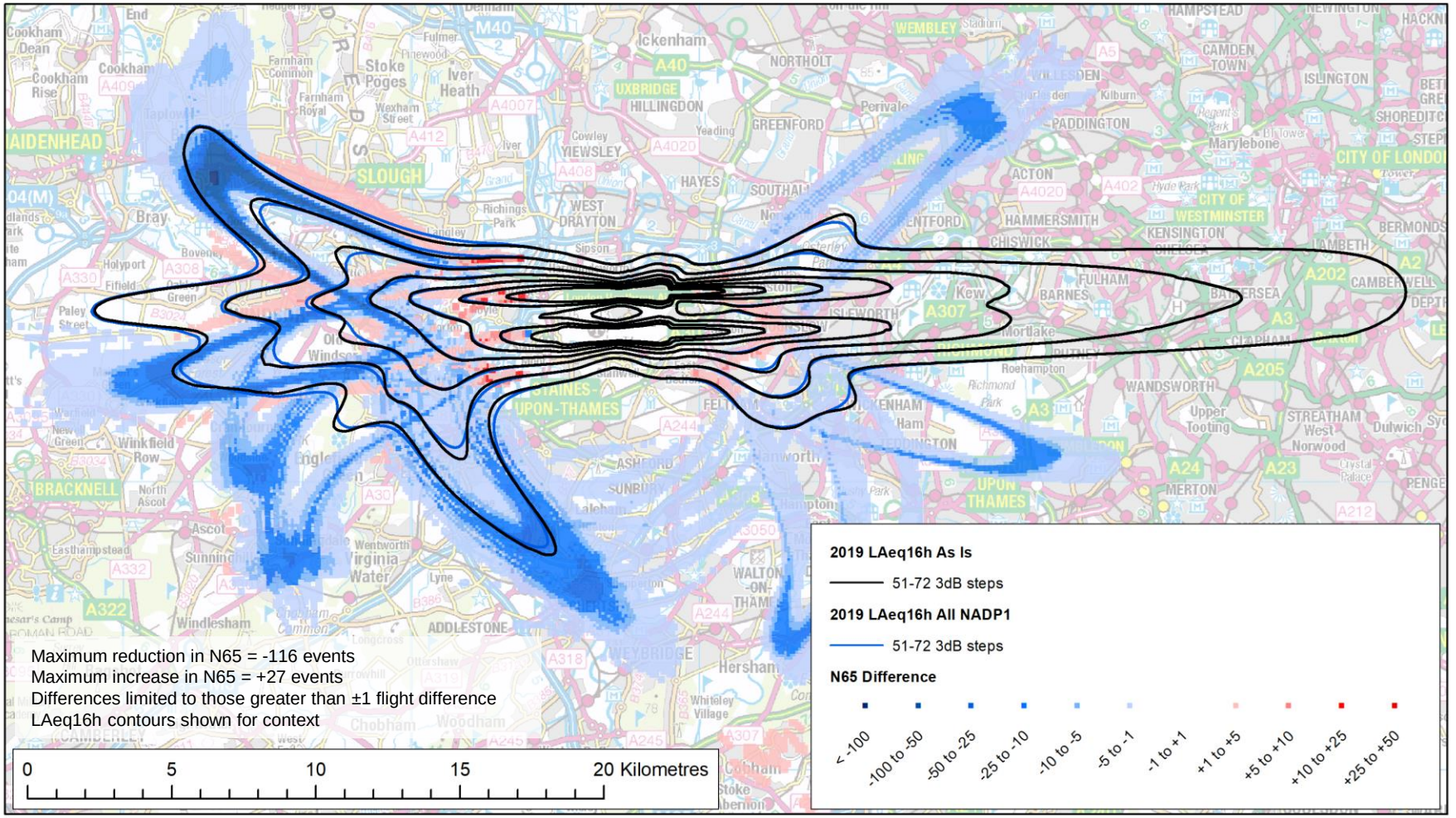
- Estimate 85% of existing operations use NADP 2
- There is more than one variant of NADP 1 and 2
  - Not unexpected, an ICAO survey of 15 airlines found 14 unique procedures
  - Every change in cutback height or acceleration altitude constitutes a new procedure, NADP 1 or 2 simply relates to the order of actions
- In many cases, the NADP 1 or 2 procedures are not ‘inverses’ of each other
  - Reversing the order of actions and changing the heights that the actions occur does not change some NADP 2 profiles in NADP 1 profiles
    - There are other factors involved. We have tried to eliminate take-off weight by controlling for distance flown, but we cannot rule out take-off weight differences. There appear to be thrust differences, particularly climb thrust. And acceleration segments are not flown in the same manner (balance between climbing and accelerating) between observed NADP 1 and 2 profiles.

Changes in noise exposure

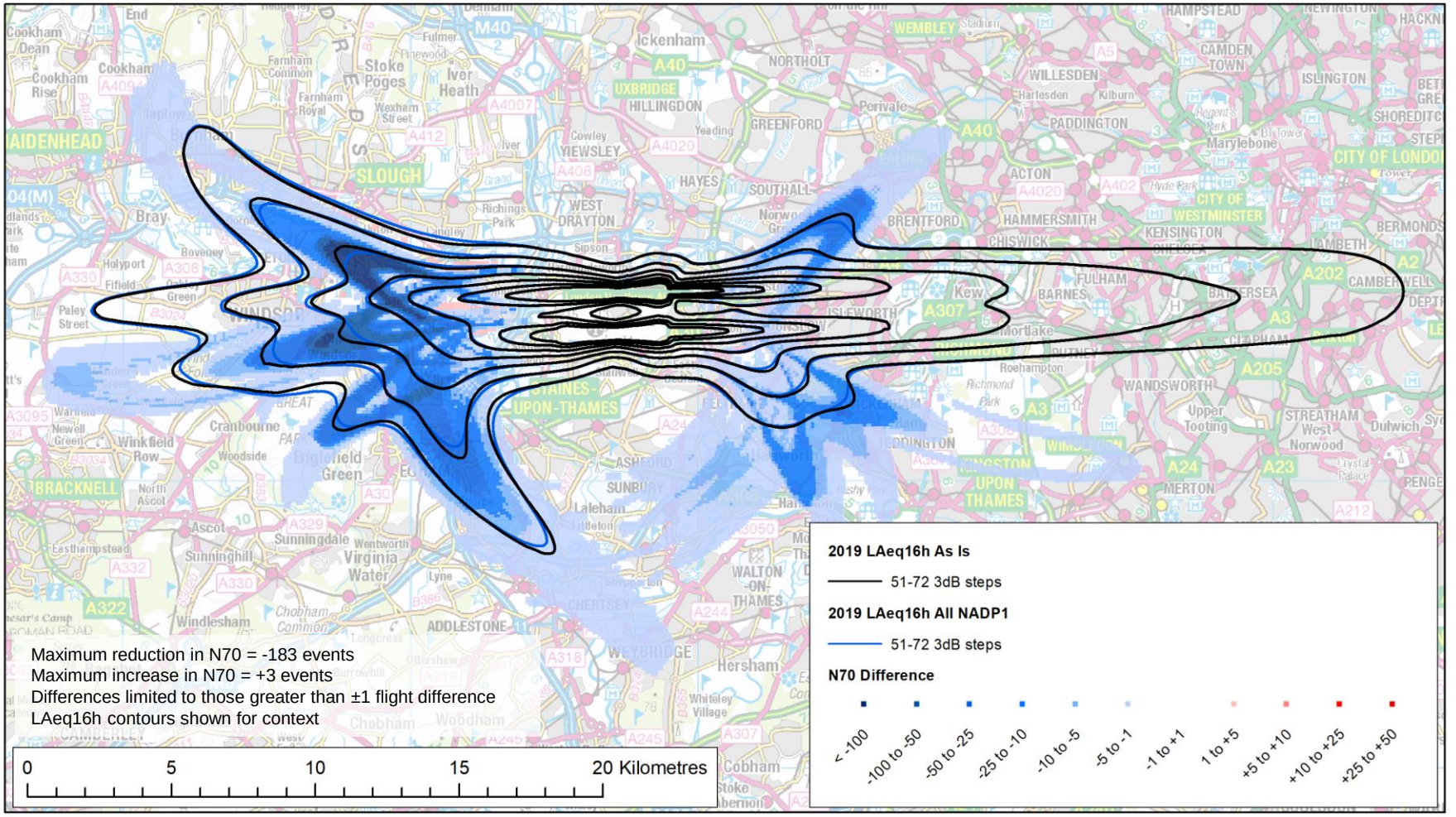
LAeq16h All NADP 1 3000ft vs As Is absolute and difference contours



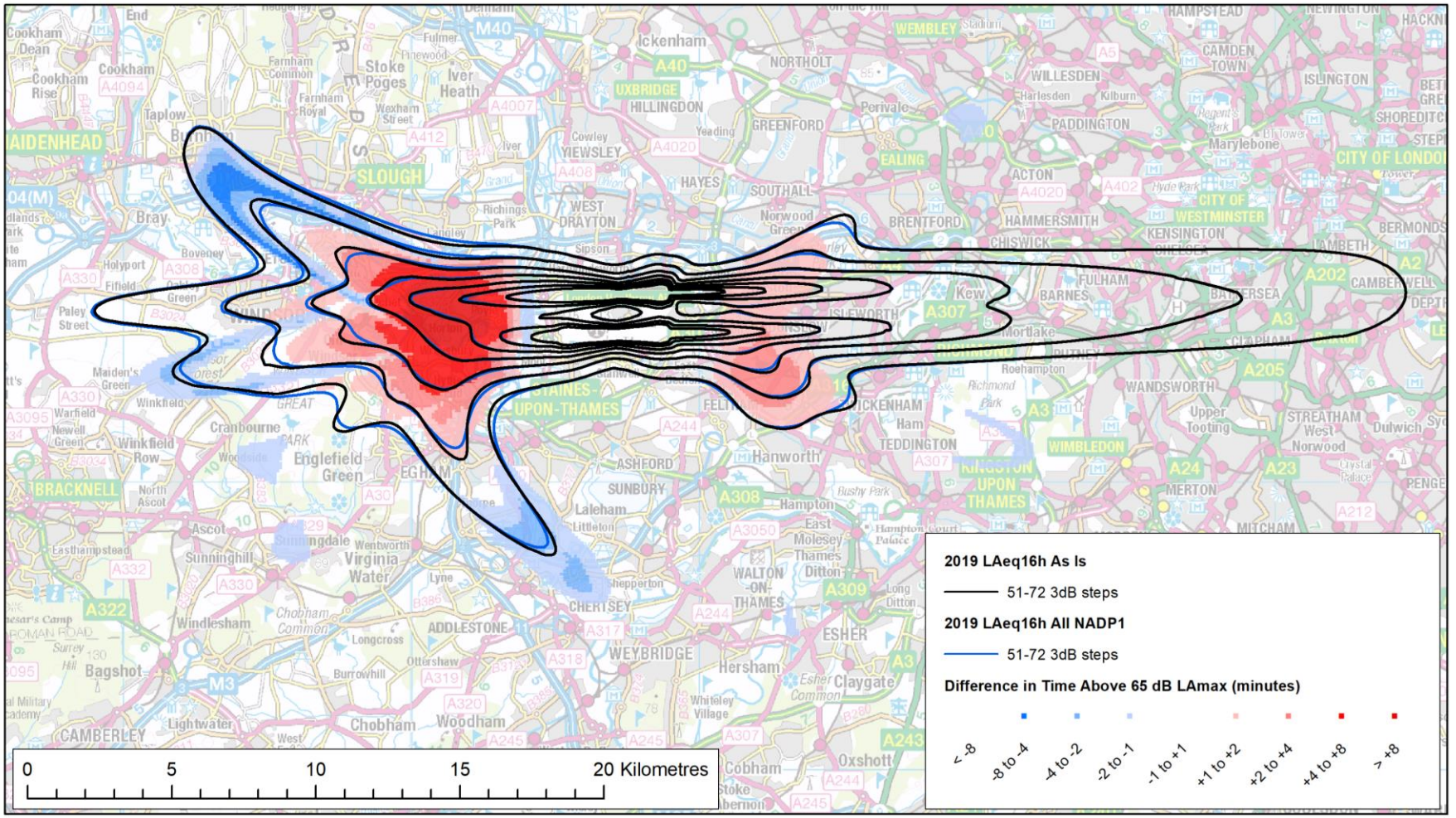
Changes in number of events above 65 dB LAmax 16h: All NADP 1 3000ft vs As Is



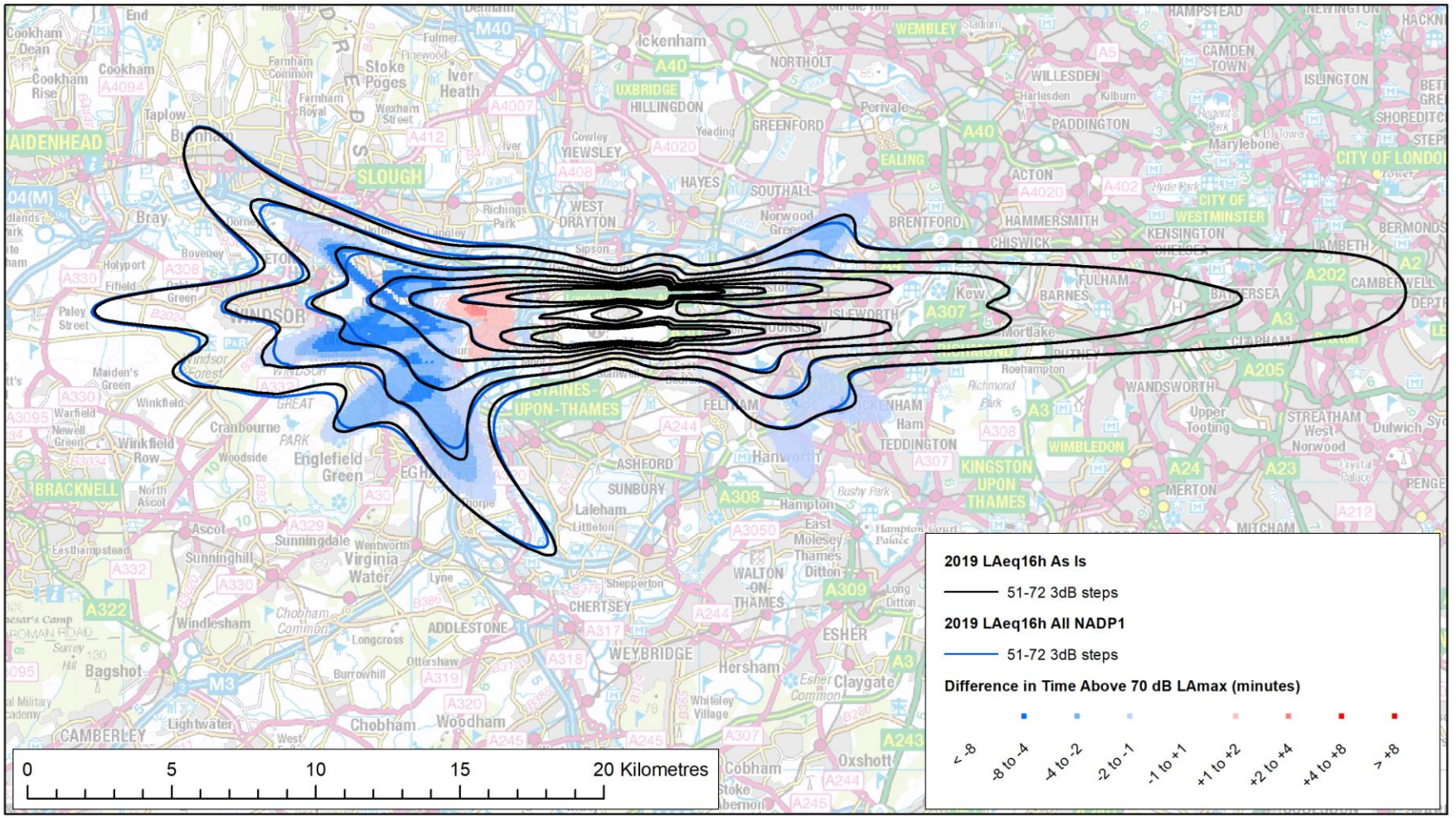
Changes in number of events above 70 dB LAmax 16h: All NADP 1 3000ft vs As Is



TA65 16h results: ALL NADP1 3000 ft vs As Is difference grid



TA70 16h results: ALL NADP1 3000 ft vs As Is difference grid



Effect on annual fuel burn and CO_2 emissions

- 60 year Net Present Value > 51 dB LAeq16h, assuming differences remain constant over time

	Annual departure emissions (tonnes CO_2)	Change (%)	Change (tonnes CO2)
As Is	17,004,400	-	-
NADP1 3000 FT	17,028,900	+0.14%	+24,400
NADP1 4000 FT	17,062,200	+0.34%	+57,800
NADP2	16,998,200	-0.04%	-6,200

- Context: Annual CO_2 departure emissions of all Heathrow flights to Dublin are approx. 40,000 tonnes

Monetary evaluation

- 60 year Net Present Value greater than 51 dB LAeq16h, assuming differences remain constant over time
- 60 year Net Present Value greater than 1 event above 65 dB LAmax, assuming differences remain constant over time

Scenario	**All NADP 1 3000 ft vs As Is**		**All NADP 1 4000 ft vs As Is**	
	LAeq16h	**N65 16h (SoNA CAN1i / CAN34)**	**LAeq16h**	**N65 16h (SoNA CAN1i / CAN34)**
Net present value of change in noise (amenity) (£, 2010 prices):	£ -18,710,872	£+65,917,495 / £+119,213,962	-£49,809,077	£+166,282,157 / £+299,091,985
Net present value of change in CO_{2e} emissions (£, 2010 prices):	-£113,091,215		-£267,557,075	

* webTAG output is positive for a benefit, negative for a disbenefit

Effect on landing and take-off NOx emissions

- Emissions of oxides of nitrogen (NO and NO_2) are relevant to local air quality
- Emissions are normally reported up 1,000 ft and up to 3,000 ft above ground level
- Emissions up to 1,000 ft contribute up to 90% of ground level concentrations due to atmospheric dispersion and mixing
- Because NADP procedures do not differ below 1,000 ft, NADP 1 or NADP 2 lead to no difference in NOx emissions below 1,000 ft
- To estimate the overall change in emissions below 1,000 ft or 3,000 ft it is necessary to express changes as a function of the total landing and take-off cycle, including taxi and final approach, since these fixed elements contribute towards local air quality

Changes in landing and take-off NOx emissions

- Figures are for an average summer day
- Results for NADP 1 scenarios expressed relative to All NADP 2 scenario. As Is scenario similar to All NADP 2
- Keep in mind that the fleet was simplified into three types, representative for noise, but not necessarily so for emissions

	LTO NOx emissions (kg)		Change in LTO NOx (%)		
Scenario	**to 1,000 ft**	**to 3,000 ft**	**to 1,000 ft**	**to 3,000 ft**	**1000-3000ft**
All NADP 1 3000 ft	9,000	12,200	-	-10%	-30%
All NADP 1 4000 ft	9,000	12,200	-	-10%	-30%
All NADP 2	9,000	13,600	-	-	-

- General principle that emissions below 1,000 ft contribute approx. 90% of ground level air quality concentrations.
- Emissions above 1,000 feet contribute less than 10% to ground level concentrations. A 30% change in emissions above 1,000 feet leads to a ground change of 10% of 30% = circa 3%.
- Noting other sources, changes to NADPs above 1,000 ft are unlikely to have a practical effect on LAQ NOx emissions.

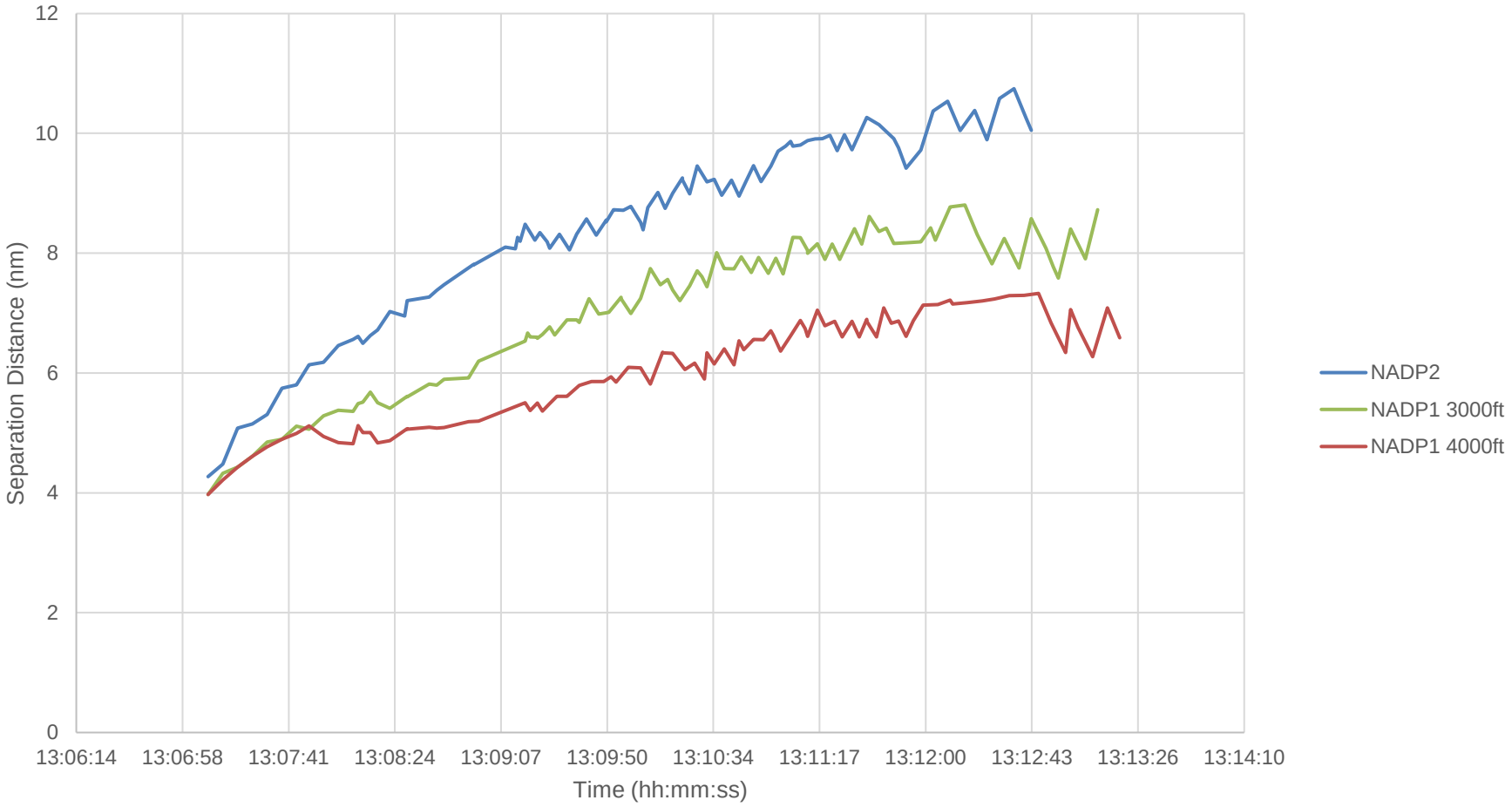
Effect of speed change on ‘catch-up’

- Restricting speed to the take-off V_2 speed for longer, will lead to increased risk of ‘catch-up’, particularly between long-haul aircraft designed with higher take-off speeds for carbon efficiency, and small short-medium haul aircraft designed for lower take-off speeds to maximise airport/runway compatibility, e.g.
  - Short-haul aircraft have a V_2 speed in the range 125-150 kt
  - Long-haul aircraft have a V_2 speed in the range 180-205 kt
- This already an issue today, but the few aircraft using NADP 1, mean that it is managed on a flight-by-flight basis
- All aircraft operating NADP 1 would create a wider issue

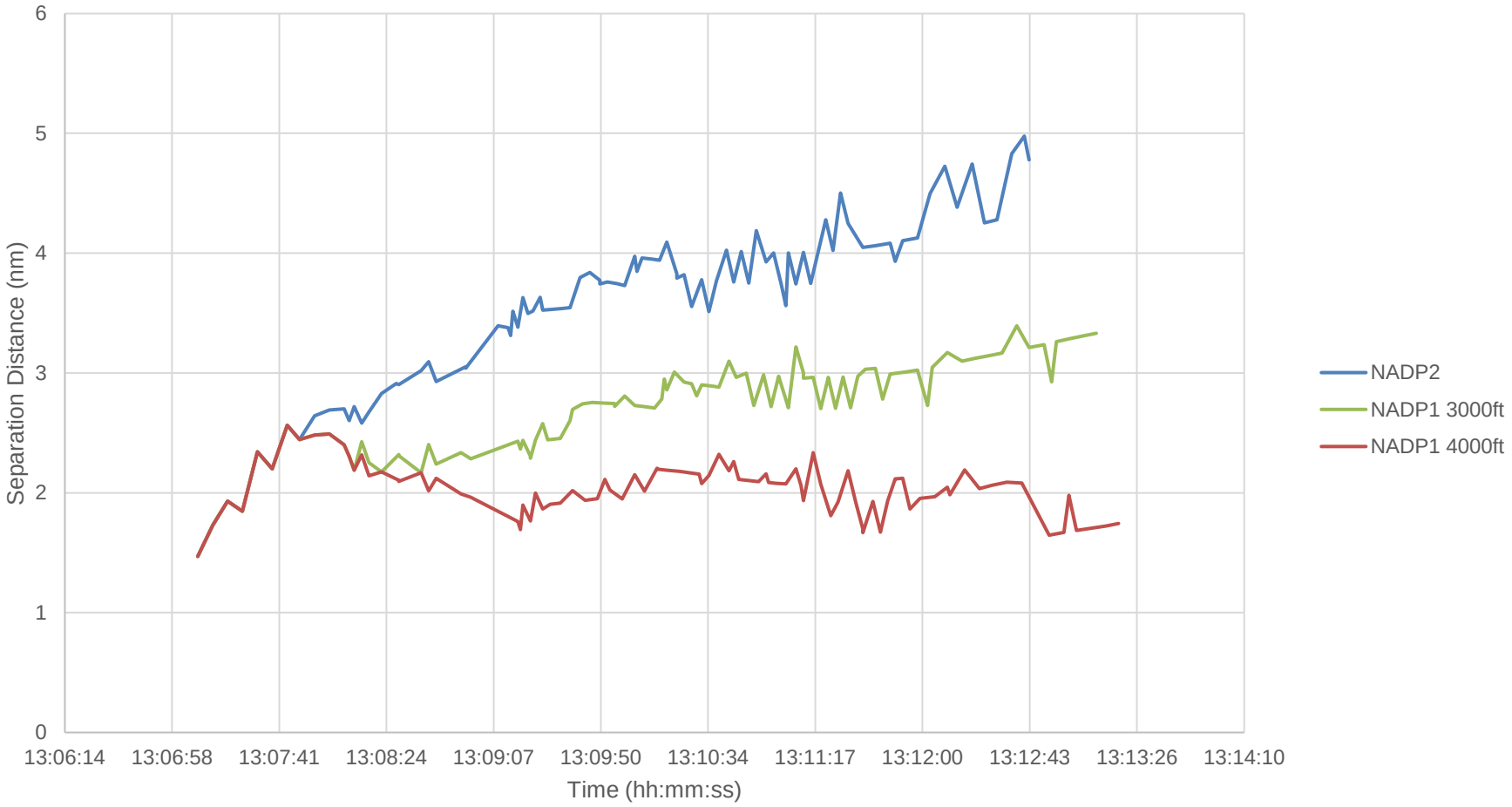
Effect of speed change on ‘catch-up’

- Worked example using slowest and fastest aircraft in the study:
  - Long-haul B787-9, V_2 187 kt
  - Short-haul A320, V_2 150 kt
  - These aircraft are the common in their category, but do not represent the highest or lowest speeds
- The issue is inherently most challenging where high speed NADP 2 operation takes off shortly after a short-haul NADP 1 operation.
  - This can happen today, but because NADP 1 operations are circa 15%, i.e. 1 in 7 departures and NADP 1 are seldomly short-haul operations, it happens rarely.
- Scenarios:
  - B787-9 NADP 2 departure following an A320 NADP 2 departure
  - B787-9 NADP 1 departure following an A320 NADP 1 departure
  - B787-9 NADP 1 4000 ft departure following an A320 NADP 1 4000 ft departure
  - 1 min and 2 min departure separations (‘splits’)

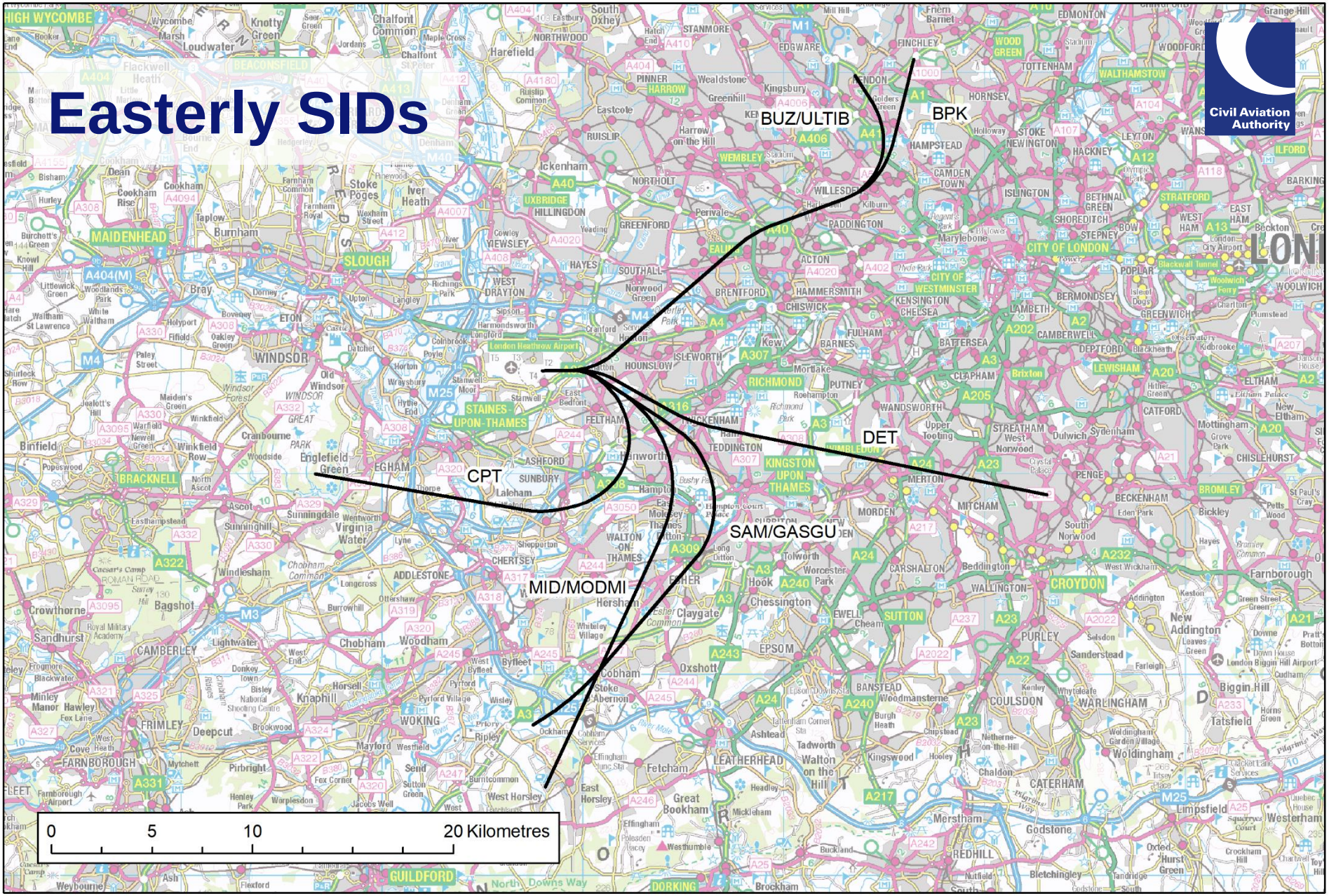
Effect of catch-up with same NADP: 787-9 (187kt) vs A320 (150kt) 2 min split



Effect of catch-up with same NADP: 787-9 (187kt) vs A320 (150kt) 1 min split



Easterly SIDs



Other possible effects

- NADP 1 procedures will result in some aircraft reaching 4,000 feet sooner than they otherwise might have done
- ATC can vector aircraft off the departure route once they reach 4,000 feet
- Could lead to aircraft being vectored off the departure route sooner and overflying some areas more often, others left often

Overall summary

KPI	NADP 2	NADP 1 3000 ft	NADP 1 4000 FT
LAeq16h			
Monetised LAeq16h			
N65			
Monetised N65			
N70			
Monetised N70			
TA65			
TA70			
CO2			
LAQ (NOx)	No change		
Changes in overflight (vectoring)			
Catch-up			
Delay			
Late running			
Increased sleep disturbance			