ACIL ALLEN CONSULTING

Precise positioning services in the Utilities Sector

An estimate of the economic and social benefits of the use of augmented positioning services in the Utilities S With advances in communications, technology, greater satellite coverage from space

Prepared for the Department of Industry, Innovation, Climate Change, Research and Tertiary Education

June 2013

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Executive Summary

The utilities sector includes electricity, gas and water services. Efficient delivery of these services is important for competitively priced services to residential, commercial and industrial customers as well as ensuring efficient and sustainable use of resources.

Augmented GNSS contributes significantly to the productivity and competitiveness of the utilities sector. It is used in conjunction with geographic information systems to construct, monitor and manage network assets, manage faults, maintain systems and forecast demand. This produces lower development costs and more efficient asset management.

Output from the utilities sector is estimated to have been between $50 million and $81 million higher as a result of the use of augmented GNSS in asset management and maintenance. With further adoption in asset mapping and control systems, this could increase to between $173 million and $305 million by 2020.

Further improvements in productivity are expected as the technology is adopted more widely across industry and as more innovative applications emerge (see Appendix B).

With advances in GNSS coverage, and its integration with other sensors, the use of precise positioning for asset management should improve rapidly and allow much greater flexibility in monitoring of assets within complex environments, particularly underground services. The primary benefit of having more accurate spatial records of such assets is greater efficiency for fault finding and maintenance as well as lower costs for new construction in their viscinity.

These estimates have been derived from industry consultation, case studies (Appendix A), publicly available economic information and technical advice from experts in precise positioning applications. The figures reflect current industry positions which, combined with estimates of adoption of existing and new technologies, provide insight into the projected productivity benefits that could be realised by 2020.

An important benefit of improved asset management is less disruption to the community, business and the environment when work is undertaken on maintenance and replacement of these services.

Key Findings

- Precision positioning plays a critical role in supporting asset management for utilities.
  - Augmented GNSS is more cost effective for capturing location data necessary in the planning and construction phase of infrastructure development.

- It is emerging as an important enabling technology for subsequent management of infrastructure assets.

- To aid this management, precise positioning is required to accurately map networks and other assets in conjunction with geographic information systems - augmented GNSS provides this precision.
- More generally precise positioning has contributed savings operating and maintenance costs associated with the development and management of the utility assets.
- Realisation of further savings will depend on future levels of adoption, further innovation in related spatial technologies and expansion of GNSS augmentation services.
- New technologies are likely to include improved GNSS services and receivers, mobile mapping technologies, remote sensing techniques and advanced surveying and setting out systems (see case studies in Appendix A).
- Compatibility between future augmentation services will also be required for these outcomes to be realised.

1 Introduction

ACIL Allen Consulting, in partnership with SKM and Lester Franks Surveyors and Planners, has been commissioned by the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education to assess the value of augmented positioning services in Australia. This report addresses the utilities sector.

The utilities sector includes electricity, gas and water services that are generally regarded as essential services supporting the community, business and industry. The industry value added of the sector was around $36 billion in 2010-11 representing around 2.5 per cent of GDP at that time.

The purpose of this report is to provide an understanding of the economic and social benefits of precise positioning information within the aviation sector. This information is to allow better informed decision-making and assist in identifying areas for growth and investment from both the private sector and government. It will also provide context to the National Positioning Infrastructure Plan being developed by Geoscience Australia.

2 Utilities use of Precise Positioning

2.1 The utilities sector

The utilities industry comprises organisations that create manage and maintain infrastructure to provide essential services such as electricity, gas and water.

Utilities are generally capital intensive and efficient management or their infrastructure, plant and equipment is one of the most critical functions of their operation. Information on the location, status and operation of these assets is fundamental to this process.

GIS systems, and related position data, have become important enabling technologies in the design, construction and management of the infrastructure assets of utilities.

2.2 Design and construction

Before any investment in infrastructure can take place designers must consider mapping and natural and built environment factors to plan optimal routes and in some cases prepare environmental impact statements. GIS systems are now the norm in planning and design. Surveying technologies increasingly rely on precise GNSS to produce route plans and prepare the base maps on which the designers base their route decisions.

Designers often have to take into account the location of other infrastructure assets especially underground power lines and gas, water and sewerage pipe systems. Precise GNSS is becoming important in mapping and locating existing infrastructure especially that located underground.

The case studies included at Appendix A show how the capture of location data using remote sensing techniques and precise GNSS provides accurate records of the location of existing assets. These records can be drawn on when planning and designing extensions and expansions to the existing systems. The approaches taken by Ergon Energy and Energex to mapping and recording their electricity distribution assets, is an illustration of this approach.

The ROAMES being developed by Ergon Energy for example is a remote sensing system that will accurately locate and describe the electricity distribution assets. The system will be enhanced in the future though the use of a state wide CORS network to provide precise GNSS positioning date for input into the system.

Ergon Energy expects to realise savings of up to $44 million over five years from this system. This represents a saving in staff and materials of around 2 per cent.

2.3 Asset Management

Asset management is probably one of the main areas of benefit from the use of GIS systems and precise positioning. The term asset management applied to any system that is used to monitor and maintain the assets of an organisation. In the utilities sector this generally refers to management of assets such as transmission and distribution systems, dams, reservoirs, power stations, water treatment plants and control systems.

Intelligent management decisions enable more efficient control of energy and water supplies, improved service to customers, higher levels of supply reliability, improved asset lifetime and reduced maintenance costs, which all contribute to significant increases to the productivity and operating margins of utilities.

Using precise GNSS to assist with the task mapping the location has multiple benefits for utilities. Asset management techniques employ precise positioning along with a number of other remote sensing and reporting systems to monitor operating status, control systems, identify faults and plan and manage maintenance.

More accurate knowledge of the spatial relationship between infrastructure assets and the environment generally enables more intelligent asset management (and ultimately efficient) decisions.

Accuracy requirements vary from asset to asset. Data capture at the centimetre level has value in making more informed decisions about the condition and operational status of infrastructure assets such as the location of underground cables of distribution pipes. Accuracy requirements for above ground assets can be less demanding but decisions still benefit from the greater accuracy and reliability of augmented GNSS.

The case study on underground detection and data management discussed at Sections A.4 and A.5 in Appendix A demonstrate the value of being able to accurately locate assets for both design and construction has reduced the chance of damage to other infrastructure reducing maintenance costs and work- around tasks.

The case study of the use of precise positioning combined with high rate sensors in New South Wales Roads and Maintenance Services (section A.3 of Appendix A) is used to improve asset performance, asset maintenance and asset valuation. This is achieved through the rapid capture of geo-referenced images of road networks across the State.

2.3.1 Benefits

The main benefit of locating assets via precise positioning techniques to the utilities sector are in the ability to spatially reference the relative position of different assets and their immediate environment. Whilst not all applications of asset management require precise positioning at the cm level, different asset classes (such as underground assets) benefit substantially from the cm level positioning accuracy. This is demonstrated in a number of the cases studies as per Appendix A.

These benefits may include:

- Data that is collected within a GIS environment is spatially correct and can be viewed in its correct position relative to other spatially correct data
  - for example underground services with respect to property boundaries.
- Assets can be managed more effectively relating to their immediate environments
  - For example monitoring vegetation in proximity to power lines. Such as with the ROAMES and Ergon Energy case studies.
- Accurate calculations can be made of distances and offsets between structures.
- An accurate location of assets within the GIS environment can be determined on the ground by setting out the coordinates using precise GNSS technology.
  - this is of major importance for locating underground services that no longer have any evidence of position visible on the ground
  - the need for greater coordination in the management of underground assets increases each year as service networks expand and increase.
- Time spent locating services and waste involved in uncovering assets is minimised.
- Data can be shared between organisations electronically in digital format via email or the internet.

Utilities that engage GNSS for asset mapping, such as Energex, have been reported as able to achieve operational cost savings in asset mapping in the order of 5-10 per cent (PwC 2008). Our research discussed in the case studies confirms this finding.

For example the ROAMES case study shows that Ergon Energy expects to realise savings of up to $44 million over five years. These savings will be realised through the elimination of some tasks currently required in management of assets by providing more accurate assessment of asset status enabling faster and more precise maintenance and repair actions. This represents a saving in total staff and materials cost of around 2 per cent across all of Ergon Energy's activities (Ergon Energy, 2012).

The use of such asset management tools has increased over the past five years as more utilities install spatially enabled asset management systems which largely comprise off the shelf Geographic Information Systems (as shown in Appendix A). Industry research suggests that adoption of such technologies (and utilising precise positioning techniques) has increased effectiveness or asset management and improved productivity of utility operations. Generally 5 cm accuracy will be required for these purposes.

Productivity improvements vary across different utility sectors with the largest direct benefit of precise positioning being realised in electricity distribution and underground services. However this is likely to spread to gas and water services as more commercial systems become available and existing control systems (SCADA) are upgraded and extended.

2.4 Underground Services

Precise location of underground assets is highly valuable and precise GNSS is fundamental supporting technology to GIS asset management systems. This saves time and money in both service delivery and lifecycle management. This is particularly relevant to managing large pipe networks that require excavation of bitumen, concrete and other hard surfaces.

Whilst it is impossible to fully detect every service asset that has been previously placed underground, it is an endeavour of new management strategies to now correctly spatially locate services as they are constructed, thus mitigating the risks of unexpectedly uncovering these services at later dates. Precise GNSS offers the most flexible approach for providing accurate spatial information to as construct surveys and as such is being widely used across many existing utility operations.

The use of precise GNSS along with GIS and remote sensing technologies is demonstrated in the case study on underground service detection and data management at section A.4 of Appendix A. Accurate information on the location of underground infrastructure is of benefit to both the owners of the infrastructure and to others who wish to locate additional infrastructure in the viscinity of existing assets. The benefits discussed below have been drawn from this case study and the NBN case study at section A.5.

2.4.1 Benefits

Location of assets, as has been demonstrated through the above ground features of energy and road networks is imperative to effective decision making and maintenance options. Linking positional information into the realm of underground services will provide numerous similar benefits.

The benefits of precise positioning in this context include:

- mitigating potential damage of the service
- fast data capture (through GNSS)
- cost effective management
- Data collected can be integrated directly to existing GIS platforms.
- The position on the grade can be set-out using the coordinates previously recorded (which will assist in protecting the underground cabling from accidental damage), prior to construction or digging, compared to current methods of radar detection or vacuum which aren't cost effective.
- Data can be shared between organisations in digital format
- security and protection of assets.

A subset area of asset management of particular interest to not only utilities (in their overall quest for better management of assets), but the broader community, is that of underground services. It is imperative to both the security and maintenance of these assets, that disruption to these services is avoided. However with limited spatial awareness of their locations, damage and disruption are often unavoidable as other construction, civil or service providers look to uncover these areas.

The estimated productivity benefits include:

- reduced maintenance costs through damage and repair to assets
- reduced costs from other agencies in evaluation of area of works (i.e. less requirement for service detection when correct spatial asset management has been applied correctly)
- improved health and safety through accurate mark outs of service depths
- reduced disruption to services from damage or disturbance resulting in higher usage of service.

3 Future Applications and Developments

With advances in communications, technology, greater satellite coverage from space based and ground based augmentation resulting in wider coverage of augmented GNSS, utility companies will have access to even more advanced positioning techniques that can provide more accurate and comprehensive spatial information across their vast network of assets in a timely and affordable manner.

For example, the use of Unmanned Aerial Vehicles (UAV) as a new technology to rapidly and repeatedly capture high volumes of asset information is currently being trialled amongst power utilities. Advances in the applications of this technology are highly dependent on supporting precision GNSS infrastructure.

In addition, with endeavours such as the NBN leading the way, there will be a renewed focus on locating underground assets as they are placed, thus building comprehensive knowledge of underground services which currently don't exist. The combined use of radio frequency identification (RFID) markers and augmented GNSSS is becoming more prevalent in the industry. This technique more accurately locates and then records underground assets (refer appendix A-4) and is emerging as a key technology in the quest for more comprehensive underground asset databases.

4 Economic Impacts

Economic impacts in the utilities sector can be driven by several factors. Increases in productivity deliver direct benefits to operations from lower costs, higher production and sales which lead to overall increases in net revenues. Dynamic benefits can also arise from innovation and product development.

Productivity as reported by the Australian Bureau of Statistics has been decreasing in the utilities sector over the last ten years (ABS, 2012). According to research undertaken for the Productivity Commission, this is likely to be attributable to significant investment in upgrading supply security over this period[1] . This has offset other improvements in efficiency that have been observed in our case studies and research. With pressure on the utilities to reduce price increases, productivity improvement is a high priority for this sector.

This report focusses on the direct productivity benefits from the use of precise GNSS technologies. We have estimated productivity improvements from evidence collected from the case studies, our estimates of current and future levels of adoption, published research and reports and from interviews with industry participants.

[1] The Productivity Commission has produced research suggesting that the downturn in productivity in the capital intensive industries can be attributed in part to the relatively high level of capital investment in recent years (Zhao, November 2012) (Top, 2008).

4.1.1 Direct productivity impacts

Estimates of accumulated productivity impacts and cost savings for the utilities sector for 2012 and additional impacts likely to accrue by 2020 are summarised in Table 1 and Table 2.

Table 1 **Productivity estimates for 2012**

Enterprise	Assumptions	Direct impact (Low)	Direct impact (High
Asset Management	Above Ground Asset management only Approximate 10-15% productivity benefit realised by Energy Utility providers for above ground assets (i.e. power lines) Less direct impact for utility providers with services located underground. Based on adoption rates between 1 and 40 per cent.	0.010%	0.0.020%
Underground Service Detection	Less direct realised benefit due to the obvious difficulties locating existing underground assets. New assets being constructed and positioned underground are being more effectively managed given the increased capacity to directly locate for service and maintenance. Based on adoption rates between 1 and 20 per cent.	0.018%	0.035%
Council Level	Greater capacity to acquire information on above ground assets. Extrapolated from estimates made in 2008 and updated with results of research and ROAMES case study	0.053%	0.080%

Note: Productivity impacts are accumulated from 1995

Data source: SKM research, case studies, industry consultations.

Table 2 **Productivity estimates for 2020**

Enterprise	Assumptions	Direct impact (Low)	Direct impact (High)
Asset Management	Above Ground Asset management only Based on adoption rates between 40 and 80 per cent.	0.015%	0.040%
Underground Service Detection	Greater sophistication in the visualisation and location of extensive undercover asset networks (i.e. Pipelines) Based on adoption rates between 1 and 20 per cent.	0.141%	0.211%
Council Level	Greater ability to locate existing assets. Augmented positioning options will further the ability of GNSS to more effectively map multiple classes of assets. Extrapolated from estimates provided from Allen Consulting group 2008	0.107%	0.160%

Data source: Case studies, interviews and literature review.

These accumulated productivity impacts are translated into industry wide impacts and summarised in Table 3.

Table 3 **Productivity estimates**

	Low estimate	High estimate
	Productivity on costs	Productivity on costss
2012	0.018% utilities 0.005% local govt.	0.135% utilities 0.008% local govt.
2020	0.0.262% utilities 0.011% local govt.	0.0.411% utilities 0.016% local govt.

Data source: ACIL Allen and SKM research *(ABS, 2013)*, *(ABS, 2013)*

4.1.2 Impact on sector output

The productivity impacts summarised in Table 3 were used as inputs to ACIL Allen's Computable General Equilibrium (CGE) model, Tasman Global[2], to estimate the impact that productivity improvements from the use of augmented GNSS has had on the Australian economy in 2012 and the potential benefits that could arise by 2020[3].

The results from this modelling for output from the utilities sector are shown in Table 4.

Table 4 **Impacts on output**

		Low case	High case	Low case	High case
		2012	**2012**	**2020**	**2020**
Increase in output	$ million	50	81	173	305
Percentage of total output		0.1%	0.2%	0.3%	0.5%

Note:
Data source: ACIL Allen modelling

The table shows that output in the sector is estimated to have been between $50 million and $81 million higher in 2012 as a result of the use and application of augmented GNSS. This represents 0.1 per cent and 0.2 per cent of total output for the sector.

Output is projected to be between $173 million and $305 million higher by 2020. This represents 0.3 per cent and 0.5 per cent of total output for the sector. .

The higher outcomes in 2020 assume that adoption levels will more than double from a relatively low base now. With advances in communications, technology and with wider coverage of augmented GNSS in the future, utility companies are well placed to access advanced positioning techniques that can provide more accurate and comprehensive spatial information across their networks.

[2] See overview report for a full description of the CGE modelling approach,

[3] Note that the productivity shocks for other sectors discussed in this report were also entered into the model at the same time.

With pressure from regulators to reduce the infrastructure costs, utilities could benefit greatly from the efficiency improvements canvassed in this report.

Adoption levels are likely to benefit from further integration of augmented GNSS with sensors and other systems for fast data capture and processing. The utilities sector is generally active in researching and trialling new applications. This is a positive for further adoption.

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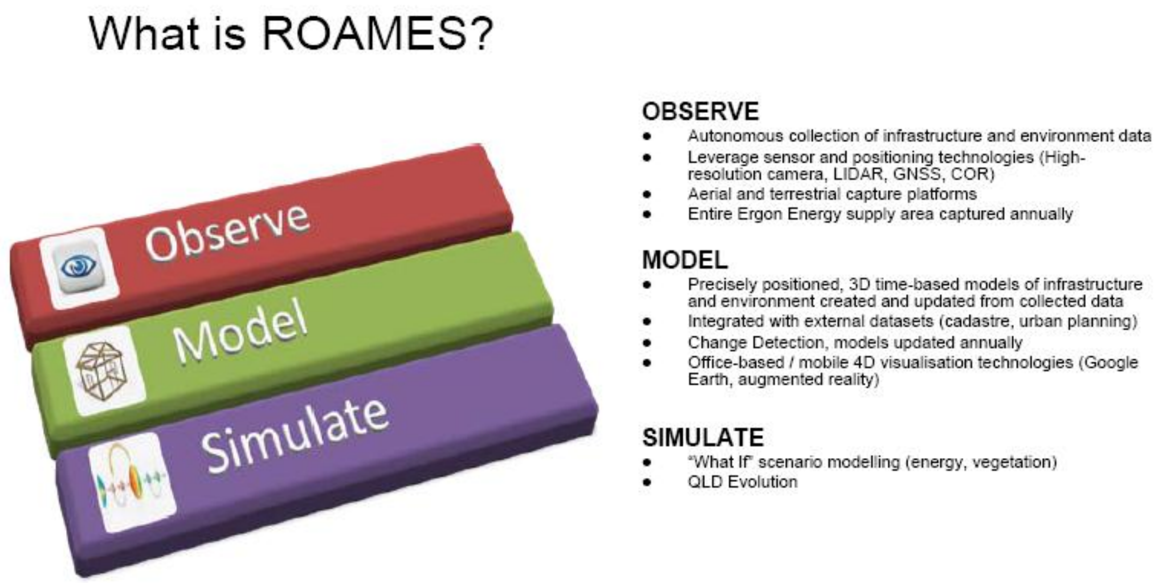
Appendix A Case Studies

A.1 Remote Observation Automated Modelling Economic Simulation (ROAMES)

This case study was provided by Ergon Energy, a Brisbane based electricity retail and distribution companies. Ergon Energy is an electricity retailer to homes and businesses in regional Queensland. It also maintains the regional Queensland electricity network.

Ergon Energy has implemented a spatially enabled remote sensing system to manage their extensive area (over 150,000km covering 97% of Queensland) of existing assets. Existing assets equate to over 8.7 billion dollars and are used to service over 680,000 Queenslanders. Thus any small improvement in management of both asset and surrounding environment can potentially save millions if not billions over the greater asset lifecycle.

Figure 1 **Remote Observation Automated Modelling Economic Simulation (ROAMES)**



1.

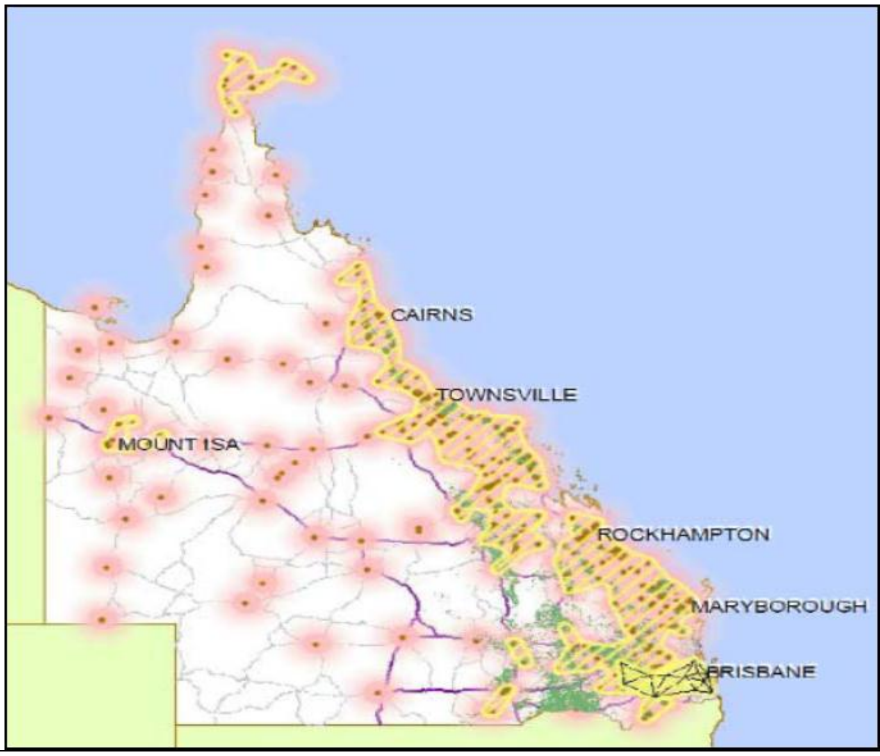
Data source: The Ergon ROAMES project – Department of Natural Resources and Mines

Remote Observation Automated Modelling Economic Simulation (ROAMES) comprises specifically modified aircraft fitted with either photographic or LIDAR distance measurement equipment. Such aircraft and then deployed over the expanses of the asset network to observe both infrastructure and surrounding environment. Information is then used to simulate both economic and environmental impacts on the asset network.

The system aims to locate assets (power poles, power lines and conductors, vegetation, buildings and terrain) at the centimetre accuracy level and relate (spatially) to existing environmental features to help determine asset condition and manage appropriately. This concept has been supported in collaboration with other government agencies and organisations at both the state and national level given the significant other uses that the collected data may also facilitate.

To support the high accuracy associated with the data capture tasks, it has been proposed that up to 600 new reference stations (CORS) be established state wide. The establishment of such an extensive reference network is seen as the most economically viable way to support this ambitious program and ensure the widest possible uptake of supported activities associated with the program.

Figure 2 **Shaded areas represent CORS coverage (less than 70km between stations) to support ROAMES positioning requirements**



Data source: The Ergon ROAMES project – Department of Natural Resources and Mines

Using GNSS to assist with the task of asset mapping has the potential to benefit the utilities sector across both private and government levels. Asset management techniques employ GNSS amongst a combination of other sensors to evaluate aspects such as conditioning and numbers.

As it stands, Ergon currently uses limited positioning technology as it provides little value given the underlying limitations of Queensland spatial infrastructure (e.g. inaccuracies in cadastre/DCDB, inaccuracies in asset locations, limited reference stations); these limitations are particularly exaggerated in the predominately rural/remote business operations of Ergon.

Whilst initial investment costs are high, the benefits of such wide scale asset management could deliver several economic benefits. Ergon Energy is currently working with the Department of Environment and Resource Management (DERM) on opportunities to use ROAMES imagery to maintain accurate cadastres (Ergon 2012). There are also numerous other benefits to all members of industry if the data from such infrastructure is made publicly available.

ROAMES is Ergon's strategic response that will enable the changes and adoption of precise positioning, however it is not just about augmenting Ergon's existing business processes with positioning technology, but rather re-thinking the paradigm (e.g. removing a task altogether) given not only positioning infrastructure but rich spatial models. Both of these provide the value proposition that ROAMES is promoting.

Ergon Energy expects to realise savings of up to $44 million over five years. This represents a saving in staff and materials of around 2 per cent.

A.2 Energex

In addition to Ergon Energy and their more advanced approach to wide area asset management, many other energy providers are utilising GNSS positioning amongst more refined tasks. Energex (Qld), utilise GNSS technology in a mobile mapping sense, amongst its management tasks for approximately 50,000 km of overhead and underground power lines and cables.

A significant issue for Energex has been compiling data bases that link their customers' location in relation to their networks. In the past there has been no dynamic link between the businesses customer database and their network maps, so that in managing their address systems assumptions, had to be made as to which part of the network serviced a specific address.

An indication of the extent of the mismatch was evident during storm events when the connection between customers addresses and the network was found to be only 38% accurate. As a result, service technicians were slower to respond to service calls, due to technicians going out to incorrect locations and failing to find the on-the-ground source of a problem quickly.

Error in the customer systems included wrong or badly managed addresses, missing or duplicated addresses.

Overall, efficiency improvements in Energex's business have come from improved integration of operations with spatial information, facilitated by greater positioning techniques. In the absence of GIS and GNSS, it would be necessary to revert to the service standards of the 1980s.

The approximate productivity benefit realised from the use of precise positioning GNSS asset mapping was estimated at 10% in 2008 (Allen Consulting 2008).

It is our view from examining the ROAMES case study and from industry consultations that the adoption and hence overall productivity benefits have increased since that estimate was made.

A.3 Infrastructure Asset Management

This case study was provided by the New South Wales Roads and Maritime Services.

Asset management is not necessarily restricted to the utility domain and must be recognised as a much broader concept that can be integrated amongst other industry sectors such as construction, civil engineering and transport. A prime example of asset management utilising GNSS combined with other high rate sensors, is the use of rapid capture geo-reference imaging amongst the Roads and Maritime Services (RMS) authority, to provide road conditioning and geometry reports on the extensive road networks throughout the state.

Rapid data capture for road condition and assessment (management and usage) via vehicle mounted geo-referencing systems, incorporate high rate GNSS data to supply the key spatial elements for image geo-referencing. This supports accurate interpolation of spatial features at the decimetre level.

Crucial to the operation and data capture is the reliability and timing of the GNSS data to ensure suitable accuracies are met. Traditionally, asset information has been referenced to the chainage of the road (which is sufficient for many purposes) however, with the availability of coordinate information, asset data can be linked directly into spatially enabled platforms such as GIS to give greater usage across multiple departments.

Figure 3 **An example of a mounted mobile geo-referenced image capture device**

Data source: Roads and Maritime Services (NSW)

A.3.1 Benefits

Precise positioning integration amongst rapid asset capture systems, such as the georeferenced imagery systems discussed above, ultimately allow large amounts of environment and asset information to be captured across vast networks of coverage.

- Data collected can be integrated effectively amongst spatially enabled platforms (GIS).
- reduced cost in re-locating assets
- reduced costs in mapping the assets
- More informed maintenance and management decisions can be made regarding the asset and upkeep of existing environment (for example, vegetation clearance from power poles).
- improved Asset performance
- more accurate asset valuation
- Datasets can support alternative opportunities, such as data collated as part of ROAMES supporting the maintenance of an accurate property cadastre.

A.3.2 Productivity Estimates

Effective management of large networks of assets is invaluable to the overall bottom line of utility companies. Intelligent management decisions enable greater distribution of service, improved service to customers (via decreased disruptions to service), improved asset lifetime and reduced maintenance costs, which all contribute to significant increases to the operating margins of the utility company.

Utilities that engage GNSS for asset mapping, such as Energex, have typically been able to achieve cost savings to operational costs of asset mapping in the order of 5-10 per cent.

More elaborate asset management concepts such as ROAMES, expect to realise savings of up to $44 million over five years.

A.4 Underground Service Detection and Data Management

This case study draws on information from NBN Co, Dial Before You Dig and SKM.

A subset area of asset management of particular interest to not only utility companies (in their overall quest for better management of assets), but the broader community, is that of underground services. It is imperative to both the security and maintenance of these assets, that disruption to these services are avoided, however with limited spatial awareness of their locations, damage and disruption are often unavoidable as other construction, civil or service providers look to uncover these areas.

As there is currently minimal survey accurate information for the layout and network of existing underground services (assets) across the country, there are a number of inherent risks transferred to the community as new development seeks to utilise and construct in the same areas where these services exist. Current methods of service detection require the incorporation and compilation of publicly available 'Dial Before You Dig' information, underground service proving through radar detection methods or NDD (Non-destructive digging), and/or survey pickup of radar detection points at ground level or over the proven exposed location.

Through these current methods, there are a range of costs and approvals required to carry out further underground work. Costs of such developments requiring the exposure of underground services can include surveyors, service locators, and excavators through to the costs of approval of dig/excavation permits. Even with such significant costs there are limitations as to the effectiveness of service detection and damage, disruption and injury are often experienced due to the uncovering of unknown assets during construction and development works.

Precise knowledge of underground asset location is also beneficial to the host and can result in large efficiency improvements in locating and servicing asset (increasing both service delivery and lifecycle). This is particularly relevant to utilities who manage large pipe networks that require excavation of bitumen, concrete and other hard surfaces given the costs associated in first detecting, then uncovering the asset of interest.

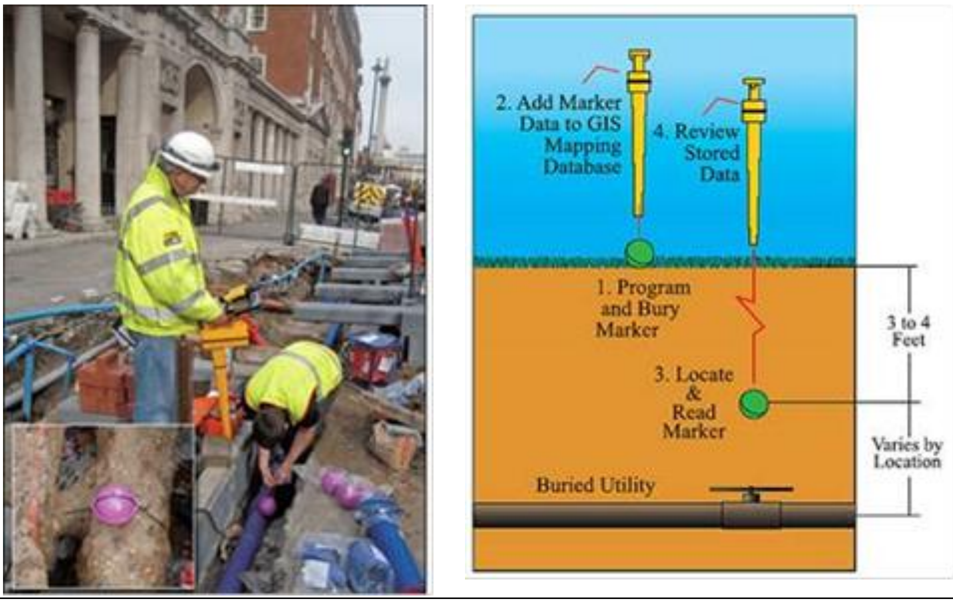
Whilst it is impossible to fully detect every service asset that has been previously placed underground, it is an endeavour of new management strategies to now correctly spatially locate services as they are constructed or provide other detection means later on, thus mitigating the risks of unexpectedly uncovering these services at later dates. GNSS, as a wide coverage high precision positioning system offers the most flexible approach for providing accurate spatial information to as construct surveys and as such is being widely used across many existing utility operations.

RFID Markers (Radio Frequency Identification)

One emerging technology that is currently being implemented is the combination of RFID markers with spatial positioning to create asset underground identification.

- Allows underground and aboveground assets to be ‘tagged’ with radio markers. These have been in use in the USA since at least 2006
- Markers are placed during construction with locations recorded via GPS. They can be buried at various depths depending on marker model
- Field teams can then relocate assets using the RFID reader and average quality GPS. Naturally they can also be shown/managed via GIS interfaces
- Tags can also contain asset information (asset type, material, depth, date constructed etc) so field teams can relocate the specific pipe if multiple pipes and markers have been placed close to each other
- Cost is approximated currently at about $25-30 each – these last about 25 years and are environmentally friendly if destroyed. The RFID reader costs about $5000
- Other RFID markers include plastic tape with embedded RFID chips spaced every 2 metres, which can be rolled along the pipes prior to filling
- Pegs that can be embedded on the surface (such as underneath cat’s eyes along the road or drilled into power poles).

Figure 4 **An example of a mounted mobile geo-referenced image capture device**



Data source: Ultimate Positioning

A.5 National Broadband Network

This case study was supplied by NBN Co Limited

Information shown on the Australian Government National Broadband Network (NBN) website indicates that the national rollout of the new high speed broadband project represents the largest infrastructure development ever undertaken in this country (Mike Rayner 2012).

A major issue relating to the project and an unfortunate reoccurrence over the years within the communications industry is that there is very little emphasis placed on long term infrastructure security by providing accurate as built information for the installed (underground) services. Thus there have been vulnerabilities with existing infrastructure assets resulting in damage of cables from future civil or construction works.

Several proposals have been submitted to NBN Limited Co to reliably provide accurate spatial locations (and resulting datasets) for the communications infrastructure and ensure significant cost savings through better management and minimal future disruptions to services.

The field data capture, to locate in ground assets is facilitated by GNSS precise positioning, which provides instantaneous coordinate information to be directly integrated in asset management systems (typically GIS). This information is either captured by on-site surveyors or specialist mobile mapping operatives who are equipped with customised GNSS receivers that are connected to an appropriate correction service (either GBAS or SBAS).

Previous practices, reliant on diagrammatic details on DBYD plans combined with expensive, specialist location services are easily avoided through correct as-built survey plans as assets are constructed. The future savings of such practices are invaluable and with GNSS being readily available to accurately capture asset position as it is being laid many operators are mandating the process. This is constant, not only across utilities, but construction and civil projects as well.

The use of GNSS and GIS within the NBN project has not been fully implemented across the country and is often dictated by the approach of the local governing body (council). However, the ability to currently use positioning in such a manor provides an affordable means for all interested parties to locate underground fibre optic cable with a high degree of confidence and allow designers to ensure future works can be placed to avoid potential conflict with the cabling

A.5.1 Benefits

Location of assets, as has been demonstrated through the above ground features of energy and road networks is imperative to effective decision making and maintenance options. Linking positional information into the realm of underground services will provide numerous similar benefits.

The benefits of precise positioning in this context include:

- mitigating potential damage of the service
- fast data capture (through GNSS)
- cost effective management
- Data collected can be integrated directly to existing GIS platforms.
- The position on the grade can be set-out using the coordinates previously recorded (which will assist in protecting the underground cabling from accidental damage), prior to construction or digging, compared to current methods of radar detection or vacuum which aren't cost effective.
- Data can be shared between organisations in digital format
- Security and Protection of asset.

A.5.2 Productivity Estimation

The estimated productivity benefits include:

- reduced maintenance costs through damage and repair to assets
- reduced costs from other agencies in evaluation of area of works (i.e. less requirement for service detection when correct spatial asset management has been applied correctly)
- improved health and safety through accurate mark outs of service depths
- reduced disruption to services from damage or disturbance resulting in higher usage of service.

A.5.3 Adoption Costs

The adoption costs of implementing management systems for underground assets are hard to measure directly and vary from utility provider.

However, the costs associated with field data capture and reliable database updates are minimal given the advent of GNSS technologies.

Appendix B Adoption

Current levels of precise position adoption amongst utility providers is limited to above ground assets only and in a vast majority of applications is further limited by the availability of accurate spatial data sets to support requirements of cm level positioning.

Adoption is largely centred on private energy providers whom manage wide expanses of infrastructure and assets such as power lines and poles.

B.1 Adoption Factors

Adoption is driven by a number of factors. More broadly speaking, the classic textbook reference by Rogers (1964) identified a five-step decision process involved in technology adoption and diffusion:

- Knowledge – potential adopter becomes aware of an innovation but has no particular opinion of it (this could be via advertising or through word-of-mouth)
- Persuasion – the potential adopter seeks further information to help form an attitude toward the innovation
- Decision – the potential adopter engages in activities that lead to a choice to adopt or reject the innovation (the process is internal to the person and can be difficult to measure empirically; however considerations of price and perceived usefulness/necessity will play into this decision)
- Implementation – the innovation is adopted and put into use (e.g., user installs geospatial data software or uses car navigation aids)
- Confirmation – person evaluates the results of an innovation-decision already made which may affect decisions such as whether to continue using the innovation or return to previous status quo (e.g. remove software or return car navigation aid).

Rogers also estimated the categories of adopters as being innovators (2.5 per cent), early adopters (13.5 per cent), early majority (34 per cent), late majority (34 per cent) and laggards (16 per cent. These reference figures are adopted for the current report, as they were based on and have been broadly corroborated by many case studies including those in the original contribution by Rogers.

B.1.1 Improvement in underlying spatial data

As was discovered during assessment of Ergon’s ROAMES project, precise positioning is often limited in application due to the limitations of accuracy on other accompanying data sets that help comprise the greater information management and decision making. For example, with limitations on the accuracy of the digital cadastre and therefore definition of boundary, it is often a wasted exercise to locate typical utility assets at the cm level when the encompassing boundary data is only relevant at the metre level.

As improvements are made to larger spatial data sets and there accuracy refined, it is likely that the applications of precise positioning will grow in importance.

B.1.2 Technology Availability

As is the case with implementation of many new systems, adoption costs and availability of appropriate technology required to integrate precise positioning amongst encompassing management systems needs to be analysed compared to benefit. It is evident that utilities with above ground assets (largely electricity distributors) realise greater current benefit and as such are prepared to invest in the higher adoption costs associated with the use of technologies supported by precise positioning.

B.1.3 Underground Location and Detection

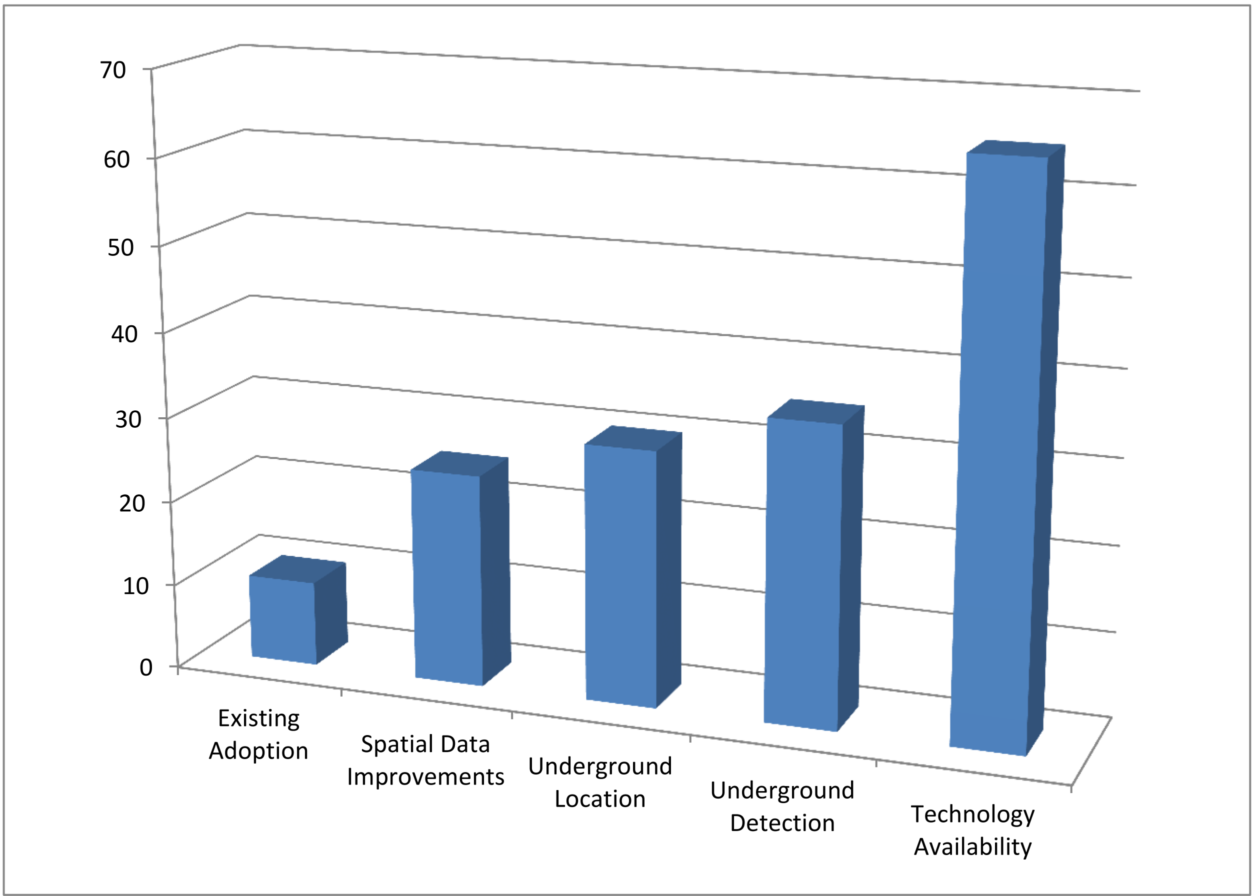
The major impediment for many utilities is of course the accurate location and detection of their extensive networks of underground assets. This is problematic as given the historical existence of many services such as water and sewerage which rely on vast networks of old pipe established over the last 50 + years, location of such assets is extremely difficult unless fully uncovered.

However, it is evident that attitudes are changing given the realisation of benefits of accurate spatial data. It is now becoming fundamental for such utility organisations to ensure accurate location of new assets as they are being constructed. With precise positioning being adopted amongst the creation of new assets, slowly, but surely, more complete asset management systems can be expected to be built up and replace the less reliable historical data sets.

Figure 5 sets out the influence that these factors are understood to have on levels of adoption.

Figure 5 below illustrates the estimated rise in adoption level (expressed in percentage) as various adoption factors are overcome through developments.

Figure 5 **Factors affecting levels of adoption**



Data source: SKM; Figure 5 represents the combined adoption of both above and below ground assets for the utility sector.

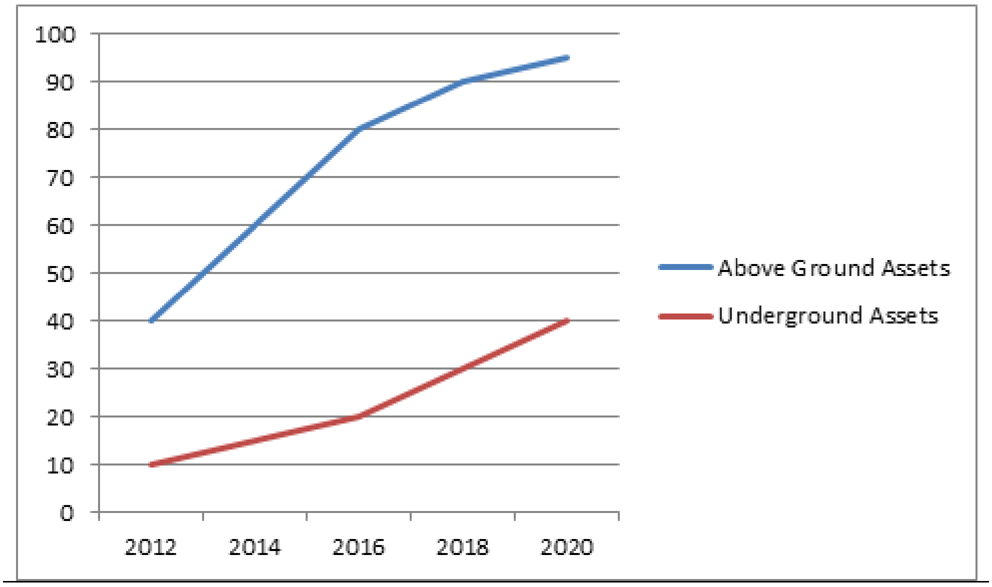
The adoption factors previously discussed and indicated within figure 8 are seen as the major impediments to adoption. As these are partially or fully overcome there will be a direct correspondence with utilities adoption of positioning systems and technologies. The estimates in Table 5 are speculative but an attempt to project the likely technological and structural advances in positioning adoption factors.

Table 5 **Estimated Timeframe for overcoming adoption factors – Utilities**

	Optimistic	Medium	Conservative
Spatial Data Improvements	2014	2018	2020
Underground Location	2014	2018	2025
Underground Detection	2018	2020	2025
Technology Availability	2014	2018	2025

The graph below (Figure 6) displays the likely increase in adoption of GNSS precise positioning technologies amongst the Utility sector. Two curves have been estimated based on the implementation of GNSS positioning amongst utility companies dealing with above and below ground assets.

Figure 6 **Adoption Curves**



B.1.4 Limiting Factors

Complete (100%) coverage via asset surveying techniques is often not possible and other techniques are often required to augment the process. GNSS has current limitations given the obstruction to satellite signals in certain areas of high vegetation, dense urbanisation and of course is limited to above ground assets only. As such, asset mapping across the sector incorporates a combination of techniques.

In addition emerging GNSS compliant alternative technologies such as Locata has the potential to extend precise GNSS into underground and metropolitan areas.

Also, given the nature of Australia's wide expanses and sparse population, there are currently difficulties associated with providing accurate centimetre level GNSS positioning at the real-time level for assets away from major population areas. This is simply due to the limitations of both communications and positional infrastructure in remote areas.

Whilst there is an increasing adoption of positioning and spatial approaches to asset management in the local government domain, these techniques are still in their relative infancy and existing systems seldom rely on centimetre level positioning due to the associated costs involved. It is a different story in the more commercial areas of utilities investment in asset management strategies utilising precise positioning is significantly higher and as such greater benefits are being realised.

Utilities with a large amount of existing infrastructure located underground have not readily adopted precise positioning for these in-ground assets and are often unable to reference spatial management techniques. Whilst efforts are made to build in spatial integrity to their existing asset management systems, given the restrictions in obtaining positions, these large networks remain at best speculative until uncovered and located directly. Ultimately, this results in higher maintenance and management costs to the utility provider.

Appendix C Social and Environmental

There are many positive implications through the applications of precise positioning amongst the utility sector. The most obvious benefit is that through correct management of large scale assets and infrastructure, utilities can better provide essential services to the greater community minimise disruptions and improve the quality of such services.

Environmental management surrounding the areas in which assets and infrastructure are contained is also a beneficial by-product of the collation of spatial data. Examples being the reduction in bushfire risk from ensuring appropriate clearances of powerlines and overheads from dense vegetation.

The concept of an augmented reality amongst full 3D visualisations of service networks is a concept being currently developed by several authorities with keen interest at local, state and federal levels. With improvements in the spatial collation of data as new services become constructed and old services relocated, advanced virtual environments will provide significant risk mitigation in the future by enabling a more interactive approach to understanding the complexity of service locations.

As has been demonstrated, through the ROAMES collaboration, improved asset management techniques engaged by private enterprises can have significant benefit to public authorities, the wider community and scientific endeavours. In fact, ROAMES as probably the most telling example of multi-purpose data use can support a vast array of environmental management objectives and further aids government in improving the capacity and accuracy of existing property boundary data (cadastre).

With great emphasis on sustainable practices, intelligent management through asset mapping, will only aid in the improvement of relationship between environment and asset network.

The generic exchange of data through certain authorities allows for more precision in planning and development stages of civil and future works. This avoids potentially hazardous situations around 'unknown' services and also avoids disruptions to fundamental services such as electricity, water and gas through damage to assets.

Appendix D References

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