A Review of the Hovercraft Noise Problem

G.F. Donno

British Hovercraft Corporation Ltd.

1.0. INTRODUCTION

In the late summer of 1965 the author was involved in the presentation of a paper[1] on hovercraft noise at a conference held at the I.S.V.R. At that time commercial hovercraft services were in their infancy and the cross-channel services with the SR.N4 were still three years away. An experimental service operating across the Solent during the previous summer had highlighted the noise problem and for several months the subject was much in evidence in the press.

Since then, hovercraft seem to have become much more generally accepted and, of course, much has been learnt regarding the nature of the problems involved. However, it should be observed that, for economic reasons, much of the hardware is the same as in 1965 and, even in the case of the SR.N4, most of the important decisions regarding noise control were made eight years ago.

In this paper the various aspects of the problem considered in the earlier presentation will be reviewed in the light of subsequent experience and research.

2.0. ENVIRONMENTAL ASPECTS

In view of the strong feelings that were aroused by hovercraft operations in the mid-1960's, it is perhaps surprising that they should have gained such a large measure of acceptance, especially since the mechanical design of the smaller commercial craft (SR.N6) remains virtually unchanged, and it is worthwhile looking at the environmental aspects in some detail.

2.1. Noise from Existing Hovercraft and Target Levels for Future Development

The likely annoyance due to the hovercraft now in service and the reduction in level necessary to achieve more general acceptability have been assessed on the basis of the British Standard[2] for rating industrial noise. It appears that:-

(i) Complaints are most likely from people near to the terminals, where hovercraft noise levels are high, and those in remote areas where the background levels are very low. This is entirely consistent with practical experience.

(ii) A 10dBA reduction in noise level as compared with existing craft would suffice to achieve a very wide measure of acceptability; 15 to 20 dBA would remove all reasonable basis for complaint.

It should be noted that in making this assessment, the fall in noise level with distance has been estimated on the basis of simple spreading alone. However, whilst atmospheric absorption is virtually negligible for frequencies below 1 kHz., ground absorption can be significant when distances of the order of ½ mile and above are involved. In built-up areas adjacent to terminals, screening by large buildings may also have important effects.

2.2. Effect of Operating Procedures

Although the SR.N6 is still capable of producing the same level of noise as the SR.N5 did in 1964, much has been achieved by the introduction of suitable handling techniques. Operators are well aware of the desirability of avoiding excessive turbine speeds, especially when approaching a terminal, and of the unfortunate effects of rapid changes from positive to negative propeller pitch[3]. Measurements have shown that brusque handling of the controls can raise the noise level by 15 to 20 dBA.

2.3. Siting of Terminals

Considerations of traffic potential and ease of access will usually dictate the location of terminals in urban areas or, at least, close to main roads, where the ambient noise levels are likely to be quite high. However, there are other aspects of the siting and layout of terminals which can have profound environmental implications:-

(i) All experience has tended to confirm the recommendation made in the earlier paper regarding terminals with easy access. Even with the best of intentions, the commander of a craft working into a difficult terminal may be unable to avoid the kind of handling deprecated in para. 2.2.

(ii) The effect of wind is very significant. If a terminal can be sited so as to be in the lee of residential areas, relative to the prevailing wind, the noise problem will be greatly alleviated.

2.4. Units for Noise Measurements

Numerous measurements have shown that the SR.N4 and the SR.N6 produce virtually the same "A" weighted noise levels, yet most people consider the large craft to be much quieter. Although the differences between them are clearly evident even in an octave band analysis, neither PNdB nor any of the more exotic units succeed in bringing out the difference in subjective impressions. Other investigators have experienced the same difficulty[4].

3.0. EXTERNAL NOISE

For hovercraft propelled by air propellers, the said propellers constitute the major source of external noise. Of the other potential sources, i.e. engines, lift fans, transmission, air cushion, only the engines merit any serious consideration as regards noise outside the craft.

3.1. Propeller Noise

In 1965 we were anticipating great things from the low tip speed to be employed for the SR.N4 propellers. Although those hopes have not been realised in full (quite frankly, we got the slope of the curve from SR.N5 results wrong because of the big gap in the R.P.M. range dictated by the propeller resonance 'red band'), the fact that a craft with about 16 times the installed power is generally more acceptable than the SR.N5/N6 does represent some modest measure of achievement.

While it was recognised in 1965 that the failure of the Gutin theory to produce realistic estimates of propeller noise was due to non-uniformities and turbulence in the flow in practical installations, means for putting such effects on to a quantititive basis were lacking. Since then, theoretical work, notably at I.S.V.R[5] and Loughborough[6], has gone far to filling in this gap. So far as the practical applications are concerned, the importance of this research lies in the strength that it gives to the case for getting the best possible flow conditions for the propellers.

Very soon now we hope to commence trials of the SR.N6 Mk.6 a twin propeller version of the standard craft. External noise reduction has been an important consideration in the design of this craft and the maximum propeller tip speed has been reduced to 0.47M (with 1,000 R.P.M. gearing) as compared with 0.6M and 0.85M for the SR.N4 and standard SR.N6 respectively. One would also hope for better flow conditions with the twin propeller configuration, although it must be appreciated that the relative wind is seldom aligned with the craft axis and the improvement is consequently not so great as might be imagined by comparing the front elevations of the Mk.6 and standard craft.

The lack of smooth, aligned, flow into the propellers is the basic acoustic reason for rejecting the frequently mooted suggestion that noise could be reduced by fitting shroud rings. Laboratory tests have certainly shown that under ideal conditions reductions of the order of 6dB can be obtained in this way. However, it has also been found[7] that, if the flow separates, the noise can be increased by anything up to 6dB, which is a sufficient reason for rejecting shroud rings in the hovercraft propeller environment. Genuine ducted propellers are a totally different matter, but in such cases one is talking in terms of duct lengths measured in propeller diameters and an entirely new breed of hovercraft.

3.2. Engine Noise,

Engine noise does not make a significant contribution to the overall external noise generated by hovercraft with air propellers. The relative level of engine noise is higher in the case of SR.N6 than SR.N4 or BH.7 but, even in the case of SR.N6, a reduction of at least 6dBA in the level of propeller noise would be necessary before it became worthwhile 'silencing' the engine intake. We are hoping that engine 'silencing' will become a matter of urgency for the Mk.6!

4.0. INTERNAL NOISE

Inside the hovercraft the major noise sources are the lift fans, engines and transmission system. Propeller noise is often significant but not, generally, of paramount importance. Much depends on the layout of the craft, as will appear when the various sources are considered individually below.

4.1. Lift Fan Noise

Lift fans have emerged as a major internal noise source in craft like SR.N4 and BH.7. This situation has arisen because the fans are located at deck level in these craft (instead of being down in the depths, as on SR.N2 and SR.N3) and clearances between the fan periphery and adjacent 'solid' structure have been reduced. Because of the relatively low frequencies involved (fan blade passage frequency, typically 120Hz) it is difficult to reduce this noise by conventional lightweight soundproofing techniques and serious consideration is being given to tackling the lift-fan noise problem at source. Unfortunately, there is very little information available on the generation of noise by centrifugal and mixed-flow fans and the theoretical work has to start, very nearly, from basic principles.

4.2. Engine and Transmission Noise

Although noise from the engines and transmission system seldom establishes the dBA level within the passenger accommodation, a significant reduction in the noise from these sources would doubtless be appreciated because of the reduced Speech Interference Level. Unfortunately, although the medium and high frequencies involved are relatively easy to deal with in theory, practical and economic considerations pose problems. These are acute in the case of a craft like SR.N4 because of the layout, the sheer size of the areas to be treated and the difficulties of obtaining 'possession' of even one cabin for experimental investigations.

4.3. Propeller Noise

With craft layouts like SR.N6, the contribution of the propeller to the noise level inside the craft is insignificant. The situation is different on SR.N4 with its pylon mounted propellers and, in some situations, they do represent a major source of low frequency noise. However, the low frequency end of the spectrum is still dominated by the lift fans and, until noise from this source can be reduced, there would be little benefit in reducing the noise transmitted into the craft from the propellers.

5.0. CONCLUSIONS

The use of propellers with lower tip speeds on hovercraft introduced since 1965 and improvements in handling techniques have resulted in a considerable amelioration of the external noise problem. However, further substantial reductions in level will be necessary before the external noise situation can be regarded as satisfactory. Whether or not such reductions can be achieved with 'open' propellers remains to be resolved; however, it is worth noting that if it were possible to 'recover' the excess noise due to turbulence, etc. and get down to "Gutin levels", the objective would be largely attained.

Practical and economic considerations continue to exert a strong influence on internal noise control. In particular, the internal layouts required in the larger craft introduced since 1965 have brought the problem of lift-fan noise into prominence. Because of the relatively low frequencies involved, such noise is very difficult to control by lightweight soundproofing techniques and it is necessary to think in terms of reducing the noise at its source. This means fundamental research on the generation of noise by centrifugal and mixed-flow fans.

6.0. ACKNOWLEDGEMENT

The author wishes to thank the Directors and Management of the British Hovercraft Corporation Ltd. for permission to publish this paper.

REFERENCES

1. Wheeler, R.L. and Donno, G.F. — "The Hovercraft Noise Problem" J. Sound Vib. (1966) 4(3), 415-430
2. "Method of Rating Industrial Noise Affecting Mixed Residential and Industrial Areas" B.S. 4142 (1967)
3. "Handling Techniques and Noise Reduction" B.H.C. Service Bulletin No. 52 April 1966
4. Levett, K.F. — "Hovercraft in the Solent - The Problem of Noise and its Assessment." I.S.V.R. Thesis - 1969/71
5. Wright, S.E. — "Discrete Radiation from Rotating Periodic Sources". J. Sound Vib. (1971) 17(4) 437-498
6. Lowson M.V. — "Prediction of Rotor Noise in Non-Uniform Flow". Loughborough University of Technology Report No. TT 7105
7. Hubbard, H.H. — "Sound Measurements for Five Shrouded Propellers at Static Conditions". NACA TN.2024, April 1950.