Proceedings of the Institute of Acoustics

Remote monitoring made less remote

C.P. Stollery MIOA and A.D. Wallis MIOA
Cirrus Research Ltd. Acoustic House, Hunmanby, North Yorkshire.

1 Introduction

This paper aims to show how Cirrus Research has approached the problems of remote monitoring by considering the design of its' instrumentation. These problems have been tackled in several ways:

1. By considering what the instrument is measuring.
2. By considering how the instrumentation is physically designed.
3. By implementing features that have little to do with noise monitoring and more to do with monitoring the noise monitor!

2 The problems associated with remote monitoring

The world of remote noise monitoring is fraught with danger and insecurity. Who would take expensive equipment, sit it down next to the road side, and leave it unattended for days upon end, and then come back and not only expect it to have done exactly what they asked but to even be still there! It is similar to taking a small child, putting them in the middle of a field, and saying wait there and tell me what happens, I'll be back tomorrow.
The days of an acoustician sitting by the road side with a hand held sound level meter, a note book and a pen are long gone, fortunately for acousticians. The problems though are numerous and still remain.

Setting up the instrumentation. Most instrumentation has a reputation for being difficult to setup. Difficulty inevitably results in mistakes which are not discovered until the end of a measurement period and then require the measurement to be taken again.

Instrumentation consumables. These are the questions you ask yourself when you set the instrument up. Is there enough battery power to last the measurement period? Is there enough paper tape to last the measurement session? The operator can make educated guesses to these questions, but the thing that actually knows the answer, the instrument, invariably keeps quiet about it.

Instrument failure. Using the example above, you might have enough paper tape for the measurement session, but it may jam in the system such that when you return you find you have summarised all your readings onto one line of the paper and consequently it's unreadable. Else the whole instrument may just stop working for no apparent reason.

Portability. Acousticians are not muscle men or octopi! In the past units have been heavy and bulky, usually consisting of many different parts.

Strange results. Most noise monitors produce a summarised report of measurements taken over a long period. If strange results are obtained then you have no knowledge of what caused it. Instrument failure? Or just an interested bystander whistling into the microphone? When the operators were present on site they could listen to what was going on and make note of anything strange.

Security. Will the instrumentation still be there when you return to pick it up or will someone have vandalised it. Noise monitoring usually takes place where people live or work and people take a lot of interest in strange looking boxes tied to lamp posts. Noise monitoring outside factories suffers a similar fate. Factory managers think that no measurements means no noise problem. Instant noise control, damage the noise monitor!

These problems are annoying enough, but what is even more annoying is to come back to instrumentation, find a problem, and have no indication of what caused the problem. For example, assume we return to a remote monitoring site to download information. A quick examination of the results show that everything was ok except for one hour in the middle of the night when the noise level appeared to be constant. This could be microphone failure so the operator replaces the microphone. In actual fact the problem was due to a cloud burst which soaked the microphone connector and shorted the mic signal. The operator replaced the expensive microphone when all he should 've done was put the instrument in a plastic bag!

3 Measurement considerations

3.1 The CRL 236 series and Short Leq

The CRL 236 series of hand held integrating sound level meters has led the world in the technique of short Leq measurement. Leq readings are taken over a short period e.g. 1 second, and stored every second, building up a time history in the instruments memory which can be downloaded to a computer for display. Further processing of the short Leq values enables the user to calculate any acoustical parameter except the peak value of the noise from the original short Leq raw data. This is a powerful technique as measurements taken at one session can be processed so they may be compared to existing measurements that may in a different for such as Ln or Ldn values.

Although hand-held, the instrument may be put in a waterproof box and connected to an outdoor microphone for remote monitoring purposes. Setting up problems have been eliminated as once the instrument is calibrated the user presses a button to start storing data. There are no measurement periods or types to set up and so less to go wrong.

Once the raw data has been downloaded to a computer it can then be summarised into a report format keeping the raw data intact which can be analysed further to identify any strange values that occur within a table.

For example, Table I shows a summary of statistical values calculated every 2 minutes, from a short Leq session using a CRL 236. A close look at the data shows up a possible problem at 17:28 as the L1 is the same as the L10 which is uncharacteristically high at 94.0 dB.

If this summary had been produced by the instrument as its only output, then we would not be able to identify what had caused this problem. By looking at the short Leq time history in Figure 1 we can clearly see a problem between 17:29 and 17:30. In this case we can identify this as probably someone placing a calibrator at 94.0 dB on the microphone.

Further, we can now code this block of bogus data and remove it from calculations, effectively removing the problem from the measurements.

Terminal 4 Leq elem..: 0.125 s dBA
from 17h 24mn20s
until 17h 44mn20s Tue 21-06-1988

period	Leq	L1	L10	L50	L95
17h 24mn	79.0	91.9	81.7	66.4	60.9
17h 26mn	63.2	71.6	66.7	60.4	58.1
17h 28mn	91.0	94.0	94.0	83.2	63.6
17h 30mn	65.4	76.1	66.9	61.8	59.4
17h 32mn	62.0	66.3	64.0	61.5	58.9
17h 34mn	67.5	77.9	72.0	61.1	57.1
17h 36mn	73.5	85.4	77.4	60.1	57.1
17h 38mn	63.3	70.1	66.4	61.6	58.5
17h 40mn	61.7	65.1	63.3	61.4	59.5
17h 42mn	67.5	76.5	71.6	63.7	58.9
overall			81.4 dBA		

Table I Statistical values calculated from short Leq

Obviously this technique is very powerful for sorting out erroneous data that would otherwise be missed by other noise monitoring systems.

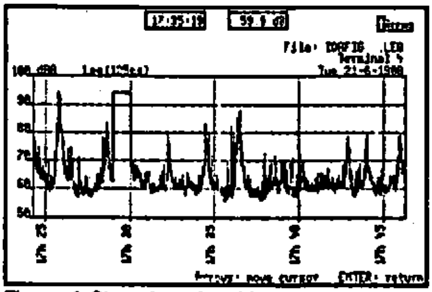

Figure 1 Short Leq time history

3.2 The CRL 700 series

One of the drawbacks of the above system is that there is little data available immediately on site to tell the user whether he has recorded what he wants. This is where an on site report or summary is useful. The CRL 700 series of instruments will produce a summary report for immediate on site analysis. In addition the short Leq data is recorded in parallel so that it may cross referenced as above in the event of problems. This instrument would seem to be the best of both worlds. An example output is shown in Table II.

3.3 The CRL 243 noise monitoring terminals

Whilst the instruments mentioned above were designed as hand held sound level meters, they lend themselves particularly well to remote monitoring when suitably protected in a waterproof enclosure. The CRL 243 series of noise monitors were designed from the outset to be used as semi-permanent noise monitoring terminals to be operated entirely remotely if required, with

```
Cirrus Research Ltd
CRL 702   012961

Baud               9600          Calibration Due  8/8/91
Time Constant      Fast          Ln          Fast
Reset Time 13:57:22  8/12/90     Battery     Ok
Time Integrator      2.00 sec    # Events    4
                     Run         Stop   120.0 Thresh. Overload
Time                1:26:37      50:39    1:25:43      00:00 hr:min:sec

           Peak    Max    Min    Cal 1   Offset 1 Cal 2
Level      123.9   75.2   45.3    94.0 -  2.5       0 dB
Time       13:57  15:11  15:18   13:57            00:00 hr:min

Total      Start  Run Time   Leq  LEPd   SEL  L 10  L 90   Max   Min
           13:57   1:26:37  49.6  42.2  86.6  50.4  44.8  75.2  45.3
[
 Event     Start  Run Time   Leq  LEPd   SEL  L 10  L 90   Max   Min
   1       13:57     01:06  58.3  54.6  76.5  61.3  47.1  71.2  46.0
   2       13:58     32:54  49.5  37.9  82.3  48.1  44.8  75.2  45.4
   3       14:37     20:30  46.5  55.5  77.3  51.2  44.8  67.0  45.5
   4       15:04     32:06  50.0  38.3  82.8  50.6  44.7  75.2  45.3
]
```

Table II CRL 700 series example summary

the use of communication link such as radio or telephone. As these units can easily be hundreds of miles away from the operator, the problems of remote monitoring are exaggerated. During the design of these units much attention was paid to the problems outlined in section 2 above and facilities provided to ease the operators task.

The terminals measure short Leq and store weeks worth of one second Leq time history. This means that the raw Leq time history for the previous 7 days is always available for analysis described in section 3.1 if required.

In addition the terminals are capable of processing the short Leq data to calculate the actual exponential slow sound level response which has more commonly been used in the past. This means that the environmental measurements produced by the terminal can be compared with other environmental measurements taken in the past using sound level as the basis rather than Leq.

The terminals also store environmental summary reports as in the CRL 700 series. In addition they also have built in intelligent algorithms designed to recognise particular noise sources such as aircraft noise or blast noise. When such a source is recognised the monitor compiles a summary report for each event and stores it. This may then be cross referenced by the operator with the raw data store and the environmental report.

The measurements stored by the terminal are designed so that the operator has as much information available for as long as possible that would enable him to perform a full analysis and diagnosis of the noise climate. As mentioned previously the monitors also have a number of functions implemented that enables them to monitor the performance of the noise monitor itself. These are described below.

4 Instrumentation considerations

The CRL 243 series of noise monitors have been mechanically designed to withstand outdoor monitoring for a number of years at a time. This involves complete weatherproof enclosures. The outside enclosure is weatherproof to IP65 and opening the door reveals a number of smaller boxes sealed to IP66 which contain the noise monitoring electronics.

This idea of double sealing often seems overkill to a lot of people but there have been many cases of electronics simply rotting away cause it wasn't suitably protected. Often the door of the outer enclosure is left open by mistake, and the instrumentation is quickly rendered useless. The CRL 243 can operate, fully sealed, even with its outer door open and the enclosure full of water. Further if the door is left open for any reason, the monitor automatically alerts the operator of this fact so that he may take action.

The unit is capable of remote calibration at pre-defined times. When each calibration has been performed, future measurements are corrected by a calibration constant. This calibration constant along with the time of calibration is stored within the instrument as a record. Thus if the calibration constant begins to drift the operator may identify this as a possible problem.

The monitor is very choosy about when a calibration can take place. To avoid missing important event information, if the monitor is currently acquiring an identified event it delays calibration such that potential important acoustic information is not corrupted. The unit will also not allow calibration if the background noise level is within 10 dB of the expected calibration value. Exactly as would an acoustician calibrating the instrument by hand. Similarly calibration is aborted if during the calibration procedure the calibration signal varies by more than a preset amount. This could be an indication of either a malfunctioning calibrator or a sudden high noise level affecting the calibration.

Many sensors exist on the monitor to let the operator gain access to information other than the acoustic climate. These include mains voltage, battery voltage, microphone temperature, microphone humidity and power supply temperature. The instrument will automatically alarm the operator if any of these sensors approach a critical level, invalidating current measurements. Thus if the operator finds that the current level is 130 dB when clearly it cannot be, he can look at the alarm status of the monitor which may tell him that the microphone humidity is 100% and is therefore causing capsule problems.

Other alarms include, door open, and system reset. The unit also has a movement detection alarm which will alert the operator if the unit has blown over or even if someone picks up the unit and carries it away.

When the instrument suffers a mains failure it automatically reverts to battery operation. After a pre-defined time running off batteries the units will ask the operator if it can shutdown some of its more power hungry modules such as modems and microphone heaters. If this is done then the unit will use less power and therefore continue operating on batteries longer. As soon as mains power is restored the unit functions normally.

One of the more frustrating things about controlling a remote noise monitor is trying to relate a stream of changing noise level to a particular event. The noise monitoring terminal allows the operator to switch it into a mode where rather than modulated digital data being sent down the communication link, the actual audio signal received by the microphone is sent. Thus the operator can call up a noise monitor, potentially at the other side of the world, and listen to the acoustic signal to see what is going on.

A good example of this function in use was when an operator noticed a marked increase in noise at a site 10 Km away. Rather than having to get in a car to visit the site he called up the terminal and set it into audio mode. He could clearly hear that the council had set up some roadworks next to the noise monitor.

Finally, one of the main fears of microprocessor based instrumentation nowadays is a system crash. This is where the unit just stops working and locks up for an unknown reason. Many people will be familiar with this happening on computers, the screen goes blank and you realise that you've just lost your entire document. In all current microprocessor instrumentation there is a nagging doubt that if you leave it unattended, when you return to it the instrument will have crashed.

The solution here may well be to produce instruments that have no bugs in them. A nice thought but a pipe dream. The next best thing is to have a system such that if a crash does occur, it recovers elegantly and continues doing its job.

The CRL 243 has what is called a watchdog system. This is a hardware device that monitors the instrument. If it stops doing a particular task, in this case, taking a 1 second Leq reading, the device resets the system. The unit then automatically resumes what it was doing and informs the operator that the system had crashed.

Thus in the event of a system crash the unit will automatically recover and continue doing its designated task.

5 Conclusion

The CRL 243 noise monitoring terminal has been designed to help reduce the problems associated with remote monitoring on three counts.

1. By measuring a combination of summarised data, raw data, and identified data, the operator has at hand all the information required to produce other measurements and diagnose possible problems.

2. By reporting and self-diagnosing problems the unit alleviates many of the mysterious happenings that can apparently occur during a remote monitoring session.

3. By making sure the instrumentation is suitably protected environmentally and warning if this protection is violated.

4. By recovering from system crashes elegantly, no data is lost and the unit continues as if nothing had happened.

6 Other relevant papers

1. R.W. Krug, "A software configurable measurement system", Proc. Internoise Dec 1991.

2. A.D. Wallis R.W. Krug, "The Sydney & Brisbane Noise Terminals", Proc. Westprac Dec 1991.

3. C.P. Stollery, "Aircraft event detection algorithms implemented in a simple microprocessor", Proc. Internoise 1991.

4. Wallis A. & Luquet P. "Noise control applications of Short Leq" Proc. Internoise, Munich Germany. AUG 1985.

5. Holding J.M. "A comparison of different methods of computing the statistical indices" Proc. Internoise, Newport beach California. Dec 1989.