INTEGRATION OF WEATHER DATA INTO ENVIRONMENTAL NOISE ASSESSMENTS

Bjorn Winsfold Norsonic AS, Tranby, Norway
Ian Campbell Campbell Associates Ltd, Bishop's Stortford, UK

1 INTRODUCTION

Weather conditions have been identified as a major contributor to the uncertainties associated with investigation of the uncertainties associated with environmental noise measurements. Others have shown how both wind direction and temperature inversions can effectively change the source that is driving the background noise level at any particular location. Further more as the wind increases it will of its self create new noise sources as will wet ground; the levels generated by these effects can be high and materially corrupt even foreground noise measurements. The effects of all of these meteorological parameters need to be taken into account when evaluating environmental noise measurements.

2 METHOD

2.1 Current situation

Over the years noise measurement equipment has become less expensive in real terms whilst the man-hours associated with making the measurements have continued to increase; this is causing a move towards making more unattended noise measurements. Advances in technology have made the validation of these unattended measurements more certain by the addition of functions such as real time frequency analysis, detailed time profiles and true audio-records of the subject noise. To this list the real time logging of key weather data now needs to be added.

Rating of environmental noise is now moving towards the EU requirement for results to be expressed in terms of L_{DEN}; this is a long-term index designed to reflect the noise climate at a location. It is built up from the 24 hourly assessments that are time weighted to reflect the subjective assessment during the day, evening and night periods. The same parameter will also be used in the proposed noise mapping exercises throughout the European Union and it is important that any measurements made can be correlated with these predictions. An understanding of the effects of meteorological conditions prevailing at the time measurements are made will be important in understanding the differences between the two methods. Night time periods will be particularly important as the levels are lower allowing any weather artefact to be more significant; furthermore any error will be compounded by the penalty level weighting that is applied to the recreational and rest periods of the day.

The prevailing weather conditions are just like noise levels in that they are continually changing; albeit at a somewhat slower rate but still need to be evaluated on a minute by minute or at least hour by hour through out a measurement if the uncertainties in the measurement associated with the weather conditions are to be controlled. To allow the effects to be understood it is important that the weather and noise data are available in the same time frame and preferably in the same file. There is in fact nothing new about reporting weather data along with noise measurements; traditionally this tended to be the reporting of observations of the prevailing conditions at spot times during a measurement, usually the beginning and end. Automatic logging of meteorological results has been to date limited to large-scale permanent noise monitoring systems around airports and major industrial facilities, as these are the only situations where the necessary on line computing power has been available. These types of installation account for only a small percentage of the total number of environmental noise determinations that are made, the majority being short to medium term measurement spanning just a few days or weeks. With the cost of noise measuring instrumentation continuing to fall in real terms and the cost of technician hours used to supervise the work on the increase then automatic systems offer an attractive method of controlling the cost of acquiring data. It is to complement this new generation of automatic environmental noise analysers that this work has been undertaken to integrate weather measurement data into the basic sound level meter.

2.2 Development

An example of such and implementation is the Norsonic Nor-121 Environmental Noise Analyser. This is a two-channel portable noise monitor with a 120 dB dynamic range that has been specifically developed for these short to medium term applications. A third measurement channel has been integrated and this is used to report the weather data in parallel with the noise level information. The instrument uses a nested report structure that allows the basic day, evening and night periods to be measured along with more detailed reports that break the noise level down into say one hour and five minute sub-reports; as would be used for day and night time assessments following the BS-4142 procedure. The weather data may be synchronised with one of these sub reports, normally say five or fifteen minutes. This allows the $L_{eq.t}$ and L_{90} values to be supported by time-synchronised curves of the wind speed and direction, rain, temperature etc.

The measurement of weather data is not new technology; most of the transducers used are mature in concept and can be integrated into electronic data logging systems to make the information available over a standard interface. For the measurement of wind speeds either hot wire or rotating vane wind direction sensors may be used. Electromechanical three-cup anemometers have established a track record of reliability with the modern types providing a direct digital output and hence have been selected for this application. They typically operate over the range 0.5 to 35 ms^{-1} with a resolution of 0.03 ms^{-1} and give an accuracy of ±0.5 ms^{-1} allowing the results to be processed in terms of average and peak wind speed. Wind direction is measured using a rotating vane device; this provides an analogue output proportional to the source angle that has to be fed to a digital conversion circuit prior to connection to the system. This will give a valid result for wind speeds over 0.6 ms^{-1} with an accuracy of ±2.5°. In addition to this key meteorological data additional solid-state sensors are employed to log the temperature (range –40 to +50°C with a resolution of 0.1°C and accuracy of ±0.3°C), barometric pressure (range 800 to 1050 hPa with an accuracy of ±0.8hPa) and relative humidity (range 1 to 100% RH, with a resolution of 0.1% RH and a accuracy of 2% RH). Rainfall is determined using a bucket type rain gauge that will show cumulative rainfall in any 24-hour period; it has an effective collection area of 200 cm^2 and will provi de a resolution of 0.1 mm and an accuracy of 0.2mm. The bucket capacity that the selected device will process is sufficient to measure a maximum rainfall intensity of 10 $mmmin^{-1}$. For use in cold environments an optional heating element is available for the rain gauge. A novel optional transducer is available to detect wet ground that is based on a leaf humidity detector; it will return a logical 1 if the condition is true to signal that there could be an added component from vehicle tyres etc. All of this weather data is converted to digital format and stored within the weather station to await collection by the sound level meter; this buffering is sufficient for several hours operation but depending on processor work load the sound level meter will collect the data every second or so. All that is necessary is to connect the weather station to one of the environmental noise analysers two RS-232 ports and activate the weather station firmware with in the analyser. As a result within the analyser there are time-synchronised reports giving both noise and weather data. This information may be reviewed on the instruments display or exported to standard spread sheet or database programs for post processing.

With the data presented in this manner it is easy to identify those situations where there could be problems. Application specific post processing packages will be able to identify set conditions and flag results accordingly, for example exclude those results taken when the wind speed exceeds 5ms^{-1}. As the results are available in standard Excel spreadsheet format it is not a difficult task to develop macros that will categorise the noise level according to the prevailing wind direction.

Hence in those situations where there are a number of sources, that are located in different directions, that contribute to the ambient climate it will be possible to determine which ones were significant at any particular time during the measurement.

3 RESULTS

Examples are shown of such assessments that are based on measurements in one location over the period 4th to the 24th January 2004. The location was a technology park 10 km to the North of

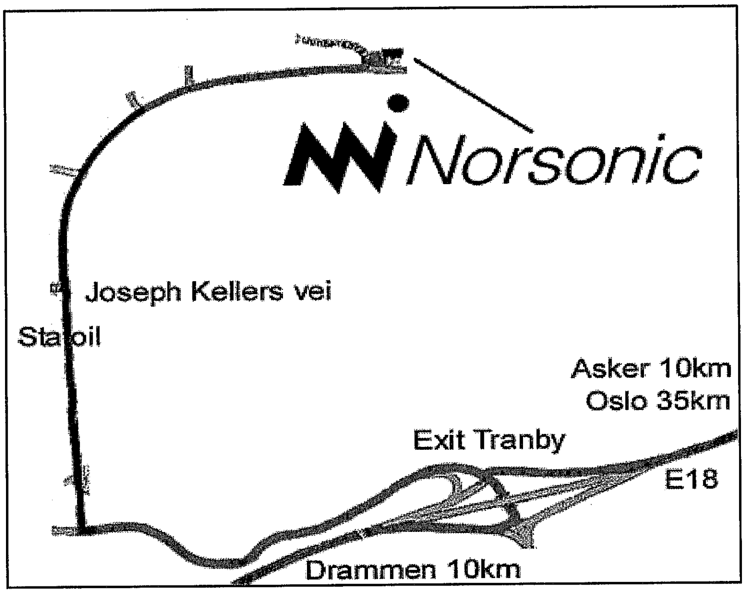

Figure 1
Test noise monitor location

the City of Dramen in Norway and some 2.5 km from the main E18 Motorway from Oslo to the southern cities. The motorway and City of Dramen are the main drivers for the background noise level at the monitor location as the ground falls away in that direction giving a clear line of sight down into the city. Near field noise sources are general traffic and light commercial activity in the park itself with occasional forestry activity in the wooded areas that surround the park; the noise climate is therefore a classical one of high day time and low nigh time levels. The objective of the test was to confirm the correct operation of the system and to see if the data shows the effects of weather induced near field noise sources and the degree to which it could identify the change in background noise level due to wind direction.

During the test period there was an extended period of calm weather resulting in insufficient data to draw statistically valid results however the work is continuing as initial results are encouraging.

3.1 Effects of wind on $L_{eq,t}$ measurements

In figure 2 the effects of wind-induced noise can be seen. The curve shows noise indices $L_{eq,5min}$ and $L_{90,5min}$ on the left hand Y-axis and average and peak wind measurements on the right hand Y-axis, again in 5-minute periods. Although the 5-minute average values are low there are significant gusts rising above 5 mms^{-1} during the night time. These gusts have no effect on the $L_{90,5min}$ but can be clearly seen in the $L_{eq,5min}$ showing how foreground noise levels can be corrupted by wind generated noise. Figure 2 shows a similar measurement but in this case the wind gusts occur

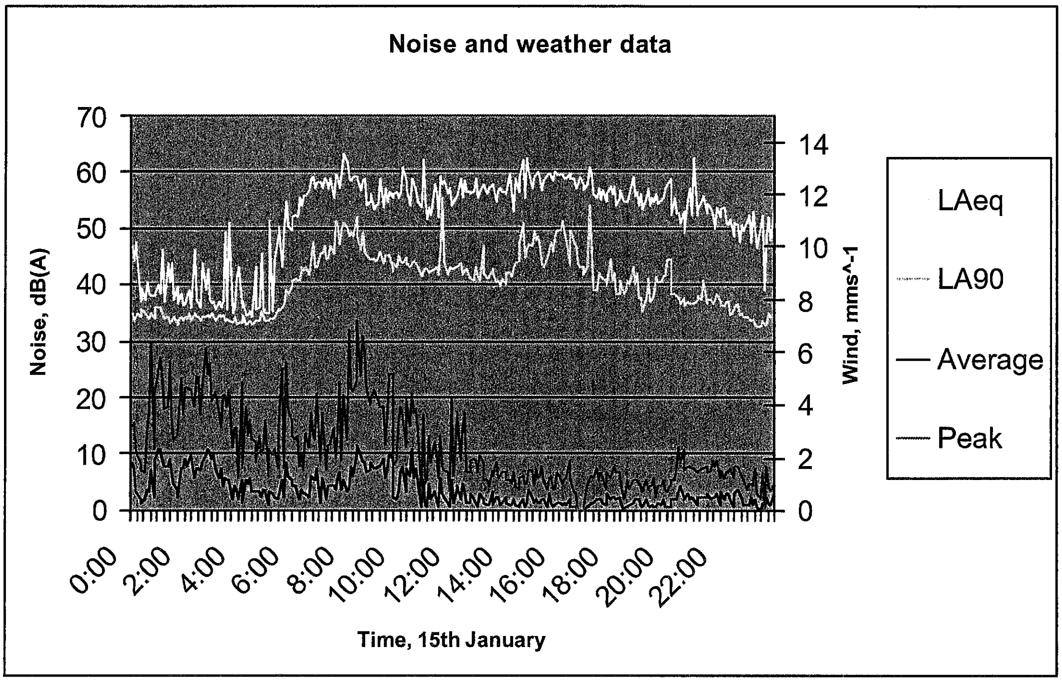

Figure 2.
Wind induced noise during the night

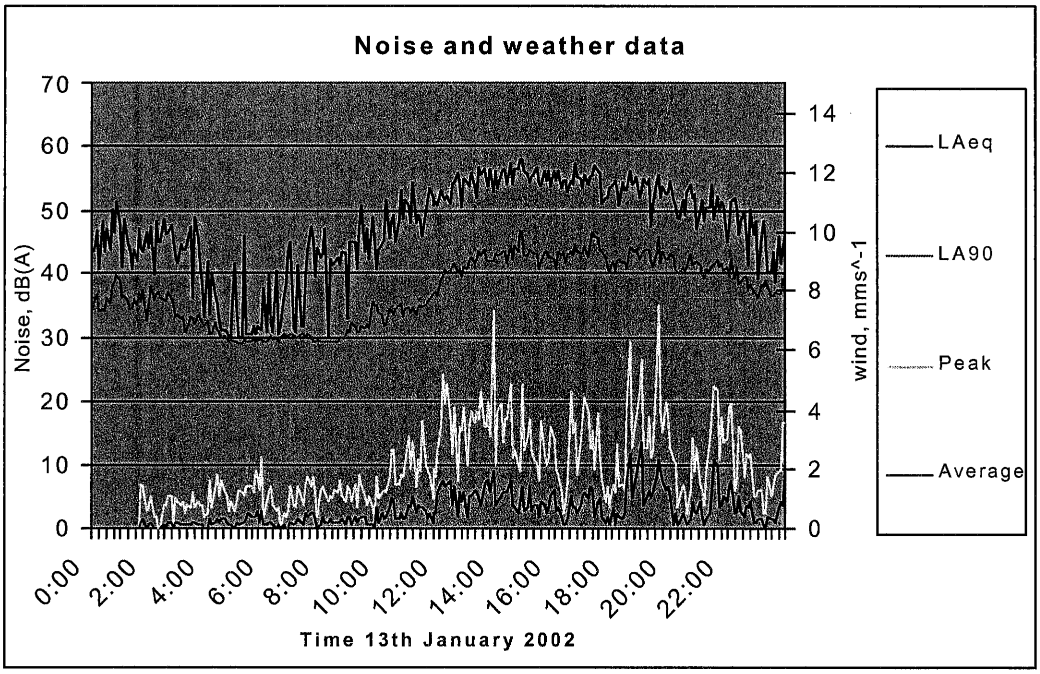

Figure 3
Wind noise masked by day levels

during the day and the much higher noise levels that are present during the day mask the resulting wind induced noise.

A further analysis was made were the noise levels for each 5 minute period throughout the day were classified as being wind below 3 mms^{-1} or above 5 mms^{-1} and then the results of each set averaged. The results of this analysis is shown in figure 4; the gaps in the higher wind levels are due to the fact that at that time of day there were no occurrences of high wind levels during the 20 day monitor period. For the time periods where data is available it clearly shows that the average levels are higher when the wind is above 5 mms^{-1}.

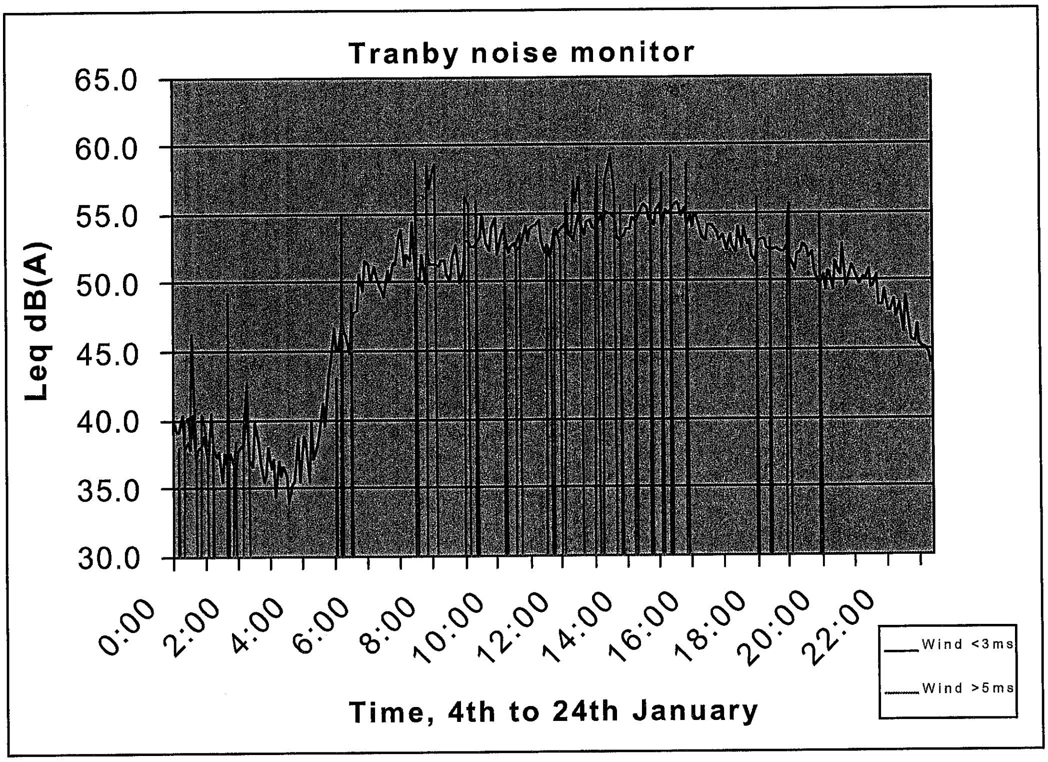

Figure 4
Effect of high wind levels on foreground noise measurements

3.2 Effect of wind on the propagation of background noise levels

The investigation of the effect on the driver of the background noise level at the monitor site was the wind direction; having previously seen that high wind noise does not have a significant effect on the $L_{90,5min}$ value. The wind was only above the limit value of 3mms^{-1} for 14% of the test period hence there was a good opportunity to establish the $L_{90,5min}$ value in calm conditions but only a short period against which the wind biased levels could be determined. When there was a significant wind fortunately it was coming from the southeast and hence should have had the effect of increasing the noise levels at the location; the wind rose for the 20-day period is shown as figure 5. Again all the individual 5-minute values were classified as either still wind conditions or in 45^{o} segments depending on the direction of the wind; it was only in the southerly segments that there was sufficient data to draw any conclusions. All the results for each 5-minute period in the wind segments from 137 to 225 degrees were averaged, as were those in the still wind category. This allowed the average noise levels for still conditions and wind favourable for the propagation of background noise levels to be compared. The results of this analysis are shown in figure 6 and again indicate that the background levels are on average higher when there is a positive wind component against the no wind condition. Further work is needed to verify that this is due to the effect of wind direction bending the noise from the motorway and city to the measurement site. When more data is available it should be possible to show the effects of northerly winds that should have the effect of reducing the background noise level.

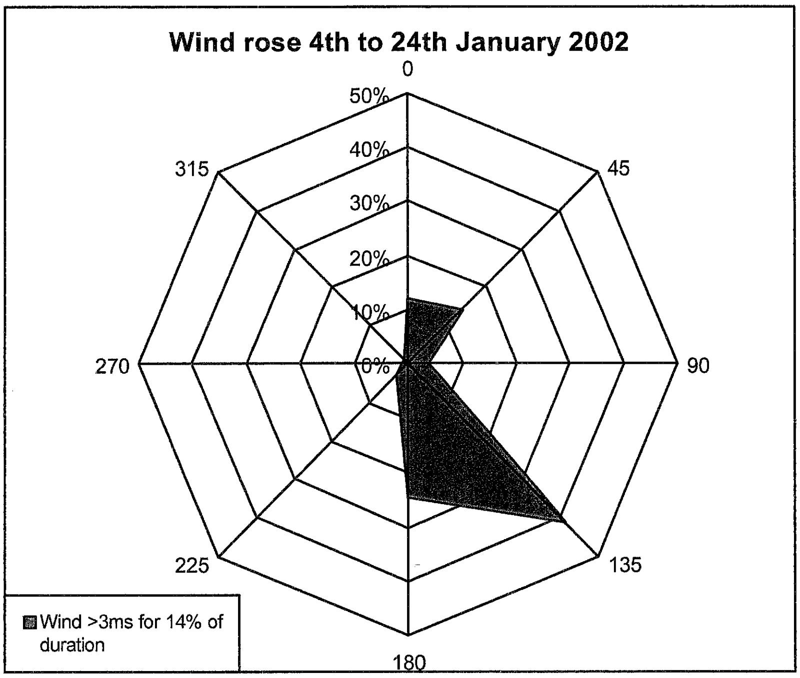

Figure 5
Wind rose

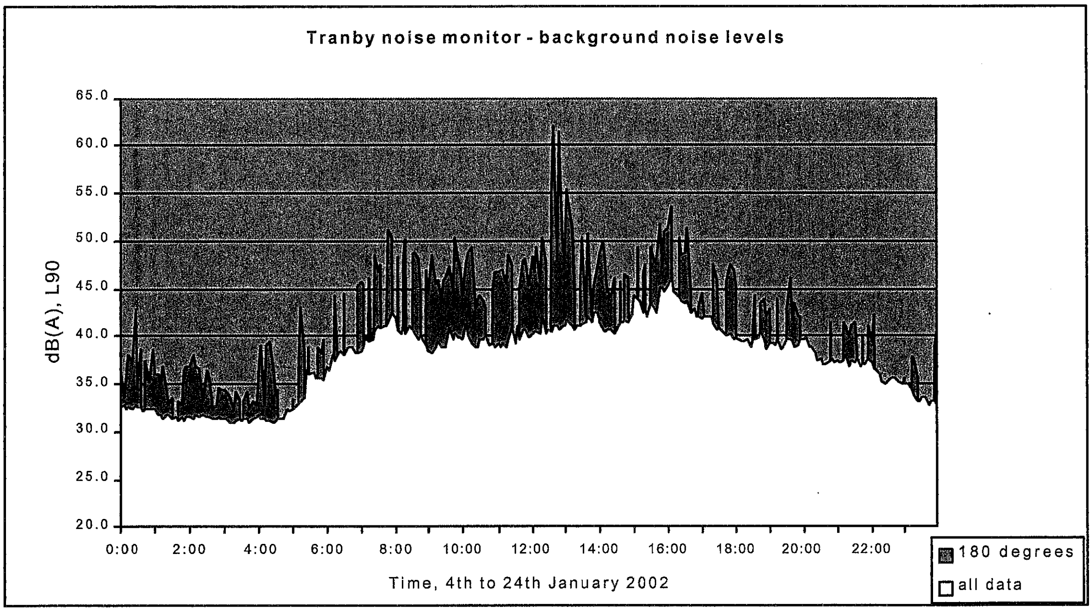

Figure 6
Effects of a wind condition favourable for the propagation
of background noise levels

4 CONCLUSIONS

It has been possible to show that a standard weather station may be integrated into a normal portable environmental noise analyser and that this can provide data in a format that allows the effect of meteorological conditions on noise measurements to be determined in real time. Differences of several dB in the $L_{eq,t}$ values due to weather induced artefacts as well as a similar difference in background $L_{90,t}$ values have been detected in a short test measurement. The impact of this data on standard procedures such as BS-4142 tests need to be considered as an important part of the uncertainty assessment. Similarly when measurements are made to verify computer based noise maps the actual meteorological conditions that existed at the time the measurements were made will need to be corrected to the standardised assumptions that apply to these computer generated noise maps.

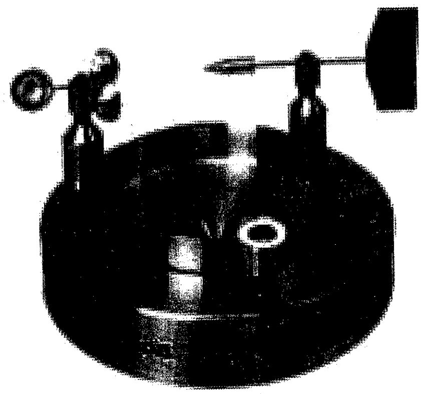

Figure 6
Reinhardt MSW9 Weather Station that has been integrated into the Nor-121 Environmental Noise Analyser