The Development of a Noise and Weather Monitoring System using the Cellular Network

[1]Neil Jepsen and [2]Damian Ellerton

[1]Jepsen Acoustics & Electronics Ltd. 22 Domain Street, Palmerston North. www.noiseandweather.co.nz

[2]Marshall Day Acoustics. PO Box 8335, New Plymouth. Damian.ellerton@marshallday.co.nz

Abstract

This paper describes some of the technical and other issues encountered in developing a noise and weather monitoring station. A System of 31 stations has been developed capable of measuring and reporting 1 second L_{Aeq}, L_{A50}, L_{A90}, L_{A95}, L_{Amax}, L_{Amin} and one third octave band data, in real time, to a web server. Fifty SMS commands allow such things as remote calibration, noise alarms, and real time audio recording. The owner/ operator can ring a logger at any time and listen to the site microphone, and the server can be programmed to record audio when noise exceeds alarm limits.

Orginally published at the 22nd Biennial Conference of the Acoustical Society of New Zealand, November 2014

1. Introduction

This all started in about 2004 when an oil exploration company requested supply of telemetered noise and weather data from two sites in New Plymouth. Early equipment used UHF radio and was quite successful, but was later replaced in 2013 with the internet based system that is the subject of this paper. Hard on the heels of this radio system, Marshall Day Acoustics in New Plymouth asked if we could develop a semi-portable logger for simultaneously monitoring noise and weather in the New Plymouth region, and that's how the current project got started.

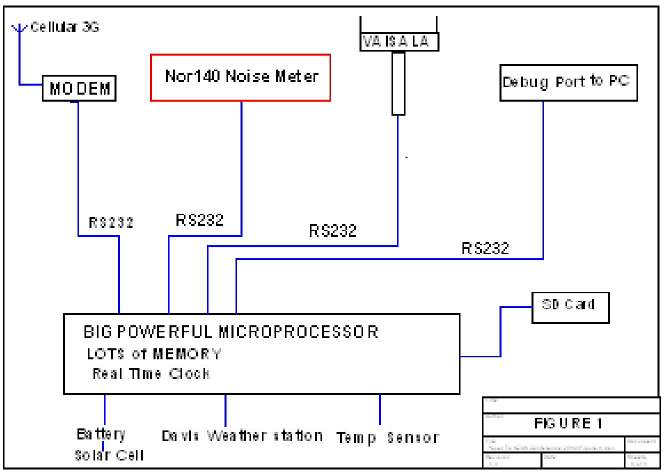

Figure 1

2. Data Collection

Collecting noise data from a sound level meter (SLM) is not all that difficult. Most SLMs will store the data collected and make it available at the serial or USB port for download to a PC, although unfortunately, none of the manufacturers have agreed on a standard set of commands or download format.

The Norsonic class 1 Nor 140 SLM will respond to three letter serial port commands to do anything that can be selected from the keyboard, such as stopping and starting the meter, selecting the measure- ment period, weighting, resolution, third octaves, etc. Simple three letter commands will also instruct the meter to stream the Lx data, third octaves, 1 second L_{Aeq} and other data to the meter serial port, which can be connected to a microprocessor for storage and uploading on the internet. For example, 'UB0,900" will cause 900 sets of 1 second L_{Aeq} values in the format xx.y, to be streamed to the serial port. Lx values are requested separately one at a time. In essence, in a logger, the meter is set to a 15 minute recording period, as if doing a normal noise assessment. At the end of 15 minutes, the microcontroller stops the meter, downloads all of the 1 seccond data and stats from the previous 15 minute period, and restarts the meter.

Once this process was mastered, a microprocessor board was developed that would interface to the serial port of the meter, the serial port of a Vaisala weather station, the data port of a Davis weather station, and the serial port of a cellular modem. The board also had a 4th serial port for debug purposes to a PC. (Figure 1.)

3. How it Works

When the unit is first powered up, the modem contacts the server via the cellular 3G network and the internet and gets the time in GMT from the server. The processor converts GMT to local time (including DST). The internal RTC is set to local time at this point. The processor then starts the SLM for a 15 minute measurement period.

During the next 15 minutes, the processor continuously looks for incoming phone calls and texts, and averages things like weather, battery and temperature. At the end of the 15 minute period, the processor stops the meter, downloads the noise data to its memory, and restarts the meter – all of which takes 15 seconds so 15 seconds is lost from the beginning of the next measurement period.

At this point, two copies of the date and time-stamped data are saved to the local SD card, and the unit then attempts to connect to the server via the cellular radio network and the internet. If the connection is successful, then a copy of the noise and the weather data together with the date and time it was collected, is sent to the server in Palmerston North. If the upload is successful, a message back from the server instructs the processor to delete one copy from the SD card.

If an upload is unsuccessful, the SD card data is retained until a future data upload is successful. About 5 years of data can be stored on a single SD card.

4. First Hiccup

In the early days, company ******* was used as the cell provider. The processor board code was written in- house, but the modem code was contracted out to a Wellington software house. At that time, most of the intelligence was in the modem not the processor, and the modem was responsible for doing all of the communications with the website, getting the time from a web server and managing data flow from the processor board to the web site. Naively the word of the cellular provider - that data communications would be reliable and trustworthy - was taken at face value. It wasn't. Almost every night, the provider would shut down the link at around 1 am for maintenance, or worse, disconnect it entirely without warning or explanation.

At that time, noise data was streamed from the noise meter to the modem without intervening storage, so of course an outage on the cellular data network resulted a hole in the data. Unfortunately at about the same time the Wellington programming experts began having troubles of their own, and their code solutions were not really up to the task, so they were replaced by another larger more expensive Wellington company. Modem software cost alone to date was $ 9000.

However, fortunately before the second replacement started work and incurred further software spend, they were taken over and new policies dictated that outside work was to be discontinued. Development once again was stalled – but it could have been worse.

This was November 18 2010. On that date, it was decided that all software must be written in house in order to maintain control. A new processor was selected, a new board layouts done and four months invested in writing new code (this time in house) for a new modem on the telecom network. This work was completed on 20th of February 2011 and took over 500 man- hours.

5. Realtime Clock - Hiccups 2

It is imperative of course that the date and time of data collection is maintained correctly and accurately. Initially data was stamped with UTC, which is 12 hours behind NZ local time. In some ways this is a better approach in that stations anywhere in the world are all on the 'same page', and there is no daylight savings to take into account.

Initially, the modem collected UTC from a US based time server in Colorado, which worked well until the US Government 3 years ago for fiscal reasons, decided to no longer fund US based world time servers. This was catastrophic because it potentially affected each remote logger, some of which were hundreds of km away and it was not a simple matter to reprogram them. (At that time, remote firmware updates were not possible). Fortunately it was realised that the Palmerston North Inspire server (where the data is stored and the web site is hosted), and all other HTTP servers for that matter, returns GMT after very HTTP transaction so this was read this every 15 minutes, and the local RTC kept GMT. However it's very inconvenient to need to remember that this morning's data is date and time stamped with yesterday's date, but this afternoons date is correct but the time is 12 hours behind, but if it is summer, then the time will be 13 hours behind. After mental gymnastics on a daily basis while doing devel- opment and troubleshooting, it was decided that local time would suit everyone better; now GMT from the server is converted to local time every time the server is contacted, and the logger RTC checked and kept in sync with local time. Even though the logger RTC can maintain time to within a few seconds a month, check- ing the server time every 15 minutes assures perfect time keeping.

Incidentally, the algorithm that decides if the time is summer or winter time is not easy, as DST does not stop and start on a fixed date in New Zealand - it changes on the first Sunday in April and the last Sunday in September, which are on different dates, and may even be in different weeks, each year.

6. SMS Command - Hiccups 3

Because the cellular network is used for communicating with the remote loggers, it is relatively simple to program SMS commands. There are about 50 SMS commands, which allow SMS control of many logger functions from a cellphone. For example:

- Remote calibration check
- Calibration adjust
- Time check of the RTC
- Battery check
- Reset meter
- Reset modem
- Turn noise alarms on and off

- Read cellular signal strength
- Read meter serial number
- Bootload new firmware
- Whoru

The SMS initiated calibration check initiates a known 1 kHz signal to the microphone input on the preamplifier, which generates an output of 92 dB. The level that the meter sees is reported back to the user by text message, and should be the same as previous tests. It is also graphed on the server page. This is a check of the preamplifier, meter, cables and telemetry, and web site display. It will detect serious microphone damage, but only if the damage loads the injected signal voltage.

As in any electronic system software developments are continuous, and it is essential that firmware in the remote loggers is easily changed. Initially, this could only be done by swapping the SD card at the logger, but now, new code can be put up onto the web server followed by a coded SMS to the remote station telling it to download the new firmware (operating code) from the server.

Every SMS to the logger generates a reply to the sender. If the sender makes spelling mistake or sends an invalid command, a response is texted back saying:

> " I'm sorry 027* *** ***, I don't understand that command. Please try again"

In hind sight that may have been a mistake: In 2013, a logger at Pahiatua was playing up, requiring a service call. Plugging a laptop into the debug port at the logger site revealed a message from telecom:

> "Welcome to telecom. To connect to the internet ensure your APN is ....blah blah blah blah blah....",

to which the logger replied:

> "I'm sorry 4227. I do not understand. Please try again".

This had been going on for about two days, and blocked the 3G channel. Telecom (Spark) do not send these unsolicited text messages to our loggers any more.

The "whoru" text is useful in quickly checking if everything is alive and well, and the response includes ID, battery volts, sim serial number and site name.

7. SMS and Email Alarms

The logger will send an email to up to eight (8) email addresses whenever the unit powers up for the first time, or whenever predetermined noise alarm limits are exceeded. All SMS commands to the logger also elicit a text response to the sender.

8. Listen-in Feature

An unattended noise logger has the major disadvantage that attributing noise to particular source can be very difficult. Shape, duration and level of 1 second L_{Aeq} profiles can be used to ID some sources such as aircraft and traffic [1,2,4]. At major airports radar information is also collected for ID purposes [3]. However for most other noise monitoring, audio recording of the source is the ultimate. Unfortunately audio files are too large and expensive to send via the cellular network, and compression to one of the many lossy formats is technically challenging with a non-specialized processor. To overcome this major downside, a new mode has been developed. A codec has been incorporated into each logger, allowing incoming calls to be picked up, in parallel with normal measurements.

Figure 2.

This makes it possible to ring a site from any telephone, and listen to the remote noise meter microphone from the comfort of the office for example- and to identify a noise source by actually listening to it.

A server app also allows the user to pre-program noise recordings several times a day, on the basis of either time of day, or noise level. With SMS, the user can program the logger to instruct the server to ring up the logger and record audio from the microphone.

The automated recording works on the premise that every 5 seconds, the logger looks at the L_{Aeq}, L_{A10} or L_{Amax} (user selectable). When a threshold is exceeded, the logger sends a message to the server saying

> "please record the noise at xxxx{site ID} for the next nn seconds".

The recording is date and time stamped and stored on the server for future analysis and use in identifying the source. The profile and stats curves are of course easily cross referenced to the recording.

There are two minor downsides to this method: currently there is no audio buffer in place so the recording is usually 10 – 20 seconds after the event, and secondly there is a small cost associated with the cellular phone calls. However, these minor problems are overshadowed by the huge advantage of being able to listen a unattended logger at anytime from anywhere.

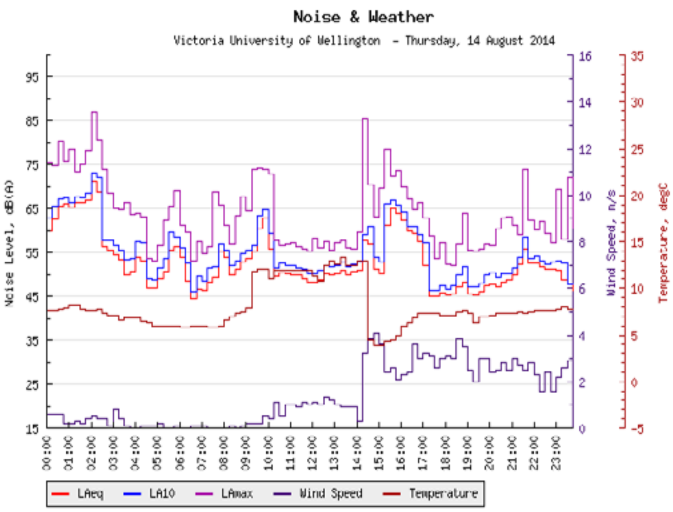

Figure 3

Figure 3 is the day of August 14 2014. At 2 pm, there was a lightning strike in Wellington, accompanied by the classic wind speed and direction shift of a thunderstorm. The L_{Amax} was over 85 dB; except for 5 am September 5, no other L_{Amax} event of this magnitude is seen in the months on either side of this event. The monitor is at Victoria University and the lightning strike destroyed the wind wand at Wellington airport.

9. Future Work

Currently, the loggers find their biggest use in monitoring noise from oil and gas exploration, motor racing, geohermal energy, and sea ports. Future work is aimed at improving audio recording for lower cost real-time recording. The possibility of producing lossy format low sample rate MP3 files at the logger site with a local codec is currently being developed.

Acknowledgements

Thanks to Marshall Day Acoustics, and in particular, Damian Ellerton, for their faith and patience with early developments and failures along the way. Thanks also to Hegley Acoustic Consultants, and Malcolm Hunt Associates for adopting the equipment for permanent loggers on behalf of their clients also.

References

1. Airport Noise: A study of the modelling of noise from light aircraft. Xavier Oh. 14th Biennial Conference of the New Zealand Acoustics Society. 1997
2. Advances in Aircaft Noise Event Characterization. K.Adams. Inter-noise 1998. Christchurch. New Zealand.
3. Realization of A Rotterdam Airport Noise Monitoring system (RANOMOS). M.J. Belien. Inter-noise 1998. Christchurch. New Zealand.
4. Development of an improved airport noise moni- toring system for Wellington Airport. M. Hunt. Inter-noise 1998. Christchurch. New Zealand.

Publication Dates and Deadlines

New Zealand Acoustics is published quarterly in March, June, September, and December.

The Deadline for material for inclusion in the journal is 1st of each publication month, although long articles should ideally be received at least 4 weeks prior to this.

Advertising

Enquiries regarding advertising are welcome. For a list of current prices and any further information please contact: advertising@acoustics.org.nz

Society Membership

Associate Membership of the Acoustical Society of New Zealand is open to anybody interested in acoustics. Members receive benefits including;

- Direct notification of upcoming local events
- Regular mailing of Noise News International
- Reduced charges for local and national Society events
- Priority space allocation for trade stands at society events
- Discounted rates on selected acoustic products

To join the society, visit www.acoustics.ac.nz or contact the Secretary; secretary@acoustics.org.nz