HIGH SPEED TRAIN NOISE PRESENT AND FUTURE: AN OVERVIEW

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1. INTRODUCTION

The Community of European Railways, comprising the railway companies of the 12 European Community (EC) members together with Austria and Switzerland, have drawn up plans to establish a European high-speed railway network within the next 20 years. By definition, high speed trains are considered as trains running at 250 km/h or above on new lines and 200 km/h or above on up-graded lines. It is anticipated that the network would form the core of the European transportation infrastructure from the mid-1990's onwards.

In France, the TGV has been operating with outstanding success between Paris and Lyon at speeds up to 280 km/h since 1981; a second TGV line opened in September 1989 between Paris and Le Mans, operating at speeds of 300 km/h. Plans are well advanced for the TGV-Nord to Lille and the Channel Tunnel. Italian and German Railways are currently testing high speed trains and Spain wants to use the French TGV between Paris, Barcelona, Madrid and Seville.

British Rail has detailed plans to build a new high speed line from London to the Channel Tunnel to complete the London-Paris/Brussels link, which is seen as the heart of the European high-speed network.

Although trains are the safest, most economic and the most environmentally friendly of all conventional transportation systems, many communities are now re-appraising the cost of new railways in terms of environmental impact, with such factors as noise, vibration and visual intrusion coming to the fore.

A general increase in public awareness of environmental issues over recent years is forcing developers in every sphere to consider environmental factors more carefully. This has been particularly true with high speed railways; British Rail's proposed link from London to the Channel Tunnel has faced severe environmental opposition, which could lead to a 40 per cent increase in the estimated construction costs.

Planners looking to build new rail routes, especially for high speed operation, need to consider many different environmental issues, although noise is held to be one of the most significant factors.

2. NOISE SOURCES

High speed operation generally involves modern electrically-powered trains running at speeds above 200 km/h. At the speeds involved, the primary source of noise comes from wheel-rail interaction. The power unit itself, even on a diesel-engined trainset, will be less significant.

Fears have been expressed in some quarters about the possible increases in aerodynamic noise at high speeds. However, data from high speed tests conducted by French National Railways (SNCF) suggest that even at speeds approaching 400 km/h aerodynamic noise is unlikely to be a major contributor to the overall level of train noise.

Train and track designers have responded well to the challenges of environmental concerns. Incorporation of the latest design techniques and high maintenance standards will help minimise noise generation. As the primary source of noise is the wheel-rail interface, this is obviously the area needing closest investigation. The various noise-producing mechanisms are still not fully understood, but research has given clear indications of those sources needing closer study.

Some of the sound radiation comes from the rail, and this can be significantly improved by elimination of corrugations, which offers a 10 to 15 dB(A) reduction in noise. The effect of the rail as a source of noise is further reduced by the need for high quality trackwork for successful operation at high speeds. Well-maintained continuous welded rails and a line with few points or crossings all help to reduce noise generation. A significant proportion of wheel-rail noise is generated by the wheelset, and the widespread use of disc brakes on modern trainsets brings another major benefit: the absence of tread brakes means the wheels stay smoother for longer. This saving can be quantified at around 10 dB between equivalent trains which are running at the same speed.

For design reasons, chiefly the limited amount of space available on motored bogies, tread brakes continue to be used on power cars. As a result, these produce clearly identifiable maximum noise levels which can be seen on a graph of noise against time for a train passing a given spot.

Figure 1 compares the noise profiles generated by five different trains, showing clearly the advances made in cutting noise in recent years. Graph A shows a conventional British Rail InterCity train, formed from a mixture of disc- and tread-braked stock hauled by an electric locomotive at 160 km/h. Graph B is one of BR's 200 km/h HST trainsets with two diesel power cars and eight disc-braked coaches. Graphs C and D show SNCF's TGV-Sud-Est and Atlantique trainsets running at 270 and 290 km/h respectively. Graph E is a computer simulation of the proposed Three Capitals trains between London and Paris, with tread-braked power cars and disc-braked trailers. The noise specification for these trains is a maximum of

96 dB(A) at 300 km/h, measured 25 m from the train. At the same distance the noise level at 225 km/h will be 92 dB(A).

It is clear from the various curves that noise levels have not increased as speeds have risen. This indicates that designers and engineers have responded positively to environmental concerns and incorporated noise-reducing measures in later generations of rolling stock. To ensure that noise levels remain low, consistent high quality maintenance of track and rolling stock is needed. In any case, high speed lines demand high maintenance standards.

3. NOISE CONTROL

Even though the level of noise from high speed trains is being minimised through better design, there may still be situations where environmental considerations demand a further reduction of noise in the community. Assuming that noise cannot be further reduced at source, this may not be easy to achieve, and is likely to be very costly.

Further noise control modifications to the rolling stock could include fitting of skirts over the wheels, although prospects for this technique are not encouraging because of the inability to shield both wheel and rail at the same time. Similarly, the use of resilient wheels has proved impractical because of unacceptable wear rates.

Use of disc brakes on the power cars in place of tread brakes is difficult because of restricted space. This change could bring a significant reduction in power car noise, although it remains to be seen whether a powered disc-braked wheel is as smooth as an unpowered one. Use of articulated vehicles, and hence fewer wheels, has proved beneficial, to judge from the results achieved with the TGVs.

As well as incorporating the latest technology into train design, noise has to be controlled by care in designing the track by the use of noise barriers, cuttings and tunnels, by controlling speeds where appropriate, and by laying out the route to avoid sensitive areas. An early consideration during the design of a high speed link is to route the line away from residential areas and schools as far as possible. Running alongside existing railways or motorways, as with the design of the TGV-Atlantique line, will restrict any new noise to an existing 'noise corridor'.

Changes to operating patterns such as reducing the line speed limits will have only a minor effect. For example, the 25 per cent reduction of speed on the proposed London-Channel Tunnel link from 300 to 225 km/h will only bring a reduction of 4 dB in the maximum noise level and 2.5 dB in L_{Aeq}.

Restricting the number of trains would also have some effect, but a dramatic cut in traffic volumes would be needed to bring any significant change to the noise environment, and such a move might make a project economically unacceptable.

Finally, noise control can be incorporated into the design of the route itself. Noise levels reduce as the distance from the track increases, typically falling by 4 to 6 dB each time the distance is doubled. Over open grassland, noise levels could fall by about 18 dB as the distance from the track increases from 25 to 200 m.

This reduction in noise level through 'geometric spreading' may be supplemented in some circumstances by the effect of ground absorption at certain frequencies. It may also be possible, at the design stage, to use natural features such as hills and valleys to control the sound generated by the railway.

The most effective means of control at present is the installation of barriers or screens alongside the track. A 2 m high barrier close to the track will reduce noise levels by up to 10 dB. Natural cuttings have much the same effect as an artificial barrier, and may be more visually acceptable if small trees and other vegetation are allowed to grow. An alternative approach could be to use retaining walls to create false cuttings within embankments upon which vegetation or trees can be grown.

If it is possible to run the line in a tunnel, then obviously this will bring environmental benefits. A good example is the *coulée verte* where the TGV-Atlantique line passes through the Paris suburbs. The new line is built in a concrete box in a disused railway cutting, with the reclaimed land over the top being used for non-noise-sensitive purposes such as recreation areas and gardens.

4. SUMMARY

Despite the progress made in controlling the noise levels, community fears have not been completely allayed. Careful planning to meet environmental guidelines is still needed. There is, however, little scientific information relating community response to noise from high speed trains. Although many studies have been conducted to determine the relationships between noise exposure and community response for conventional trains, only a small percentage of this information relates specifically to high speed trains, and it is not possible to draw valid conclusions about responses to high speed trains from these limited data. Although there is no evidence that response to high speed train noise will be any different to that for conventional train noise, objectors to new lines and other high speed developments argue that this information should be obtained before planning guidelines for noise are defined.

There is also no information about the effect of constructing a new line in an area which has not previously been exposed to railway noise. Some data exist for new roads and airports but the evidence is inconclusive although there is evidence that some, although incomplete, adaptation to the noise might take place; again, objectors argue that these data may not apply to new high speed routes although there is no scientific evidence to support this claim.

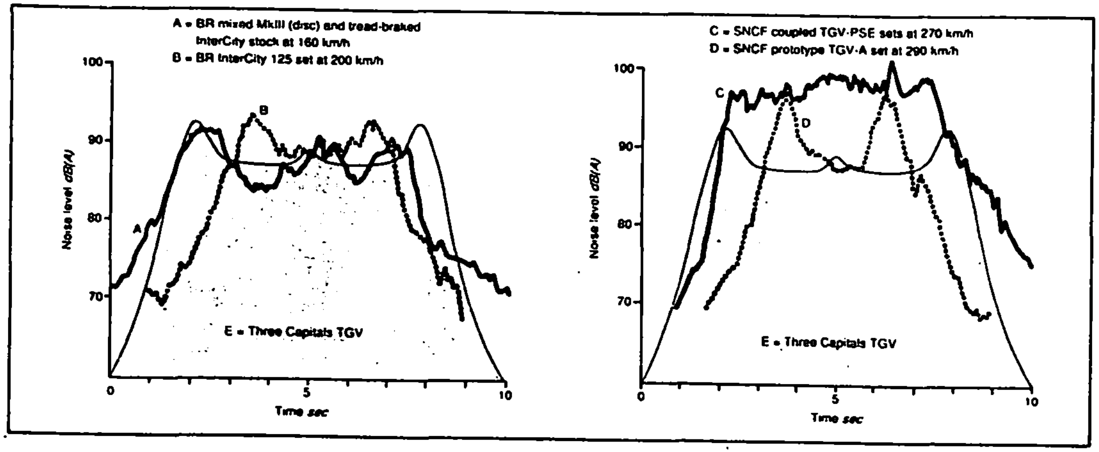

Figure 1. Computer simulation of the Three Capitals TGV at 225 km/h compared with recordings made 25 m from the track while BR (left) and SNCF (right) trains pass at various speeds.

(Figure reproduced from Railway Gazette International July 1989 from a paper prepared by the author. The computer simulation was prepared by BR Research, Derby.)