Assessment of the webTAG monetised health costs for two illustrative PBN departure route scenarios

Purpose

ANEG members have asked for research on the health impacts of concentrated flightpaths associated with implementation of Performance-Based Navigation (PBN) technologies. This paper explains how the impacts of PBN flightpaths would be assessed using the webTAG appraisal methodology, which takes account of known health impacts associated with changes in noise exposure. A guide to webTAG previously circulated to ANEG members is attached at annex A.

Introduction

Performance-Based Navigation technologies will enable improved aircraft track-keeping over present-day operations where each airline interprets the path to be flown in order to follow a conventional navigation departure route. The amount of air traffic control intervention, or vectoring of aircraft away from departure routes above 4,000 ft will also greatly reduce as the intent is for PBN departure and arrival routes to be designed to reduce interactions between routes that today necessitate air traffic control intervention, improving the safety, predictability and efficiency of airspace.

PBN will necessarily cause some redistribution of flights that will result in changes in noise exposure on the ground. In many cases PBN departure routes will replicate existing departure routes, i.e. the nominal departure flight path will be the same or similar, but flights will be more concentrated around the nominal flight path. Where flights concentrate noise levels will increase, elsewhere noise levels will decrease. In some cases, it may not be possible to replicate a departure route and therefore the nominal track over the ground will change and flights will concentrate around the new track.

To address concerns around the effect of flight concentration it has been proposed that additional flight paths be introduced to mitigate the effects of concentrate and to provide more clearly defined respite from noise. Multiple PBN respite flight paths will not produce the same level of dispersion seen on some flight paths historically as flights will be concentrated around each respite flight path. An inevitable consequence of more equitably sharing flights will be that some residents will experience more noise and some will experience less noise.

How noise exposure translates to noise impact and monetary value is highly dependent on the local population distribution in the vicinity of the flight path changes. Population distributions are highly irregular with populations clustered around local features. In addition PBN departure routes may be implemented in any number of ways, thus ultimately the impacts and health costs will be specific and unique to each scenario. Thus it will not be possible to generalise any theoretical or actual scenario to any other scenario as to what the impacts and health costs might be.

Scenarios assessed

Notwithstanding this the physics of aircraft noise propagation mean that the effects of concentration and respite flight paths will have common and consistent effects on noise exposure. In order to illustrate these effects and show how they relate to noise exposure, noise impact and changes in health costs, this note considers three illustrative scenarios:

1. A single conventional departure route with a high degree of vectoring
2. A replicated PBN departure route following the same track over the ground, with no vectoring
3. Two PBN respite departure routes that separate either side of the original departure route as soon as practical after departure to a maximum separation of 3km, with no vectoring

For each scenario the average summer day and night noise exposure has been calculated using the CAA's ANCON model, using a common fleet mix. To avoid any distortion, the population distribution in the vicinity of the departure routes is assumed to be homogeneous and representative of a dense urban environment. For each of three scenarios, the noise exposure is mapped to each population receptor point.

DfT's webTAG model determines the relative cost of a proposed change by estimating the net health costs of changes in noise exposure between two scenarios. The three scenarios enable three comparisons to be assessed:

1. Conventional departure route vs single PBN departure route
2. Conventional departure route vs two PBN respite departure routes
3. Single PBN departure vs two PBN respite departure routes

The traffic mix along the departure route has been assumed to be representative of a busy route with 150 movements per 16 hour average summer day and xx movements per 8 hour average summer night and represents a mix of short-haul twins (A320), wide-body twins (B777-300ER) and wide-body four-engined aircraft (A380).

Flight Track Dispersion

The flight track dispersion for the three scenarios are illustrated in Figures 1 to 3 respectively. The dispersion in Figure 1 represents the measured average dispersion for Heathrow departure routes in summer 2017. The dispersion in Figures 2 and 3 was measured from one of the Heathrow westerly PBN trial routes that took place in 2015.

Noise exposure

The daytime noise exposure contours (51-72dBA LAeq,16h) are shown in Figures 4-6 for the three scenarios respectively. A comparison of the conventional and single PBN route contours is illustrated in Figure 7. The single and twin PBN respite route contours are compared with Figure 8.

The night-time noise exposure contours (45-66dB LAeq,8h) are shown in Figures 9-11 for the three scenarios respectively. The areas and populations within the contours are show in Tables 1-6 respectively.

It is immediately apparent that there is little difference between the noise exposure for the conventional departure route and the single PBN departure route (Figure 7). For the single PBN route the population within the 51dB and 60dB LAeq,16h contours increases by +1%, for all other contours the changes are <0.1%.

There are a number of factors that explain this outcome. Close to the airport, PBN offers only limited concentration, the main concentration effect is due to the lack of vectoring, which by definition occurs above 4,000 ft, and so distant from the airport. The dispersion of noise to the side of a flight path is principally dependent on the elevation angle (Figure 12) and thus as altitude increases the effects of concentration diminish (Table 7).

For the twin PBN respite routes, the shape of the contour changes much more dramatically. Because each route shares half the traffic, the 51dB extends along the flight paths to where the previous 54dB contour was, but of course the 51dB now has two lobes. The population within the twin PBN respite routes contours reduces by 14 and 16% respectively within the 60 and 57dB LAeq,16h contours, but increases by 5% within the 51dB contour.

webTAG

webTAG quantifies the health costs of changes in noise exposure between two scenarios and portrays them as an annual cost, as well assessing that cost over an appraisal period, where future costs and benefits are discounted as they are less valuable the further away they are in time.

webTAG Analysis

For webTAG we can compare three scenarios:

1. Conventional navigation departure route vs Concentrated PBN departure route
2. Conventional navigation departure route vs Twin PBN respite departure routes
3. Concentrated PBN departure route vs Twin PBN respite departure routes

Tables 8 to 10 present the daytime LAeq,16h population noise exposure changes input to webTAG for the above three scenarios respectively. Results for night-time are similar and are not shown for brevity.

The data represent the population in 1dB bands between 51-52dB and 72-73dB. These have been calculated at each population postcode receptor as required by webTAG, something which cannot readily be done from noise contours. The colour coding, taken from the webTAG workbook highlights where the number of people indicated experience no change in noise exposure (yellow), where the scenario increases noise exposure (red) and where it reduces noise exposure (green).

In some ways this provides a clearer indication of the changes in noise exposure than contours do, except it obviously does not indicate where the populations are that experience the changes. Table 8 shows that the maximum increase in noise exposure for a concentrated PBN route is +1dB, the maximum decrease is -1dB. As explained previously this is a consequence of the fact that the main concentration occurs further from the airport, where the relatively high altitude of aircraft already causes noise to disperse over a relatively wide area, such that concentration of tracks results in a relatively modest increase in noise exposure. Had the concentrated track not been in the same location the result would be quite different. Nevertheless based on the uniform population distribution used for this study, 16,600 experience increases in noise of +1dB, whilst 8,400 people experience decreases of -1dB.

In contrast the introduction of twin concentrated PBN respite routes splits the departure track and traffic in two and, as shown in Table 9, results in noise increases and decreases of up to 6dB. 108,200 people experience an increase in noise exposure, whilst 116,000 people experience a decrease in noise exposure, but continue to experience noise exposure of at least 51dB LAeq,16h, approximately 20% of the total population exposed to more than 51dB LAeq16h.

Table 10 compares the twin concentrated PBN respite departures against the single concentrated PBN departure route. Results are very similar to those in Table 9. 108,600 people experience an increase in noise exposure, whilst 115,500 experience a decrease.

Table 11 presents the 10-year Net Present Value (NPV) for the three scenarios showing the NPV for each identified health impact.

Conclusions

The noise effects of PBN concentration have been assessed using an illustrative scenario with a single busy departure route (150 ATMs/day, 15 ATMs/night). The amount of concentration was based on radar data analysis for a Heathrow average conventional departure route in summer 2017 and a PBN trial departure from 2014.

The results show that noise increases due to concentration occur mostly further from the airport as tracks are already relatively concentrated near to the airport. Further from the airport, the high altitude (greater than 4,000ft) results in noise dispersing over a wide area, such that concentration results in noise increases of a maximum of +1dB, provided the nominal track remains in the same location. As a result of concentration, 16,600 people experience a +1dB increase in noise and 8,400 people experience a -1dB decrease resulting in a ten year health cost Net Present Value of -£28.3m, 60% of which is attributable to amenity impact (annoyance).

Maintaining the same degree of concentration, but instead splitting the single concentrated PBN departure route into two routes at 6km from start of take-off roll (about as soon as practicable) and separating to a maximum distance of 3km, results in population reductions within the 60dB contour (-14%), 57dB contour (-16%) and 54dB contour (-6%). However, the population within the 51dB LAeq,16h contour increases by 5%. In effect the introduction of the two respite routes shifts noise from within 54-60dB contour band into the 51-54dB contour band. Individually, however, this means some people experience decreases in noise, but some experience increases; of +6 and -6dB respectively for individual population receptors. In total 108,200 people exposed to noise above 51dB experience an increase in noise, whilst 116,000 people experience a decrease in noise exposure. Of the total population exposed to noise above 51dB, 57% experience no change, 21% experience more noise and 22% experience a decrease. The health NPV benefit is £643m, 56% associated with amenity (annoyance).

Caveats

- The study assumes a homogeneous population distribution.
- The study assesses a single departure route – multiple departure routes will reduce the opportunities to implement respite routes and noise interactions between routes will lessen the effects of noise sharing.
- The inclusion of arrival noise exposure (when taking into account long-term average-mode noise) will lessen the changes in noise exposure between departure route options.
- The scenario assumed the routes could split as soon as practicable after departure
- For a less busy departure route the shifts in noise exposure (from 54-60 to 51-54dB) will occur at lower noise levels – the contours shrink, but the geometry of the twin PBN departure routes remains fixed.

ERCD

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Table 1: Daytime LAeq,16h (51-72dB) areas populations for the conventional departure route

LAeq16h	Area	Pop	Hses
(-)	(km^2)	(-)	(-)
>51	56.3	503900	251950
>54	32.4	276700	138350
>57	18.5	144500	72250
>60	10.3	69600	34800
>63	5.7	30600	15300
>66	3.1	11100	5550
>69	1.7	3100	1550
>72	1.0	200	100

Table 2: Daytime LAeq,16h (51-72dB) areas populations for the single PBN departure route

LAeq16h	Area	Pop	Hses
(-)	(km^2)	(-)	(-)
51	56.9	509600	254800
54	32.5	276700	138350
57	18.5	144700	72350
60	10.3	70300	35150
63	5.7	30600	15300
66	3.1	11100	5550
69	1.7	3100	1550
72	1.0	200	100

Table 3: Daytime LAeq,16h (51-72dB) areas populations for the two PBN respite departure routes

LAeq16h	Area	Pop	Hses	Pop change relative Conventional route
(-)	(km^2)	(-)	(-)	(%)
51	58.8	527200	263600	+4.6%
54	30.7	258900	129450	-6.4%
57	16.3	121300	60650	-16.1%
60	9.3	59900	29950	-13.9%
63	5.6	29900	14950	-2.3%
66	3.1	11100	5550	-
69	1.7	3100	1550	-
72	1.0	200	100	-

Table 4: Night-time LAeq,16h (45-66dB) areas populations for the conventional departure route

LAeq8h	Area	Pop	Hses
(-)	(km²)	(-)	(-)
45	33.5	284500	142250
48	19.5	152300	76150
51	10.8	73100	36550
54	5.7	27800	13900
57	3.1	9000	4500
60	1.7	1700	850
63	1.0	0	0
66	0.6	0	0

Table 5: Night-time LAeq,16h (45-66dB) areas populations for the single PBN departure route

LAeq8h	Area	Pop	Hses
(-)	(km²)	(-)	(-)
45	33.5	283800	141900
48	19.4	152300	76150
51	10.8	73600	36800
54	5.7	27800	13900
57	3.1	9000	4500
60	1.7	1700	850
63	1.0	0	0
66	0.6	0	0

Table 6: Night-time LAeq,16h (45-66dB) areas populations for the two PBN respite departure routes

LAeq8h	Area	Pop	Hses	Pop change relative Conventional route
(-)	(km²)	(-)	(-)	(%)
45	32.5	272800	136400	-3.9%
48	17.5	133100	66550	-12.6%
51	9.8	63100	31550	-14.3%
54	5.7	27500	13750	-1.1%
57	3.1	8800	4400	-2.2%
60	1.7	1700	850	-
63	1.0	0	0	-
66	0.6	0	0	-

Table 7: Effect of altitude on lateral noise distribution

Lateral distance	Height	Slant distance	Elevation Angle	Increase in noise when overhead
(m)	(ft)	(m)	(deg)	(dB)
1000	4000	1577	50.6	+2.6
1000	5000	1823	56.7	+1.7
1000	6000	2084	61.3	+1.2
1000	7000	2356	64.9	+0.9

Table 8: Daytime Population noise exposure changes for a single PBN Concentrated departure route vs Conventional navigation departure route

		Single PBN Concentrated Route																					
	(dB Leq, 16h)	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
Conventional Navigation Route	51	86700	6500																				
	52	1800	65900	3500																			
	53		1400	57500	2000																		
	54			1800	51700	1100																	
	55				1000	42000	400																
	56					1200	34300	100															
	57						800	29800	800														
	58							400	23100	300													
	59									20400	600												
	60										16500	400											
	61											13600	400										
	62												8600	300									
	63													8800									
	64														5300	200							
	65															5300							
	66																3400						
	67																	2700					
	68																		1900				
	69																			1400			
	70																				700		
	71																					800	
	72																						100

Table 9: Daytime Population noise exposure changes for twin Concentrated PBN departure routes vs Conventional navigation departure route

		Twin PBN Respite Routes																					
	(dB Leq, 16h)	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
Conventional Navigation Route	51	18600	10400	6600	5800	3800	6200																
	52	6400	14300	5800	4800	4000	4000	3400															
	53	6200	4200	13600	4800	3800	3600	3800															
	54	5600	4400	3400	12000	6400	2200	4200	600														
	55	5400	4000	2600	2000	10000	4000	2200	2600														
	56	6000	3200	2200	2000	1000	9000	3000	3000														
	57	7600	3200	2000	2000	800	800	10000	2800	1200													
	58	3700	4300	2000	1000	1400	800	600	7200	2800													
	59		2200	3400	2200	1400	1200	400	800	8400	1000												
	60				1400	2000	1700	1200	1000	800	8000	800											
	61						100	800	1000	1400	1800	8700	200										
	62										400	1700	6800										
	63												300	8500									
	64														5300	200							
	65															5100	200						
	66																3400						
	67																	2700					
	68																		1900				
	69																			1400			
	70																				700		
	71																					800	
	72																						100

Table 10: Daytime Population noise exposure changes for twin Concentrated PBN departure routes vs Concentrated PBN navigation departure route

		Twin PBN Respite Routes																					
	(dB Leq, 16h)	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
Single Concentrated PBN route	51	18600	10200	7000	5000	3800	6200	400															
	52	6000	14300	5600	5000	3800	4600	3000															
	53	6200	4200	13600	4800	4400	3000	4200															
	54	5200	4200	3200	11800	6400	2200	3800	1000														
	55	5600	4200	2600	2200	9400	4400	2200	2600														
	56	6000	3000	2200	2000	1000	8600	3200	3000														
	57	7200	3000	1800	1800	800	800	9800	2600	1400													
	58	4100	4200	2200	1000	1400	800	600	7000	2600													
	59		2500	3400	1800	1200	1200	400	800	8400	1000												
	60				1800	2200	1500	1200	800	800	8000	800											
	61						300	800	1200	1400	1600	8500	200										
	62										600	1900	6500										
	63												600	8500									
	64														5300								
	65															5300	200						
	66																3400						
	67																	2700					
	68																		1900				
	69																			1400			
	70																				700		
	71																					800	
	72																						100

Table 11: webTAG 10-year NPV for three scenarios by noise effect (2010 prices)

	Baseline vs Single PBN route	**Baseline vs twin PBN respite routes**	**Single PBN route vs Twin PBN respite routes**
Net present value of impact on sleep disturbance*	-£3,454,201	£142,353,040	£143,710,735
Net present value of impact on amenity*	-£17,333,153	£365,781,060	£364,128,652
Net present value of impact on AMI*	-£675,623	£5,663,213	£6,338,836
Net present value of impact on stroke*	-£2,737,869	£51,667,574	£51,156,534
Net present value of impact on dementia*	-£4,128,630	£77,794,400	£77,018,193
Net present value of change in noise*	**-£28,329,476**	**£643,259,286**	**£642,352,950**

*positive value reflects a net benefit (i.e. a reduction in noise)

Figure 1: Conventional departure route track dispersion

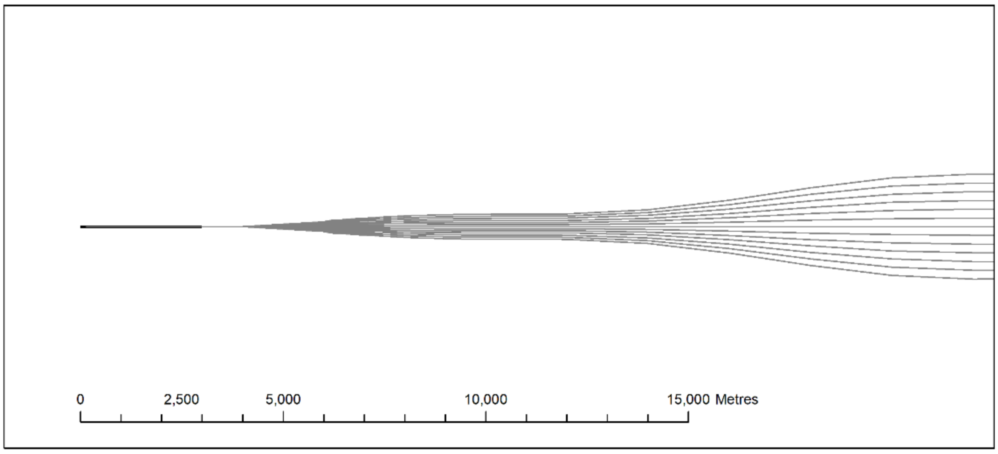


Figure 2: Single PBN departure route track dispersion

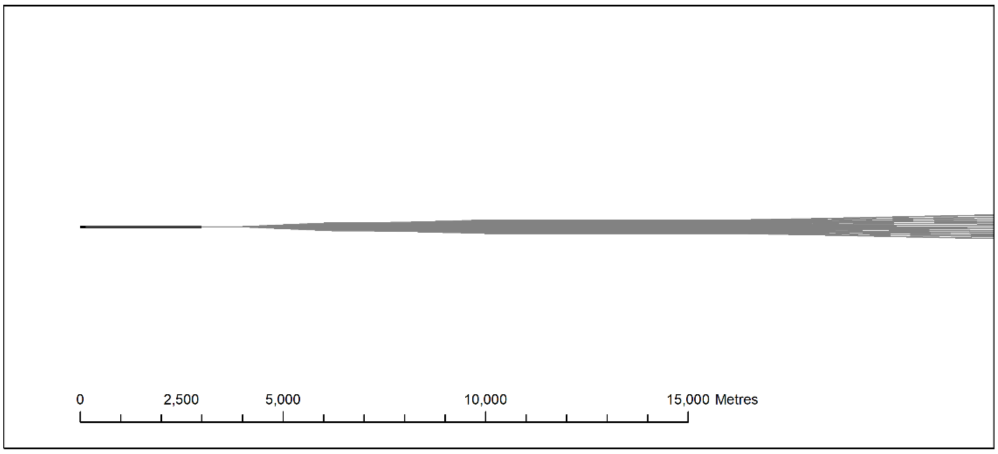


Figure 3: Two PBN respite departure routes track dispersion

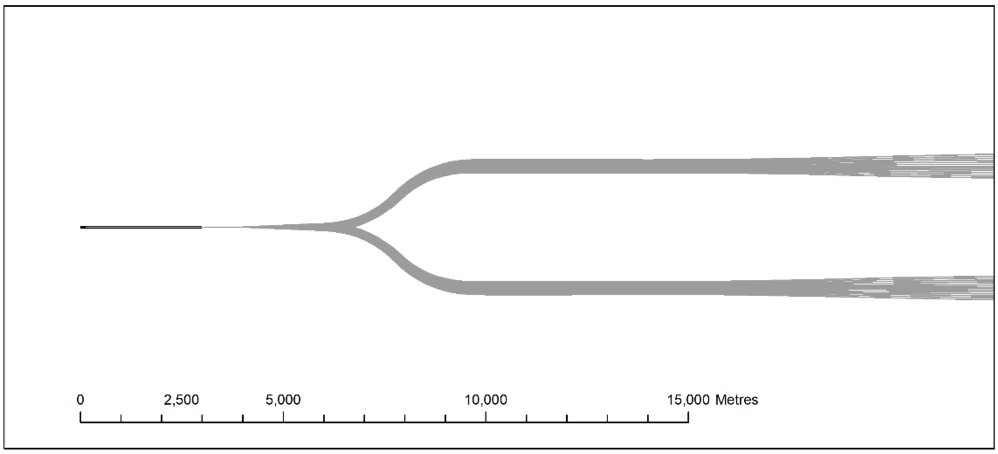


Figure 4: Daytime LAeq,16h contours (51-72dB) for the conventional departure route

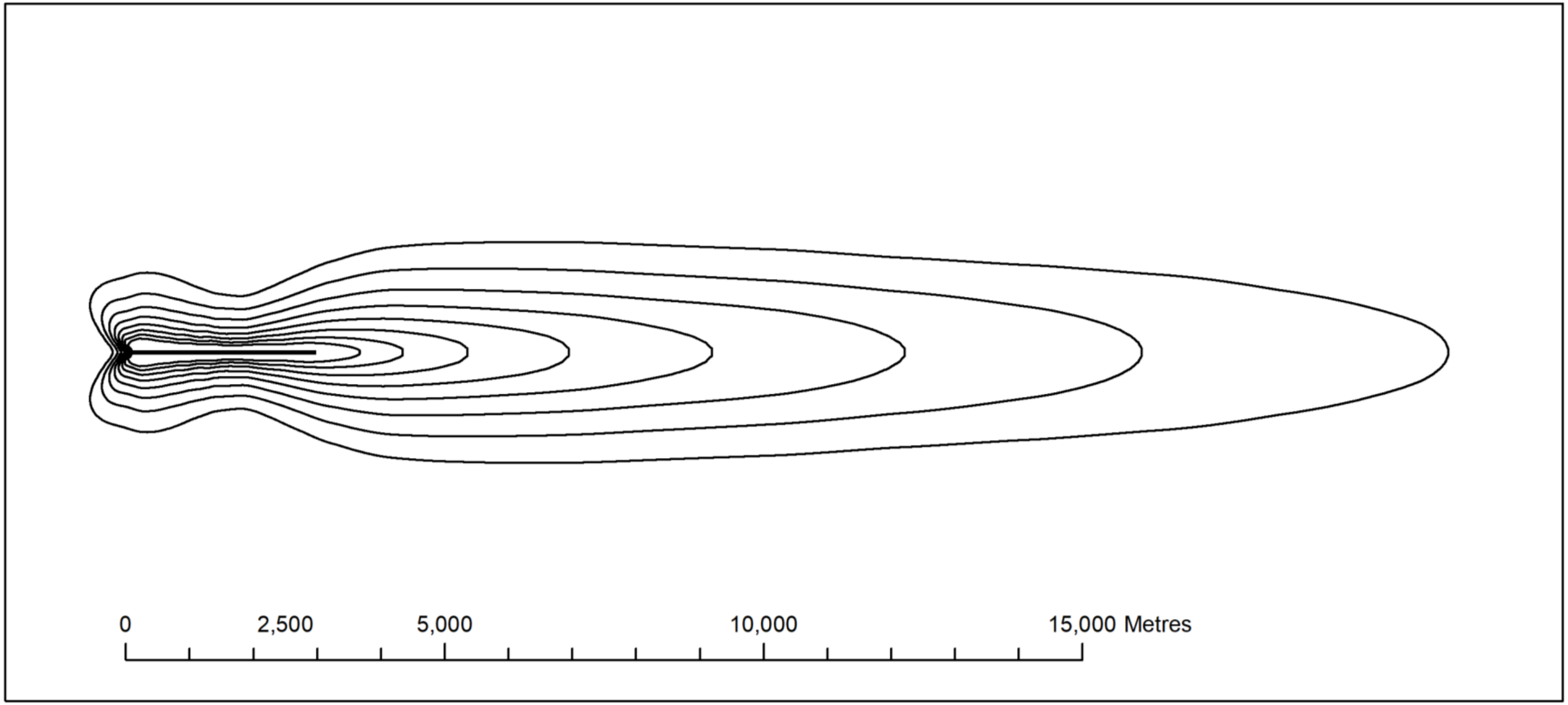


Figure 5: Daytime LAeq,16h contours (51-72dB) for the single PBN departure route

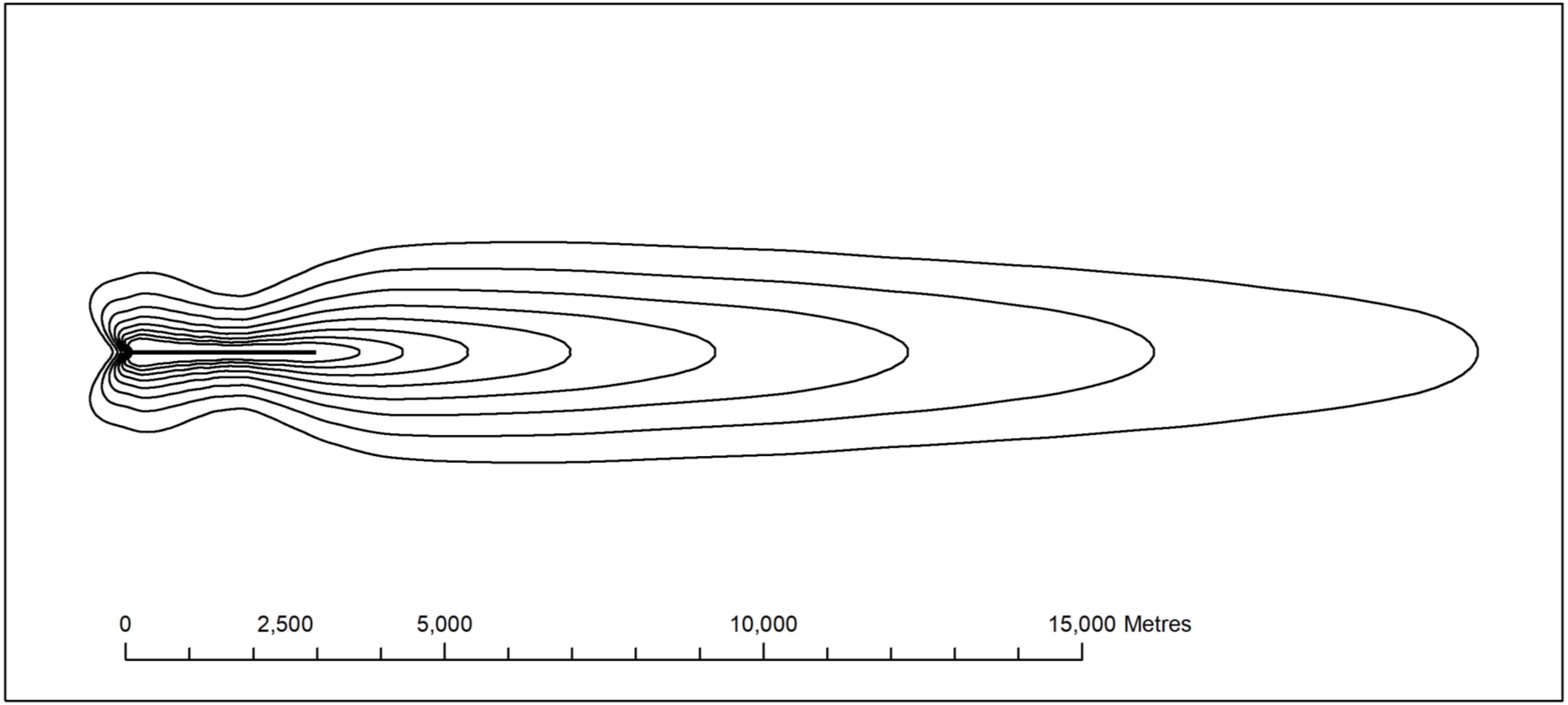


Figure 6: Daytime LAeq,16h contours (51-72dB) for the PBN respite departure routes

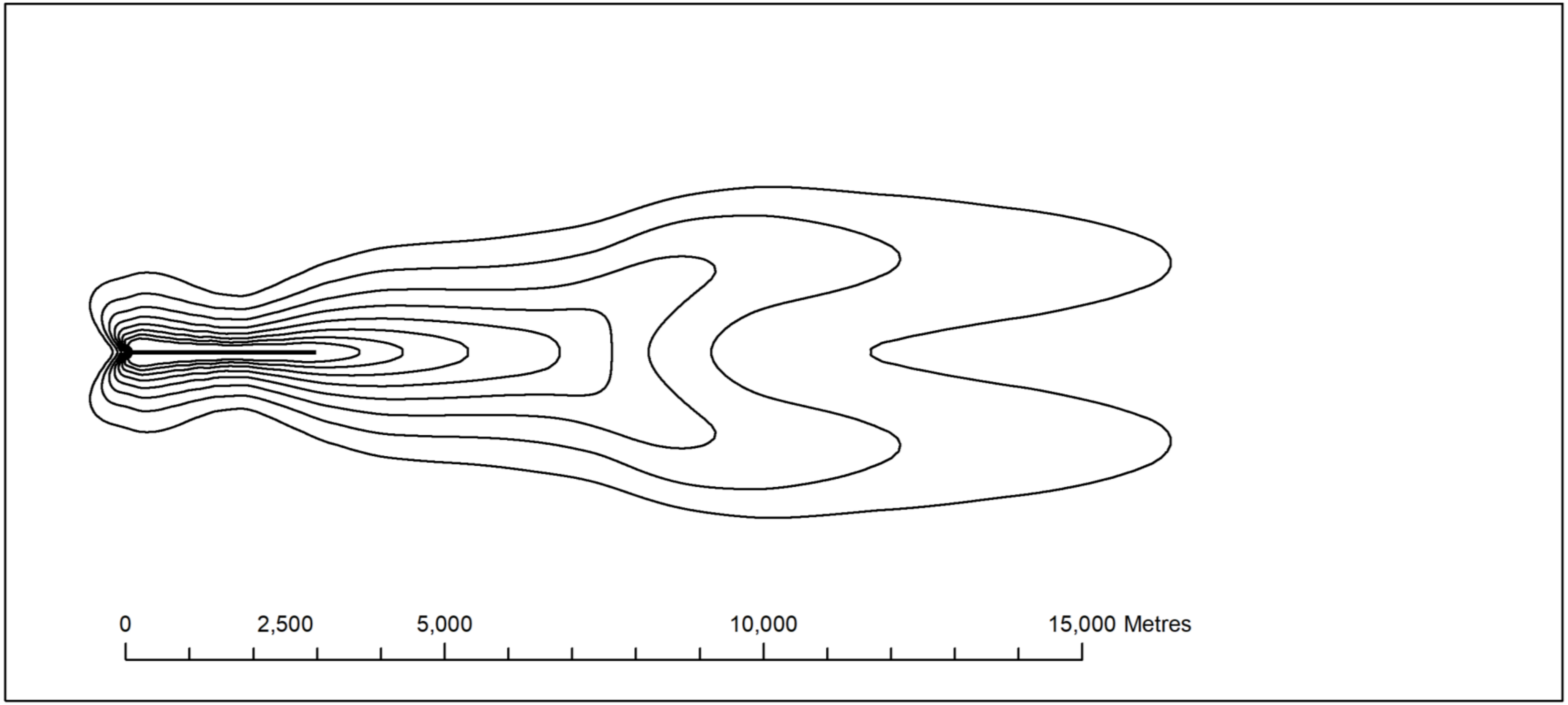


Figure 7: Daytime LAeq,16h (51-72dB) contours for Conventional and single PBN departure routes

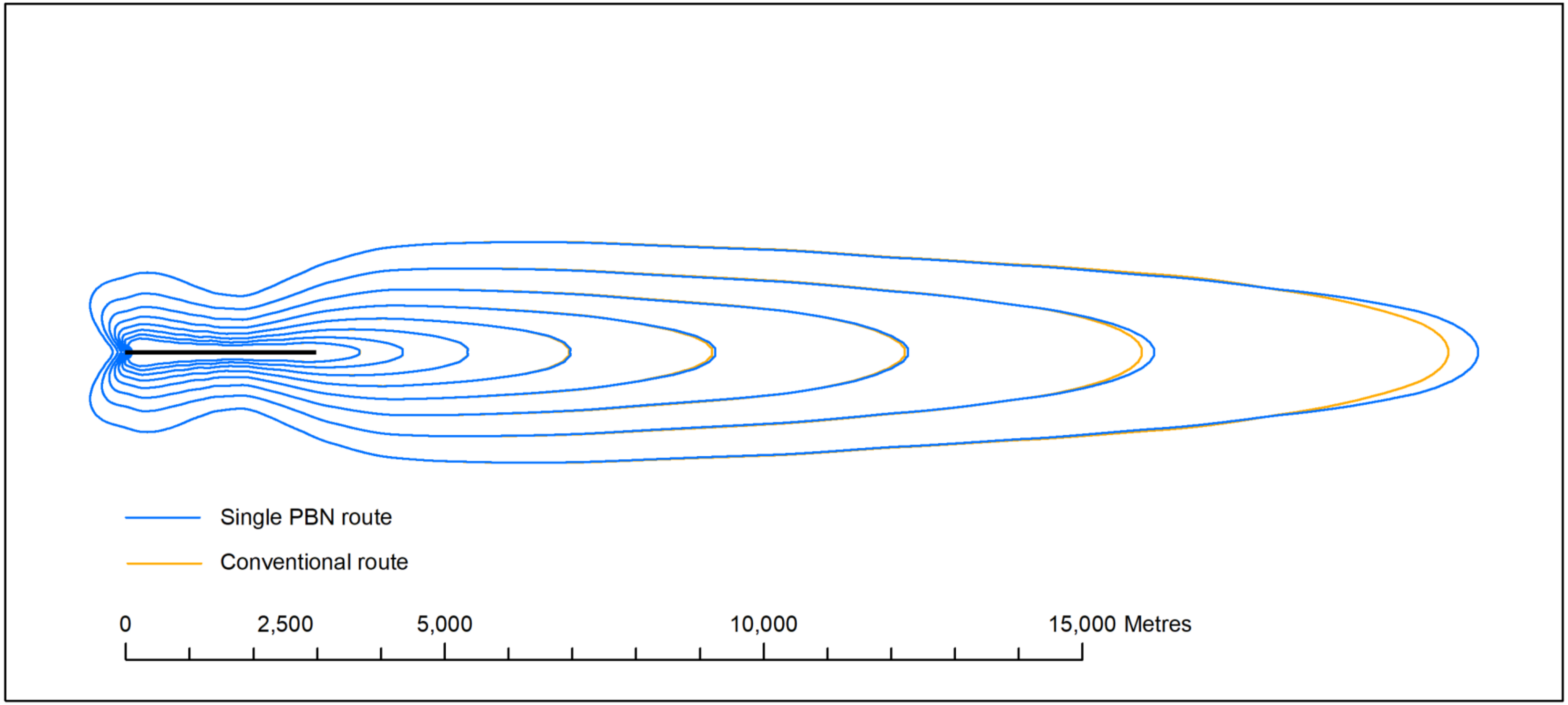


Figure 8: Daytime LAeq,16h (51-72dB) contours for single PBN and twin PBN respite departure routes

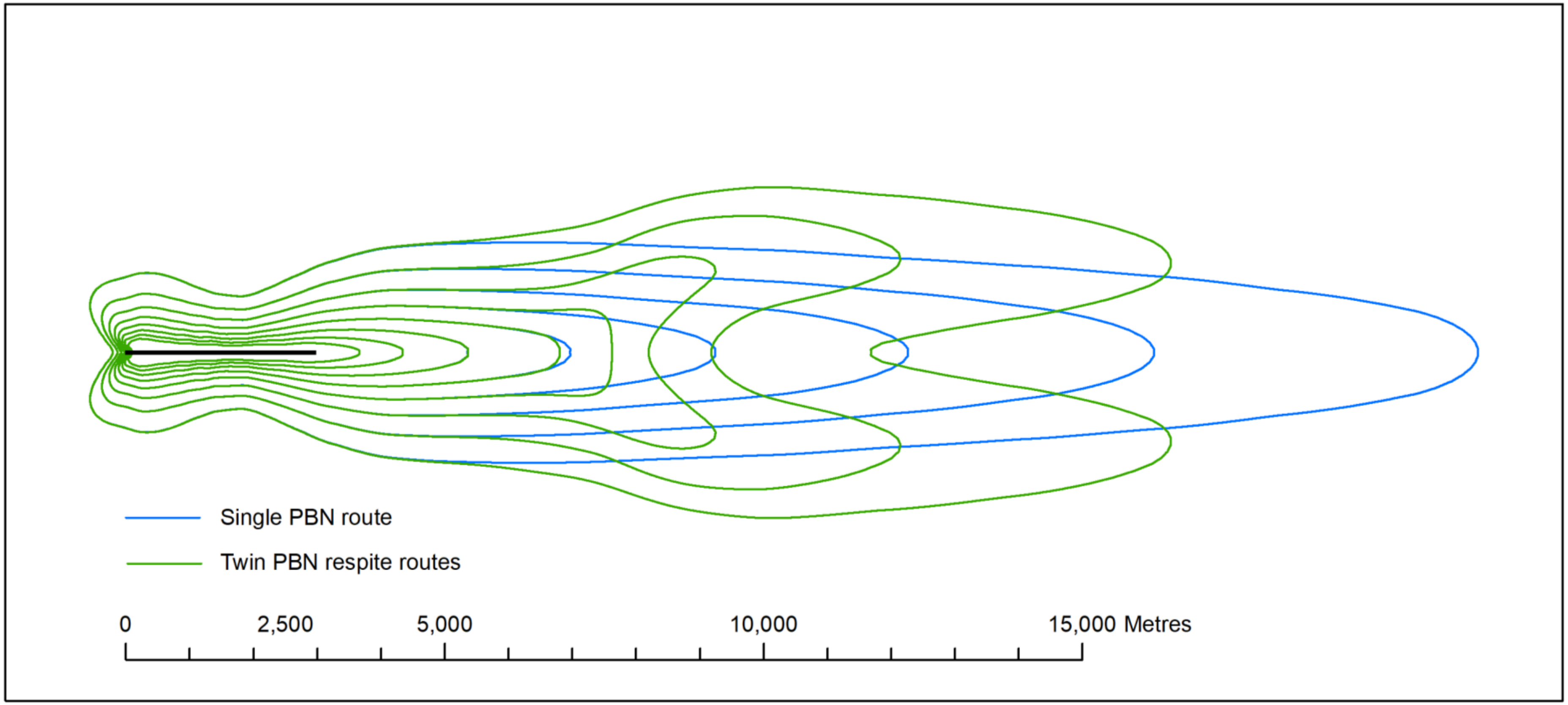


Figure 9: Night-time LAeq,8h contours (45-66dB) for the conventional departure route

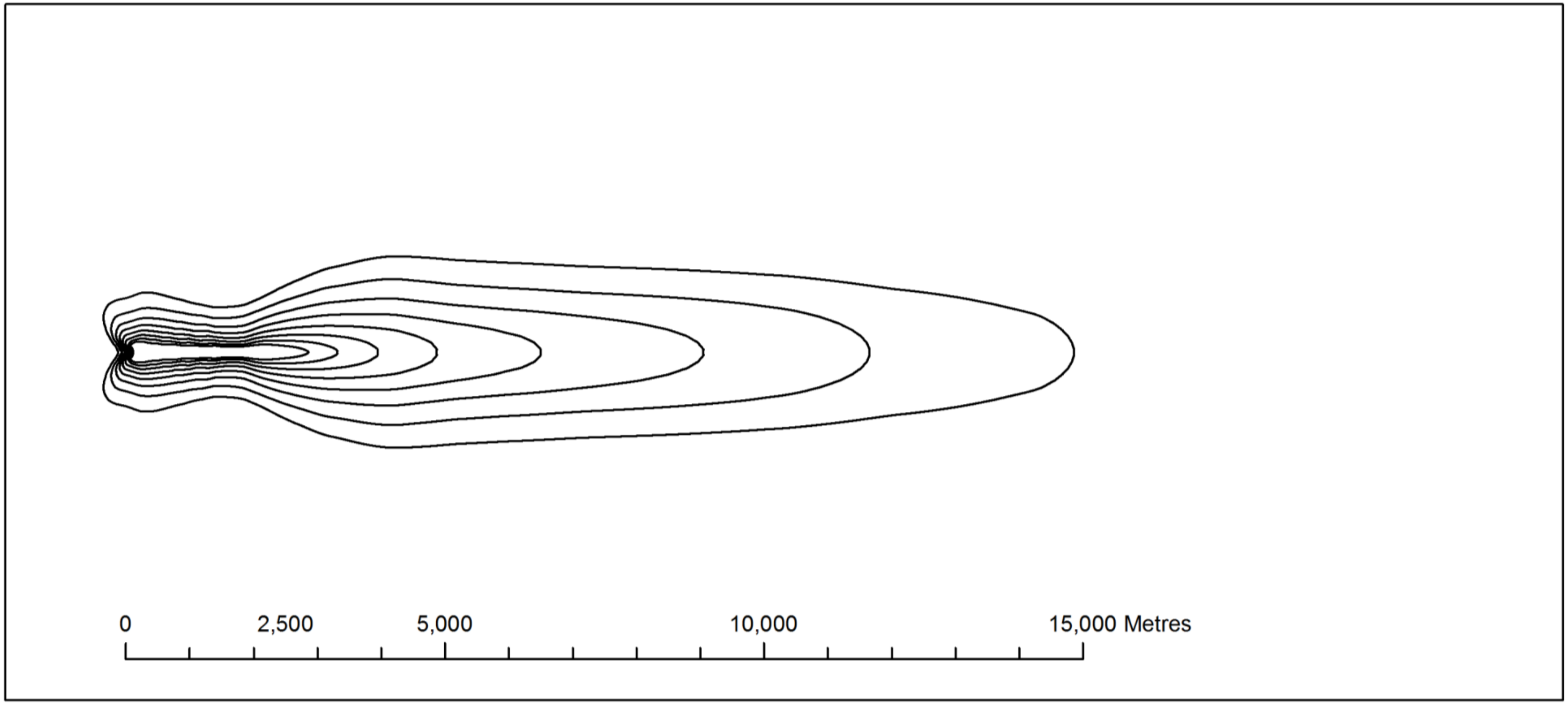


Figure 10: Night-time LAeq,8h contours (45-66dB) for the single PBN departure route

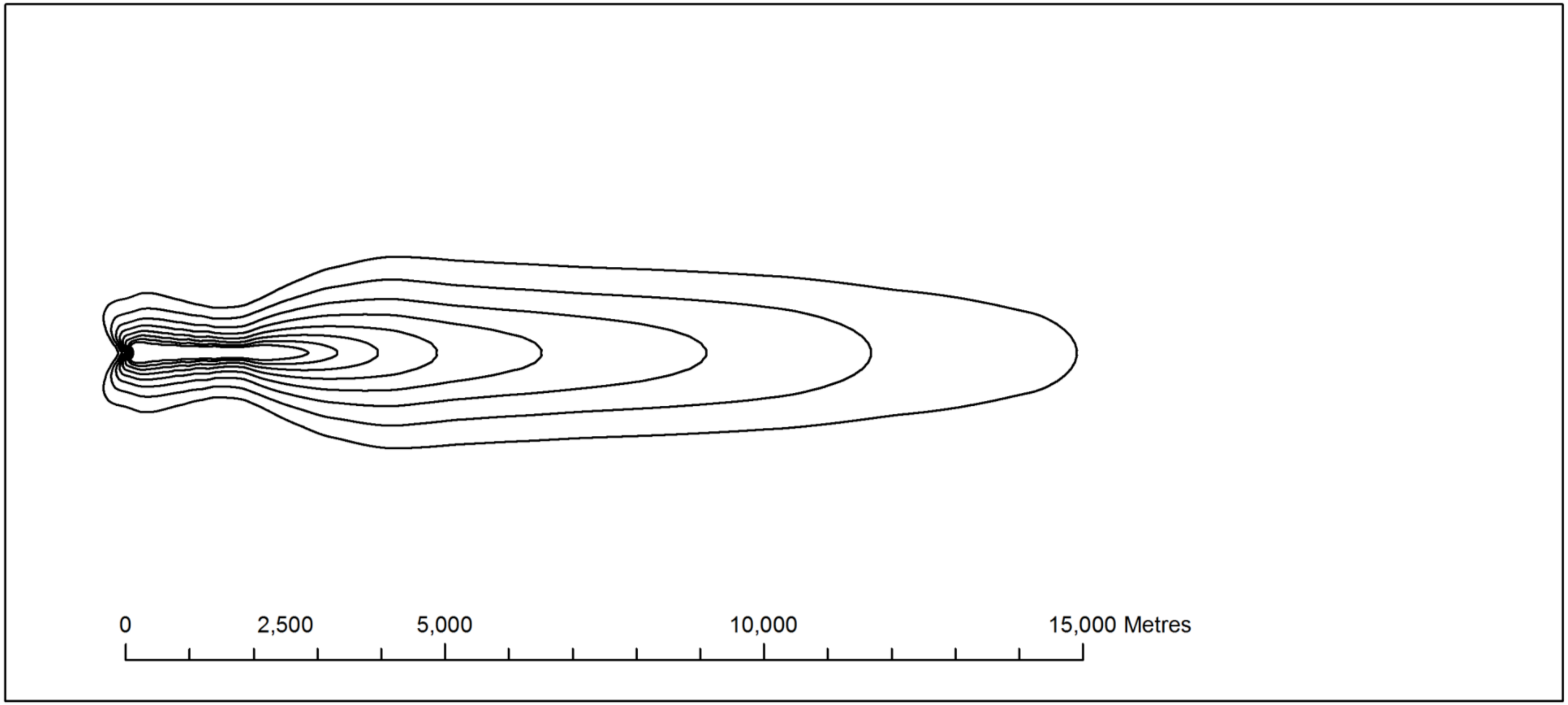


Figure 11: Night-time LAeq,8h contours (45-66dB) for the PBN respite departure routes

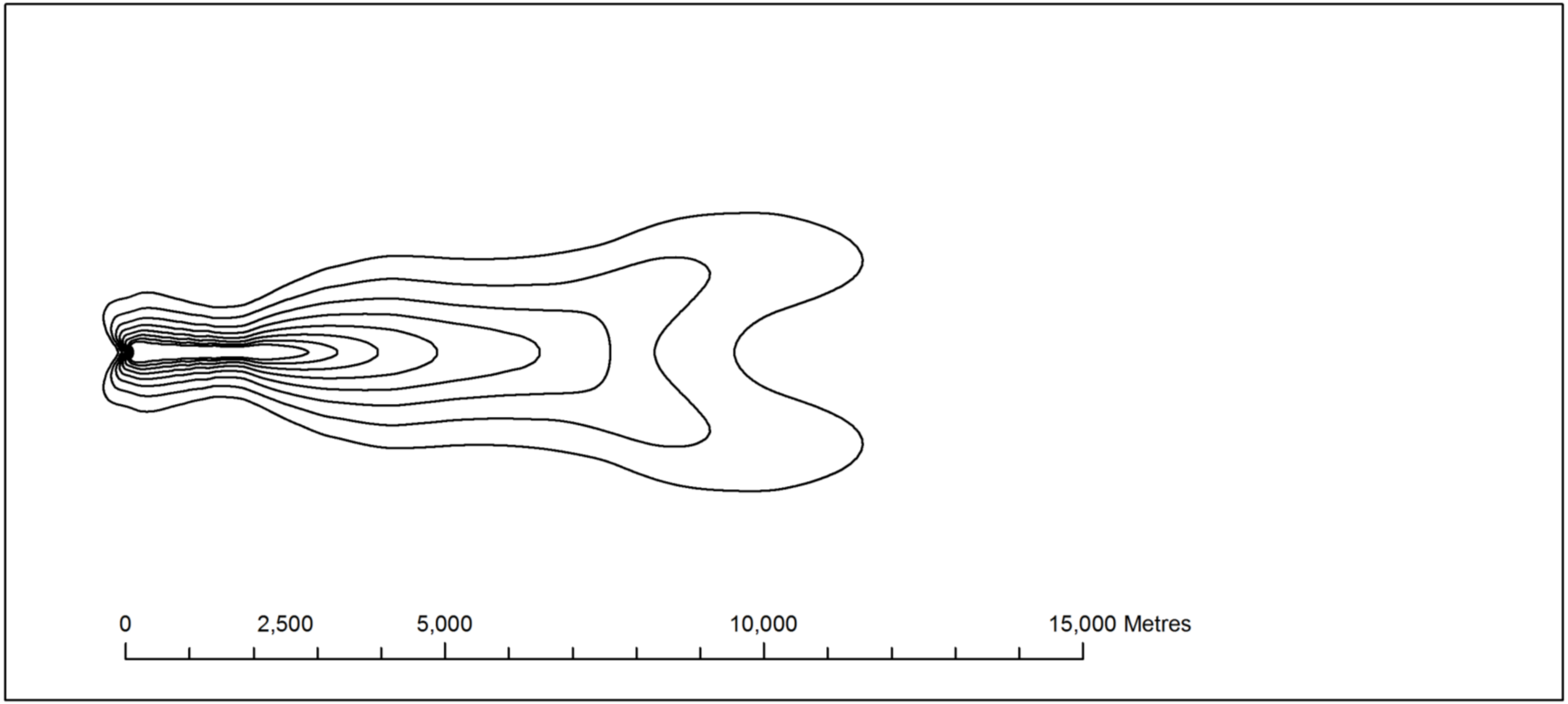
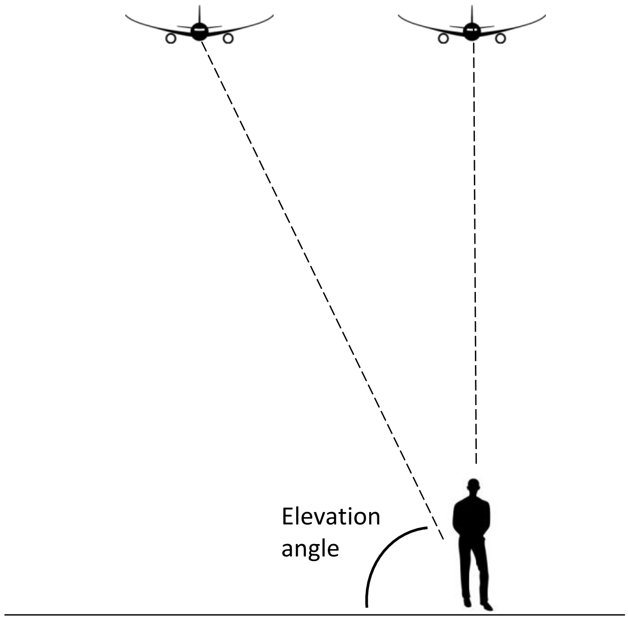


Figure 12: Elevation angle between ground observer and an aircraft



Annex A: webTAG