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Norfolk Island Mobile Network Review Project

Final Report

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DISCLAIMER

This report addresses the requirements outlined by the Department of Infrastructure and Regional Development.

The information, opinions and conclusions provided in this report are based on information provided by Department of Infrastructure and Regional Development, Norfolk Telecom, stakeholder interviews on Norfolk Island, publicly available information and GQI Consulting's experience and professional judgement.

GQI Consulting has assumed that the information and documents provided to us are a true and accurate reflection of the information to which they relate and have made no independent checks of the information.

The conclusions and statements in this report are based on information available at the time of preparing this report.

GQI Consulting make no representations or give any warranties for the opinions, conclusions and statements provided in this report and take no responsibility for any reliance on this report for any purpose other than for which the report was prepared.

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ABBREVIATIONS

Abbreviation	Description
2G	Second Generation mobile technology, sometimes also called GSM
3GPP	Third Generation Partnership Project
4G	Fourth Generation Partnership Project
ACMA	Australian Communications and Media Authority
ADSL	Asymmetric Digital Subscriber Line – Fixed line broadband technology
ARPU	Average Revenue per User
BSC	Base Station Controller
Capex	Capital Expenditure
E1	Transmission capacity equivalent to approx. 2Mbps
eNB, e Node B	Evolved Node-B
Gbps	Gigabits (1000 x Mbps) per second a measure of transmission speed
Gbytes	Gigabytes a measure of volume of transition downloads and uploads over a period of time usually a month
GPS	Global Positioning System
IP	Internet protocol
IRR	Internal Rate of Return
ISP	Internet Service Provider
LTE	Long-Term Evolution of third-generation cellular systems or 4G
Mbps	Megabits per second a measure of transmission speed
MVNO	Mobile Virtual Network Operator
NBN	National Broadband Network
NI	Norfolk Island
NIDS	Norfolk Island Data Service
NPV	Net Present Value
NT	Norfolk Telecom
OLTE	Optical Line Terminal Equipment
Opex	Operating Expenditure
PSTN	Public Switched Telephone Network
RAN	Radio Access Network
RBS	Radio Base Station
RF	Radio Frequency
RNC	Radio Network Controller
RSP	Retail Service Provider
RX	Receiver
SMS	Short Message Service
USO	Universal Service Obligation
VoIP	Voice over IP
VoLTE	Voice over LTE (4G)

1 SUMMARY

1.1 Introduction

The Department of Infrastructure and Regional Development, (the Department), commissioned GQI Consulting Pty Ltd (GQI) to:

- identify the necessary telecommunications infrastructure that will be required to provide 3G mobile services on the island and the likely timeframe in which the roll-out of a 3G network could take place
- determine the state and condition of existing 2G telecommunications infrastructure and assess whether it is capable of being upgraded to provide 3G services, or whether the installation of completely new infrastructure will be required
- establish a number of options for implementing 3G mobile services on the island, including:
 - ensuring that a 3G mobile service is capable of being upgraded to provide a 4G LTE service with minimal effort, and
 - whether different levels of upgrades can take place to enable 3G mobile services (i.e. basic which may include upgrading existing technology, or full replacement)
- provide an estimate of the cost:
 - of providing a 3G mobile service on the island (including a cost estimate of the different upgrade options which may be available), and
 - a consumer may face as a result of the infrastructure upgrade (in terms of capital costs being passed on, as well as by utilising additional services a 3G network is capable of such as data, MMS and video calling).

This report covers the assessment of the existing 2G mobile network, Norfolk Island's mobile network requirements, technical solutions, costs and recommended plan to upgrade the existing 2G mobile network.

1.2 Background

Norfolk Island is an external Australian territory in the Pacific Ocean about 1,600 km east of Sydney. In addition to being one of Australia's most geographically isolated communities, Norfolk Island is also one of Australia's oldest territories, having been settled six weeks after Australia's founding settlement at Sydney, New South Wales.¹

Telecommunications on Norfolk Island are currently governed by local legislation and regulations, although some aspects are governed by Commonwealth regulations for example radio spectrum allocations which are managed by the Australian Communications and Media Authority (ACMA).

Norfolk Telecom is a Norfolk Island government business enterprise overseen by the Administration of Norfolk Island. Norfolk Telecom operates the Island's fixed and mobile telecommunications infrastructure and networks and is responsible for connecting these networks to international destinations and the internet.

¹ http://www.regional.gov.au/territories/norfolk_island/index.aspx

GQI undertook this Study and provided options for an upgrade to the 2G mobile network on the assumption that a potential upgrade project would take place under the current Norfolk Island Telecommunication industry framework.

1.3 Methodology

1.3.1 Overview

GQI visited Norfolk Island in May 2015 to inspect the existing mobile network technology and to discuss user requirements and commercial aspects of the operation of the mobile network with Norfolk Telecom and Administration of Norfolk Island officials.

With the Department's approval, GQI also held informal discussions with technology supplier Ericsson² which has its technology deployed in the existing 2G mobile network, and Challenge Networks³ which was involved in the existing network deployment and currently provides operations support for the network.

The technical solutions included in the report are based on 3GPP^{4,5} standard architecture which supports the global standards to which all mobile network and mobile devices comply.

Capital and operating costs as well as customer revenues are based on GQI benchmarks and research of publicly available information.

1.3.2 Stakeholder consultation

GQI held discussions with the Department and a range of stakeholders including staff at Norfolk Telecom, the Norfolk Island Government and the Administration of Norfolk Island, as well as mobile network technology vendors.

1.4 Telecommunications on Norfolk Island

1.4.1 Overview

The telecommunication networks operated by Norfolk Telecom are shown in Table 1 together with estimated number of services currently in operation⁶.

² <http://www.ericsson.com/au>

³ <http://www.challengenetworks.com.au>

⁴ <http://www.3gpp.org>

⁵ <http://netx.mpirical.com/ABNH11#network-map>

⁶ Information from Norfolk Telecom

Network	Technology	Services	Number of users
Public Switched Telephone Network (PSTN);	Copper cable, some fibre and an Ericsson AXE switch	Fixed line switched voice and leased lines	1,560
PSTN	Asymmetric Digital Subscriber Line ADSL	Fixed broadband	630
Public mobile phone network	2G (GSM) or Second Generation	Prepaid mobile voice, voice messaging and Short Messaging Service (SMS)	1,540 plus average of 165 roamers to the island
International Connectivity	Satellite	International connectivity to and from the island	All

Table 1: Summary of telecommunications on Norfolk Island

1.4.2 Existing 2G Mobile Network

The existing 2G mobile network on Norfolk Island was built by Norfolk Telecom in 2007.

The equipment used to build the mobile network consists of refurbished Ericsson 2G mobile phone radio base stations (type RBS200), and a new AXE10 switch for the core network and Radio Network Controller (RNC).

This equipment is technologically obsolete and is likely to need upgrading in the next 2 to 3 years to prevent a major loss of service.

The number of 2G mobile services includes:

- 1,540 local prepaid SIM cards, and
- approximately 165 visitors are on the Island at any one time.

1.5 Conclusion

GQI has undertaken this Study to review the state of the existing 2G Mobile network on Norfolk Island, user requirements and options for a future upgrade.

This Study has found that the existing 2G mobile network infrastructure and technology is likely to need upgrading in the very near future to continue to guarantee reliable mobile services and provide similar standards of mobile coverage and services available on the Australian mainland.

This report recommends that a 4G technology mobile network be deployed on Norfolk Island, while allowing the existing 2G mobile network to be de-commissioned after a short transition period. It is recommended this 4G network be operated in the 1,800 MHz spectrum band as sufficient 1,800 MHz spectrum is currently available at a relatively low price.

A 4G solution is more cost effective in terms of capital and ongoing operating costs than a 3G technology solution which would very likely need to be upgraded to 4G technology during the 10 year period of the financial modelling.

In addition, the 4G solution provides greatly enhanced capabilities such as Voice over LTE (VoLTE) and high speed wireless broadband with peak speed in the proposed configuration of 75Mbps.

The proposed 4G solution is estimated to cost \$3.7 million and could be fully implemented in 10 to 12 months.

GQI consider that any future changes in the regulatory environment would likely have little impact on any new network(s) built ahead of any changes when considered from a technology and network standpoint. This is because it is likely that there will only one economically viable network owner and operator on Norfolk Island into the foreseeable future.

2 CURRENT SITUATION ASSESSMENT

2.1 General

GQI undertook a discovery phase to assess the current situation of the mobile network on Norfolk Island which included:

- desktop research
- initial Q&A with the Administration of Norfolk Island
- Norfolk Island Visit
- discussions with technology vendors and contractors, and
- discussions with stakeholders on Norfolk Island.

2.2 Existing 2G mobile network

2.2.1 Overview

The current mobile network is a Second Generation or 2G mobile network and provides only voice, Short Message Service (SMS) and voicemail capabilities. Billing is all prepaid.

The technology used to build the 2G mobile network consists of refurbished Ericsson 2G mobile phone radio base stations (type RBS200), and a new AXE10 switch for the core network and Radio Network Controller (RNC). This radio equipment was second-hand and already technologically obsolete when installed in 2007, making support and spare parts difficult to obtain today.

Initial funding for the 2G mobile network was provided by the Administration of Norfolk Island.

The prime contractor was Challenge Networks, who continue to provide ongoing support for the network.

The mobile industry in Australia and the world has moved to Third Generation or 3G with broadband data capability and more recently has further evolved to Fourth Generation 4G or LTE in order to meet customer demand for faster mobile broadband services. Customers on Norfolk Island are also requesting these faster wireless broadband services.

2.2.2 Major network components

A typical 2G mobile network has major technology components as shown in Fig.1. The existing 2G mobile network on Norfolk Island is deployed using the typical 2G architecture and technology which consists of:

- passive infrastructure e.g. equipment shelters and poles
- active network components, BTS, BSC and Core
- backhaul transmission systems connecting the BTS, BSC with the core systems that control the radio connections, and
- connection to the PSTN, as the network supports voice calls only.

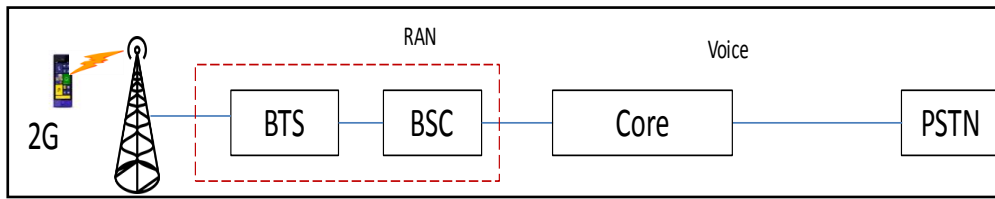


Fig. 1: Typical 2G mobile network technology components

2G - Second Generation sometimes also known as GSM Mobile User handsets
 BTS – Base station
 BSC – Base Station Controller
 RAN – Radio Access Network consisting of BTS, transmission and BSC
 Core – Connects and controls the calls from the BTS to the PSTN
 PSTN – Public Switched Telephone Network

Fig. 2 below shows the location of mobile base stations on Norfolk Island.

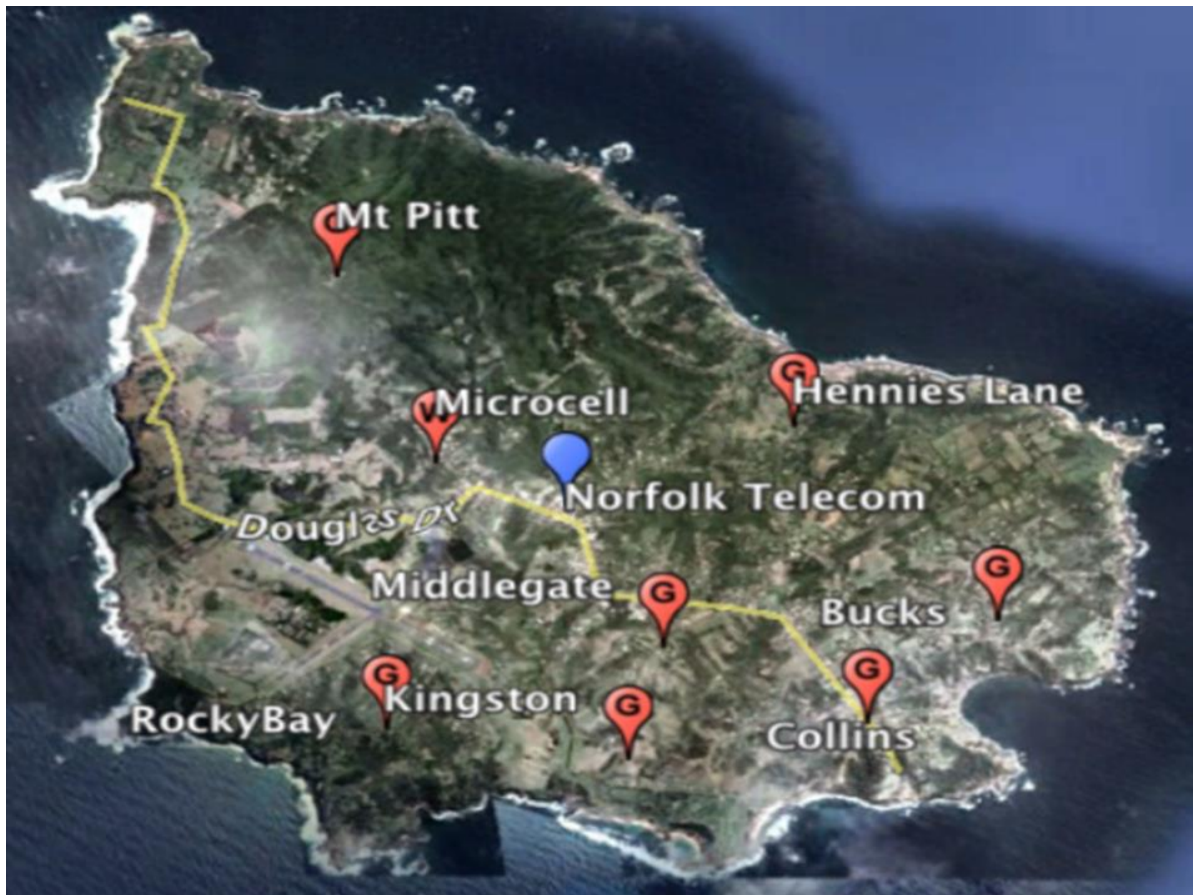


Fig. 2 Mobile base station locations on Norfolk Island. 'G' and 'M' indicates 2G base station locations.

Table 2 lists the existing radio base station locations together with technical details of each site.

Name	Pole	Antennas	Equipment	Batteries	OF Access	Access to Site	Comment
Hennie's Lane	10m	2 Omnis	RBS200	No	No	Roadside	Standard hut
Bucks	10m	3 Omnis	RBS200	100Ah	yes	Access road private proper	Standard hut
Collins	10m	3 Omnis	RBS200	100Ah	Yes	Roadside	Standard hut
Kingston	5m	3 Omnis	RBS200	100Ah	Yes	Access road	Standard hut
Middlegate	10m	3 Omnis	RBS2202	No	Yes	Roadside	Standard hut
Microcell	10m	2 Omnis (small)	Microcell	No	No	Roadside	Low power pole mounted
Rocky Point	10m	3 Omnis	RBS200	No	Yes	Roadside	Standard hut
Mt Pitt	10m	2 Omnis, 1 panel	RBS200	Yes	Yes	Access road	5x3m Concrete bunker
Mt Pitt	10m	2 Omnis, 1 panel	RBS200	Yes	Yes	Access road	5x3m Concrete bunker

Table 2: Norfolk Telecom 2G radio base station summary

2.2.3 Passive infrastructure

Passive infrastructure includes radio site poles, huts and power infrastructure. Much of this plant may not be reusable because of insufficient space, capacity and/or age. Major items of passive infrastructure regarded as unusable are:

- sealed batteries which are nearing the end of their service life of 8 years (this applies to Core Network batteries as well as those at radio sites),
- 4 huts which require considerable re-arrangement to fit new equipment (huts without batteries have ample space) and
- a number of poles which may need to be strengthened or replaced to meet antenna headframe load. Poles are generally 10m high.

Ample space is available at the Norfolk Telecom office to house any new core network equipment.

2.2.4 Active network

- 2G core network and radio base stations
 - the 2G core network and radio base station equipment (Ericsson AXE10 and RBS200) is based on obsolete, 25 year old technology which is difficult to maintain and support.
 - these components cannot be upgraded to support current mobile technologies.
 - antennas are nearing end of life.
- Billing and voicemail
 - the manufacturer of the existing 2G mobile network's billing system (Argent) is no longer in business and therefore it is not supported or maintained.
 - the 2G mobile network contains a composite voicemail system which is not compatible with current mobile technologies.
- PSTN core
 - although not strictly part of the GQI Brief, it was noted that the PSTN core network switch (AXE103) is obsolete and difficult to maintain and support.
- Other active network issues
 - the feature level of the current 2G mobile network system is well below that expected of a modern efficient mobile system.

2.2.5 Backhaul systems

- all radio base station backhaul links are of E1 (2 Mbps) capacity. All but two use line systems on copper pair cables.
- the remaining two are on optic fibre pairs via fibre media converters which terminate on Mt Pitt.
- Norfolk Island is well served with optic fibre, having 24 fibres passing all base station sites but two.

2.2.6 Satellite systems

- Norfolk Island connectivity back to the Australian mainland is via two satellite systems as follows:
 - IP traffic via O3b⁷ medium earth orbiting satellite system
 - The contract for this arrangement provides for 50Mbps capacity (40 Mbps down and 10 Mbps up). This will be upgraded to 75Mbps in October 2015 with a further capacity upgrade to 100 Mbps to take place by October 2016. This contract is for a period of 5 years.
 - Backup 2 Mbps digital link via C8 satellite to New Zealand. This link interconnects to Telecom New Zealand (TNZ).

⁷ <http://www.o3bnetworks.com>

2.3 Norfolk Telecom organisation

Below in Fig. 3 is a functional organisation chart for Norfolk Telecom showing roles and current incumbents.

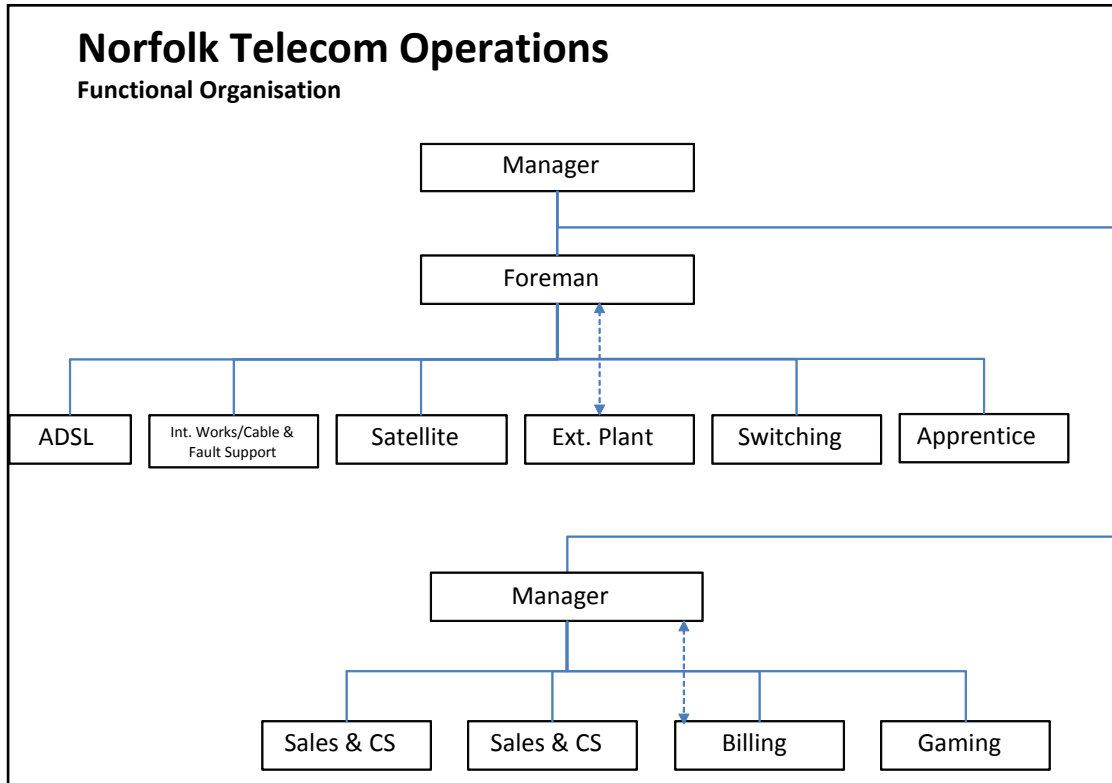


Fig. 3: Norfolk Telecom functional organisation and resources

2.4 Norfolk Island telecommunications customer numbers and services

The number of estimated telecommunications customers and services types on Norfolk Island based on information provided by Norfolk Telecom are provided in Table 3 below.

Service type	Estimated Number
PSTN (fixed line voice) subscribers	1,560 ⁸
GSM (2G mobile) subscribers	1,540
Number of visitor GSM (2G mobile) subscribers	165
ADSL (fixed broadband) subscribers	630

Table 3: Services in operation on Norfolk Island

2.5 Other comments and observations

2.5.1 Telecommunications industry structure

GQI have been briefed on the Norfolk Island reform process currently underway.

⁸ Information provided by Norfolk Telecom. This seems a high number of fixed line services in view of the fact that the total island population is 1,600.

As part of the reform process, the telecommunications regulatory environment as well as the fixed and mobile telecommunication network ownership structure and operating arrangements could change in the future.

In undertaking this Study, GQI have assumed that a 2G mobile network upgrade would be undertaken under the current regime. Despite this, GQI have factored into the design of the upgrade solutions a potential change in the industry structure. In terms of a change to the industry structure, GQI consider the following to be key issues:

- industry structure and network ownership - potential roles for Australia's 3 mobile operators and NBN Co
- Universal Service Obligations (USO)
- promotion of a market based competition model suited to the size and conditions of the Norfolk Island telecommunications market
- role for current Island-based organisations such as Norfolk Telecom and Norfolk Island Data Service (NIDS) in the new arrangements, and
- transition arrangements.

2.5.2 Fixed networks

The fixed PSTN core switch also uses old Ericsson technology and is considered obsolete and difficult to maintain. Decisions on the upgrade path for the PSTN switch could be coordinated with the upgrades to the mobile system.

2.5.3 Other issues to be considered

GQI consider the following to be key issues related to the 2G mobile network that will need to be addressed as part of an upgrade:

- the optimum frequency band to be used using available spectrum bands for coverage and the cost of this
- radio equipment size and technical characteristics for installation in existing shelters
- the equipment cost of different technology options
- the impact on handsets currently in use on Norfolk Island and the timing of their upgrade by customers, and
- the high cost of satellite transmission back to the mainland, the impact of this cost on the business case and ways of reducing it.

3 OPTIONS

3.1 Introduction

3.1.1 General

GQI's Study identified a range of technical solutions. For each of the options GQI developed a high level technical design, identified key components and their costs (capex and opex) and evaluated the costs of each option. This process is described in more detail in Sections 4 and 5.

3.1.2 Key options

The following are the main options for upgrading the 2G mobile network on Norfolk Island:

- Option 1

upgrade the mobile network to 3G with a transition period of dual 2G and 3G operation to allow customers time to upgrade handsets. Provision would be made for the 3G network to be readily upgraded to 4G LTE with further investment. This would involve reusing passive infrastructure, but installing new, 4G active equipment

- Option 2

upgrade the mobile network to 4G LTE with a transition period of dual 2G and 4G LTE operation to allow customers time to upgrade handsets.

Two further sub-options were considered based around a 4G LTE mobile network rollout:

- Option 3

use the new system (preferably 4G LTE) to also replace the fixed voice network with fixed wireless units, thereby avoiding the need for a new fixed voice switch upgrade

- Option 4

long-line the base stations back to the Australian mainland and terminate on one of the mainland operator core networks. This would require the cooperation of the relevant mainland operator to implement such a plan.

Note that the option to continue with the status quo and simply expand the existing Wi-Fi hotspot networks has been considered but ruled out. This is because it would not meet the requirements of the Department's brief to provide advice on a new mobile phone network which is capable of supporting services typically available on the mainland in regional and rural Australia, as well as the existing network being comprised of equipment which is technologically obsolete and will likely need upgrading in the next 2 to 3 years to prevent a major loss of service.

3.2 Requirements for a new Norfolk Island mobile network

GQI have developed a set of user requirements and corresponding network technical parameters such as coverage, system capacity, core dimensioning and network performance to meet the user requirements and developed a high level technical solution. These requirements are summarised in Table 4.

Parameter	Assumption
Island permanent population to be serviced	Stable at 1600 ⁹
Data speed 3G	Peak 42 Mbps
Data speed 4G	Peak 75 Mbps
Initial wireless data usage per user	Up to 2Gbytes per month av. per user
Average voice traffic per customer	20 milli Erlang ¹⁰ /user in busy hour.
Coverage on Norfolk Island	On street, handheld coverage 90% of locations 90% of time. In building coverage also to be provided
Frequency band of operation	1,800 MHz band
Estimated number of Radio Base Stations to provide the coverage	Existing 9 plus 3 new for improved coverage and to cater for smaller cell radii with higher frequency 1800 MHz compared with existing 900 MHz
Initial Core Switch Subscriber Capacity	3,000. Realistically current equipment would cater for a minimum of 10,000
Connection to other networks	Interconnection at local and international PSTN for voice and the internet for data

Table 4: New 4G mobile network key capacity and technical design parameters

3.3 Technical considerations

3.3.1 General:

Technical solutions have been developed based on global mobile industry standards as set out in ITU 3GPP1 using carrier grade equipment provided by one of the Tier 1 equipment vendors/handset/terminal device manufacturers. In developing these technical solutions, GQI has sought information from vendors of mobile technology solutions capable of being customised to suit small island networks such as Norfolk Island.

One of the issues with Norfolk Island is its small size and population. This poses special issues in terms of optimising cost and viability. For example, initial capital per customer to establish a mobile phone network is of the order of \$100 per subscriber on the Australian mainland. For Norfolk Island, GQI has estimated a new 4G network would cost \$3.7m for and average capex of \$2,400 per user. As a consequence, the option of multiple operators competing on Norfolk Island at the network level is unlikely to be viable.

GQI note that the Department's brief was to advise on the upgrade using 3G mobile network technology (with provision to move to 4G at a later date). The general view within the mobile industry is however that 3G technology, first deployed in Australia in 2003, is a mature technology which will in the next few years itself become obsolete. The estimated initial cost to implement a 3G network is in the order of \$4.4m. Within a 10 year period, it is expected that a 3G network would need to be upgraded to 4G at an additional cost approximately equivalent to implementing a 4G network from the outset (\$3.7m). Therefore, GQI consider that an upgrade from 2G to 4G LTE technology be favoured over an upgrade to 3G technology.

⁹ http://www.regional.gov.au/territories/publications/files/Government_Business_Enterprises_Deloitte_Main_Report_Nov2014.pdf

¹⁰ An Erlang is a measure of traffic. If a service was in use for one hour this would be equivalent to one Erlang of traffic

3.3.2 Technology capability

Capability of 3G and 4G technologies are assumed to be as follows:

- 3G networks - require a minimum of 2 x 5 MHz pairs of carriers/channels (or 20MHz total) to obtain maximum data rates of 42.4 Mbps.
- 4G networks – require a 10MHz carrier/channel pair (20MHz total) to obtain maximum data rates of 75Mbps.

3.3.3 Spectrum

The 2G mobile system currently operates in the 900MHz frequency band. According to ACMA records Norfolk Telecom currently have¹¹:

- 2 x 8 MHz apparatus licence in the 900 MHz, 2G frequency band.
- 2 x 45 MHz apparatus licence in the 1,800 MHz band.

Both bands could potentially be suitable for 3G and 4G technology if sufficient spectrum were available.

GQI believe that Norfolk Telecom would need:

- 2 x 5 MHz paired allocation of spectrum(carriers) for a 3G network or a total of 20 MHz of spectrum
- A minimum of 1 x 10 MHz paired allocation of spectrum (carrier) or 20 MHz for 4G.

From the information available to GQI, Norfolk Telecom does not have sufficient spectrum at 900 MHz for either 3G or 4G deployments.

Hence while it may be possible to obtain additional 900 MHz spectrum on Norfolk Island, GQI consider that this could be expensive as 900 MHz spectrum is premium spectrum and hence commands premium prices.¹² Given the small area of Norfolk Island, any coverage or performance advantage gained by using the 900 MHz rather than the 1,800 MHz spectrum band would be small and not justify its significantly higher licensing cost. The 1,800 MHz band is also a more common band available in most current 4G handset models.

As sufficient 1,800 MHz spectrum is currently available at a relatively low price, GQI recommends 1,800 MHz spectrum could be used for the new network.

3.3.4 Network coverage

It is expected that all existing sites would be re-used and the microcell site will be converted to a full power site and moved closer to the Burnt Pine town centre.

GQI have not undertaken a full and comprehensive radio coverage and cell plan but have relied on information provided by Ericsson and Challenge Networks. From this information, it is concluded that acceptable coverage can be achieved at 1,800 MHz. As a precaution, we have assumed that the 1,800 MHz spectrum band will be used irrespective of the option considered.

GQI's high level coverage assessment for this spectrum band indicates that coverage and performance for voice calls would meet acceptable

¹¹ http://web.acma.gov.au/pls/radcom/site_search.site_lookup?pSITE_ID=136315

¹² Norfolk Island currently pays ACMA license fees of \$33,944pa for 2 x 8 MHz in the 900 MHz band and \$1,350pa for 2 x 45 MHz in the 1800 MHz band.

standards (equivalent to present 2G coverage) and also meet acceptable performance standards for data services.

Three marginal coverage areas commonly reported by Norfolk Telecom staff and other users on the island include:

- Country Road
- West of the Airport
- East of Mt Pitt

To ensure these areas are brought up to acceptable coverage standards, it is recommended that three additional base station sites be installed near the centre of these marginal areas as part of a mobile network upgrade.

Technical input provided by Ericsson suggests that for optimum performance from 3G or 4G technologies, all sites should be three sector sites with panel antennas mounted around the top of the poles as shown in Fig. 4¹³.



Fig. 4: Typical view of the top of a three sector cellular base station tower

With three sectors on 12 sites GQI consulting would expect that the network would provide coverage of 90% of the island area for 90% of the time (equivalent to Australian mainland standards). The coverage may be better and would be confirmed during the detailed design process. Therefore GQI would expect a new 3G or 4G Norfolk Island mobile network to have up to 12, three sector sites.

3.3.5 Equipment prices

GQI informally contacted a vendor of 3G/4G technology and a 3G/4G mobile systems integrator and obtained high level budgetary pricing for the required technology and installation of a 3G and 4G mobile network on Norfolk Island.

The prices used in the assessment of the options in this Study are based on these discussions, publicly available information and internal GQI benchmarks.

3.3.6 Other considerations

Operating costs of the upgraded network are based on the existing Norfolk Telecom 2G operations budget and other known costs, adjusted for scale and the efficiency factors which would be expected from a new system.

¹³ In a three sector site the area around a base station tower is divided into three non-overlapping triangular shaped coverage segments with the apex of each located at the tower.

Handsets:

The issue of existing handsets in use on the island has also been considered from the standpoint of compatibility with a new upgraded mobile network. GQI has been unable to extract numbers of each type and generation of handsets on Norfolk Island, however anecdotally there appear to still remain a significant proportion of '2G only' handsets.

Irrespective of the solution chosen there would need to be a transition period during which owners of older '2G only' handsets are able to upgrade to current models. The 2G network would therefore need to be kept in service during this period. Based on typical model renewal rates for a developed market, a swap-out time of 6 to 12 months after the new system is commissioned would appear reasonable.

Note popular handsets brands such as iPhone 5 and later and also Samsung Galaxy S6 and Note 4 etc. are 4G compatible (data and voice).

Passive infrastructure:

The upgraded mobile phone network equipment could be housed in existing huts, though 5 would require considerable but acceptable re-arrangement of power supplies, batteries and ancillary equipment to accommodate the new equipment.

As part of an upgraded mobile network, an assessment of the air conditioning at each site would need to be done to determine if the current air conditioners are capable of handling the additional heat load from the new technology during the changeover period. This may result in the need for new air conditioners.

The existing batteries at each site are over 8 years old and are considered to be at the end of their usable life and will need to be replaced. This applies to both the core network batteries and radio base station batteries.

Where allowed by local regulations, the poles on which the antennas are mounted should be increased in height from the current 10 metres to a minimum of 15 metres. This would result in improved coverage and would be particularly important if the 1800 MHz band is selected as it does not provide the same level of coverage compared to 900 MHz.

Active equipment:

The active 2G radio base stations and core network equipment are obsolete and will need to be replaced with new systems based on either 3G or 4G technology. The existing 2G network will need to remain in operation for a transition period of 6 to 12 months to allow users to swap out their 2G only handsets to those capable of operation on the new network. Once all handsets are swapped out the 2G network would be decommissioned and removed.

A new prepaid billing system would be required with upgrade Options 1-3 since the existing system is old, difficult to upgrade for data billing and is expensive to maintain and support. However Option 4, which envisages the use of an existing incumbent core network in Australia, would utilise that operator's pre and post-paid billing platforms. This option is entirely dependent on reaching an agreement with an existing Australian mainland operator.

GQI have observed that the PSTN core network is also obsolete and difficult to maintain and recommend that it should be replaced. Option 3 considers an

integrated fixed and mobile network on the one platform that could address this issue.

Backhaul transmission:

All upgrade options require high capacity links of at least 50 Mbps to connect the radio base station sites to the core network. As the existing 2 Mbps E1 backhaul system has limited capacity these links will need to be replaced. The best solution for this has been identified as an Ethernet transmission on existing optic fibre. This would require terminals at each radio base station and at the core network location.

Currently the optic fibre does not reach two of the existing radio base station sites. Two options are available to connect the optic fibre to these radio base station sites: either to extend the optic fibre or to install high capacity microwave radio links to the core network site (or Mt Pitt and from there to the core), whichever is the most cost effective, since each provides the same facility.

It has been assumed that up to three more radio base station sites would be required to either fill coverage holes and or compensate for lower penetration of radio at 1,800 MHz. Their location and configuration would need to be determined as part of a detailed radio design process during the tendering stage. Of the three new sites it is assumed conservatively that two would be linked by optic fibre and one by microwave radio.

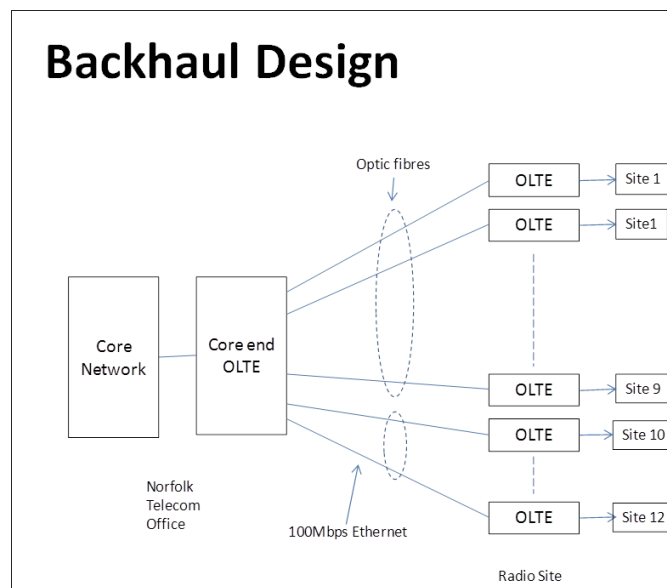


Fig. 5: High level block diagram of mobile network transmission OLTE – Optical Line Transmission Equipment

3.3.7 Satellite transmission to the mainland and international destinations

Currently Norfolk Telecom has a 50 Mbps capacity O3b¹⁴ satellite link between Norfolk Island and the Australian mainland via Dubbo to Sydney. This link costs a reported \$45,000 per month. GQI understands that the O3b capacity will be expanded to 75Mbps by end of 2015.

Norfolk Telecom also have a 2Mbps (E1) link on a C band satellite from Norfolk Island to New Zealand for PSTN and 2G mobile voice services.

¹⁴ <http://www.o3bnetworks.com/>

GQI has assumed that in the short to medium term Norfolk Island would continue to be serviced by the O3b satellite system for providing connectivity to the Australian mainland and the internet as well as the C-band satellite link to New Zealand used for voice and backup.

A future 3G/4G mobile network could utilise the existing and future capacity of the current O3b satellite link to mainland Australia.

4 OPTIONS EVALUATION

4.1 Summary of options

Table 5 below sets out the 4 options considered in this Study¹⁵:

Option	Description
1	Provide a 3G/3.5G mobile telephone system to replace the existing 2G system
2	Provide a 4G LTE mobile telephone system to replace the 2G system, providing Voice over LTE and wireless broadband data services
3 (Variation on 2)	Provide a 4G LTE system for mobile <u>and fixed</u> line use, thus replacing all networks
4 (Variation on 2)	Provide a 4G LTE mobile telephone system to replace the 2G system, interconnecting to a core network on the Australian mainland belonging to an existing mobile operator

Table 5: Summary of options considered

4.2 Option 1

4.2.1 Overview

Option 1 involves upgrading the mobile communications system to 3G. The upgrade would be to a recent evolution of 3G technology which includes high speed data capability provided by HSDPA/HSUPA (High Speed Downlink Packet Access and High Speed Uplink Packet Access). In the industry this is referred to as 3.5G. See Fig. 6 below for the overall system architecture and interconnection.

3.5G offers both voice and high speed data. However the voice part uses a different form of modulation which is incompatible with 2G. As a result the current 2G system would have to work alongside 3G for a period until '2G only' users on the Island have upgraded their handsets to 3G handsets.

The estimated initial overall cost to implement a 3G network is in the order of \$4.4m. Within a 10 year period, it is expected that a 3G network would need to be upgraded to 4G at an additional cost approximately equivalent to implementing a 4G network from the outset (\$3.7m).

¹⁵ GQI considered the option of continuing the present arrangements and serving wireless data needs by expanding the Wi-Fi hotspot networks however this was ruled out since it would not meet the assessed needs of upgrading the existing mobile network which is technologically obsolete, nor would it provide a network solution which is consistent with mobile services typically available on the Australian mainland in regional and rural areas.

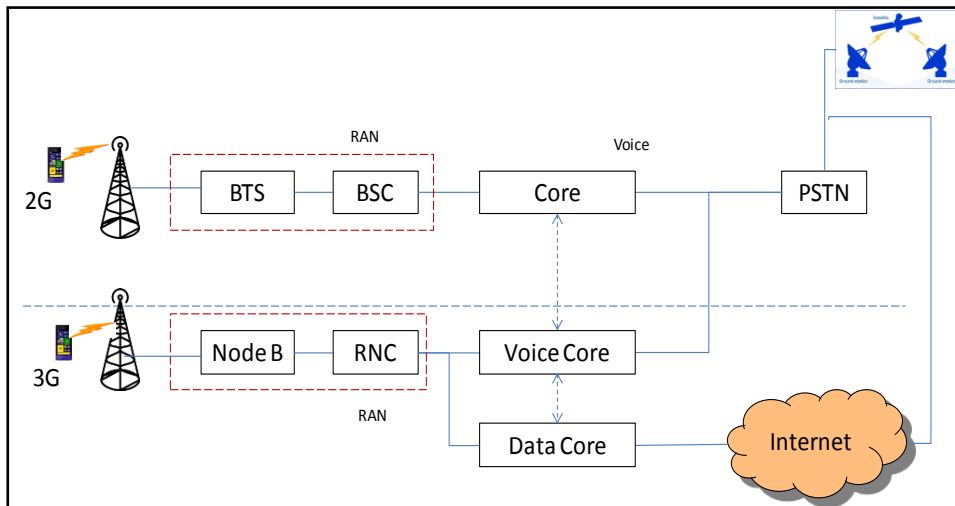


Fig. 6: Option 1, upgrade 2G to 3G

2G - Second Generation sometimes also known as GSM Mobile User handsets

BTS – 2G Base station

Node B – 3G Base Stations

BSC – 2G Base Station Controller

RAN – 2G & 3G Radio Access Network

RNC – 3G Radio Network Controller

Core – Connects and Controls the calls from the BTS to the PSTN

PSTN – Public Switched Telephone Network

4.2.2 Option 1 commentary

Specific assumptions

- 2 x 5 MHz carrier pairs, for voice and data
- 42.4 Mbps downlink speed peak

Cost drivers

- Cost of core is higher than for latest 4G
- Cost of radio access
- Transmission from Norfolk Island back to the Australian mainland similar to 4G

Compatibility with existing infrastructure

- Will be a separate network, 2G to remain operational for the changeover period

Product development roadmap

- Since 3G technology is approximately 12 years old, it is expected to be obsolete in 5-8 years, after which support and parts will be difficult to obtain
- It is likely a 3G network will require another upgrade at that time, probably to 4G
- Over time system features of a 3G network will fall behind user expectations and Australian mainland standards

User equipment compatibility

- As users upgrade handsets and devices to latest models, the network will progressively lack ability to support the latest device features

4.2.3 Summary Option 1

Advantages	Disadvantages
Proven stable platform. Should perform well for a period of 5-8 years	Shorter product life, not as future proof
Compatible handsets are more common and are cheaper at this stage	Higher capital investment required
	Fixed terminals difficult to find
	Lower data rate for given bandwidth allocation
	Expected lower data revenue

Table 6: Summary of Option 1 Advantages and Disadvantages

4.3 Option 2

4.3.1 Description

Option 2 involves upgrading to a 4G LTE network. It is recommended the 2G system continue to operate alongside 4G LTE until all users on the island upgrade their handsets and mobile devices to the latest 4G LTE devices. See Fig. 7 below for a diagram of the 4G LTE system architecture and its interconnection with 2G. The estimated initial overall cost to implement a 4G network is in the order of \$3.7m.

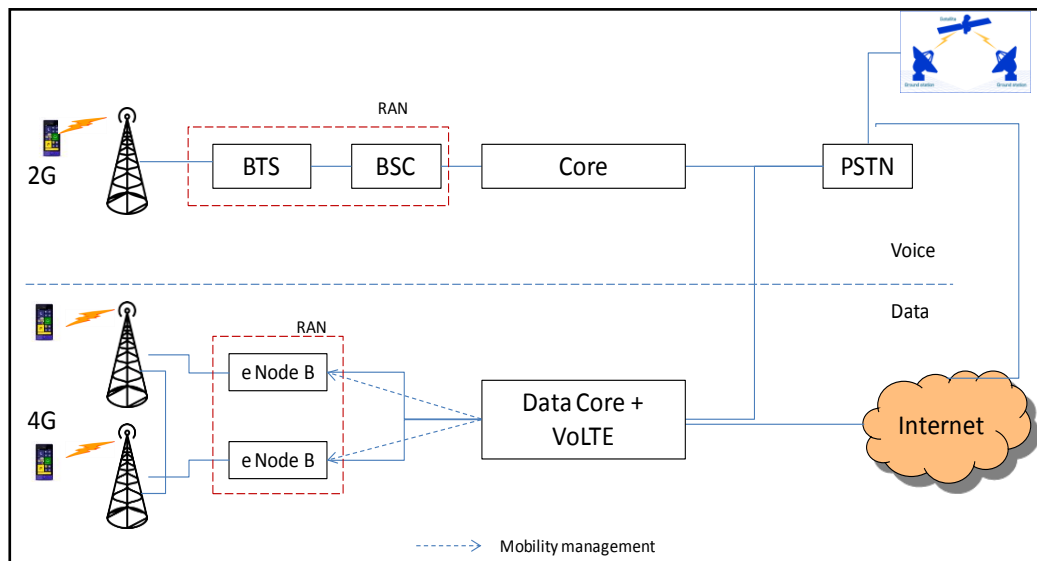


Fig. 7: Option 2, upgrade to 4G LTE

- 2G - Second Generation sometimes also known as GSM Mobile User handsets
- BTS – 2G Base station
- eNode B – 4G Base Stations
- BSC – 2G Base Station Controller
- RAN – 2G & 4G Radio Access Network
- Core – Connects and Controls the calls from the BTS to the PSTN
- VoLTE – Voice over LTE (4G)
- PSTN – Public Switched Telephone Network

4.3.2 Option 2 commentary

Assumptions

- 1 x 10 MHz carrier pairs required
- Download speed 75 Mbps peak

Cost drivers

- Cost of core network
- Cost of radio access
- Cost of transmission back to the mainland

Compatibility with existing infrastructure

- Would be a separate network, 2G to remain operational for the changeover period

Product development roadmap

- This technology is 'state of the art' and can be expected to have at least 10 years of product life, over which time it will be supported by the manufacturer and have spare parts available if necessary.
- A feature improvement roadmap is expected to be available over the period of product life

User equipment compatibility

- User equipment (e.g. handsets) should continue to be available during service life with increasing set of user applications and features on 4G LTE handsets and devices over time.

4.3.3 Summary Option 2

Advantages	Disadvantages
Future proof over product life	Few, but handset migration may need to be extended to ensure all handsets have VoLTE capability (most current 4G handsets have that capability)
Higher data speed for given bandwidth allocation	
Expected higher data revenue uplift for the operator	
Lower equipment capital investment required	
Suitable for fixed wireless application and replacement of copper based PSTN with moderate additional investment	

Table 7: Summary of Option 2 advantages and disadvantages

4.4 Option 3

4.4.1 Description

This option is outside the scope of the Brief from the Department, however it is offered for consideration as one of the potential means of upgrading the fixed network (PSTN). This option would involve upgrading the mobile network to 4G and utilising the upgraded mobile network for both mobile voice and data as well as for fixed voice and data at customers' premises, thereby addressing the ageing and obsolete fixed network infrastructure.

GQI believe that suitable fixed wireless terminals to replace existing PSTN Customer Premises Equipment (CPE) could be sourced for a price in the range of \$200 to \$400, installed at the customer's premises. These would deliver voice and high speed data for internet access.

The estimated total cost for 1,600 fixed services would be between \$320,000 and \$640,000.

This option could have benefits since it can be provided at a marginal cost using the mobile network which will have to be implemented initially with considerable excess capacity. This excess capacity is the result of the minimum size of 4G equipment which is typically significantly larger than the number of mobile users on the Island. Overall, it would require about the same capital investment as replacing the PSTN switch and would allow the copper network to be de-commissioned thereby lowering maintenance and operating costs.

It is however outside the scope of the Study and in reality can be implemented at any time in the future, could be staged over a period of time or applied selectively to specific customers where advantageous.

There have been strong representations about the risk of failure posed by the obsolete PSTN switch which is difficult to support and maintain because of its age. However it should also be recognised that the mobile network would provide a high degree of diversity in case of a catastrophic failure of the PSTN.

Also, the value of continuing to have a separate diversified (both physically and by technology) network on Norfolk Island (rather than putting all eggs in the one 4G LTE basket) would need to be considered.

Finally, the impact of a future NBN Co presence on the island as well as a changed regulatory regime needs to be taken into account and factored into the overall consideration for the future.

GQI therefore strongly recommends that this option be considered for the future, but cannot recommend that it be included in the original package.

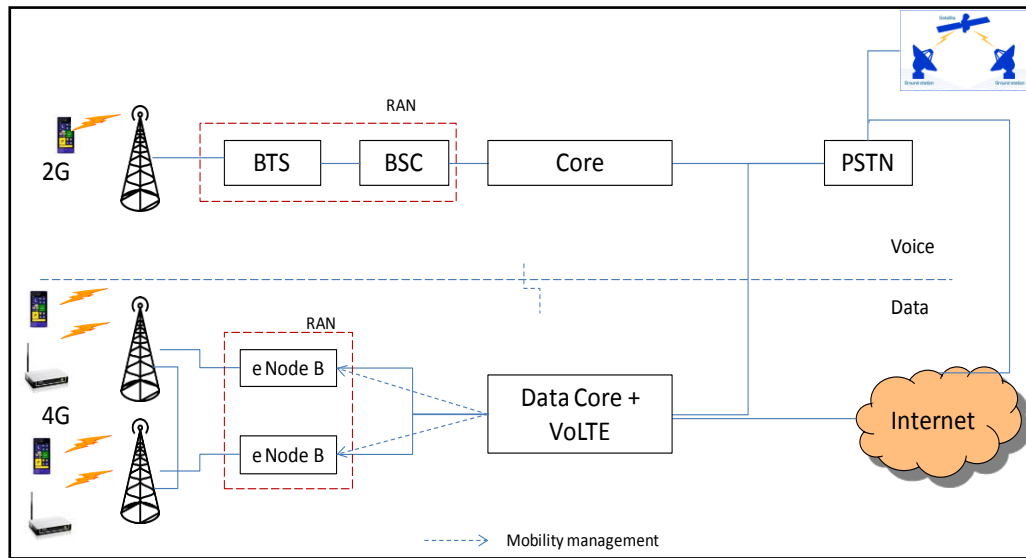


Fig. 8: Fixed/mobile integration on one 4G network

4.5 Option 4

4.5.1 Description

Option 4 involves installing a radio access network (e Node Base Station) on the island and connecting it over the O3b satellite link back to a core network on the Australian mainland owned and operated by one of the incumbent operators. This would require agreement with the operator but more importantly would require a negotiated rate per user to be included in the overall costs together with the additional transmission cost to link the e Node Base Station back to the Australian mainland. This together with the additional cost to carry local Norfolk Island calls to be delivered back to the island would need to be less than the annualised cost of the core network in Norfolk Island.

Overall the capital investment saving would be around \$2m, however there would be a charge by the mainland operator for the incremental cost of their core network, nominally around \$20 per service or \$32k overall. Also the cost of O3b capacity to link each e Node B back to the mainland would be very high, perhaps prohibitive, plus the cost of a 2 Mbps link back to Norfolk Island to carry traffic terminating on Norfolk Island.

It would appear that based on the current cost of O3b transmission this option is not viable unless a more cost effective link from Norfolk Island to the Australian mainland (such as a submarine optic fibre) is available at some time in the near future. Also, it could only be implemented in cooperation with a mainland mobile operator. It is therefore suggested that this option be explored as part of the tendering process for a new system by engaging one or more Australian operators in the bidding process.

This option is likewise offered as another option for consideration by the Department, however it is not possible to recommend at this stage except for consideration during the tendering stage.

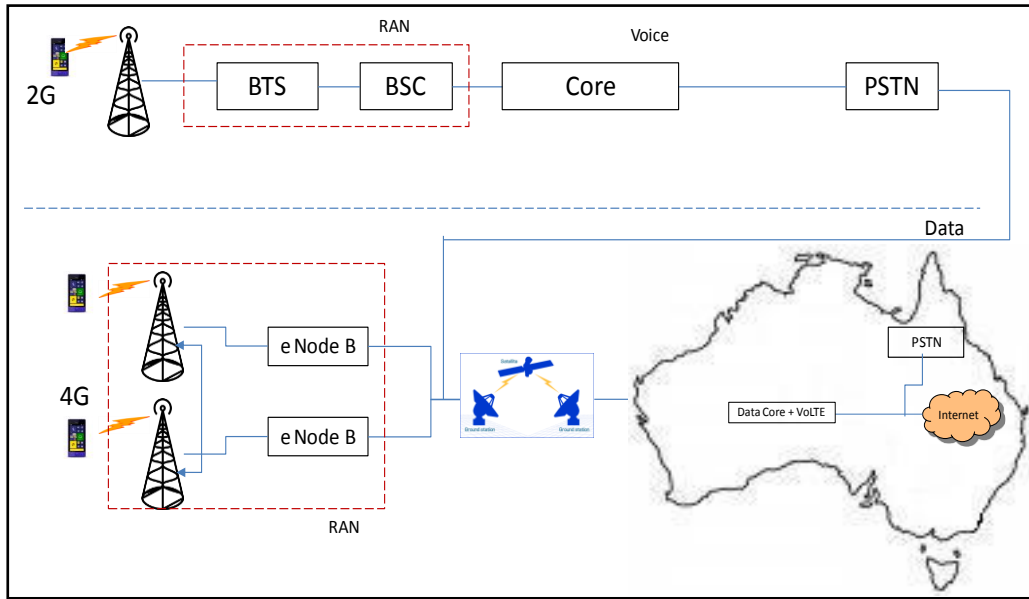


Fig. 9: Long-line back to core network in Australia

5 FINANCIAL ANALYSIS

5.1 Introduction

GQI developed a high level financial model to estimate the costs and financial and outcomes of the different options. A summary of the estimated capital cost which is the major driver of the financial outcomes and other assumptions made in the model are provided below.

5.2 Assumptions

5.2.1 Capex assumptions

GQI have sought high level capex estimates from vendors for a 3G and 4G mobile network for Norfolk Island.

The following capex estimates in Table 8 are based on high level discussions with Ericsson a global mobile technology vendor, Challenge Networks a mobile network integrator, desktop research and GQI's industry knowledge.

The cost estimates provided in Table 8 are for budgetary purposes only.

The 4G core network equipment and other components such as the radio base station equipment are cheaper than the 3G equivalent components as 4G equipment uses latest technology and architecture that is more efficient than the previous generation.

Item	Estimated Unit Cost (AU\$)
Core equipment (including Switches, Home Location Register (HLR), gateways, billing, and design/vendor Project Management (PM) and other delivery services)	
- 3G	\$2,100,000
- 4G	\$1,700,000
Radio site infrastructure	
- 3G Node B, 3 Sector	\$60,000
- 4G eNode B, 3 Sector	\$40,000
Common site items for both 3G and 4G options	
- 3 Sector Antenna, Cables and Mounting	\$17,000
- Power Supply and Batteries (1-2KVA)	\$15,000
- New Shelter	\$5,000
- New Pole (installed)	\$8,000
- Pole Strengthening	\$5,000
- Optical Fibre Extension (\$/km)	\$15,000
Norfolk Telecom costs for project management, legal, buildings, funding and consulting.	\$300,000 Assumed the same for all options

Table 8: Estimated costs of major 3G and 4G network components

5.2.2 Financial/general assumptions

GQI understands that population growth on Norfolk Island is low¹⁶ and that the mobile market has matured to the point where almost all residents own a mobile. Consequently, GQI has assumed that there will be no significant growth in mobile subscriber numbers during the forecast period and that the growth in voice ARPU revenue will be in line with inflation over the same period.

With respect to new 3G/4G mobile data services, GQI have assumed that based on the current take-up of fixed broadband services, 25% of subscribers will initially use this service selecting, on average, a notional 2 Gbyte, \$80 per month plan. Based on experience in other markets, the number of subscribers using data services is expected to grow strongly following the introduction of the service gradually tapering off to 5% pa growth in later years.

5.2.3 Other Considerations

In addition to the technical and financial factors supporting each solution option above, other factors have also been given consideration should the telecommunication regulations and industry structure move closer to the Australian mainland situation. These include how Norfolk Island might be impacted by key Australian Government telecommunications programs that are currently the responsibility of the Department of Communications, including the:

- Australian Universal Service Obligations (USO) regime
- Mobile Black Spots Programs, and
- National Broadband Network (NBN).

GQI believe that all options considered and recommendations made would not preclude the proposed new mobile network being integrated into the Australian mainland networks in the future.

5.3 Evaluation criteria

GQI has developed a set of criteria listed below to evaluate the identified options:

1. Solution
 - Technical feasibility
 - Performance
 - User requirements
2. Financial and business parameters
 - Capex, opex, Return on assets, IRR, NPV
 - Funding capability
3. Timing
4. Regulatory
 - Government policy requirements for Norfolk Island reform
 - Departments policy requirements
 - Telco regulations and industry structure and competition
5. Other

1-3 are considered the key criteria upon which options should be evaluated.

¹⁶ Reference: Information in Deloitte Access Economics report "Norfolk Island Government Business Analysis – Phase Two Analysis, Part 1 – Summary Report" issued November 2014

5.4 Impact of the Norfolk Island reform process

5.4.1 The regulatory environment

GQI has undertaken the above analysis on the assumption the status quo in the regulatory environment will continue, since the changes that may occur as part of the Norfolk Island reform process may take longer than the estimated 10 to 12 months to build a new 4G mobile network.

GQI believe that careful consideration be given to the possible impact of the Norfolk Island reform process on both the mobile network as well as the long term viability of the current Telco industry players if the reforms include regulatory changes which de-regulate the market, network ownership and network/business operations.

GQI concludes that changes in the regulatory environment would likely have little impact on any new network(s) built ahead of any changes taking place when considered from a technology and network standpoint. This is because it is likely that there will only one economically viable network owner and operator on Norfolk Island into the foreseeable future.

5.4.2 Competition

The small population of Norfolk Island coupled with its relative isolation and high cost factors mean that competition at the network infrastructure level (e.g. multiple fixed and or mobile networks) is unlikely to be economically viable at least without subsidies.

However it may be possible to introduce a measure of competitive tension at the network operating level and at the retail level.

- At the network operating level this could be introduced through an outsourcing Managed Service model. Such an arrangement would involve an experienced and competent contractor to be engaged to operate and maintain the Norfolk Island PSTN and mobile networks under agreed and measured Service Levels and KPIs, with penalties for non-performance and possible bonuses for exceeding standards by tying these to revenue increases.
- At the retail level it could be possible to introduce new players performing customer facing functions of sales, billing and customer service. Several competing Retail Service Providers (RSPs) could be envisaged.

As in other markets there are potential benefits to end users in allowing competition in telecoms even if this is at the retail level. Fig. 9 below outlines a potential industry model with:

- One network owner (Netco)
- Network Operator (Opco) optionally using a Managed Service contractor
- Multiple customer facing Retail Service Providers (RSPs) including Internet Service Providers (ISPs) and Mobile Virtual Network Operators (MVNO).

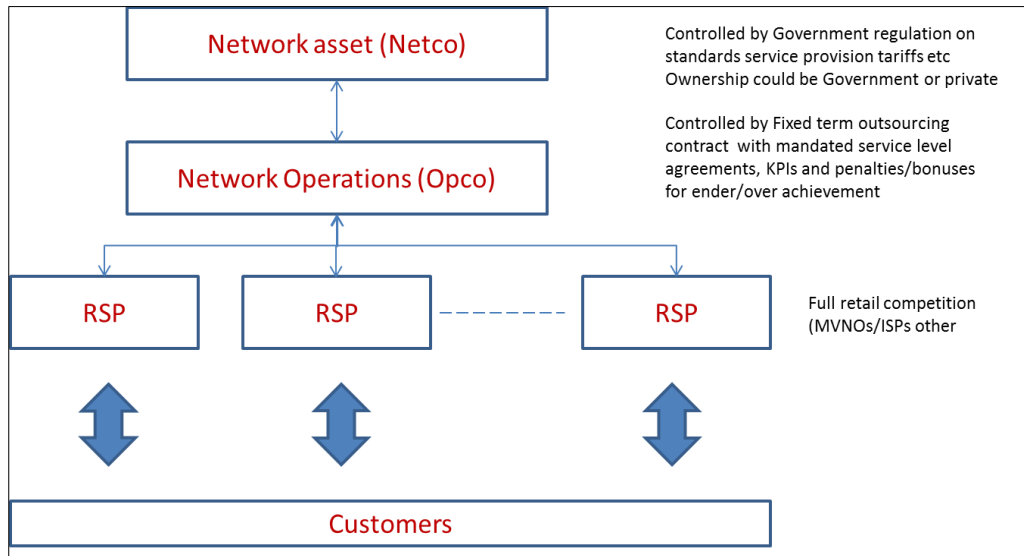


Fig. 9: Possible industry structure for telecoms on Norfolk Island

6 KEY FINDINGS

1. The results of this Study lead GQI to support Option 2 'Upgrade existing 2G to 4G with Voice over LTE capability' as the solution for Norfolk Island. This would cost an estimated \$3.7m.

This option is recommended for consideration because it:

- requires the least capital investment
 - provides the best 'customer experience' to users on the island and is the most future proof
 - has the potential to generate the greatest data revenue up-lift hence the greatest financial return, and
 - provides a readily available low cost means of upgrading the PSTN and the copper based broadband network if this option was chosen.
2. It is recommended given the 2G network age and maintenance issues, that Norfolk Telecom should develop a risk management plan to cover the increased likelihood of system disruptions.
 3. It is recommended that as a matter of urgency a similar study be carried out on the best way to upgrade the fixed PSTN and fixed broadband networks as there may be efficiencies in a coordinated plan that covers fixed and mobile networks.
 4. It is recommended the 2G system remain in service for a period of about 6 to 12 months to allow time for customers to upgrade their 2G phones.