NOISE LEVELS OF HELICOPTERS PERFORMING ELEVATED PAD TAKE-OFF AND LANDING PROCEDURES

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1. INTRODUCTION

The CAA apply special operational requirements to elevated helipads. This type of facility used to be defined as any helipad with an operating platform of between 20 ft and 400 ft above the ground, but is now defined as any site where an incursion into the height velocity curve of a helicopter may occur.

The CAA restricts the usage of elevated helipads to helicopters which are able to meet the CAA full Group A Performance Certification for such facilities. These are helicopters with at least two engines which have been shown to be capable of performing defined safety manoeuvres in the event of an engine failure. The take-off flight profile from an elevated helipad is typified by an initial period in hover close to the pad, followed by a slow rearwards or vertical ascent to a height of about 30 - 40 m above the helipad and then transition into forward motion and climb away.

In the course of preparing technical evidence in relation to the noise environment in the vicinity of a proposed elevated helipad, very little measured data on helicopters performing such manoeuvres was identified. Extensive noise measurements were therefore undertaken by the author on three separate types of helicopters performing these types of manoeuvres. The results of some of these measurements are presented here together with a brief discussion on two specific technical issues concerned with the prediction of helicopter noise levels close to helipads.

2. DESCRIPTION OF TEST SITE

The location of the proposed elevated helipad was on the River Thames, in central London. At this point the river is about 200 m wide and is surrounded by tall buildings and bridges. The obvious location to have undertaken noise tests would have been at the site of the proposed helipad as then the rather complex acoustic environment caused by the presence of the buildings and the open expanse of water could have been taken into account in the measurements. However, apart from some fly-by tests at relatively high altitudes, it was not possible for safety reasons to realistically fly helicopters in and out of the proposed site.

Instead, the test site used was at Bruntingthorpe Airport and Proving Ground, in Leicestershire UK. This is an ex USAF base and has a runway 2 miles long and 60 m wide. At the centre of the runway is an intersection with a taxiway 30 m wide which crosses the runway. It was felt that the runway would fairly represent the acoustical hard nature of the river surface, although the presence of surrounding tall buildings could not be simulated. Nevertheless one measurement position was set up at a height of 100 ft above the ground using a hydraulic hoist and a mast. The purpose of this measurement point was to have a microphone at a height equivalent to the upper floor levels of the tall buildings surrounding the proposed helipad site, and hence monitor any particular noise characteristics which might arise at this elevation during the special take-off procedures from an elevated pad.

The intersection of the taxiway and runway was used as the assumed helipad location and it was possible to undertake noise measurements to distances of 1.5 km from the landing and take-off point at a distance of 60 m from the ground track of the helicopter, and also out to a distance of 250 m laterally from the landing and take-off point, with an intervening acoustically hard surface between the ground track of the helicopter and the microphone at each measurement position. The layout of the test site is shown in Figure 1. Up to twelve microphone locations were used.

Large marker boards were placed on the ground at the 500 m, 1 km and 1.5 km locations on either side of the assumed helipad location. These were used during the trials to determine the flight profiles flown by the helicopters.

3. INSTRUMENTATION

The instrumentation was kept as simple as possible and consisted of a tripod mounted Bruel and Kjaer sound level meter at each location, with the microphone at a height of 1.2 m above the ground. Each of the eight measurement locations within 500 m of the landing and take off point was cabled back to a Racal Store 14 tape recorder, whilst the remaining four locations were manned by two technicians with individual sound level meters and tape recorders. Care was taken to calibrate the system prior to the start of each measurement exercise. The multi track tape recorder was run either at 30 ips, which gave a flat frequency response from 0 - 20 kHz, or at 15 ips, which reduced the frequency response to 0 - 10 kHz.

The tape recordings were analysed using a Bruel and Kjaer Type 2231 sound level meter and a Bruel and Kjaer level recorder Type 2317 (for confirmation of results only), both set to 'slow' response, to provide the following noise measurement parameters: L_{Amax} dB, L_{AE} dB.

4. TEST SCHEDULE

Two series of noise tests were undertaken in June 1990 and September 1990. In the June 1990 trials, measurements were undertaken on three different helicopters: a Twin Squirrel AS-355 F1, a Sikorsky S-76A and an Agusta 109A. Six take-offs and landings were performed for each helicopter (ie. 12 movements). In this series of tests each pilot was requested to perform what he considered to be a normal departure from an elevated pad, climb to a height of 1500 ft following the edge of the runway, turn through 180°, overfly the runway at a predetermined height which varied from 800 ft to 1500 ft and perform a normal approach for an elevated platform, again following the edge of the runway on approach. An experienced observer, flying with the pilot monitored the height and indicated air speed (IAS) when overflying each marker board. For the last two tests the pilot was asked to attempt to follow the flight profiles which were originally defined for the proposed helipad.

Following these initial tests the defined flight profiles into and out of the proposed helipad were revised by the applicants for the helipad; in particular the angle of descent for the AS355 was reduced from 17° to just under 14° with a final approach at 6°. The revised flight profiles for the AS-355 are shown in Figure 2. Another series of noise measurements was then undertaken at Bruntingthorpe in September 1990, this time just for a Twin Squirrel AS-355 F1. Noise measurements were made for a further six take-offs and landings, with the helicopter attempting the revised flight profiles. Measurements were also made during overflights at heights of between 500 ft and 2000 ft with some of the overflights off-set from the line of the runway.

5. RESULTS OF NOISE MEASUREMENTS

Table 1 shows the averaged values of the measured noise levels for some of the locations during the first noise trials at Bruntingthorpe. The overflight noise levels for both sets of tests are given in Table 4. Table 2 gives the individual test results during the second noise trials at Bruntingthorpe. The individual flight profiles flown during these tests are shown in Figures 3 and 4. It can be seen from these figures that there was a relatively high degree of consistency in the flight profiles flown and this is reflected in the consistency of the noise test results shown in Table 2. One feature of take-off noise which was observed from the first noise trials, was a distinct lobing effect of noise to the rear and side of the helicopter just at the nose down attitude at the forward transition point. This was most noticeable with the S-76A and resulted in noise levels being much higher than anticipated in directions away from the general heading of the helicopter.

The results of the measurements at Location 2 (the elevated microphone position) showed similar levels to that measured at Location 1, which was closer to the landing and take-off point but on the ground.

The advantage of performing measurements of the type undertaken at Bruntingthorpe is that they can be used to increase confidence in more theoretically based noise prediction techniques. If measurements are made at locations which encompass the range of distances of concern from a helipad then interpolation of the measured results can help to produce a more accurate set of noise contour values, whether they are expressed as NNI or $L_{Aeq,T}$.

6. TECHNICAL ISSUES INVOLVED IN PREDICTING HELICOPTER NOISE LEVELS FOR PLANNING PURPOSES

The noise environment around a helipad will depend on many factors which include:

a) The number of helicopters using the facility.

b) The types of helicopters and noise levels for individual types of helicopters.

c) The mix of helicopters.

d) The variation in movements on a seasonal, daily and hourly basis.

e) The landing and take-off profiles of the helicopters.

f) The way sound propagates from the helicopter to adjacent areas and in particular the type of terrain over which the sound is propagating.

g) The influence of local effects such as reflection of sound from high rise buildings.

h) Noisy activities occurring at the helipad itself eg. ground running noise.

Two of these issues viz sound propagation and ground running are discussed here in more detail.

Sound Propagation

One issue which arises in the prediction of noise contours around a proposed helipad, is what rate of attenuation with distance to use. In practice, this is a complex issue because of the noise radiation characteristics of helicopters and the type of terrain over which the sound may be propagating. The author takes the view that if a simplistic approach is to be adopted, then for a helipad which is surrounded by acoustically hard surfaces an attenuation rate of no more than 6 dB/doubling of distance should be used to calculate L_{Amax} values at different distances in the vicinity of the helipad. This is supported by the results of the measurements taken at Bruntingthorpe, which show a higher correlation when normalised to a distance of 150 m, based on 6 dB/doubling distance, as opposed for example, to 8 dB/doubling of distance which might be used if the methodology of Reference 1 were to be followed. For practical purposes, if helicopter noise measurements are only made at a single measuring point then this should be at a distance of about 150 m, as the potential error in predicting noise levels to other typical distances of interest is likely to be reduced.

Ground Running

Ground running noise can significantly increase noise contour values close to a helipad (if they are expressed in terms of L_{Aeq}). Ground running is the state a helicopter may be in just prior to take-off or just after landing ie. on the helipad with engines and rotors turning. It is necessary to distinguish between 'ground idle' and 'flight idle' ground running conditions, or air taxiing, all of which may occur once a helicopter has landed on the helipad.

When the engines of a helicopter are first started a running period at reduced speed is required in order to stabilise conditions. This is termed 'ground idle' conditions and the main rotor may be turning at some 45% to 65% of full speed (dependent upon type of helicopter). After this the speed select levers are advanced and a 'flight idle' condition is reached with the rotors turning at full speed. This condition of 'flight idle' is significantly noisier than at 'ground idle' conditions. A period of ground running will also occur to stabilise engine temperatures before the helicopter engines are shut down. This is done at 'ground idle' conditions.

Another aspect which must be considered in relation to noise during ground running is that of taxiing from the landing spot to a parking spot on the helipad. For the Twin Squirrel AS-355 this is usually done in a hover condition. When the helicopter is close to the deck there is an upwash effect from the ground which helps the helicopter to maintain lift. This condition of hover is called 'hover in ground effect' (HIGE). This again is a noisier condition than ground idle.

Detailed test data for an AS-355 in ground running conditions is given in Reference 2. For propagation over a hard surface the following noise levels are reported, at a distance of 150 m, averaged over 360° around the helicopter.

Ground Idle	64 dB L_{Aeq}
Flight Idle	77 dB L_{Aeq}
HIGE	80 dB L_{Aeq}

In order to assess the effects of ground running noise it is necessary to make an assessment of the amount of time a helicopter may be in any particular mode of ground running. For the proposed helipad in central London, it was calculated that at the closest noise sensitive location to the helipad the total noise level due to all activities at the helipad, expressed as $L_{Aeq,T}$, would be dominated by ground running noise. The level of this type of noise became approximately equal to the combined noise from landings and take-offs, further away, at a distance of about 150 m from the centre of the helipad.

7. CONCLUSIONS

This paper has provided details of measured noise levels of helicopters performing elevated pad take-off and landing manoeuvres. The purpose of the measurements was to assist the planning process for a proposed elevated helipad, by providing test data which could be used directly to compute noise index values, such as NNI and $L_{Aeq,T}$ at defined locations in the vicinity of the helipad.

In considering the total noise environment around a helipad a number of issues have to be considered and these have been addressed briefly in this paper. Of particular importance, is the inclusion of ground running noise in the calculations for $L_{Aeq,T}$ as it has been found that this can dominate the noise environment in the vicinity of the facility.

8. REFERENCES

[1] DORA Communication 7908, 'A Guide to the Calculation of NNI'
[2] "Noise Measurement Flight Test for Aerospatiale AS355 F Twin Star Helicopter: Data/Analysis", Report No FAA-EE-84-04.

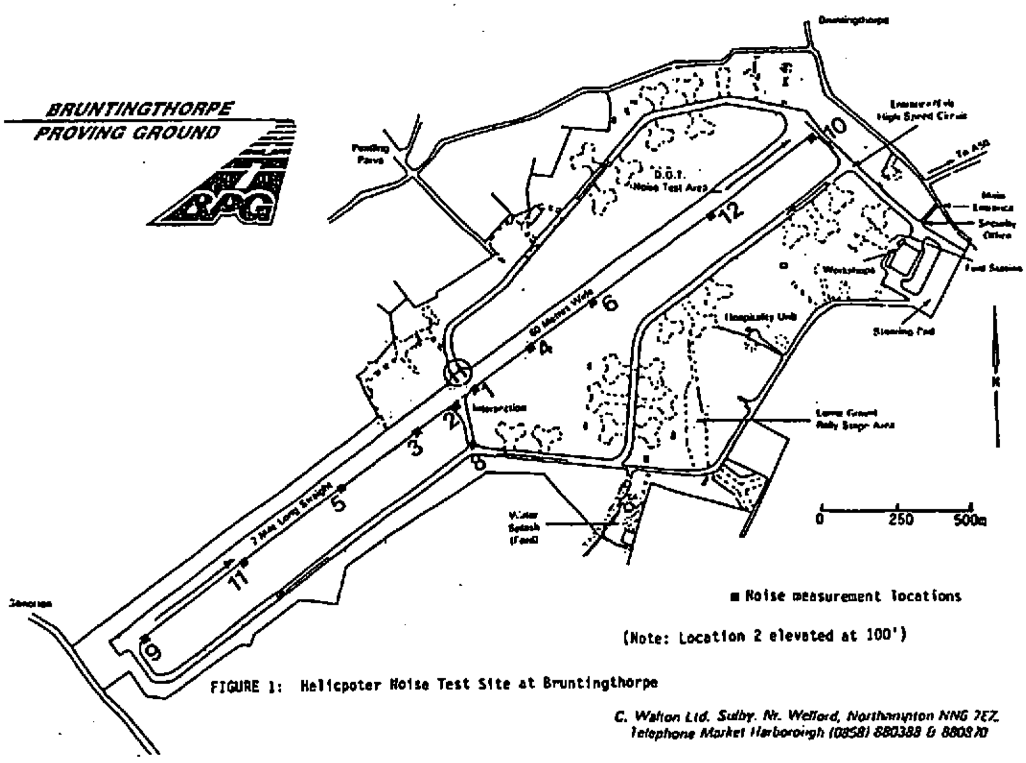

FIGURE 1: Helicpoter Noise Test Site at Bruntingthorpe

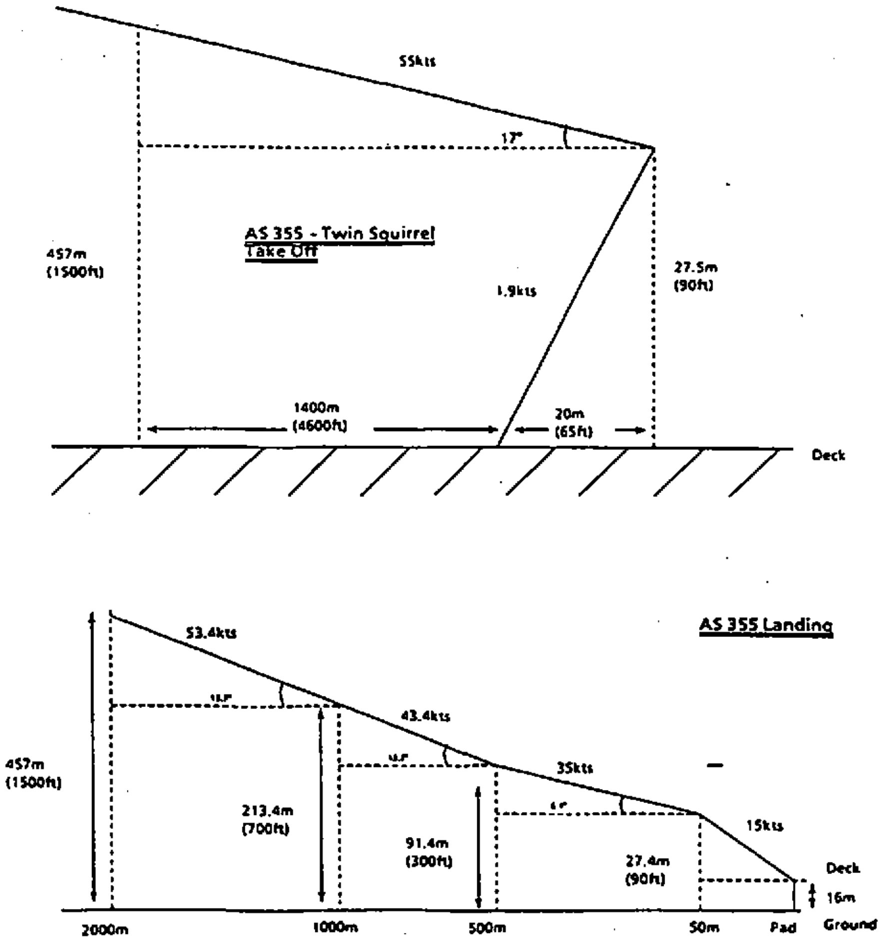

FIGURE 2: Defined Elevated Pad Flight Profiles For AS-355

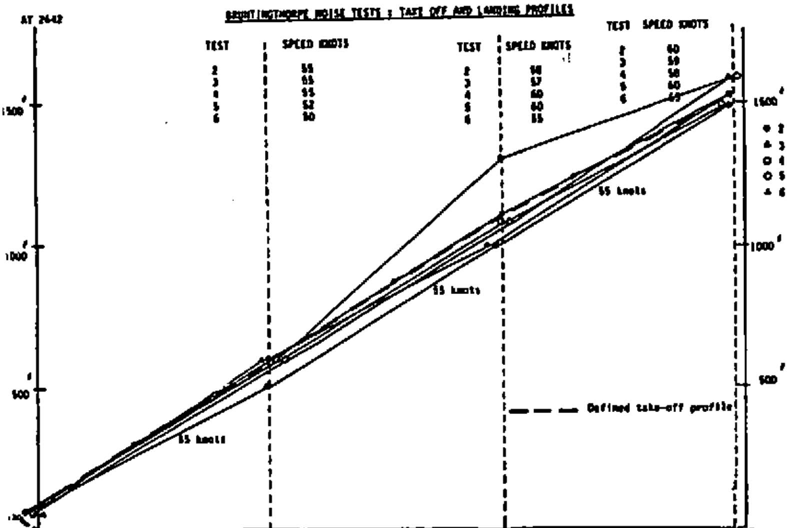

FIGURE 3: Take-off Profiles During Sept 1990 Noise Trials

AS 355 F1 Sept 1990

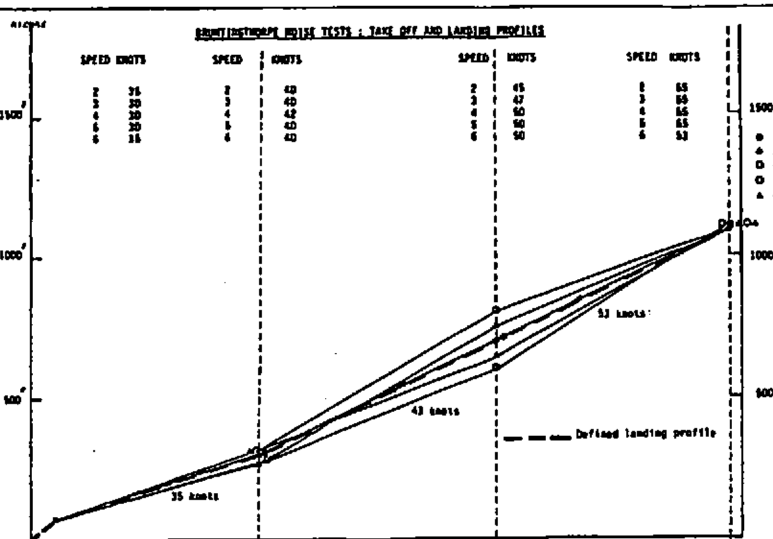

FIGURE 4: Landing Profiles During Sept 1990 Noise Trials

AS 355 F1 Test Sept 1990

NOISE LEVELS OF HELICOPTERS

Location No	AS-355 F1				S-76A				A-109 A			
	Take-off NE		Landing NE		Take-off NE		Landing NE		Landing NE		Landing SW	
	L_{Amax}	L_{AE}	L_{Amax}	L_{AE}	L_{Amax}	L_{AE}	L_{Amax}	L_{AE}	L_{Amax}	L_{AE}	L_{Amax}	L_{AE}
1	87	102	87	99	91	103	94	102	87	98	91	100
2	86	101	87	101	92	105	91	102	85	98	90	99
3	77	89	84	95	87	96	88	97	86	95	76	85
4	82	93	78	89	82	91	78	87	77	87	82	93
5	72	84	79	92	77	88	82	92	78	89	64	78
6	77	89	71	82	77	87	64	76	71	80	77	89
8	79	94	82	94	85	97	84	93	77	88	80	89

TABLE 1: Average of Measured Noise Levels dB 'Slow' During Helicopter Noise Tests at Bruntingthorpe Proving Ground, June 1990

Wind details:		
	AS-355 tests	350/10, less than 10 knots
	S-76A tests	Variable, mainly 070, less than 10 knots
	A-109A tests	Variable, very light

Test No	Location 1		Location 5		Location 6		Location 8	
	L_{Amax}	L_{AE}	L_{Amax}	L_{AE}	L_{Amax}	L_{AE}	L_{Amax}	L_{AE}
Take-off NE:								
1	89	102	71	85	76	88	77	90
2	88	102	72	84	75	87	75	91
3	90	102	69	83	74	86	77	-
4	88	103	70	84	75	86	77	92
5	88	100	70	82	74	86	77	88
6	87	98	69	82	74	86	78	90
Log Average	88	101	70	84	75	87	77	90
Landing NE:								
1	90	102	82	92	65	79	79	90
2	89	103	83	93	62	80	77	89
3	90	102	82	91	66	80	78	-
4	89	98	83	94	67	80	78	88
5	88	101	78	90	66	78	77	88
6	88	100	82	92	68	83	78	89
Log Average	89	101	82	92	66	80	78	89

TABLE 2: Measured Noise Levels for AS 355 Noise Tests at Bruntingthorpe Proving Ground, September 1990
Levels are dB, 'Slow' (See Table 3 for Trial Details)

HELICOPTER NOISE TRIAL - BRUNTINGTHORPE

1	Date:	14th September 1990	12	Payload Available:	475 kg (elevated platform)
2	Helicopter Type:	AS355 - F1	13	Basic Weight:	1645 kg
3	Helicopter Registration:	G-SASU	14	Crew Weight:	80 kg
4	Operator:	Aer Omega	15	Fuel Weight:	255 kg
5	Captain:	Capt. James Barnes	16	Pax or Ballast:	80 kg
6	Wind:	NNW 0 - 10 knots	17	Operating Weight:	2060 kg
7	Temperature:	20°C 50% RH	18	Fuel Used:	151 kg
8	Cloud:	Haze	19	Ops Weight end of Trial:	1909 kg
9	Weather Remarks:	Generally fine, wind light, no rain	20	Time Trial Commenced:	13.45
10	MAUW:	2400 kg	21	Time Trial Finished:	15.40
11	RTOW:	2200 kg	22	Flight Time During Trial:	1 hour

TABLE 3: Helicopter Details for September 1990 AS-355 Noise Trial

Helicopter	Date	Lateral Offset of Ground Track From Measurement Position		Height	Air Speed Knots	L_{Amax} dB	L_{AE} dB
AS-355 F1	6/90	60 m	NW	1500 ft	114	70.3	80.8
	6/90	60 m	NW	1200 ft	114	71.5	82.2
	6/90	60 m	NW	1000 ft	114	72.2	82.8
	6/90	60 m	NW	800 ft	114	73.3	82.9
	9/90	60 m	NW	1500 ft	120	69.5	80.3
	9/90	60 m	NW	2000 ft	120	66.5	79.2
	9/90	410 m	NW	1500 ft	120	67.4	79.6
	9/90	190 m	SE	1500 ft	120	69.0	79.4
	9/90	60 m	NW	500 ft	120	77.7	85.8
S-76A	6/90	60 m	NW	1500 ft	140	72.5	82.6
	6/90	60 m	NW	1200 ft	130	75.1	84.2
	6/90	60 m	NW	1000 ft	130	74.6	83.9
	6/90	60 m	NW	800 ft	140	78.3	86.6
A-109A	6/90	60 m	NW	1500 ft	130	72.8	83.3
	6/90	60 m	NW	1200 ft	130	73.7	84.9
	6/90	60 m	NW	1000 ft	130	75.7	85.4
	6/90	60 m	NW	800 ft	125	76.4	87.0

TABLE 4: Summary of Overflight Noise Levels, dB 'Slow', Bruntingthorpe Noise Tests