Economic Issues Regarding LINZ Conversion of its Precision Reference Network to Real Time Status

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Executive Summary

Background

Land Information New Zealand's (LINZ) currently owns a network of Continuously Operating Reference Stations (CORS) and uses this network together with access to a network owned by EQC, both operated by GNS Science to monitor and manage New Zealand's "semi-dynamic datum".

It has the opportunity to bring its network up to Real Time status providing for LINZ own purposes 1 to 3 cm positional accuracy with 1 second latency which will benefit not just its own business but also that of EQC as well as providing a network that could efficiently service a wider third party commercial market.

The Real Time CORS upgrade

The potential benefits for Real Time positional technology in New Zealand are substantial, estimated to total several tens of millions of dollars over the next decade.

The cost of LINZ current network of 33 stations was about $2 million in capital and has an annual operating cost of $250,000. Against this the cost of an upgrade of the LINZ network is:

- $50,000 in additional capital;
- Approximately $30,000 to $40,000 to bring forward the replacement of $300,000 worth of communication and receiver hardware; and
- An additional $10,000 in annual operating expenditure.

As such the upgrade represents an increase of around 4% on present operations .

The principal benefit from the LINZ network upgrade outside of its own use would be in reducing the need for third party commercial users to provide their own Real Time CORS stations at or near the same locations. The national economic benefit from avoiding this duplication of most of the present network resources is expected to exceed the costs of the upgrade in the ratio of twenty to one (ie the project has a B/C ratio of 20:1).

Charging for Real Time data

The present LINZ and EQC network data is made available to all parties (including third party users) by the operator GNS Science free of charge.

While the Real Time data can be segregated and charged for it has many of the features of a public good as the marginal cost of providing the data to additional customers is zero.

Introducing charges into the GNS Science operation would also bring complexities as it jointly manages both the LINZ and EQC networks on a no charge basis and it would have to be contracted to separate both the LINZ data and the customers to whom it is provided. At present data is provided to third parties on the basis that the supplier is not held accountable for errors or outages and neither LINZ nor EQC would want to raise the operational standards above their current contract levels.

Another consideration is the size of the upgrade. The incremental cost of the upgrade represents only 4% of the cost of LINZ CORS business and as such it does not warrant special one off pricing treatment when the base service is provided free of charge. It is best to consider the third party use of the Real Time upgrade as facilitating the use of the technology into wider markets with notional efficiency benefits.

Indications are that the industry is competitive and growing and that as a result the provision of LINZ network free of charge (the EQC network is to be provided free of charge) is unlikely to lead to third party capture of any capital benefits from Crown provided facilities.

Conclusion

In this environment the upgrade should proceed taking into account the needs of the third party commercial market so as to avoid duplication of LINZ stations and the Real Time data from the LINZ stations should be made available to all-comers free of charge.

Economic Issues Regarding LINZ Conversion of its Precision Reference Network to Real Time Status

1. Introduction

This paper considers the economic benefits that can be expected to arise from the upgrading of Land Information New Zealand's (LINZ) network of Continuously Operating Reference Stations (CORS) to Real Time status and the costs of making that network available to the wider market.

The paper also considers the appropriateness of cost recovery for live stream or "Real Time" data from an upgraded network.

In preparing this report we have read widely on overseas experience and in particular on proposals in Australia for the development of government owned real time networks. We have also had discussions with the major operators in the current industry and with several users. A list is included at the end of the report.

While much of the information is helpful the situation that LINZ finds itself in is rather different to that contemplated in other jurisdictions. LINZ owns part of the current NZ CORS network with operational management in the hands of GNS Science (GNS) who also manage the GeoNet network for the Earthquake Commission (EQC) (a network that has three times the number of stations of the LINZ network), while there are also third party strategically located commercial stations. The LINZ and EQC networks are to a very high standard, the stations being grounded in bedrock, while third party stations are located and of a standard more in line with the needs of particular commercial uses. Currently both EQC and LINZ make their data available to each other and to third parties to the extent that there is demand for such data, free of charge, with EQC doing so under its legislated science role.

The GeoNet network is being upgraded progressively to Real Time status as communication system improvements become available. EQC intends continuing to make the data from its real time upgrade available free to all users.

The third party commercially located stations are invariably at Real Time status.

In this environment LINZ is considering upgrading its stations to Real Time status:

- For the benefit of its legislated market;
- For compatibility with the shared EQC GeoNet network; and

- For the use of third party commercial applications; the latter being driven principally by the national benefit to be gained by facilitating the uptake of uses of the technology and avoiding the need for private sector duplication of many of the stations that make up the LINZ network.

Thus this report considers the development options facing LINZ and the likely benefits arising from each of these sources. It considers only the incremental costs associated with upgrade options and the prospective benefits from each.

2. Legislation

LINZ is the Government Department in New Zealand that is responsible for managing Land and Seabed Information that includes the cadastral survey and land title systems, hydrographic and topographic mapping, and the geodetic system.

LINZ Statement of Intent for 2009-2012 identifies three core roles:
:

- transaction management - maintaining and operating the regulatory framework and systems for rights and transactions involving land
- information management – generating, collecting, compiling, and providing geographic information, and information relating to property rights and transactions, and
- land management – administering a range of Crown-owned lands for the benefit of the New Zealand public.

The Statement of Intent also acknowledges the increasingly valuable contribution in wider economic terms that a high technology Department such as LINZ can make. Among the areas identified where that potential exists is that of working across the wider land information sector to ensure that useful geospatial information of many different kinds is readily available to support innovative use of the information by others.

This potential is a critical consideration in this report because of the apparent suitability of the LINZ network not only to the core enhanced cadastral users but to the wider economic uses foreshadowed in the Statement of Intent.

3. Background

In 2001 LINZ commenced installation of a Continuously Operating GPS Reference Stations (CORS) network known as PositioNZ. The business case developed for PositioNZ's installation and operation was based on the premise that the network would be used to monitor and manage New Zealand's "semi-dynamic datum". The network was not designed to be Real Time but designed to deliver "30 second Receiver Independent Exchange Format (RINEX) hourly and 24 hourly files". This status is referred to as post processing. Under post processing there is no reliance on real time communication between the base and roving station with the data being downloaded and processed at the user's discretion.

The difference between LINZ existing CORS network and a Real Time Network is an upgrade in the communications equipment and potentially of the GPS receiver hardware to GNSS status. With a Real Time station or network of stations, the Real Time CORS station provides a stream of Real Time data (data with a latency of about 1 second). This data provides continuously transmitted precision location data referred to as "corrections" to a roving GPS/GNSS receiver that is operated by the user. Modern, networked, systems transmit "corrections" using data from one or more base stations in the vicinity of the user.

The receivers used by the end user (the surveyor, heavy construction machine operator, utility worker, agricultural contractor etc) are highly sophisticated proprietary pieces of equipment sourced from an internationally established and competitive industry. The receivers are programmed to produce data in the form that is readily useable by various end user markets. The receivers are expensive but very reliable portable equipment that are often designed or programmed for particular end user activities and are either purchased or hired from a provider company.

4. The LINZ Network

LINZ requires the system or systems that are from time to time necessary to enable the required accuracy of its geodetic datum and enable accepted interaction capability for cadastral users. The required accuracy level is to the millimeter /centimeter level. There is increasing demand for Real Time capability by these users.

The New Zealand cadastral system uses New Zealand Geodetic Datum 2000 (NZGD2000). This datum is continuously monitored, updated and corrected as necessary. The primary use of the “LINZ network” is to facilitate the measurement of the dynamics - tectonic surface deformation of New Zealand and management of the deformation model inherent in the definition of NZGD2000.

The traditional methods of connecting to the datum have been physical and remote (to physical ground marks and trig beacons). The uptake of Global Navigation Satellite Systems (GNSS) technologies in the economy means that there is an ever increasing demand from among LINZ traditional users for LINZ to facilitate the connection to the datum by electronic means. In 2001 LINZ commenced installation of a Continuously Operating GPS Reference Stations (CORS) network known as PositioNZ. This network has partially addressed this demand by providing limited (post processed) access to the official datum.

LINZ PositioNZ network is a nationwide network of sites that are equipped to enable the exact reference point and communications necessary for the various survey and related functions that LINZ is required to carry out or facilitate under legislation. It consists of 33 stations[1] at approximately 100 km spacing. There are 18 stations in the North Island and 15 stations in the South Island from Fiordland and Bluff in the South Island to Kaitaia in the North Island. Sites cost about $60,000 each to develop to operating status giving a replacement cost of the mainland network of about $2 million. LINZ has no current plans to extend the network to any great extent although some infill stations may be constructed.

LINZ operating policy for the network is to upgrade it on a systematic basis having regard to technological changes in the industry and the demands of its users. The established next technology which LINZ has successfully trialed and is in the process of implementing requires an upgrade of the communications on board the stations to enable operation on a Real Time basis.

5. Other Precision Reference Networks / Developments in New Zealand

There are two other relevant Precision Reference Developments in New Zealand.

- Commercial Providers

There are currently two main commercial operators providing services using Real Time stations. There may be more operators in the future. The two operators currently have approximately 20 fixed sites, all Real Time, between them[2]. These

[1] LINZ also operates 3 stations at the Antarctic and 2 on the Chatham Islands.
[2] There is also quite limited demand as yet for temporary rental stations from each of the two commercial operators.

sites have all been developed in the last 5-6 years and are concentrated in the more obvious areas of particular economic development, such as Auckland, Tauranga, Taupo, Wellington, Christchurch, Dunedin and Queenstown.

Because additional sites in an area are useful for reasons of accuracy and also since reliability and backup/redundancy are achieved if there are multiple sites, the private developments to date are not regarded as an unnecessary duplication of the LINZ or GeoNet CORS sites. Rather they are seen as evidence that there is a growing commercial business based on Real Time technology. The fast tracking of the LINZ network to Real Time would, however, go some way to ensuring that there was no unnecessary duplication of sites and that any further development of fixed and portable stations by commercial providers would be in support of the wider commercial use of the technology. Further, commercial providers would also be able to adopt LINZ Standards so that their stations could also be adopted into the geodetic network, thereby extending the PositioNZ network.

Because of the lower costs of an upgrade (and more so if its use continues to be free) an upgraded Real Time LINZ network would facilitate the use of the technology outside of the more major economic areas currently being served.

- GNS Science

The other relevant Precision Reference development is the GeoNet network operated by GNS Science and largely funded by the Earthquake and War Damage Commission (EQC). This network consists of 100 sites at 30 km spacing that covers the bloc of New Zealand that is particularly interesting to scientists and the insurance industry because of the risk associated with earthquakes and volcanic eruptions. The bloc includes the North Island tectonic shear belt from Wellington to East Cape and the Taupo Volcanic Zone. Because the technological developments are towards Real Time capability, and because of its potential value in the Real Time hazard warning area, the GeoNet network is in the early stages of being totally upgraded to Real Time status. The legislative requirement for such an upgrade (as was the case for the GNS Science network itself) does not require that it meet economic investment criteria. Nevertheless, EQC is convinced that the network has been instrumental in providing more certainty about the potential damage liability of the area and that as a result significant reductions in reinsurance premiums (i.e. a real economic benefit) have resulted. The EQC has commissioned an economic analysis to establish the position. Because these stations are being upgraded and since live streamed data from the stations so far upgraded is (and will also be in the cases of the rest) accessible and available free to commercial operators, the opportunity exists for LINZ to dovetail its upgrades with GNS Science's programme to give the timeliest effect to a national cadastral and commercial coverage upgrade.

6. The relevance of the LINZ network

(a) Current Use under Post Processed Status

LINZ PositioNZ CORS network was configured to provide post processed data. Post processed use has increased (from 40 files/month in 2003 to more than 1000 files/month in 2007). LINZ cannot identify how many of these files are specifically used for cadastral surveys but considers that the proportion is likely to be small. Ongoing (automated) development of the post processing service is increasing this use but it is still only used in a fraction of transactions. The use of the LINZ network to anywhere near its potential for cadastral purposes depends on upgrading its capability to Real Time status.

(b) Potential Use under Real Time Status

Development of the LINZ network to Real Time status would be expected to provide significantly greater opportunities for increased productivity and reduced costs for cadastral users and their clients and therefore a much greater increase in cadastral usage.

LINZ now streams Real Time (1 second) data from a number of its sites and tests have been carried out into the viability of using the network for real time applications. It is apparent that the LINZ network could form the basis of a network that could be used to not just support its legislated cadastral functions but in the process could assist in facilitating the use and growth of real time precision positioning commercial applications across the country. The commercial applications include applications that are cadastral related and therefore related to LINZ core activities but many more, such as use in construction, agricultural servicing, quarrying and mining for example, that are not.

Real Time precision technology has been commercially available on a limited but growing basis in New Zealand for about 5-6 years. The uses and potential uses of the technology are many and are expanding. They include land development, widespread functions associated with asset mapping and management and precision machine operation and control functions in such industries as agriculture, mining and construction.

Developments overseas and increasing experience in New Zealand have heightened interest in and the use of real time technology and solutions that use positioning applications.

(c) Limitations of the Configuration of the LINZ network

The tacit international industry standard for a network of sites for use in the wider field of real time precision applications is currently 70 km spacing. LINZ network was developed on 100 km spacing. The optimal configuration for a Real Time network was not an essential consideration in the development of a post processed network.

100 km spacing is less than optimal for Real Time applications however, whether cadastral or in the wider realm. Real Time applications still work best when close (70 km or less) reference points are available and when there are multiple sites available. On the other hand continuous technological improvement, including satellite coverage, is likely to see extensions of the effective distance coverage from stations in future years.

(d) The case for Reconfiguring the LINZ Network

In the current economic conditions, LINZ is struggling within its budget for the funding to enable it to upgrade its network to Real Time status, let alone seek what would almost certainly need to be additional taxpayer funds for an expansion of the existing network.

There are however a number of reasons why LINZ should consider expanding its network, especially to provide some infill in areas of more significant economic interest in regions not covered by the EQ/GNS Science network. These include the importance to LINZ to retain its status as the geodetic leader in the country and the integrity of the geodetic datum which is enhanced by the extra accuracy and therefore quality of transactions that are sourced from LINZ bases. (It should be noted that similar results could be obtained regardless of who the provider is if sites were designed to meet LINZ standards). There are also wider economic benefits as noted later in this report, that would be generated from a strategic infill by a number of stations and which would be of very low risk of not meeting any reasonable national economic return threshold and which would in fact be of high probability of achieving well in excess of the returns required for comparable government supported infrastructure investments.

The use of Real Time CORS requires reliable cell phone coverage[3] so there are limitations on where Real Time technology can currently be used. The Real Time technology also relies on line of sight with any of the 6-10 satellites[4] typically

[3] Radio can and is occasionally used but is generally considered as limited in application for real time commercial applications
[4] This number will increase significantly as new systems come on line

“available” at any one time. In cities with a significant number of high rise buildings[5], where much of the demand is likely (e.g. construction sites or utilities facilities activity) therefore, there will often be a requirement for multiple CORS sites (such as are provided by the commercial operators). While progressive improvements in the technology means that better performance than previously is being obtained from using single sites, it is a fact that access to multiple sites is preferable to users because multiple readings or corrections are available giving increased assurance of availability, accuracy, reliability and redundancy.

It is important to note that all the third party providers and users and potential users of this precision reference technology who were contacted during the course of this report's research, strongly support a timely upgrade of the LINZ network and indeed any augmentation of the network if that was to be an option.

7. The Current Position of the Real Time Commercial Industry

The commercialization of this Real Time precision technology is still in its infancy in New Zealand. The industry was enjoying steady early growth from its beginnings 5-6 years ago until the economic recession knocked the construction industry in the major cities and resort sites. In New Zealand the major commercial applications to date have been for the location, mapping and management of utilities, land development, road construction, urban site developments and mining and quarrying. There is also some use in agriculture - in crop and facilities mapping and in ground fertilizer application for example. For obvious reasons the technology is increasingly referred to as the ‘infrastructure for infrastructure”.

While construction projects outside of roading are currently much reduced because of the economic recession, this will not be the case again in the future. The commercial industry is surviving the downturn because non-construction uses of live precision location technology are growing and should continue to grow.

There are two principal commercial operators in New Zealand in the sale and servicing for use of this real time precision technology. Both have very strong overseas backing and to date have grown the market as, when and where they have sufficient confidence that a market for each of their “site” investments exists. The industry is transparent and competitive. There are other potential entrants. As a result the potential for existing operators to extract any extra benefits such as monopoly or duopoly rents from a Government supported network are expected to be low.

A feature of the sectors that the technology is being marketed to – various forms of land development, construction, mining, utilities management, and agriculture – is that there is

[5] Generally referred to as ‘Urban canyons”

wide use of contractors and subcontractors resulting in many comparatively small firms being involved. In these circumstances security of supply (networks) is a factor that will help grow the market. Critical to the value of developing the LINZ network, the proprietary receiver software has improved to the point where very limited training is needed in its use, particularly where there is a key reference to a fixed station. One of the major users considers that the “early adaptor” phase is now well tried and proven in New Zealand and that it is essential as an input to the competitiveness of the New Zealand economy that coordinated efforts are made to reap the benefits of the much wider use of the technology that is possible.

8. Overseas Developments

The introduction and development of Real Time capability in countries that New Zealand would generally compare itself with has been the subject of significant interest and analysis leading invariably to forecasts of substantial further developments in the next few years. There is no one apparent dominant model for those developments. Rather the details of developments vary considerably. In some cases such as the United Kingdom and also several European countries and Australian and several US states, the national or state government equivalent of LINZ are either operating Real Time networks or in the process of building them. In Japan and California the equivalent of GNS Science are operating Real Time networks. However in each case the “government” network is only a part of the picture with commercial participants also significantly involved in providing their own sites, presumably as and where it is commercially opportune to augment the “government” network. The market seems to regard the availability of a larger Real Time network as an essential component for tapping the potential benefits of precision reference technology.

9. The Cost of Upgrading

The cost of upgrading the LINZ network to Real Time status is a particularly relevant factor in these considerations.

LINZ 33 mainland New Zealand sites cost about $60,000 each, which includes communications giving a replacement cost of the mainland network of about $2 million.

The cost of upgrading each site to real time status is essentially the cost of upgrading the communications equipment at some sites. This cost is expected to be only about $50,000 for those sites requiring upgrading. Many sites will be upgraded by GNS as part of their upgrades to their VSat communication system which many LINZ sites use, and this will be irrespective of LINZ stations going to Real Time status or not. There will be some additional ongoing annual maintenance costs expected to be about $10,000 per year for the network in addition to the current $250,000 annual maintenance cost. To maximise the benefits of the real time network it is anticipated that receiver hardware will also be upgraded from GPS to GNSS capability. The additional costs for this are expected to be approximately $300,000. Much of this is expected to be done as part of the regular network maintenance programme and would be carried out irrespective of the LINZ network going to real time capability.

10. The Benefits / Potential Benefits of Use of Real Time Positioning Technology in Australia

Contemporaneously with LINZ considering accelerating the upgrade of its network to Real Time status, there were considerations underway in Australia of how any GNSS precision technology use might be optimised, included the option of development of a nationwide Real Time CORS network monopoly. The ANZLIC (the Spatial Information Council which represents all Australian Commonwealth, State and Territory agencies that deal with spatial information) and the Australia Spatial Consortium which is a Committee of the Heads of the lead organisations in the public sector, the private sector, the research sector, and the professional sector have been considering how Australia should go forward. These policy bodies are known to consider that Australia's approach has been fragmented and consider that this is resulting in significant foregone opportunities in the Australian economy. They consider that precise positioning has emerged as a critical new capability for the agriculture, mining, engineering and construction sectors, and will progressively expand to provide benefits in almost all sectors of the Australian economy, including logistics, transportation and navigation.

At the most grand level, i.e. full national coverage, they note (using estimates from the Allen Consulting Study that they commissioned) that an investment that includes $300 million of ground based (station) infrastructure can generate an estimated $32 billion plus in additional productivity gains over the next 20 years. Taking the Australian results at face value they are equivalent to a Benefit/Cost ratio for the Australian economy at least of the order of 40:1. These potential Australian benefits are calculated on three industries only, with benefits being shared between the Mining industry (50%), Agriculture (30%), and the Construction industry (20%).

An indication of the range and scale of potential benefits is illustrated by the following findings and estimates from Australian sources[6].

[6] "Economic Benefits of High Resolution Positioning Services" The Allen Consulting Group, November 2008 and the considerations of ANZLIC (the Spatial Information Council which represents all Australian Commonwealth, State and Territory agencies that deal with spatial information) and the Australia Spatial Consortium

· Controlled traffic farming techniques provide a 10% improvement to annual crop yield, a 52% reduction in fuel, oil and chemical costs, as well as reduced soil erosion, and improved water usage for those areas which have access to the 2 cm accuracy positioning.

· Greenhouse gas emissions are estimated to have been reduced by 89 kg / hectare.

· Estimated productivity increases in the mining and infrastructure construction industries with some stages of the mining process getting a 30% productivity increase.

· Improving the allowable shipping depth clearance through use of advanced differential positioning techniques, could boost the productivity of some ports by up to 10%.

· Machine guidance and the innovative use of spatial data were cited as reducing the costs of construction of the Port of Brisbane motorway by 10%.

· Construction companies can use accurate site plans and automated guidance of earthmoving machinery to shorten construction times, reduce fuel costs and improve safety.

· Utility Companies and Local Authorities who need to know exactly where their assets are located can improve the maintenance of existing assets and better design the deployment of new ones.

· Improvement in the mapping and management of billions of dollars worth of pipeline and energy assets.

· Improvement in the asset management of the built infrastructure environment, such as power and the telecommunications network facilities.

11. The Benefits / Potential Benefits of Use of Real Time Positioning Technology in New Zealand

(a) For LINZ and the related New Zealand Cadastral Industry

The market for and benefits to the survey industry that is LINZ’s main client from the proposed technology upgrade is significant. The productivity of surveys is increased from the achievement of time and labour savings. There are also safety improvements where relevant from avoiding lane closures for example. These benefits are from providing Real Time networks in general of which LINZ might only supply part of the network/solution. Benefits include being able to work more cost efficiently, i.e. only needing to use one person with a GNSS receiver. It would also enable users to connect directly to the datum with immediate authority.

LINZ business units, topographic and hydrographic, are also expected to benefit from the ability to be able to more efficiently increase spatial accuracy for their datasets. LINZ itself would likely benefit from access to data from additional sites under the expected increased cooperation and data access that the proposal is expected to promote. Indeed if free access (see later) is to be provided to the Real Time LINZ sites, LINZ should make it mandatory that it be provided with free access to third party sites for LINZ in-house use [7]. This would be particularly beneficial for hazard monitoring (GeoNet) and for hazard (e.g. earthquake) response. Following a large earthquake the additional live access would be advantageous in redefining the cadastre and the spatial alignment of the cadastre and geodetic systems. The availability of a wider data set would assist LINZ to update its velocity model, a critical component of LINZ national datum. There are also expected to be some cost advantages for LINZ from its geodetic contractors being enabled to access data at reduced cost. Discussions with contractors has indicated that the savings could be of the order of 20 percent. This is a significant cost saving and is also indicative of the productivity improvements that are possible downstream as more and more surveyors move to use of the technology.

It is relevant to consider why the use of the technology has not already become widespread if such productivity improvements are available. There are a number of things that contribute to this. Because the existing LINZ network is post processed status, it does not lend itself to promoting the use of the technology for surveying and the potential productivity gains in surveying have not been achieved to date. In the very low percentage of surveying tasks where Real Time technology is used at present, the typical way of operating is either by way of the commercially provided fixed stations, or from an owned or hired temporary station and rover. As an indication of costs, temporary stations cost in the order of $40-$50,000 to purchase and rovers about $20-30,000 each. Hiring rates vary by length of contract but the short term daily rates are of the order of $300 per day for a temporary station and of the order of $500 per day for a temporary station/rover set. The result is that at present even the larger survey firms generally consider use of real time technology on larger jobs only. If the LINZ real time network was available, there would be no need for the mobile stations in the above scenario.

While the productivity potential for Real Time use in surveying is significant, the relatively high cost of operation where there is a dependency on mobile stations is a cost as well as an operational hurdle that a network would help overcome. The potential benefit of a live streaming LINZ network to general surveying is expected to be in the millions of dollars per year.

[7] Providers spoken to support this idea

(b) For Commercial Non-Cadastral Uses

As well as LINZ survey related roles, Real Time CORS technology lends itself to use in a range of new commercial adaptations.

The New Zealand situation is quite different from that predicted for Australia. New Zealand obviously does not have anything like the scale of mining or cropping industries that dominate the potential in that country.

Discussions with providers/users reveal that the uses in New Zealand, and potential for those uses include (Where they have not been specifically identified the potential values cited below are not annual amounts but are the accumulated order of benefits over a decade).

- Infrastructure development

The potential for use in this area is evidenced by the existing use of the technology in New Zealand to give the design machine path and vehicle position live on a screen in the cab to enable the grader, excavator etc to be operated to a very high degree of accuracy (centimeters) without the need for constant placement and reassessment of pegs for example. The machine operator is able to give more attention to other aspects of the performance such as blade angles etc. The results include greater output, less overcut / undercut and better finish. As with other uses, the operation is enhanced the more that there is access to fixed sites or a network of sites The technology is used in all the motorway projects in Auckland for example and in rail extensions and double tracking.

The Government has committed to a significant infrastructure investment programme over the next few years, particularly in road construction. (In the 2007/08 year new roading and road reconstruction expenditures totaled about $600 million out of a total roading budget of just over $2 billion. To put the issue into perspective when compared to the cost of upgrading the LINZ network (at an NPV of about $200,000) the costs of these projects alone is enormous. A miniscule efficiency gain of 0.1% on the above roading capital projects for one year would pay the entire cost of the LINZ upgrade. In an Australian case the technology was claimed to have reduced the construction cost of a motorway by 10%.

The potential benefits to this industry (quality, time and cost) appear to be in the tens of millions of dollars per annum.

- Utilities asset location, mapping and management

The utilities asset management area is a proven user of the Real Time technology and there is considerable scope for growth. Throughout New Zealand Councils and Utility companies are in various stages of precision mapping of these assets. There is still a substantial amount to be done and the potential benefits afforded by an augmented network and the expected increase in the share of that work that could /would be undertaken using the CORS technology would amount to many millions of dollars. While benefits are primarily from time, quality and cost gains they also extend to traffic inconvenience reduction and operator and public roadside safety. Again the benefits from a network should reach the millions of dollars.

- Construction

The Construction industry has been one of the main areas of use of the technology in this country (indicated by the locations of the existing commercially owned fixed stations). The New Zealand commercial providers of the Real Time precision technology have both noted the downturn in New Zealand's Construction sector (particularly the commercial and apartment construction components) as providing a brake on what they described as encouraging growth prior to the second half of last year. The sector would nevertheless benefit from the availability of a network.

- Mining and Quarrying

The technology is used in these industries and there is potential for expansion. Quarrying in particular is a significant activity, especially given the road building programmes assured for the next decade.

- Agriculture

As noted New Zealand does not have the large acres of cropping as in Australia where so much potential is seen for the technology particularly in the machine control area. Nevertheless there are already applications of the technology particularly for ground based fertiliser and spray use design and application. Because the locations are often outside of the main centers these applications to date have had to use the comparatively expensive option of mobile stations. Given the vast areas where spray and fertilizer are used, and the value of high accuracy to the user (and the neighbour who may often not want a free ride) the potential use in agriculture, while nothing like Australia at many billions, is substantial and could be worth tens of millions.

- Sport and Recreation

There are already uses in this field, including stadium and ground turf management. There are also developments afoot in precision river navigation. The value of a live streaming precision network to the many and growing use of the more commonly available "accuracy to the metres" technology are many as with the addition of software, cellphones for example can access the more precision streams. What the potential uses and value of this might be is largely unknown but almost certainly there will be some benefits from applications in this area.

- Port management and navigation

This is seen by the commercial suppliers as a definite area of potential that would be assisted by a LINZ network. The potential for this market is unproven in New Zealand but could be significant.

(c) Summary of Potential Benefits

The net benefits of applications in the above activities would be expected to sum to at least tens and possibly hundreds of millions of dollars. It is difficult however to attribute the particular share of these net benefits to an upgrade of the LINZ network and its availability to third party users - the degree to which there is the need for the use of other ground based stations for support, the relative size of projects in New Zealand compared with those international applications where benefit analyses have been carried out, and the need for and the efficiency level at which supporting technologies are required are all significant unknowns. However with a value threshold for a discounted benefits to cost ratio of over 1 needed to justify any investment and a partial analysis in Australia indicating a benefit to cost ratio of the order of 40 there are certainly indications that the cost of an upgrade of the LINZ network at less than 10% of the cost of a new ground based network, should be able to repay itself many times over.

As noted above the national commercial sector benefits would not all accrue from the upgrading of the LINZ network. The (commenced and committed) upgrade of the GeoNet network to Real Time status and the further development of the private stations/networks (which desirably will be made in the knowledge of the particular developments of the Government networks) would also be contributors to the benefits. Should the LINZ network not be upgraded most of the benefits would still accrue but would be linked more closely to the willingness of commercial users to develop and market their own sites, possibly in direct location competition with each other. Such developments are likely to be spread over a longer time frame and would tend to favour large scale users rather than many "small" users who make up a significant component of the potential market and who in many cases would either need to be jointly marketed or club together to use the technology optimally.

From a national efficiency perspective the upgrading of the LINZ network to Real Time status should have regard to the benefits that are achievable from the use of the network by third party users. Indeed these would appear to be such as to outweigh the benefits to be achieved for LINZ own legislated activities and therefore from a national benefit perspective priority should be given to undertaking any upgrade in a manner that would consider regional commercial opportunities so as to assist the avoidance of unnecessary duplication of sites by commercial operators.

12. The Case for and Cost of an Accelerated Upgrade

An efficiency issue to be considered is the optimal timing for the upgrade of each site. LINZ base plan would involve spreading the upgrade over 5 years at a rate of 6 sites per year. Taking into account the needs of the wider commercial market and the desire not to unnecessarily restrict the development of that market or to require the duplication of sites the upgrade should be scheduled by adopting a site upgrade profile in consultation with both potential cadastral and commercial users. Such a prioritizing of sites would in effect be maximizing the benefits to the combined user group at no additional capital cost to LINZ current plans. Depending on needs and values identified in the consultations there may also be justification in reviewing and accelerating the schedule such that instead of 6 sites being upgraded over each of the next 5 years (the counter factual) perhaps 12 sites could warrant upgrading in 2009/10, 10 sites in 2010/11, and the remaining 8 mainland sites, which may not have a pressing Real Time precision cadastral or commercial value (either because of the presence of upgraded GeoNet sites or lack of cell phone coverage / economic “prospects”) being upgraded over the remaining 3 years of LINZ current programme (or even over a longer time horizon if there is no demand).

The accelerated option above would be effectively bringing forward the development of communications and receiver hardware at 10 sites or about $150,000 of investment by an average of 2-3 years. The total economic cost of the accelerated proposal versus the counter factual or base case is likely to be of the order of $30,000 - $40,000.

13. Is an Accelerated Upgrade Justified

If the base LINZ programme for upgrades (i.e. over 5-6 years) was considered adequate to meet the needs of its own cadastral market requirements, any accelerated development profile would be required to manage the needs of the commercial market. It could be argued that that market alone would need to justify, on a site by site basis, any acceleration. In many cases this would not be difficult as for example exhibited by the indicated benefits of Real Time status for use on roading projects. As many individual roading capital projects cost in the tens of millions of dollars each is likely to be quite capable of generating efficiency benefits much greater than the $6,000 or so economic cost of advancing the upgrade of an individual site by two or three years.

However the LINZ base case for upgrade is clearly inadequate even for cadastral purposes. As noted earlier, Post Processing has had very limited use for cadastral purposes. Surveyors advise that the steady improvement in receiver technology and the improvements in cell phone coverage mean that if a sufficient network of quality live streaming fixed site stations were available then a quantum increase in the amount of surveying using the technology is likely. At present the amount of use is constrained by the cost of hiring or buying mobile stations and the extra time and technical training needed to operate this equipment with certainty compared to the signals from an assured accurate site such as a LINZ station. The productivity improvements from using the technology vary depending on the size of the task in particular but are typically advised as about 20 percent, comprising mainly of time savings.

Further there are also benefits to LINZ and these would also be available to the advanced sites earlier. On their own they should provide sufficient (or certainly close to sufficient) benefits to make the accelerated investment worthwhile without reference to the non-cadastral benefits (otherwise of course LINZ would not be committed to undertaking the 5 year upgrade).

Looked at this way the non-cadastral national benefits could be considered a bonus albeit likely a very significant bonus. The likelihood is that tens of millions of dollars of benefits will accrue, albeit attributable between three network builders. Also as noted above the reality is that the annual benefits are such that many of the associated projects would proceed with investment by the private sector if it became clear that LINZ was not going to proceed with an accelerated programme. The benefits outside the cadastral industry from an accelerated LINZ investment are therefore the avoidance of unnecessary duplication (or worse) of sites, the earlier spread of the use of the technology outside the main industrial areas, and the increased surety for users and potential users that their investment in receiver sets and their commitment to the use of the technology is transferable to contracts in a wider geographical environment.

With an incremental capital cost of 2.5% ($50,000 on top of the sunk $2 million in the current network), an increase in operating costs of 4% ($10,000 compared to the current operating costs of $250,000 per annum) and the bringing forward of some of the $300,000 of planned communication equipment upgrades by 2-3 years at a net present value equivalent of about 2% ($30,000- $40,000) of the current capital, the upgrade of the entire LINZ network would cost about $80,000-$90,000 or about one and a half times the cost of adding one new station to the network. When the likelihood is that most of the LINZ stations would, if not brought to CORS standard in the next few years, be duplicated by private sector stations then it is easy to appreciate from a national perspective that the upgrade will bring significant economic benefits.

If an upgrade saves the duplication of, say, 25 of the LINZ stations then the project would have a benefit to cost ratio of about 20. This excludes the direct benefits from LINZ own services which in LINZ views would more than meet the costs of the upgrade. With these benefits likely the benefit to cost ratio far exceeds that of most projects undertaken in the public sector – certainly much higher than many of the projects that are included in the roading capital programme where the benefit to cost ratios are usually in the 2 to 4 range. In these circumstances the government should be asked to support the advancement of the project so that the opportunity for avoiding any unnecessary duplication of the LINZ network by third parties is not lost.

Should any additional stations meeting LINZ quality requirements be required on an infill basis (and outside of the EQC/GNS Science network) then such a planned expansion should be brought forward to avoid any unnecessary duplication by a third party that does not agree to use LINZ standards. However should such a third party use LINZ standards then LINZ should seek access to such stations on a quid pro quo basis.

14. Cost Recovery

This leaves the question of whether LINZ should seek to recover the costs of the investment in upgrading its network to Real Time status from some charge or registration levy on users.

(a) Treasury Guidelines

The Treasury has set guidelines for setting charges in the public sector. The guidelines acknowledge that the full costs must be met by someone - be it Users or (and) Taxpayers and are concerned with efficiency, fairness and fiscal rationality. The main ones are:

- encouraging decisions on the volume and standard of services demanded that are consistent with the efficient allocation of resources
- minimising the cost of supply over the short term, and over the long term when capital costs are significant
- keeping transaction costs low and evasion at acceptable levels
- dealing equitably with the taxpayer, those who benefit from the output and/or those whose actions give rise to it.

Treasury note that the costs of pure public goods should be recovered from the community as taxpayers or possibly ratepayers rather than beneficiaries.

(b) Public Good Arguments

The following analysis considers whether the LINZ Real Time CORS network could come within the definition of a Public Good and then to what extent its wider operating environment may compromise its ability to operate on strictly commercial terms.

A Public Good is defined as such because excluding people from its benefits is either difficult or costly, and its use by one person does not prevent its use by another.

The first part of this definition suggests that it is not practical to charge for use of the good as there are either problems in restricting usage to fee paying clients or very high dead weight costs involved in charging. The fact that there are commercial operators in the market with sites similar to those in the LINZ network is a clear indication that this does not hold. Those commercial operators are clearly limiting access to data to licensed or fee paying clients. The second part of the definition indicates that the good has a zero marginal cost and thus is not consumed by usage. It does appear that the LINZ network will meet this requirement for many years once the communication capacity expansion that is an integral part of the upgrade for not just the LINZ network but also for the GeoNet and the commercial market networks is completed.

Having a zero marginal cost inevitably means that while it is possible to limit access to fee payers it is more difficult to determine a method of charging that is fair to all users. Charging systems will inevitably discriminate against those making infrequent use of the network or using it for marginal benefits and in favour of those making greater use of the capacity or receiving greater net returns from its use. To the extent that any average price system did restrict usage, there would be consequential efficiency losses to the community. On the other hand the transaction costs associated with developing a system of charging based on individual receiver use and therefore a price reflecting a use related benefit of LINZ individual station data would be high and introduce its own market distortions.

(c) Commercial Network issues

A further issue requiring consideration for LINZ charging is that the LINZ network is operated under a management contract with GNS Science as part of a combined GeoNet and LINZ network. The standards under the two contracts are similar and were put in place for the operation of a post processing rather than a live stream service. However while a live stream service does provide significant benefits to both EQC and LINZ both parties are able to live within the service standards within their current contracts. Some of the prospective services in the commercial market may desire higher service standards from their network provider than EQC and LINZ need or would be prepared to meet. LINZ have particular concerns that while the accuracy of the Real Time “corrections” it would live stream from its upgraded Real Time stations should meet normal performance standards, it would not want to be held accountable to users of its network for errors or outages. These can result from problems anywhere along the station, satellite, cell network or receiver chain and direct management of any legal accountability would be expensive. Both LINZ and EQC intend to ensure they are contracted out of any accountability. On the other hand LINZ current stations do have very high rates of availability (battery failure, storm strike, vandalism are the main risks and all are very rare). The existing contractual requirement is to restore these sites within 3 days. While LINZ would only agree to its normal restoration arrangements where one of its live streaming stations suffered a problem/outage while being used for commercial purposes, it has said it would accept some change to those arrangements on a reasonable endeavours basis at the time with any additional costs involved being met by the party seeking the augmented response or possibly by prior contractual arrangement agreed with and at the cost of a third party.

Were LINZ to charge for the data however it may have to provide a more robust service and any associated cost may outweigh the value of charging for the data.

(d) Information Management Issues

In considering the position of LINZ it is also relevant that the GeoNet network which is managed in conjunction with the LINZ network by GNS Science is unequivocally in the "science stream" and its data is provided free of charge to all parties. With the GeoNet network having more stations than the LINZ network, albeit only covering about 25 percent of the country, and the LINZ network at the, arguably, less than optimal 100 kilometre spacing, there will be occasions where both LINZ and GeoNet stations jointly provide the data corrections. The inter-relationship with GNS also includes an agreement whereby GNS Science meets one third of the maintenance sites for LINZ sites. GNS Science effectively operate the two networks as a single entity with LINZ and EQC having rights of access to each others stations data. GNS Science also permits third party access to GeoNet data under its scientific data obligations and also provides LINZ current data free of charge. GNS Science have expressed concern that it may have to separate the two operations and exclude non contracted/licensed parties from the LINZ data. Besides the consideration of having additional deadweight management costs to cover if a separation is made, the apparent inconsistency in applying a different approach for two Government agencies would be difficult to justify.

As noted above the private sector companies already make the data from their stations available free to each of the Government agencies for scientific and other non-commercial purposes. LINZ acknowledge that the additional data can be of real value to their operations, particularly where earthquakes occur, for the integrity of the datum. The evidence is that there is currently considerable co-operation already between network owners and the benefits to participants from continuing towards an improved and harmonized datum environment is likely to outweigh any merit in moving to a two way charging system. If this access arrangement can be formalized on a two way contractual basis with station owners wishing to access LINZ live stream data, the case for charging is further reduced.

(e) Overseas Precedence

Little is to be gained from overseas experience. There are several different models being used in overseas jurisdictions, some applying cost recovery and some not. There is no strong pattern of preference either way. However in almost all cases there is evidence that many jurisdictions are more concerned to facilitate development of networks in support of their economies as a priority over cost recovery issues.

(f) Efficiency Issues

With the additional operating costs for LINZ live stream data at very close to zero and the incremental capital cost of the upgrade at $50,000, with a further $300,000 in planned receiver hardware expenditures also being brought forward, all of which can be justified within LINZ own operations alone and with the economic cost of bringing the phased upgrade package forward at about $40,000, there does not seem to be any efficiency gains to be had for the market from instituting a complexly managed and wide-ranging free market charging mechanism for LINZ data.

In other words LINZ contribution to the wider precision Real Time developments would seem to be better dealt with by being clearly outside the expectation and obligations of meeting commercial demands that a consideration for access to the live data could entail in exchange for free access to data from third party stations.

15. Concluding Comments and Summary of Conclusions

The proposal to fast track LINZ upgrade of its CORS network to real time status is clearly in alignment with the social and economic challenges facing LINZ and New Zealand. It is essential that LINZ have cognisance of the economic impact of its activities. Cadastral and Geospatial information generally is increasingly becoming a critical component underpinning a wide range of services and economic growth. Real Time precision location based technology will have a significant and irresistible role to play in the progress of a growing number of services.

Also relevant to the considerations in this report are the global changes in information management towards more open sourced approaches to generating and sharing information. The evidence is that the benefits of leading, investing, facilitating and cooperating to enable provision and speed up adoption and use of the potential of precision location based services in the cadastral industry and in the wider economy will contribute to producing substantial national social and economic benefits and for a comparatively minimum cost.

Having regard to the costs and benefits for the proposal, we therefore consider that LINZ should endeavour to fund an accelerated upgrade of its network to Real Time status. The reasons for this include

- The cost of the upgrade (capital and operating) is very small;
- The upgrade will have some direct benefits to LINZ;
- The upgrade will contribute to significant benefits for many users of geospatial and cadastral linked activities which are part of LINZ core business;
- The upgrade will also contribute to significant benefits for a number of industries which are not linked to LINZ traditional core roles. These industries include construction, facilities and utilities management, agriculture, mining and quarrying;
- The above benefits taken together mean that an accelerated upgrade of the LINZ network to Real Time GNSS status will have benefits to NZ as a whole of the order of 20:1;

For a multiplicity of reasons it is not realistic or advisable to recover the costs of upgrading the network.

A corollary of this, and consistent with the development of wider network information policy, LINZ should take every opportunity to promote shared (non-charged) access and use of the data.

Finally, if in the future any strategically located infill stations can be economically justified for LINZ purposes then such stations should form part of the LINZ network and the data from such stations be provided free to all parties.

List of Organisations and Persons Interviewed

Land Information New Zealand	Graeme Blick Dave Collett
New Zealand Geospatial Office	Geoff O'Malley
EarthQuake Commission	Hugh Cowan
GNS Science GeoNet Project	Dr Ken Gledhill
Global Survey / Leica	Bruce Robinson
GeoSystems / Trimble	Martin Hewitt
State Services Commission	Keitha Booth

Numerous Users of Real Time Services including operators and consultants in a range of Industries. (To encourage frank views and the provision of some quite sensitive information, which has helped frame the comments and findings in this report, we assured several interviewees that they would not be identified in the report. While some of the users that were interviewed volunteered that they had no objection to being recorded as having contributed to the study, for consistency the names and affiliations of the users that were interviewed are not recorded here.)