The Noise Advisory Council

Hovercraft Noise

Report by a Working Group of the Council

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THE WORKING GROUP ON NOISE FROM SURFACE TRANSPORT

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HOVERCRAFT NOISE

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SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

The Working Group examined several aspects of noise from the operations of commercial amphibious hovercraft. Its considered view is that although services are not yet widespread, the noise emitted is a local problem and should be dealt with (paragraph 74).

The conclusion reached by the Working Group is that the most effective answer is to reduce hovercraft noise at source. It recommends that the Government should support research into the production of quieter propellers (paragraph 81) and into the possibility of shrouding existing propellers (paragraph 83). To secure the implementation of results from research, the Working Group recommends the adoption of a noise certification scheme (paragraph 75) and suggests some factors which would need to be taken into account (paragraph 76). Parallel with this action on individual hovercraft, the Working Group recommends that research should be undertaken into public response to exposure to hovercraft noise and into the determination of appropriate noise limits for hovercraft operations expressed over a period of a working day (paragraph 79). To assist in day to day noise control, the Working Group recommends further study of piloting techniques, ground equipment and screening measures (paragraph 84).

The Working Group recommends that information on planning measures, including minimum requirements based on the findings of public-response research and general principles for separating noise from noise sensitive areas, should be collected and published (paragraph 85).

Finally, the Working Group recommends that local authorities whose districts are affected by the routes followed by hovercraft should be included in consultations about hovercraft services (paragraph 87).

HOVERCRAFT NOISE

Introduction

1. In reviewing the progress made generally in controlling the generation of noise, the Noise Advisory Council identified hovercraft as a source of serious though localised noise pollution. At the beginning of 1976, the Council requested its Working Group on Noise from Surface Transport to examine the possibilities of reducing noise emissions from hovercraft and whether any other measures could be taken to alleviate the effects of hovercraft noise.

2. Most people have heard of hovercraft and increasing numbers are using the ferries serviced by these machines. However, few people are aware of how hovercraft came to be developed or how widely they have become used throughout the world and this report seeks to set the noise problem of hovercraft in its proper context. As a starting point, the Group turned to the Hovercraft Act 1968, for the following description: "a vehicle designed to be supported when in motion wholly or partly by air expelled from the vehicle to form a cushion of which the boundaries include the ground, water and surface beneath the vehicle." The industry usually refer to them as "air cushion vehicles" or "ACVs" but in this report, for the sake of simplicity, the word "hovercraft" is used.

3. There are 2 sorts of hovercraft in use today, apart from such specialised machines as hoverbarges and hoverplatforms. The 2 sorts are amphibious, propelled by airscrews, and sidewall or non-amphibious, using waterscrews. The Group was assured that the latter are little noisier than conventional vessels and therefore do not pose a problem, although they have not the former's versatility. Amphibious hovercraft have broadly 4 uses, passenger, military (these 2 are often variants of the same model), small commercial craft (rescue, survey, etc) and sports. Of these, the amphibious passenger carrying hovercraft is, with its regular services and for reasons which appear later in this report, the one which seems to be the cause of most complaints and the Group therefore concentrated on these machines. Some of the recommendations will have application to other types and uses of craft, and the Working Group issues this report while there is time for something to be done, with the hope that the action suggested will help to make hovercraft even more acceptable and lead to a wider use of this British invention.

4. The Working Group's first impression was that hovercraft seemed to cause very little complaint. Further consideration showed that this was because very few people reside permanently, or even temporarily while on holiday, within the sound of hovercraft operations. If this form of transport became more widely used (and the Working Group applauds efforts to develop its utilisation where appropriate) there seems little doubt that more annoyance would be caused, unless steps are taken to make the craft quieter.

5. The Group also realises that the market and deployment of hovercraft is worldwide, but this study concentrates on the UK industry. By its constitution, the Council can only recommend remedial measures in the UK, but it understands that the UK legislation affecting hovercraft safety and licensing arrangements has served as a model for other countries and it would be gratifying if action to control the effects of hovercraft noise afforded similar guidance.

6. Representatives of the manufacturers, and operators of hovercraft, and of the local authorities of the areas affected by hovercraft operations met the members of the Group and provided considerable assistance. The Group records its appreciation of this and in particular, of the work of Mr John Leach, a Principal Professional and Technology Officer with the Department of Industry until his retirement, who produced a most useful summary of the background and of the factors relevant to a consideration of the effect of hovercraft noise on the communities in which the craft operate. This summary is now lodged in the Technical Library (Hovercraft Section) of the Department of Industry.

7. It soon became clear to the Working Group that the current problem of hovercraft noise bears no comparison in terms of size or complexity, with those of aircraft noise or road traffic noise. The population affected by hovercraft noise is several thousands, against the millions affected by road traffic noise, and the hundreds of thousands affected by aircraft noise. Employment in the hovercraft industry in the UK amounts to a few thousands. The number of craft in daily use is very small. But the Working Group considers that the financial implications of remedial action would also be small in proportion and that considerable benefit could be achieved by an outlay of funds which would be hardly noticed in other situations.

The Development of the Hovercraft

8. Since the eighteenth century, from time to time men have become preoccupied with the idea that vessels would travel much faster if the friction of the surface of the water on the hull could be overcome. In other words, if the craft could be made to "skim the surface". It was the work of Sir Christopher Cockerell which led to this aim becoming a practical achievement.

9. Since 1955, when the principles of hovercraft motion were first patented, progress has been rapid. Important stages have been the first cross-Channel flight in 1959, extensive trials in several estuaries around the British coast from 1962, the commencement of regular commercial services, to the Isle of Wight in 1964 and across the Channel in 1968. Trials have been carried out on almost every type of terrain, in many parts of the world. In 20 years, the hovercraft has grown from a laboratory experiment to an accepted though specialised form of transport.

10. The Group notes from a paper presented by Mr Neil MacDonald to the UK Hovercraft Society and published in Hovering Craft & Hydrofoils, that the numbers of hovercraft currently in commercial service is as shown in Table 1. The figures include side-wall non-amphibious hovercraft and a very small number of craft on charter for marine surveys.

Table 1

Country	No of Craft
Britain	15
France	3
Portugal	4
Greece	1
Brazil	4
Venezuela	3
Bolivia	2
Uruguay	1
United States of America	1
India	1
The Philippines	3
Hong Kong	8
Japan	14
New Zealand	1
Nigeria	3
Soviet Union	200+
World Total	264+

11. There are many advantages in using amphibious craft instead of conventional ferries in estuaries or on reasonably short sea crossings. Landing facilities can be simpler and cheaper, tides can be ignored. Speeds are much higher. In other parts of the world there is potential for use on land that is subject to flooding, and across stretches of water that seasonally dry up or become frozen. Hovercraft are also proving their capabilities as ice-breakers!

12. In the UK, there are five routes operating commercially, with amphibious hovercraft: Southsea to Ryde; Southampton to Cowes; Dover to Calais and Boulogne and Pegwell Bay (Ramsgate) to Calais. The British Hovercraft Corporation (BHC) is the main manufacturer, although shipbuilders Vosper-Thorneycroft have produced 2 prototypes (both for military uses). There are several firms producing smaller commercial and sports craft. A French hovercraft, the Sedan N500, operates into Dover.

13. Military requirements have played a formative part in the development of hovercraft. Realising the importance of reduced noise emissions from hovercraft in defence roles, the Working Group hopes that research in both commercial and military fields will be of mutual benefit to each other.

The legal position on the control of hovercraft noise

14. The Working Group looked at the several alternative means of action against the emission and transmission of noise from hovercraft in commercial operations.

15. The Hovercraft Act contains powers to make regulations to control the noise and vibration caused by hovercraft and to exempt hovercraft from the

Control of Pollution Act 1974, although the Working Group understands that regulations are not likely to be made until the problem of hovercraft noise is more widespread and until technology for reducing the noise emissions is available.

16. Harbour authorities' control over ships and seaplanes was extended to include hovercraft, by the Hovercraft Application of Enactments Order 1972. The same order enables local authorities (including harbour authorities) to make bye-laws controlling the use of hovercraft. Bye-laws which imposed speed restrictions on hovercraft, or laid down their routes, could have the effect of reducing any noise nuisance caused by the craft, to those living along the route.

17. Action against noise nuisances (either occurring or likely to occur) can be taken by local authorities or individual occupiers of affected premises, under the powers of Part III of the Control of Pollution Act 1974. Hovercraft are specifically brought within the ambit of the Act by sections 105(1) and 73(2). The Act enables a local authority to serve a notice on the person responsible for noise amounting to a nuisance, requiring the abatement, or the prevention of the noise. The notice may also specify the action to be taken to achieve this. There is a right of appeal to a magistrate's court. An occupier of any premises affected by noise may apply to a magistrate's court for an order in similar terms.

18. If the noise is a nuisance, but is caused in the course of a trade or business, the person responsible may claim that the best practicable means have been used for preventing the noise or counteracting its effect. This defence is defined in the Act to mean that everything technically possible at reasonable cost has been done.

19. In the UK there are no absolute values against which a noise can be judged whether it is a nuisance or not. The term "nuisance" itself is flexible and depends on local circumstances. Examples of the sort of criteria which might be used in an action concerning an alleged noise nuisance are the increase in overall noise levels caused by the intrusive noise, the extent of interference in people's conversation or concentration, or the "acceptable" noise exposure levels proposed in the Report of the Committee on the Problem of Noise (the Wilson Report 1963).

20. A civil action for noise nuisance can be taken at common law. The remedy sought is an injunction to restrain the defendant from continuing the nuisance; damages can be claimed. Action of this sort can be very expensive. The defence of best practicable means is not available to the defendant, but, if the action is to succeed it must be proved that the nuisance substantially affects the health, comfort or convenience of the plaintiff.

21. The Group also looked at the use of planning controls to control noise. A hovercraft operator requires planning permission to develop land as a hoverport, unless using "operational" land and the effects of the noise generated by hovercraft while on the land can be abated by conditions specifying the hours of operation, the construction of noise barriers or the type of surrounding terminal buildings and also the permitted noise levels. The Department of the Environment's general advice to local authorities on planning policy as related to the impact of noise from, or on, new development, is given in Circular 10/73

(19 January 1973), although the noise from hovercraft is not specifically covered in the text (see paragraph 86 below).

22. In general, the conclusion of the Group is that successful legal action against noise from hovercraft in commercial operations would be difficult, and that more effective means of control are available in the regulatory power of the Act of 1968, or under planning regulations.

23. It is necessary for completeness to add a word about sports hovercraft. Local authorities report that the noise from rallies and races causes some complaint. The Working Group considers that action under the Control of Pollution Act 1974 should be effective if required. The group was informed that the Hover Club of Great Britain is in contact with the Department of the Environment about a code of practice for minimising noise from these events and the Group hopes that this will be pursued.

Progress in the reduction of noise from hovercraft

24. In the early development of hovercraft most of the designers, manufacturers and operators were drawn from the aircraft industry. They were well aware of the aircraft noise problems which were rapidly increasing in the early sixties, and therefore of their own social responsibilities in relation to the environmental problem associated with commercial hovercraft operation and the problem of internal noise in relation to passenger comfort and crew habitability.

25. However, whereas the earliest experimental commercial services do not seem to have evoked any public reaction (probably because of the novelty and the infrequency of the service), the first relatively intensive service between Ryde and Southsea in the summer of 1964 caused some protests. In retrospect, it is evident that the inherent noise problem was exacerbated by the location of the Ryde terminal and by the piloting techniques in vogue at the time.

26. Investigation into the environmental noise problem began in 1962. The Hovercraft Directorate (now disbanded) of what has become the Department of Industry sponsored programmes within the industry and with the Institute of Sound and Vibration Research of Southampton University. In addition, considerable research work was also carried out by RAE Farnborough, Loughborough University of Technology and the Inter-Service Hovercraft Trials Unit at Lee-on-Solent.

27. By the mid-1960's the research programme into the SR N5 and SR N6 built by BHC had led to the following conclusions:

a. The major source of external noise is the propeller. Engine noise is not negligible but rates a very poor second relative to the propeller. Other noise sources are of no consequence outside the hovercraft.

b. Propeller noise is much worse than could be predicted from the accepted theories current in the 1950's, probably due to the turbulence of the air in which the propellers rotate. The subjective effect is particularly unfortunate, both because of the greater sensitivity of the ear to higher frequencies and because of the harshness imparted to the sound.

c. The most effective practical means of reducing propeller noise is to reduce the tip speed.

28. In the early 1960's hovercraft were still at the experimental stage and the costs of developing propellers specifically for them could not be justified. Consequently, SR N2, SR N3, SR N5 and SR N6 were all designed to use modified aircraft propellers operating at a relatively high tip speed (approximately 0.85M at maximum turbine revs per minute in all cases). As originally projected the SR N4 was to have had 14′ 6″ diameter propellers operating at a similar tip speed. However when the magnitude of the environmental noise problem became apparent special 19′ diameter propellers with the maximum tip speed reduced to 0.59M were designed and developed for this craft. The success of this design can be appreciated from the fact that the SR N4, with about 15 times the installed power of the SR N5/N6 machines, generates noise levels which are typically 3 to 5 dBA lower at distances of less than 1000′. However, it should be noted that the weight of the propellers was doubled and the overall penalty (including higher and stronger pylons) was of the order of 5%, that is approximately 1½ tons per propulsion unit of the bare weight of a Mk 1 craft. The resultant increase in capital cost cannot have been less than 5% and was probably a good deal more.

29. To help alleviate the noise problem of the existing SR N5/N6 hovercraft, in 1966, BHC produced advice to pilots on handling techniques in their Service Bulletin No 52. This bulletin points out that "noise levels can be reduced by keeping turbine speeds as low as possible and avoiding large and rapid changes of propeller pitch".

30. The latest BHC contribution is the design of the twin propeller SR N6 Mk VI which began in 1972. One of the major design objectives with this craft was to achieve a large reduction in environmental noise and to this end the maximum tip speed of the twin 10′ 0″ diameter propellers was limited to 0.47M By its very nature of configuration, employing twin propellers mounted side by side tends to give a much better inflow condition than the standard SR N6 configuration and, in addition, particular care was taken to give the maximum practicable tip clearances and to minimise upstream obstructions. An overall reduction in sound level from that of the standard SR N6 of 15 dB(A) was achieved (see figure 1). The weight penalty involved is of the order of 15% (based on the bare weight) and the increase in cost probably 20% to 30%, since most of the extra weight is in expensive mechanical parts (propellers, gearboxes, etc). Moreover, although the performance is satisfactory, the manufacturers have suggested that the move to lower tip speeds has gone too far. To date no orders have been placed for the SR N6 Mk VI, probably because of the cost penalty. There is, however, growing military interest overseas in this type which, if it leads to firm orders, would reduce the outlay to UK operators.

31. In 1974, Hovertravel Ltd, who operate the Southsea/Ryde route, modified a military SR N6 Mk 2 by cutting down the propeller from 9′ 0″ to 6′ 10″ in diameter and enclosing it within a shroud. Compared with the standard SR N6, a reduction of 7—9 dBA was achieved. This modification was jointly sponsored by the firm and the Department of Industry. The results of a comparison between a standard SR N6 and the SR N6 with the modified shrouded propeller were given in a joint report produced by Portsmouth and Gosport Environmental Health Departments (April 1976) and are reproduced as figure 2.

32. The most recent prototype produced by Vosper Thorneycroft is the VT-2. Although designed with military uses in mind, the VT-2 is similar to the SR N4, although only about half the weight. The builders decided to incorporate ducted propulsor units. Dowty Rotol developed the 2 variable pitch propulsion fans which at 13′ 6″ diameter are the largest ducted air propulsors in the world. This ducted fan propulsion system is a significant advance in hovercraft technology in terms of compactness and noise reduction. The advantages, however, incur an increase in weight and structural complexity, manufacturing tolerances in the duct system being critical. The noise emitted is about 8 dB(A) less than that of the SR N4 under similar conditions, and is said to be not so strident or harsh as that from open propellers.

Noise from hovercraft in current commercial operations

33. Mr Leach gave to the Group considerable information about the operations and noise levels of hovercraft of various types (these latter are set out in Table 2) and also about the considerations which had been borne in mind in the development of the major hoverports at Pegwell Bay and Dover.

Table 2

External noise from hovercraft at 15m.

Means of Propulsion	Type	Overall Noise Level dBA
Air propeller	SR N5/N6	114
,, ,,	SR N2	113
,, ,,	HD 2	111
,, ,,	SR N4	109
Low Velocity air jet	CC 7	96
Water screw	VT-1	89
,, ,,	HM 2	83

34. The SR N6 Mk 1S hovercraft services the ferries to the Isle of Wight; it weighs about 13 tons and carries 56 passengers. Figure 3 shows measurements of peak sound levels in dB(A) against distance for standard SR N6's. The BHC and City of Portsmouth College of Education data relating to the Southsea/ Ryde service were obtained while the hovercraft were at a terminal and so the distances were more easily plotted than if the craft had been travelling along their route. The other measurements were of pass by noise.

35. The results show evidence of "excess" attenuation over and above simple spreading in accordance with the inverse square law. Attenuation of sound over distance, due to the inverse square law, is usually taken to be 6 dB per doubling of distance. Figure 3 indicates greater attenuation, and the predominance of frequencies below 1 KHz in the hovercraft noise spectrum suggests that this is due probably to ground effects rather than atmospheric absorption. On the other hand the experience of Portsmouth and Gosport environmental health officers indicates less than the normal attenuation of hovercraft noise over water. Noise

received from hovercraft operations has usually traversed both water and land; this confuses the attenuation prediction and could account for the noise levels measured along Southampton Water being higher than expected from measurements around the hoverports.

36. Figure 4 shows similar data for the SR N4 Mk 1 hovercraft, which weighs about 180 tons and carries 37 cars and 280 passengers and is used on the cross-Channel routes. In 1978, BR put into service the new Mk 3 ("stretched" from a Mk 2 by the insertion of a 50′ midships section) which weighs 250 tons and carries 60 cars and 416 passengers. BR's other Mk 2 is currently being converted to a Mk 3. As with the SR N6 results, most of the readings were obtained while the hovercraft were at the terminal. The lack of long range measurements make it difficult to estimate the excess attenuation, but the indications are that this is less than for the SR N6 if only because of the greater height of the pylon-mounted propellers and because the lower tip speed generates lower frequencies.

37. The scatter of the results summarised in figures 3 and 4 is of the order to be expected in the measurement of noise in the open air and results from meteorological conditions, terrain, screening, ranging errors and variations in handling techniques. It seems that the peak sound levels generated in normal commercial service are unlikely to exceed 90 dB(A) at 150 metres and may well be no more than 75 to 80 dB(A). Consequently, only very brief interference with speech is to be expected inside buildings in close proximity to a hoverport and the risk of serious hearing damage is most unlikely.

38. The most obvious difference between noise from hovercraft and noise from road vehicles or aircraft is the duration of the peaks. For purposes of comparison, figure 5 shows typical noise profiles of the pass-by of a commercial truck, overflight of a large jet aircraft and fly-past of a hovercraft. (From data assembled by ISVR).

39. One of the most persistent sources of complaints is the noise received by people living alongside the flight path of the hovercraft. In the areas involved this means that the noise of the hovercraft can at times be clearly distinguishable for as much as 12 minutes in 15. Even though the measured levels may not be very high compared with noise from other sources, this situation has led to persistent complaints.

40. Arrivals and departures of hovercraft usually result in the highest peak levels, but they are of short duration. An indication of the frequency of these peak levels is given in table 3. Noise emissions during manoeuvring over dry land can be 3 to 5 dB(A) higher than those in pass-by trials under cruising conditions. (Because of the logarithmic scale for noise, an increase of 10 dB(A) subjectively represents a doubling of the loudness).

Table 3

	Winter	Summer	Remarks
Dover	1A 1200—1800* 1D 0930—1530	2A 0900—2200 2D 0730—2030	
Pegwell Bay	1A 0945—1640 1D 0800—1500	2A 0740—2140 2D 0600—2000	Have applied for extension of services
Southsea	1A 0830—1735 1D 0840—1740	2A 0830—2005 2D 0840—2015	Some Bank Holidays more frequent service (Southsea and Ryde)
Ryde	1A 0850—1750 1D 0820—1725	2A 0850—2020 2D 0820—1955	
Southampton	2A 0740—1850 2D 0800—1900	3A 0740—1950 3D 0800—2000	
Cowes	2A 0820—1920 2D 0720—1830	3A 0820—2020 3D 0720—1930	

*4 per day

This table gives a general indication of the numbers of arrivals (A) and departures (D) per hour at these hoverports. The details are from the published timetables.

41. A phenomenon has been reported from both Dover and Ramsgate (and supported by experience at Southsea) which tends to confirm the effect of reflection of sound upwards over water is that the more elevated the location of the houses, the greater the noise impact. Recordings made at the top of a multi-storey car park measured 3 dB(A) higher than at ground level. Ground absorption and screening probably also contribute to this effect.

42. The Working Group was repeatedly told that, from a noise control aspect, hoverports should be sited away from residential areas; for example, dock, or industrial complexes are appropriate locations and may have the advantages of high ambient noise levels, surrounding buildings which shield the noises easy traffic access and fewer residents nearby. Residential areas are especially susceptible to noise late in the evening. For example, the services to Pegwell Bay which are timed to avoid night operations are sometimes unavoidably delayed by the weather. This can mean that the last hovercraft of the day arrives as late as 2300 hours, when the ambient noise level has decreased considerably and this intrusion of noise causes complaints.

43. A paper presented at a conference at ISVR, Southampton University, in 1965, showed that a spacious layout which permits craft to arrive and depart with the minimum of manoeuvring can result in a significant reduction of noise at the hoverport.

44. With the SR N4 propulsion configuration of 4 propellers mounted on pylons at the corners of the craft, manoeuvring in a confined space involves pylon angles causing interference with the airflow between front and rear propellers, and with the rapid change of blade pitch, the resultant noise is said to be most unpleasant. The larger diameter propellers (21′) of the SR N4 Mk 3 mean that at equivalent RPM the tip speed will be increased and consequently the noise output will go up. However, the improved thrust at low speeds will mean that less engine power and slower propeller RPM will be required during ground manoeuvres which should result in an overall improvement (see also paragraphs 47, 51 and 68).

45. The Working Group noted that because of self imposed discipline by all hovercraft operators, due to the need to conserve the use of expensive fuel, no random or casual running of engines now occurs. Craft are brought into the landing area at Dover and Pewell Bay and the engines are shut down immediately.

46. A maintenance base is included in the hoverport complex at both Pegwell Bay and Dover. Both incorporate a jacking system for lifting the SR N4 hovercraft for skirt and hull maintenance. A closed circuit cable runs around pulleys or bollards fixed outboard of the 4 corners of the craft. A winch is installed along the centre line of the jacking position and well forward of the craft. The cable is then attached to the front of the craft which on winding in causes the craft to automatically self centre in line with the jacking positions. The winch is either hydraulically or electrically operated.

47. At Dover, with the lengthened SR N4 Mk 3, British Rail Hovercraft have planned to use 2 strategically positioned winches pulling forward at an angle equally offset each side of the centre line. With this type of device craft can be manoeuvred on partial lift at reduced power and minimum noise from the propellers into position for jacking.

48. At Pegwell Bay hovercraft can be jacked up within 2½ minutes. During the day little attention is drawn to the hovercraft movements because of the ambient noise level, which is however probably somewhat less during the day and much less at night, than in Dover Harbour. It is the occasional need to jack up the craft at night which causes the complaints. This rarely happens, and then only once in any one night. In order to get the maximum utilisation of craft most maintenance is carried out during the night. With both operators now increasing their fleets night maintenance will be limited to essentials.

49. The fact that people tend to travel by traditional routes and that Dover-Calais has been the recognised route to France, helped in the choice of Dover for a hoverport. Also, it was realised that the existence of the BR facilities meant that passengers and cars could be transferred to ships with minimum inconvenience if technical failure or weather conditions caused cancellations. Development and experience have shown that such contingencies are not so necessary as was originally thought.

50. The fact that the hovercraft service was part of the overall British Rail complex to which it could look for support, outweighed the constraint of being in a harbour having a high density of shipping and the absence of a direct unhampered route to the landing area. The design of the new Western Dock Hoverport has benefited by the experience gained at the earlier site in the Eastern Docks. The working area is much more spacious and a substantial wall has been built at the eastern side of the complex.

51. Also, experience at the Calais hoverport where the operating area above the top of the ramp has a gradient of 1 in 74 for water drainage, showed that this slope helped to "unstick" the hovercraft on take off. The lift and turn could be completed with reduced engine power and propeller thrust, resulting in lower noise emission. This feature has been incorporated in the new hoverport at Dover.

52. At Pegwell Bay, there were no existing facilities, but there was scope to develop a "custom built" hoverport from the start. The hoverport is built on the foreshore. The approach ramps are short but sufficient to permit operations at all stages of the tide, whilst the operational area is very spacious. Due to the wide coverage given by the ramps which are angled to the terminal buildings, and the unobstructed approach from the sea, it is possible for the hovercraft commander to set a direct course for the landing area from well out to sea, without having to deviate or manoeuvre until setting the craft down. The cliffs facing the bay also provide some noise attenuation.

53. Ideally hoverports should be sited in an area where the prevailing wind is offshore. Hovercraft noise is directional in its emissions and the use of polar diagrams of noise levels generated by new types of hovercraft would be of use to the planning authorities in considering proposed development of hoverports. As far back as 1965, such trials were carried out with tethered craft and multiple (14 Channels) microphone stations. This kind of trial contributes to basic research and evaluation since the craft operating conditions, distance and azimuth can all be precisely defined, while the identification of noise sources on the basis of frequency is not complicated by Doppler shifts due to the craft motion.

Discussions with manufacturers, operators and local authorities

54. All those approached by the Working Group provided written comments and several representatives were invited to a discussion with the Group. The original aim was to consider what noise emission levels could be set for the next generation of hovercraft and recommend mandatory limits accordingly. There seemed no doubt that future models would be quieter, but as the Working Group learnt how small the manufacturing industry is and in particular that there is a practice of continuous replacement of components of craft in operation, it became clear that noise reduction is not simply a question of fleet-replacement.

55. The Group then considered 3 ways of controlling hovercraft noise: reduction at source, operating techniques and planning measures. For the first 2, the approach to the smaller SR N6's differed slightly to that for the larger, cross-Channel SR N4's

Noise Reduction at Source by Engineering Development

56. There was general agreement that the technology is available to reduce noise

from SR N6's in 2 ways. Firstly, enclosing the propeller of the standard version in a shroud would reduce noise by about 8 dB(A) and secondly the prototype Mk VI version with 2 propellers is about 15 dB(A) less noisy than the standard SR N6.

57. However, the cost of utilising these developments is the problem. The operators stressed that they could not afford the less noisy but more expensive versions without Government aid. Shrouding the standard version's propellers cost £50,000 per craft and the extra propeller of the Mk VI version would add as much as 25% to the purchase price of the standard SR N6. Extra weight and higher fuel consumption were other penalties of noise reduction. At present operators charged a premium for speed but they feared losing trade to the slower ferries and, on some journeys, to hydrofoils which charged the same, if they increased their fares, which would be inevitable if less noisy versions had to be used. It was stated that amortising over one year the costs of modifying the 6 SR N6 craft in service on the Solent would necessitate an increase in the fares of 6p in the £1. Hovertravel had received a Government grant of £20,000 some years ago towards quietening the SR N6 and had spent the same from their own resources, but the programme had not been completely worked through.

58. So far as the SR N4 is concerned, it already incorporates noise improvements gained from experience with the SR N6 models. One drawback is that the noise sources (the propeller units) are about 40′ above sea level, much higher than that of the SR N6 and therefore noise emitted in the hoverport is much more difficult to mask. Further quietening was said to be uneconomic unless Government research funds were available.

59. It was pointed out by the operators that the far larger aircraft industry, after some initial resistance to change for the sake of noise reduction, had agreed to a programme of noise reduction for new aircraft. The hovercraft industry is very much smaller—so the Government has less incentive to put money into it—and most of its products are for export or military purposes. The noise problem is confined to home products.

60. The possibility of a form of noise certification was considered by the Group. This could be on the lines of the 1970 scheme for aircraft, which requires new types of subsonic jet aircraft to be about half as noisy as earlier types of equivalent weight. In practical terms this means a reduction of 10 dB. A suggested fly-pass measurement method was put to the Group by Mr Leach, and to cover the wide range of hovercraft for noise legislation he suggested a 3 tier classification as follows:

Group 1: Hovercraft operating over land and/or inland waters. This would include most sports hovercraft and other lightweight machines.

Group 2: Hovercraft operating in partially smooth coastal waters. Typically, such hovercraft would be expected to be of the same sort of size as SR N6.

Group 3: Hovercraft operating in the open sea and foreign-going hovercraft generally. The SR N4 is a typical example of such craft.

61. Agreement between the manufacturers, the operators and the central licensing authority on the details of a test method should not be difficult to

reach. These details should include: the distance of the track from the microphone; wind speed limit; craft operating conditions and speed. Experience of noise measurements of the SR N6 at Gosport had shown that the peak level received at the microphone position occurred when the hovercraft was about 25° beyond the plane of the microphone, and this phenomenon would need to be taken into account.

62. A suggestion from the National Physical Laboratory was that for convenience and compatibility between the noise certification method and the measurement of noise exposure, the single event noise exposure level, L_{AX} ought to be specified for certification purposes. This is a time integral of the A-weighted sound pressure level and so makes due allowance for the duration of the individual noise event.

63. For planning purposes, it would be an advantage if guidelines for acceptable overall noise levels could be established. The first step would be to select a scale to express noise from hovercraft operations. In view of the Noise Advisory Council's recommendation in "Noise Units", the Equivalent Continuous Sound Level Leq was suggested. There seems no reason why Leq should not be used and a report by Mr K Ratcliffe of the Institute of Sound and Vibration Research (Project No 103/B5) concluded that Leq, or its derivative noise pollution level L_{NP}, are likely to provide the best basis for rating noise from hovercraft in use, because these measures make allowance for background noise and the time distribution of the noise events. The Working Group was glad to learn that, arising out of its enquiries, an investigation of procedures for determining the noise exposure due to hovercraft around a hoverport was being undertaken by the National Physical Laboratory.

64. The next step would be to discover public response to various levels of exposure to hovercraft noise both around hoverports and on the routes of hovercraft. The only published material in this field which the Working Group could discover was a joint report by the Environmental Health Departments of Portsmouth and Gosport (1976) and ISVR Memorandum No 580 "Hovercraft Noise Annoyance in the Solent" (February 1978). The former sets out peak sound levels in dB(A) measured at Haslar Wall, a point about 1,400 yards from the flight path of the Southsea/Ryde hovercraft ferry, over a period from May to November 1974. There have been persistent complaints about hovercraft noise from people living in the Gosport area, that is, inland of Haslar Wall. These levels range from 59 to 81 dB(A) (Ryde to Southsea) and from 62 to 79 dB(A) (Southsea to Ryde). The latter report describes, for an area of land on the east bank of Southampton Water, 70 dB(A) and 65 dB(A) peak noise contours. A population of about 25,000 people live within these contours. The survey showed that 90% of the population heard the hovercraft noise and 23% were bothered by it. The Working Group was informed by NPL that hourly Leq values of about 65 dB(A) had been obtained in areas where there is a high level of dissatisfaction with hovercraft noise.

65. The wide scatter of noise levels obtained from hovercraft on fly-pass indicated to the Working Group that reduction at source is a more effective way of abating the effects of hovercraft noise than, for example, sound insulation of dwellings.

Operating and Maintenance Handling Techniques

66. These have some influence on noise generated, and there is therefore some scope for reducing noise through different operating techniques. Once a craft is cruising, noise emission remains virtually constant. The pilots' skill is important in reducing noise on arrival or departure or when manoeuvring. and most complaints about noise are said (by local authorities) to be caused by crew-training exercises.

67. BHC's 1966 handling manual was drawn up for SR N6 hovercraft, but the principles covered the SR N4 also. Pilots use the manual when it is safe and practical to do so; for example where the approach is in a straight line to the terminal, craft can be decelerated gradually using a progressively lower turbine rpm/higher pitch angle technique once the speed of the craft has fallen to a safe level. A similar technique can be used on departure, and this reduces noise emissions and gives maximum rudder control for the amount of power selected. Fundamentally, the aim is to keep turbine speeds low and avoid large and rapid changes of propeller pitch.

68. SR N4 hovercraft have 4 variable pitch propellers on swivelling pylons, powered by separate engines, and so pilots have far more control than with the SR N6. Reductions in the noise from SR N4's on approach and departure, which can be achieved by using the technique of lower engine power and lower turbine settings, increase drag which in turn increases skirt wear and skirt maintenance time. As a result, crossings take longer and operating costs increase.

69. Most of those who commented to the Group agreed that manoeuvring the craft for maintenance work is the source of many complaints, particularly when carried out between 2100 and 0700 hours. The operators said that night-time maintenance is very infrequent. The Group was surprised to learn that the propellers cannot be disengaged from the lifting fans. Manoeuvring into and out of maintenance areas is by means of propellers, and there would be some reduction in noise if they could be disconnected while the craft was being lifted and positioned, although the Group was given to understand that the integrated power system used in the UK hovercraft is cheaper to install and run. The system of locating the SR N4's on a jacking system by winches seemed to the Group to be very practical.

Planning Measures

70. The choice of a site for a hoverport is usually limited by physical and operational constraints. Accessibility for travellers and visitors is vital. A site within or adjacent to conventional dock facilities is appropriate, with the advantage that the ambient noise levels are higher, and dock installations and buildings serve as a barrier to the noise from hovercraft at the terminal.

71. At some hoverports, residential areas within 500 yards produce few complaints. Sometimes an inversion effect through meteorological conditions results in dwellings some distance from the source receiving greater noise exposure than those nearer the hoverport. Although one scheme for sound insulation of dwellings is being implemented, other local authorities felt that this would be a very poor second to reduction at source.

72. Paragraph 51 recounts the advantage of a sloped operating area to help craft take off, resulting in the use of less power and less noise. There should be

adequate room to manoeuvre, especially in the maintenance area and the hoverpad should be sited so that craft could approach and depart in a straight line. Opinions about shielding the maintenance area were divided; there is some evidence that noise from a concealed source is less noticeable, but it is doubtful if a noise barrier for the SR N4 would be acceptable. The height of the propellers and the manoeuvring space required would mean that the masking buildings or screens would need to be so extensive as to be visually unacceptable.

73. It was suggested to the Group that new hoverports should be granted temporary planning permission initially, in order that the full effects of the noise from operations could be studied. The planning conditions should include the type of hovercraft, hours of operation and the number or frequency of movements each day. The local authority representatives thought there should be a night-time ban on all operations in areas where residential property is affected and that the flight-paths should be agreed between the operators and the local authorities concerned.

Findings and views of the Working Group

74. There is widespread agreement that noise from hovercraft annoys some people very much. Complaints are comparatively few, but the number of people annoyed is thought to be much greater. It is difficult to quantify the problem. Numbers of people seriously affected in Cowes, Ryde and Portsmouth are said to be small. At Southampton and Dover, the hoverports are sited in industrial or harbour areas, thus mitigating the effects of noise from hovercraft operations. In a survey of an area adjoining Southampton Water, 23% of the people questioned were bothered by hovercraft noise, but a "high proportion did not know where to complain about hovercraft noise or noise in general". (ISVR Memorandum No 580). It is claimed that in Gosport, pass-by noise affects about 20,000 people and has provoked numerous complaints. There have been persistent complaints from residents around the terminal at Pegwell Bay. There appears to be no evidence that familiarity with hovercraft noise leads to its acceptance; it is widely held that the public are becoming less tolerant than they used to be about noise in general. The conclusion of the Working Group is that the level of complaints is not a true indication of the extent of the problem of hovercraft noise. In any event, the Noise Advisory Council in general regards any noise problem, however few may be the complainants, as worthy of examination and if possible, abated.

75. The Working Group considers that reduction of noise at source is by far the most effective way of controlling the effects of hovercraft noise. A noise certification scheme applied by regulations under section 1 of the Hovercraft Act 1968 seems appropriate. It will encourage operators to replace existing craft with quieter versions and give manufacturers a target for design.

76. A noise certification scheme would require a standard noise test and the Working Group recommends that the drafting of a test measurement method to cover the suggestion in paragraphs 60 to 62 should be put in hand without delay. It seems to the Group appropriate that the Department of Trade should consider taking the lead in this, with the manufacturers and operators and other Government departments. Preferably the scheme should include side-wall and non-commercial hovercraft also. The best performance for existing in-service

hovercraft should constitute the first stage values. As the SR N4 designs had benefited from experience gained with the SR N6, the second stage should require the SR N6 to achieve a level equivalent to that of the SR N4. There should be a third stage effectively 5 dB(A) lower than the second. The effective dates for the second and third stages would have to take into account technical progress, operational viability and environmental benefit. Because of the extending use of hovercraft in many other countries, some form of international agreement might become necessary, but the Working Group considers that the UK should not let this possible requirement delay a start being made.

77. Clearly the sort of test method referred to above relates only to hovercraft in a fly-pass situation. Arrival and departure, or manoeuvring for maintenance all result in higher noise emissions (paragraph 40) although there does seem to be a direct relation between noise levels in the fly-pass and on-land situations. Consideration should also be given to the possibilities of specifying a "stationary" or "hovering" noise measurement method (see paragraph 53).

78. An adjunct to the concept of noise emission standards is the imposition of noise charges, or a levy on each hovercraft "movement" made by a craft not meeting the required value. This would encourage the bringing into use of quieter craft. The Working Group retains an open mind on the effectiveness of this measure on a relatively small industry.

79. For the control of overall hovercraft operation noise levels, the Working Group recommends the adoption of the Leq scale, expressed over a 14-hour period, as the Group was strongly of the opinion against night-time operations or maintenance. Research into people's response to hovercraft noise (see paragraph 64) should indicate the appropriate limit to include in further regulations under section 1 of the Act of 1968. If the results show an increased disturbance during evening hours, it might be necessary to stipulate one level for say 0700-1700 hours and another for 1700-2100 hours.

80. It appears to the Working Group that "reduction at source" effectively means dealing with the problem of quietening the propeller. Two approaches were reported to the Working Group: the use of some form of enclosure and the re-design of the propeller. The Group considers that these are not true alternatives; that is to say, neither is the more effective for all types of craft; both have considerable promise of noise reductions. The Working Group's view is that further work on both courses should be undertaken.

81. BHC, in conjunction with the Institute of Sound and Vibration Research is drawing up proposals for a research programme into the noise properties of air propellers and the Group strongly recommends that this project be given Government support.

82. The Working Group also considers that the use of ducted propulsors (as developed by Vosper Thorneycroft and Dowty Rotol), offers some possibility of achieving worthwhile reduction in hovercraft airscrew noise. The Group hopes that there will be some way of benefiting jointly from the experience with the VT-2 propulsors and with results from the investigation of duct effects which, it is understood, will form part of the BHC/ISVR project.

83. Improvement of the noise generated by the SR N4 (already reduced as a result of experience with the SR N6) will presumably have to await the outcome of the air propeller research. The Work Group suggests that the work into shrouded propeller units on the SR N6 initiated by Hovertravel and the Department of Industry should be resumed. When the most effective arrangement is decided, having regard to noise reduction, safety and economy, consideration should then be given to modifying the hovercraft employed on the Isle of Wight ferries. The Group recommends that some Government assistance should be given towards the cost of the development phase of this work and a rough estimate of £39,000 with a contingency of £50,000 in addition, was given to the Group by Hovertravel.

84. The Working Group accepts the operators assurance that, in general, pilots can be relied on to control their craft in a responsible way, so as to keep noise emissions to a minimum. The Group hopes that due attention will continue to be paid to handling techniques and that new methods will be taken up by all pilots and operators. In particular, the Group would like thought given to ways of manoeuvring the craft for maintenance with a view to making this quieter. The development of ground equipment, including fixed and moveable barriers as employed at airports and alongside motorways, to aid reduction in noise propagation, should also be undertaken. Possibly developments in these 3 fields (that is, piloting techniques, manoeuvring, and ground equipment) should be amalgamated into codes of practice or formal guidance notes in order to help the crews and hoverport staffs and to assist local planning authorities when considering applications for the development or extension of hoverports. As the Department of Trade is responsible for licensing hovercraft crews and operations, it appears to the Group to fall to that Department to consider how this can best be done.

85. The Working Group is not in favour of the granting of temporary planning permission only for new hoverports, while the full effects of noise from the craft in every operation is studied, because of the considerable capital expenditure involved in the setting up of a hoverport. This is not to say that extensive "trial runs" should not be an obligatory preliminary to the consideration of a site for a new terminal, because of the widespread and apparently unpredictable spread of noise from hovercraft operations and response to it. The course favoured by the Working Group is that of publishing a set of minimum requirements covering noise aspects, to be met in respect of all new hoverports. This should cover: a suggested minimum distance from residential development; a maximum noise level imposed on the nearest noise-sensitive buildings; using a site with a prevailing off-shore wind; sufficient space to avoid excess manoeuvring; wide ramps so that hovercraft can arrive and depart by direct courses; provision of adequate sound barriers (but see paragraph 72); bans on night-time services to or from terminals sited adjacent to residential areas and on all night-time maintenance; other factors related, but not strictly within the terms of this report, will also have to be considered, e.g. fumes from the hovercraft and the noise of the extra road traffic generated by the passengers or visitors travelling to and from the terminal.

86. The Working Group understands that the Department of Environment is considering updating its advice to local authorities on planning and noise, at present in DOE Circular No 10 of 1973. The Group hopes that when this

revision is carried out, the Department will take account of the problem of hovercraft noise, both at hoverports and along the flight paths and of the views expressed in this report.

87. The Working Group considers that all local authorities whose areas are impacted by noise throughout the travel of the hovercraft should be associated with discussions about the routes of the services, because of the low attenuation of sound over water and because of possible annoyance caused to residential areas. The Group suggests that this aspect should be looked at again for the routes to the Isle of Wight.

88. The Working Group recognises there could be some benefit following the noise insulation of dwellings near hoverports, where noise levels are fairly constant throughout the day and on most days, but considers that noise attenuation by distance is dependent upon so many variable factors that for houses affected by pass-by noise, sound insulation is probably not the answer in every situation.

89. The Working Group notes that in 1963 the Committee on the Problem of Noise (the Wilson Committee) emphasised the need to consider the control of hovercraft noise while the invention was still in an early stage of development. The intervening 15 years have seen considerable advances in hovercraft design and utilisation and some measure of success in reducing noise emissions. The Working Group considers that it is timely to make further efforts to achieve quieter craft in order to assist the wider employment of this British invention, especially as the sums involved appear small for the likely benefit and when compared with expenditure on aircraft noise research and even with the Government's very successful Quiet Heavy Lorry Programme.

90. Finally, the Working Group hopes that, although the recommendations of this report are concerned mainly with hovercraft used on the Isle of Wight and cross-Channel services, progress in controlling noise from these craft will have some application to hovercraft in military service and to those used in sporting activities.

Fig.1

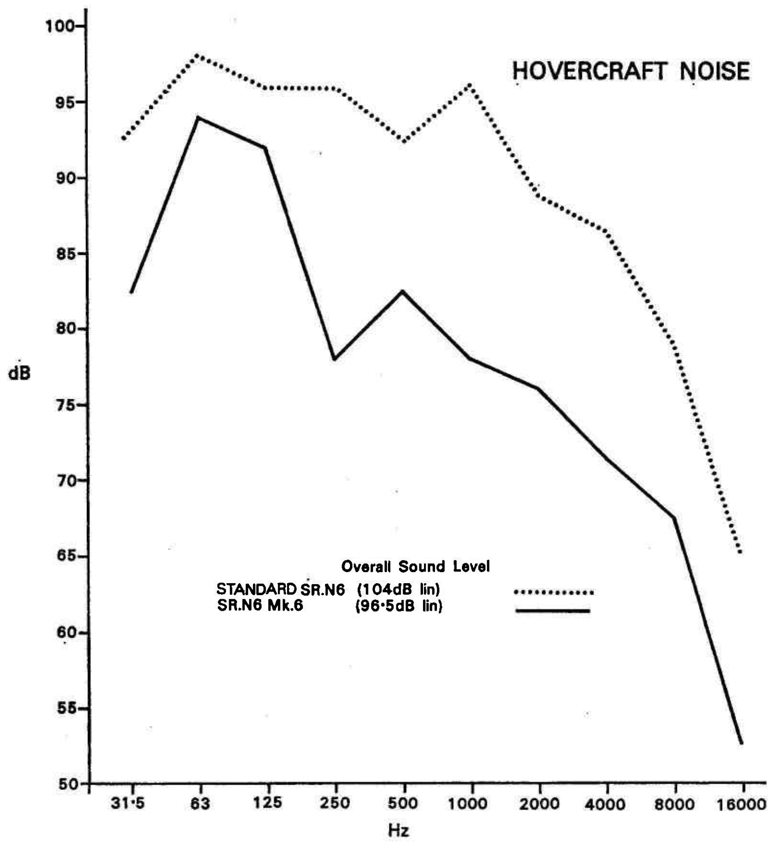
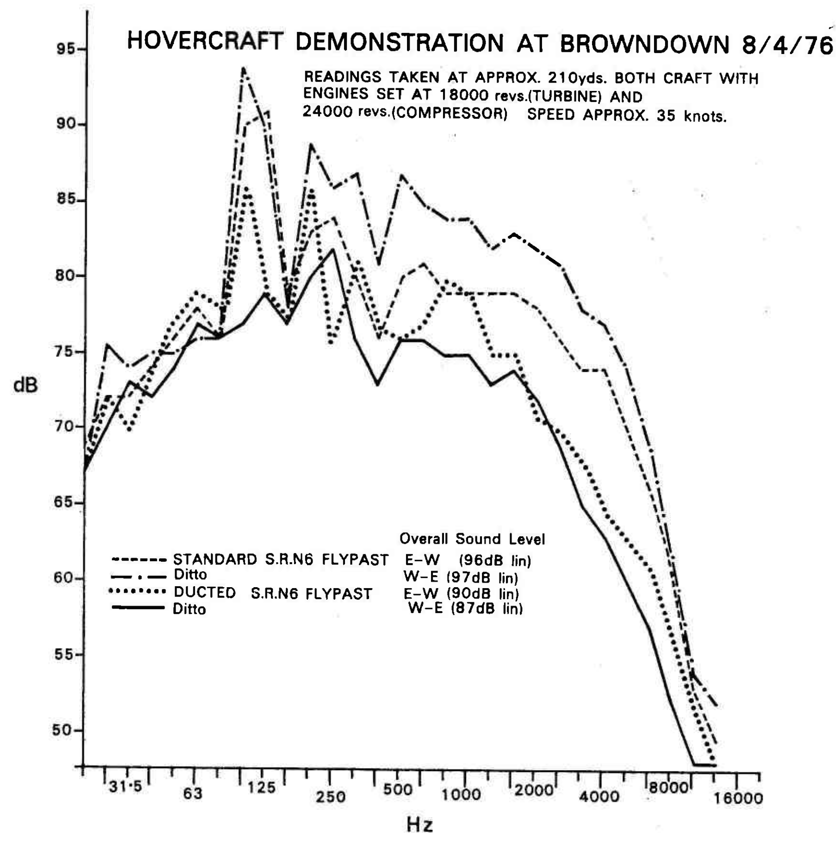
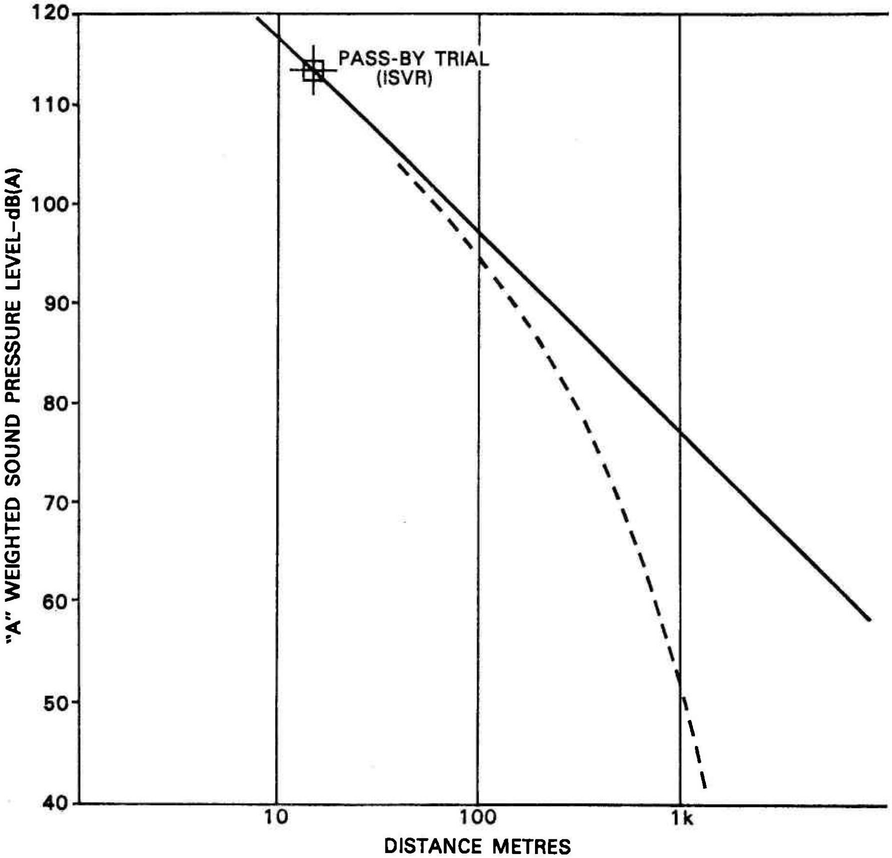

HOVERCRAFT NOISE
dB
100
95
90
85
80
75
70
65
60
55
50
31·5
63
125
250
500
1000
2000
4000
8000
16000
Hz
Overall Sound Level
STANDARD SR.N6 (104dB lin)
SR.N6 Mk.6 (96·5dB lin)

Fig.2


HOVERCRAFT DEMONSTRATION AT BROWNDOWN 8/4/76
READINGS TAKEN AT APPROX. 210yds. BOTH CRAFT WITH ENGINES SET AT 18000 revs.(TURBINE) AND 24000 revs.(COMPRESSOR) SPEED APPROX. 35 knots.
dB
95
90
85
80
75
70
65
60
55
50
Overall Sound Level
STANDARD S.R.N6 FLYPAST E-W (96dB lin)
Ditto W-E (97dB lin)
DUCTED S.R.N6 FLYPAST E-W (90dB lin)
Ditto W-E (87dB lin)
31·5
63
125
250
500
1000
2000
4000
8000
16000
Hz

SR.N6 Mk1 ENVIRONMENTAL NOISE

Fig.3



——— Attenuation of sound over distance due to the inverse square law

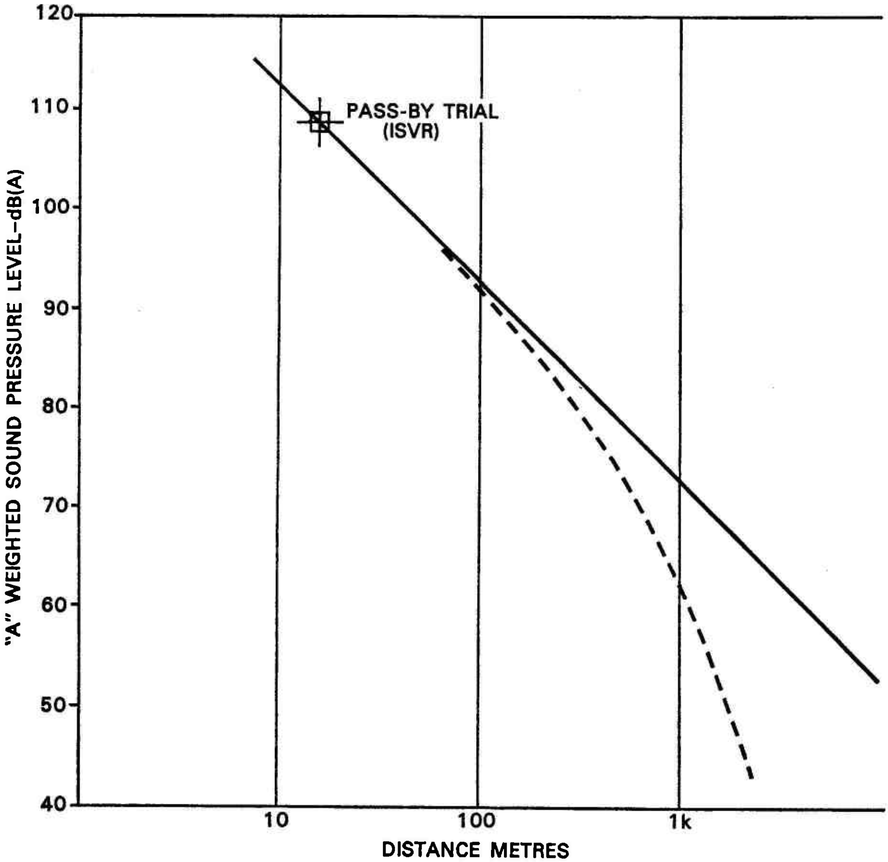
– – – Mean drawn through the experimental points

SOURCES OF DATA

B.H.C. SURVEY (1965)

K.F. LEVETT (ISVR BSc PROJECT, 1970/71)

CITY OF PORTSMOUTH COLLEGE OF EDUCATION (PROJECT, 1972)



——— Attenuation of sound over distance due to the inverse square law

– – – Mean drawn through the experimental points

SOURCES OF DATA

B.H.C. SEA TRIAL (PASS-BY)

B.H.C. SURVEYS AT DOVER AND PEGWELL BAY

ISVR SURVEY AT DOVER

TYPICAL TRANSPORT NOISE TIME HISTORIES

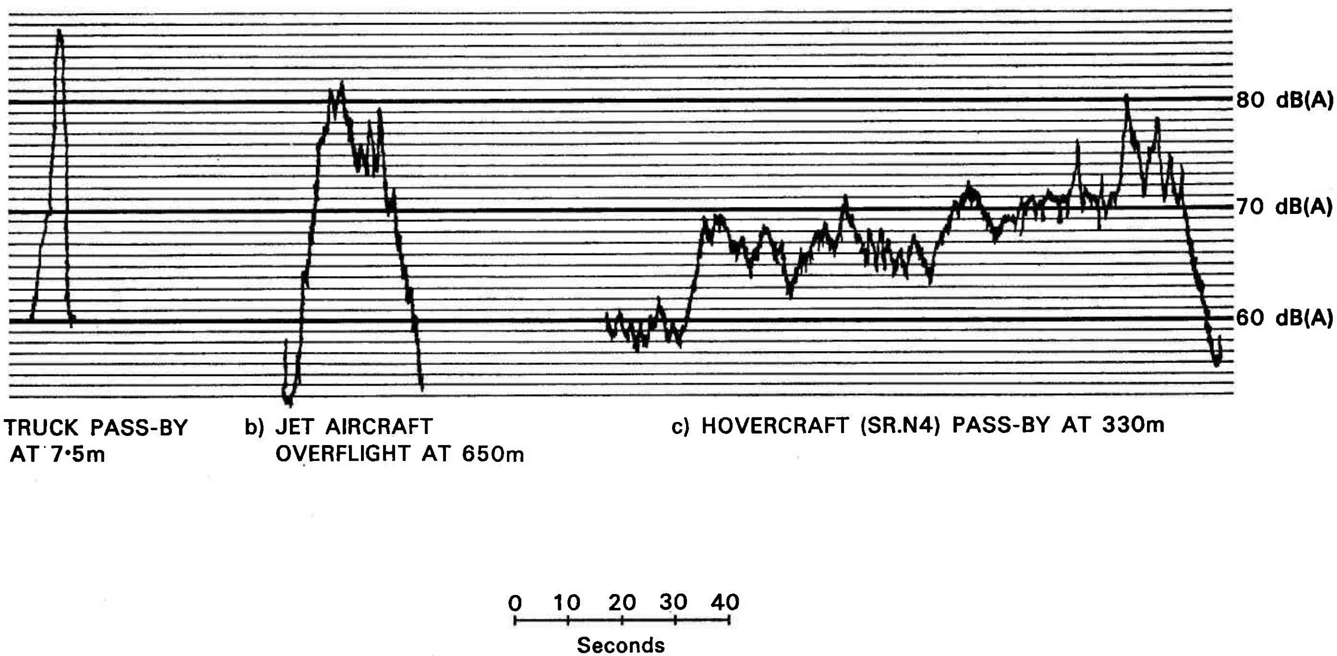


Fig.5

Other publications for the Noise Advisory Council

Aircraft Noise: Flight Routeing near Airports	HMSO, 1971
Neighbourhood Noise	HMSO, 1971
Aircraft Noise: Should the Noise and Number Index be Revised?	HMSO, 1972
Traffic Noise: the Vehicle Regulations and their Enforcement	HMSO, 1972
Aircraft Noise: Selection of Runway Sites for Maplin	HMSO, 1972 (out of print)
A Guide to Noise Units	Department of the Environment, 1974
Noise in the Next Ten Years	HMSO, 1974
Aircraft Engine Noise Research	HMSO, 1974
Aircraft Noise: Review of Aircraft Departure Routeing Policy	HMSO, 1974
Noise in Public Places	HMSO, 1974
Noise Units	HMSO, 1975
Bothered by Noise? How the Law can help you	Noise Advisory Council, 1975
Helicopter Noise in the London Area	HMSO, 1977
Concorde Noise Levels	HMSO, 1977
Hearing Hazards and Recreation	Department of the Environment, 1977
A Guide to Measurement and Prediction of the Equivalent Continuous Sound Level Leq	HMSO, 1978
The Noise Implications of the Transfer of Freight from Road to Rail	HMSO, 1978

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