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THE USE OF RASTI FOR OBJECTIVELY RATING SPEECH INTELLIGIBILITY INSIDE VEHICLES.

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INTRODUCTION

The introduction of 'RASTI' [1] as a means of a fast and simple method of evaluating speech interference has aroused considerable interest over the past year. However, the technique has been mainly confined to assessing the acoustic qualities of churches, lecture theatres and passenger terminals, etc. This paper investigates the use of 'RASTI'in a more dynamic situation, i.e. in motor cars.

Before discussing the measurements and the results it would be useful to consider the problems of assessing the acoustic 'comfort' of the interior of a car. The driver and passengers are subjected to the breakthrough of road, engine and transmission noise, as well as the noise of rain, windscreen wipers and wind, etc. The occupants have to contend with these noises whilst concentrating on driving, having discussions or listening to the radio cassette player. Any noise which has a disruptive influence on the senses tends to give a negative value to the car's acoustic environment. For instance, if the interior noise level is high, for whatever reason, then the voice will have to be raised for good speech recognition or the volume from the cassette player will have to be increased for more listening detail. The result is a higher noise level all round and consequently more chance of being tired at the end of a long journey due to an assault on the senses. These problems are also exacerbated by the vibration felt by the car occupants, but that is not the subject of this paper.

RASTI

RASTI has been developed from experiments on sound transmission systems using Modulation Transfer Function analysis. The word RASTI stands for RApid Speech Transmission Index and the emphasis in this particular application is on Rapid. It is possible to complete one measurement in as little as 8 seconds. This has the advantage that at 70mph a road surface needs to be regular for only 250 metres. It also means that many measurements can be made in a short time to verify the analysed data.

The RASTI method takes into consideration the effects of

(a) background noise, in this external noise such as road surface noise, as previously mentioned, and

(b) reverberation. The reverberation times inside a car depend of course upon the nature of the interior trim, i.e. the type of carpet, are the seats covered in cloth, leather or plastic, is the head lining plastic or plush? etc. Both these phenomena are automatically taken into account when carrying out the measurements and no corrections need be applied. Another advantage is that measurements are made with both the test signal and background noise present so that the signal and the noise need not be measured separately.

Measurement.

For the purpose of this paper five cars were used over a period of two days. The car driver and the 'RASTI' operator were the same on both days as was the road over which the vehicles were driven. The cars were driven for the measurement periods (16secs) at a steady 70mph and where possible the same sections of the road were used; it was possible to carry out seven measurements for each car before using the same section of motorway for a second time. In each vehicle the RASTI transmitter was placed on the front passenger seat with the loudspeaker facing the windscreen and the receiver was placed on the rear seat behind the driver with the microphone pointing across the car to the front nearside wing mirror. The operator sat behind the front passenger seat so that both transmitter and receiver could be operated with ease. The results were printed out onto a small Epson HX20 personal computer.

Results.

From Fig. 1 it can be seen that the Sierra had the highest overall RI index with the Maestro the worst. The list is put into descending value of RI and in fact this followed entirely the subjective rating of the vehicles. RASTI analyses the speech interference spectrum at 500Hz and 2kHz. In the case of motor cars a low figure in the 500Hz band signifies high engine noise breakthrough and also a high level of road noise, whilst a low figure in the 2kHz band suggests a high level of transmission noise and poor door and window seals.

In the case of the Saab there is a significant whine from the engine and this is reflected in the low RI figure when the engine was run at 4500secs (Fig.2). A low figure was obtained from the Fiesta at 2kHz when the passenger door was unlocked at 70mph creating wind noise (Fig.3). In a previous test some months ago a low RI figure again at 2kHz lead to the discovery that a rear door of the car under test was not closed properly.

Fig. 1.

Car	RI overall	RI 500Hz	RI 2kHz	Time	Comments
Sierra Estate	.51	.55	.47	Day 1	70mph. Dry road surface
Saab	.44	.46	.43	Day 1	70mph. Dry road surface
Volvo Estate	.42	.45	.40	Day 2	70mph. Wet road surface
Fiesta	.41	.38	.44	Day 1	70mph. Dry road surface
Maestro	.37	.26	.45	Day 1	70mph. Dry road surface

Fig. 2.

Car	RI overall	RI 500Hz	RI 2kHz	Time	Comments (car stationary)
Saab	.96	.99	.93	Day 2	Tickover
	.97	.96	.98		600rpm
	.96	.99	.93		1500rpm
	.79	.91	.70		3000rpm
	.45	.56	.37		4500rpm

Fig. 3.

Car	RI overall	RI 500Hz	RI 2kHz	Time	Comments
Fiesta	.44	.43	.45	Day 2	70mph. Wet road surface.
	.39	.35	.43	Day 2	70mph. Wet road surface and passengers window just open.
	.33	.38	.29	Day 2	70mph. Wet road surface with passenger door slightly open.

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Normally, an engineer assessing the acoustic feel of a vehicle would use just the one vehicle in a variety of different situations, i.e. at varying engine speeds, at different road speeds, in various gears and of course at constant speeds. A method of assessing the problem of road noise breakthrough but not engine noise is to drive the car to a high speed, say 75mph, put the car into neutral, switch off the engine and then carry out the RASTI measurements as the car slows down. Using the instrument's 8sec capability it should be possible to perform measurements before the speed drops below 65mph.

Care has to be taken to carry out any measurements over the same road surface every time. In the present tests it was interesting to note that the first measurement on the M67 Motorway out of Manchester gave generally higher RASTI figures than the second measurements. (Fig.4).

Fig. 4.

Car	1st Measurements			2nd Measurements		
	RI Overall	RI 500Hz	RI 2kHz	RI Overall	RI 500Hz	RI 2kHz
Sierra Estate	.54	.60	.49	.54	.56	.52
Saab	.48	.52	.44	.44	.44	.44
Volvo Estate	.45	.47	.43	.40	.45	.36
Fiesta	.45	.43	.46	.42	.38	.45
Maestro	.42	.36	.47	.35	.20	.47

This was because the road started off with a good smooth surface and then degenerated into one full of refurbished patches. Even so, as long as the cars are tested over the same road surface each time a new measurement is made, the RASTI figures should reflect the subjective impression of the car's acoustic 'comfort rating. The technique could, of course, be used to assess the acoustic effects of varying road surfaces whilst also measuring, say, whole body vibration and ride comfort.

Another considerable advantage from the engineer's point of view is that it is an easy matter to carry out a quick measurement after changing some aspects of, say, the car's interior trim. Indeed, because RASTI calculates EDT figures, provided that the background noise is low, (this condition obviously being met when the car is stationary), it should be a simple matter to make a test box with the same internal volume of the car and perform measurements on proposed carpet and seat-covering materials, thus assessing their acoustic suitability before going to the expense of having expensive, shaped samples made.

Conclusion.

All the measurements mentioned in this paper, (over 40 were measured and listed), were carried out in less than two hours. The objective results had an extremely high level of agreement with subjective impressions of all the cars' acousticcomfort ratings and the use of RASTI in this type of situation enables number to be substituted for what was previously many peoples varying opinions.

References.

[1] IEC Draft publication 268] Sound Systems Equipment part 16.
[2] Bruel & Kjaer Technical Review No. 3-1985