Options for Remote Data Acquisition and System Control

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ABSTRACT

This Paper outlines two current data transport systems used for remote data acquisition and controls systems at water and wastewater systems, briefly reviewing history and current systems and then focuses forward on consideration and comparison of traditional Very High Frequency (VHF) radio telemetry with cellular based systems.

Data collection is the area observed as being the area of fastest growth as plant owners endeavour to fulfill their obligations under their resource management agreements and government regulations by using increased plant flow monitoring and analytical instrumentation (turbidity for example).

Facility owners also seek to maximise plant value and utilization by logging pump well flows and operation periods as they monitor the adequacy of reticulation systems during such times as heavy rain events. Over time, the logged data represents a mine of information waiting to be sifted for data that quantifies historic plant and infrastructure performance (reticulation, pump stations etc) which assists in planning for upgrades or replacement, and increases the certainty of the information upon which any upgrade or extension is based.

Increased data loads challenge existing data transport systems; in particular, VHF radio telemetry, where the inherent radio bandwidth limitations are rapidly becoming a block to the increased data traffic associated with greater reporting requirements, and which severely limit future growth for such facilities as remote video observations of plant and security.

Cellular technology is providing a quantum leap in data transmission rates and allowing much more comprehensive facility monitoring, without expending large chunks of capital. What are the pros and cons of this technology? Will it supplant or just supplement the vast existing network of dedicated radio telemetry systems presently installed around the country? These existing VHF systems are generally well understood by those who install and service them and, dare we say, loved by existing facility operators, but have they had their day?

Switchbuild of Dunedin has grasped the advantages that the cellular system offers and applied it to some 50 waste and potable water pumping and storage facilities in the Central Otago area for the Central Otago District Council (CODC).

KEYWORDS

Telemetry, Cellular, VHF, Water Treatment Plant, Wastewater Treatment Plant, Pumping Station

1 INTRODUCTION

Consider the growth in the automation and data areas of plant monitoring and control. Much more data is now required for Resource Consent and government regulation reasons and this data will usually be logged from remote sites on to a base station computer automatically using telemetry of some description. Such parameters as flows, levels, dissolved oxygen, pump hours, number of starts / failures are routinely logged. This information represents a mine of information for anyone skilled with data base querying. Filtered information could be used to determine which pumps have given the best service over time for instance, or hours run vs faults and cost of repairs. This may be information that has been recorded elsewhere on the asset base tracking system Peak flow rates through a particular pipe section, as well as average flows for the same, pond levels following rainfall events etc can may also be extracted from logged data. These are obvious uses, but this

information only becomes available when system data has been logged over a long period, in many cases, years. Use of this stored information could help take a large part of the guess work out of future planning and expenditure.

Waste Solutions has seen this area of work as the fastest developing and changing area over the last 20 years. The rise in the amount of information required and available from field sites means that telemetry systems become an increasingly important tool in the management and coordination of remote site processes as well as archiving historical data for later review. The present radio telemetry systems have served us well, but there are limitations to this system that are becoming apparent as the quantity of data being moved around, rapidly increases.

2 A BIT OF HISTORY

By way of illustration of the general growth in data transmission capability, in 1991 Waste Solutions (A division of CPG New Zealand Ltd) set up a small automated pilot plant near Brisbane which we monitored and "sort-of" controlled from Dunedin, using the then latest dial-up modem; a 2400 baud Dataplex modem (NZ designed and developed). Connection was patchy, download times long enough to regularly lose the connection and control rather crude. We were not able to alter the way the plant operated other than to change a pump rate set point to one of 16 steps. Data download was very manual and labour intensive, although we could, at least, put the downloaded data straight in to 'Smartware', a DOS 3, multi-function, fore-runner to Excel and produce some useable graphs.

Photograph 1: Earliest WS remote monitored pilot plant set up outside Brisbane and monitored from Dunedin. Data Logger is the box on the left. The others contain an SLC500 PLC, VFD and other control equipment. It was not practical at the time to have both logger and PLC remote connected.

Waste Solutions currently have two operating waste-to-energy pilot plants in other countries; one in Tasmania and one in Holland, both accessible, programmable and controllable via the internet, something which was only in its infancy in 1991, and even then only in plain text. From these plants we reliably download data in to Excel for study by our process designers. The internet connection also allows considerable changes to be made to the way the plants operate and to what the local operators see and can access on the local Human Machine Interface (HMI); thus allowing us to ship the plants between centres without having to be on site to do any re-

programming that may be required for new feed stock, although we still like to visit them to check on mechanical aspects. We have not yet fitted pan and zoom cameras on robotic arms to allow us to examine faulty components; but something like this may soon be economic if the price and technology continue to move at the present rate.

Photograph 2: The most recent containerized pilot plant, from the front. Touch panel HMI visible near centre. Door on the right allows secure access to the control system and the rest of the plant. This plant is fully controllable via internet connection.

3 TELEMETRY CHANGES

Historically plants have required VHF or UHF (Ultra High Frequency) radio telemetry systems to link them to some central control or monitoring point for SCADA (Supervisory Control And Data Acquisition) use and data logging, or linking with pumping systems to allow control and data transfer to take place. This system has served well over the years but is rapidly approaching its limit in terms of the rate of data transfer and other capabilities such as remote Programmable Logic Controller (PLC) interrogation and programming.

In many situations where these systems are already set up and working well, and where there is no need to consider future expansion, these systems may chug along reliably as long as there are people to maintain them and there is interface software available to allow them to input data to the SCADA systems.

But what of future telemetry needs and how economic is the present VHF radio telemetry system compared with present cellular systems?

This triggers a whole new line of thinking regarding telemetry systems in terms of ownership costs, maintenance, installation, speed, flexibility, expandability, reliability, accountability and accessibility of cellular and present radio telemetry systems.

To answer some of these questions Waste Solutions sought the experience of Switchbuild personnel who will demonstrate during this session a live link-up to the Central Otago District Council (CODC) system which they

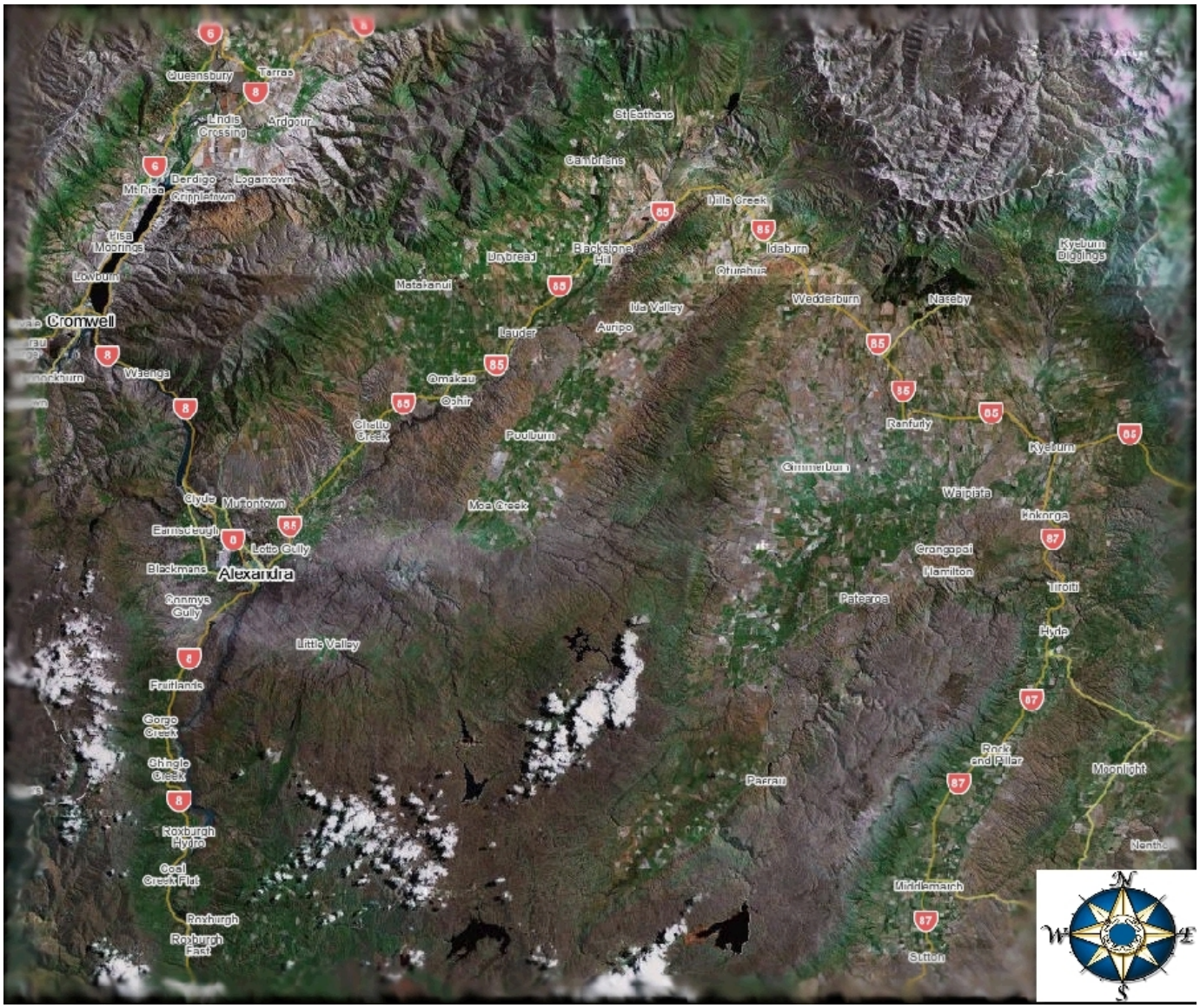
designed and commissioned, to link, monitor and control 50 separate sites around the Central Otago area and who will also answer any questions.

4 THE SWITCHBUILD SOLUTION

The requirement for real time and historic data from municipal field sites for consents and standards is increasing rapidly.

This was at the forefront of the Central Otago District Councils decision in 2006 when they decided to install their first telemetry/SCADA system. Up until that point, CODC were leasing 12 telephone lines at $540 per month just to allow 12 pumping stations to auto-dial an answering service which in turn called out service personnel. This does not include the cost of the answering service.

The CODC water and waste water sites are spread over 1,000,000 hectares, with several large mountainous ranges dissecting parts of the area. With over 50 water and waste water sites to be retrofitted, the real question was how were all these stations to be integrated?



Photograph 3: Central Otago area monitored sites covered by CODC telemetry

Fleetlink TMR is an established, privately owned, VHF network system operator system in the general area, but the service to all 50 CODC sites was not guaranteed and the lease costs were high enough to warrant investigating alternatives.

Existing communications networks using VHF radio are struggling to keep up with current data demands. This would be a concern when bad weather events increased the amount of data requiring transmission. The increased data load is caused by the fact that normally only data (levels, flows etc) that has changed since the last transmission is transmitted. However, during bad weather events, flows and levels may change frequently which results in more data having to be transmitted back to base. This can push existing systems to their limit and cause greatly increased data transmission errors and / or lost data as data is not stored at the sites, so is irretrievably lost if not transmitted almost immediately after it is generated.
The cost of maintaining and expanding these VHF networks in order to satisfy this requirement is expensive, time consuming and requires skilled installation and maintenance. At a time when the council is looking to reduce capital expenditure while still providing the required detailed data analysis as well as justification for existing plant, the requirement for high quality data has never been greater.

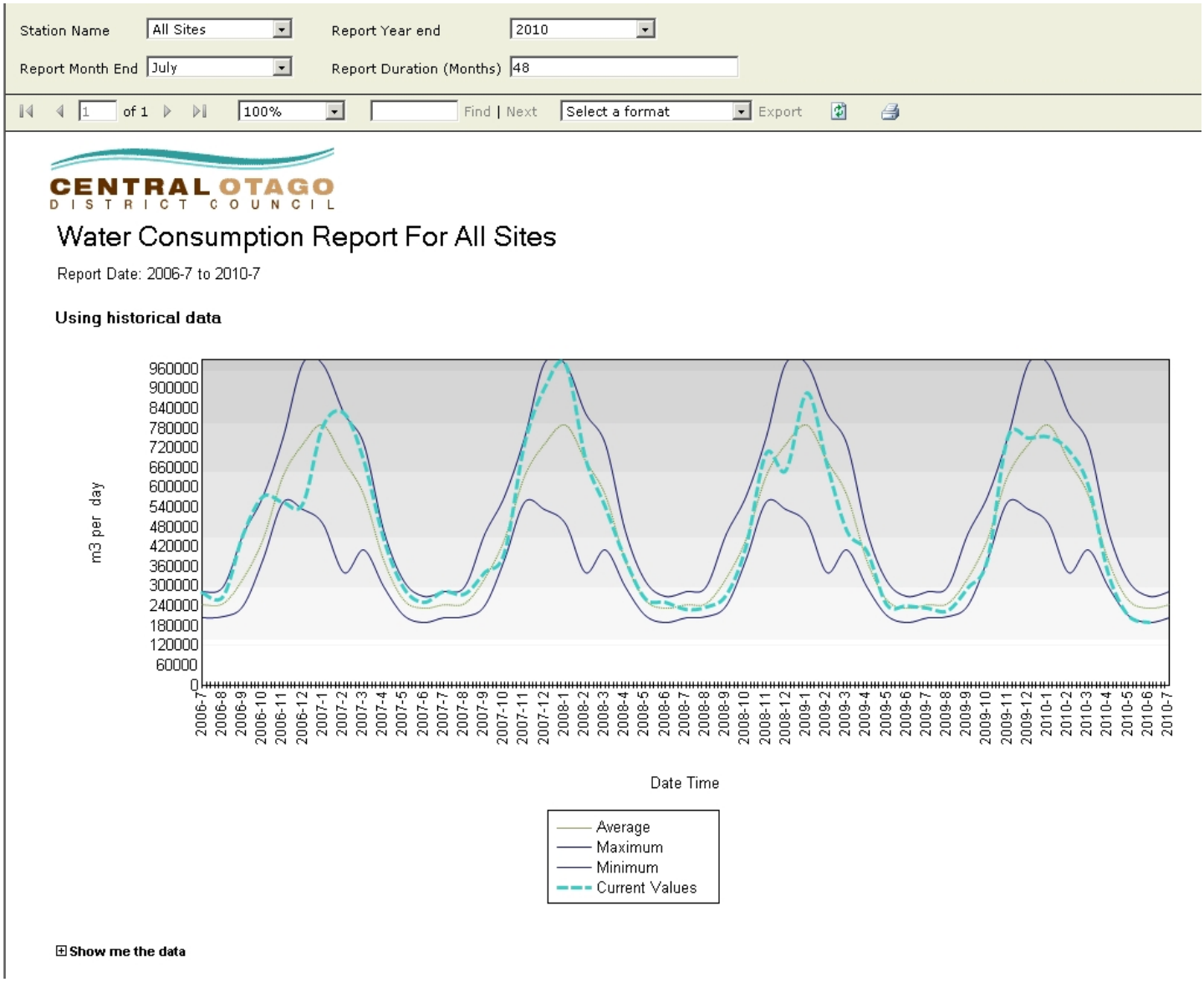
5 A CASE FOR CELLULAR

The use of cellular systems for telemetry data is not new. However, comparing the transportation of data over present cellular networks with their earlier counterparts, is akin to comparing a dial up modem on your home PC to fibre broadband, in cost, speed and performance.

Provided that standard cellular coverage exists, the facility of being able to transfer data from any field station saves a considerable amount of the time and money needed for surveying, field testing and the ongoing maintenance which is normally required of VHF systems.

The opportunity to bench test a new field site, anywhere in the country, prior to site installation is an added convenience and time saver, as is the ability for operators to gain access to the entire system from any location with cellular coverage, via a laptop equipped with a common cellular modem. This added ability to perform remote interrogation and control greatly reduces the support requirements from outsourced maintenance contractors. The concept of preventative maintenance becomes a reality when the operator has access to all the information available, where ever they are.

Being able to see asset and maintenance information for a pump whilst looking at a motor current trend graph for the last month that might be showing a gradual increase, could prompt the operator to start the standby pumping system until maintenance can be carried out on the duty pump on Monday morning, thus avoiding the early Sunday morning call out fees.



Photograph 4: Water consumption historical data recalled to screen from stored data and trends plotted

6 THE CONSIDERATIONS

The following is a table laying out various considerations for general point-to-point radio telemetry using both cellular and VHF / UHF radio systems.

Table 1: Comparison of VHF and Cellular telemetry features

	Cellular Radio Telemetry	**VHF Radio Telemetry**
1	Initial terminal installation set-up charge	Purchase and installation costs of all equipment
2	No licence fees	Annual licence fees, 1 per RTU, 1 for base station and 1 per repeater channel

	Cellular Radio Telemetry	VHF Radio Telemetry
3	Service of local unit only if / when required	All system servicing
4	Any link pathway upgrading is a Telco cost	Any upgrading is a client cost
5	Charge by data quantity transferred (in both directions)	No ongoing data transfer charges
6	No practical data amount limit	Limited by total amount of data that can be transmitted in polling time allowed.
7	Each "circuit" is individual and not subject to size-of-group limits, so general breakdown will not prevent or delay later recovery of all field stored data	Can be a serious bottleneck if field data stored during a transmission failure must be transmitted after a coms breakdown of any significant duration as polling time slot is limited which limits the amount of any stored data that can be transmitted at a time.
8	As above	Marginal transmission conditions can quickly clog system due to multiple attempts at data retransmissions crowding polling time slots
9	All link servicing taken care of by Telco.	Staff or contractors constantly on standby.
10	As a public utility, transmission failure response time generally very good. (revenue loss if not working, emergency services have a minimum requirement)	Repair of transmission failure at the mercy of a small pool of personnel familiar with the system, and their availability
11	Expansion easy where cell phone coverage exists, most new subdivisions are catered for with Telco paying for expansion	Expansion dependant on line-of-sight to base or to suitable repeaters, repeaters requiring resource consent, lease agreements etc
12	Expansion very quick and easy as only field terminal unit required	Expansion may take considerable engineering services to reliably establish radio path.
13	Antenna system very small and discreet. Easily hidden, increasing protection from vandalism etc	Antennas generally larger to much larger (Yagis at fringe reception areas), more visible and a greater vandal target
14	Connection to field PLC for programming possible without interrupting access to other field terminals	Connection to field PLC possible but at the cost of loss of contact with other RTUs on the same channel for the duration of the programming period.
15	Remote access to local Ethernet at field site for local HMI, PLC, PC etc possible due to higher data transmission rate	Remote access to local Ethernet (LAN) not really practical due to much lower data rate and polling requirements
15	Equivalent of 1000s of channels of radio available constantly, no one site is on 'the same' radio channel	Sites must be set up to use a single radio channel only, and co - share with all other radio channel users (other sites)
17	If local connect cellular tower fails, units connect to next available tower seamlessly	Radio repeater fails, ALL connected sites are disconnected until repeater is repaired

	Cellular Radio Telemetry	VHF Radio Telemetry
18	Telco have many technicians/resources available	limited to local knowledge
19	Local support required to 'somebody who knows something'	Can ring local contractor who has knowledge of setup
20	Large quantities of data can be moved with no impact on other sites	Large quantities of data hold up entire network
21	Real time monitoring of any site, without impact on other sites	Other sites must wait to use single radio channel whilst real time monitoring occurs of a site
22	All sites available for 24/7 bi directional data	All sites available for 24/7 bi directional data, provided radio channel is free
23	Network status can be monitored	Network status is only known on failure
24	Radio signal strength can be monitored and reported	Signal strength is manually tested at installation time.
25	Field sites can communicate with each other, via the base (or with each other where technology allows)	Field sites can communicate with each other if in same radio group.
26	No issues with peak demand times (i.e., bad weather events)	Radio channel can become clogged at critical times (bad weather) bringing back 'change of state' information
27	Large amounts of data can be stored on site, and transferred without upsetting network	Minimal data storage and retrieval due to radio bandwidth limitations (holding up the single radio channel bringing back data from one site, other sites not able to send information such as change of state)
28	All sites can be contacted simultaneously	Single site communications possible only, unless multiple radio channels in operation
29	Existing Telco provider can leverage costs with existing systems	New money must be put directly into development
30	Data is secure once at the cellular tower, and does not have to use public domains i.e., the internet, instead using private lans with Telco to base	Data is accessible to anyone, and also interruptible by anyone with a radio transmitter on same frequency
31	Data cost is directly calculable per site, per month	Cost is approximated, many numbers and costs are unknown
32	Networks continue to develop, with increases in speed, performance and reliability.	Network stays at same level, extra performance is payable by the principal and must be implemented across entire network
33	Standard Data services can be employed, meaning existing IT staff can help diagnose and maintain systems	Specialised datagram's used requiring software/skills to decode and use
34	Cost of ownership with Telco	Cost of ownership with client

7 FREQUENTLY ASKED QUESTIONS

Q: Does a cellular modem make a phone call to transmit data?

A: No, the modem maintains a permanent data connection to the network and sends and receives packets of data when required.

Q: Is it billed like a phone call i.e. per minute?

A: No, only the data that passes through the connection is charged for plus a flat monthly rate.

Q: How often does the cellular modem have to connect?

A: The modem is always connected; periodically it is disconnected for billing purposes and immediately reconnected (typically 2-3 seconds downtime). This does not usually disrupt plant operation.

Q: What is the reliability of the connection like?

A: We have found it to be in excess of 99.8% connected.

Q: I don't think the internet is safe, how safe are these connections?

A: We use secure layer 2 VLANS (virtual local area network). Virtual switched layers are as safe as the private network in your office. The only place the data can be intercepted is in the field between the cellular tower and the cellular modem. Encryption can be applied if necessary.

Q: How much does it cost?

A: How much data do you want to send, and how often? A two pump pumpstation with analogue level sending event logs to the base station once per hour consisting of level in 0.5% increments and pump status (stops/starts faults etc) equates to around $2-$3 dollars of data PER MONTH, plus the fixed connection charge.

The ability to leverage existing telecommunication infrastructure against the new telemetry charges is a point of negotiation with the existing telecommunications provider (Telecom, Vodafone etc). Existing contracts for company phones, broad band and data can help offset new telemetry charges. Most Telco's are happy to negotiate as a successful negotiation provides them with a further revenue stream and increases client loyalty. The total cost of network ownership is moved from the client to a third party, along with all maintenance and upgrade considerations and costs. The income of a Telecommunications company is directly affected by performance and competitiveness in the market place. This is not necessarily the case with a captive, dedicated VHF network system.

The recent public outcry over the outages of Telecom's XT network highlights our dependency/addiction to this technology and our expectations about its reliability. If a VHF network was down for two or three days, that would be frustrating for the client, with the consequences ranging from annoyance to medium plant operation disruption, but it is nowhere near matching the withering complaints that a cellular operator may be subjected to

if your son/daughter suffered by not being able to send or receive text messages between their mates. The cellular system is driven by demand. It is repaired, maintained and serviced (by others) accordingly. Maintaining connectivity is paramount to their business success.

8 CONCLUSIONS

The march of technology now allows more choice in the means used to transport data from the field to a base station. Cellular systems allow more data to be moved faster with less of the limitation inherent in the present VHF systems. The main limitation to cellular use is coverage which may not reach all required field locations.