AJTDE Volume 4, Number 2, June 2016

Table of Contents

National Broadband Network

Editorial

Mark A Gregory
RMIT University

Abstract: The National Broadband Network is a focus of the June 2016 issue with four papers providing an insight into the nation's largest infrastructure project. A historical paper on vibration measurement highlights how times have changed as the telecommunications networks evolve The Government's review of the Universal Service Obligation has commenced with the Productivity Commission being tasked to inquire into how the universal service obligation might be updated to meet current and future needs.

In This Issue

In this issue the *Journal* focus on the National Broadband Network (NBN) and four papers provide an interesting range of perspectives on how the NBN is progressing and how it affects retail service providers. Now that the Federal Election is over there is time for considered thought on the future of the NBN and whether or not the Government is prepared to alter course away from the more contentious aspects of the rollout.

The NBN from 2009 to 2016 and Beyond - A Commentary on Mike Quigley's June 2016 Address to the Telecommunications Association provides a review of the former NBN Co CEO Mike Quigley's presentation on the state of the NBN. The presentation was hosted by the Melbourne Networked Society Institute and the Telecommunications Association and held at Melbourne University.

Some Thoughts about Australian Telecommunications highlights how Australian telecommunications could do with a dose of lateral thinking and more competition, especially in bringing better connectivity to regional communities.

The National Broadband Network Brownfields Debate - Valuing FTTN and FTTP provides a financial comparison of FTTN and FTTP for brownfields utilising data in the public domain. Much of the NBN debate has centred on the selection of FTTN as a technology to be used in the NBN rollout, at a time when FTTP has become the globally preferred access network technology.

A Next Generation Wholesaler's View of the NBN - How Retail Service Providers can succeed in an NBN world provides an insight into the relationships between wholesalers and retailers seeking to gain a foothold in the transitioning telecommunications market and why more needs to be done to provide an open and fair level playing field for companies seeking to offer wholesale and retail products and services in competition with the four largest telecommunications companies.

Vibration Measurement provides two historic papers from 1969 that provide unique examples of vibration measurements carried out in the field, verify reality and discredit some conventional wisdoms in the field of cable installation.

Universal Service Obligation Inquiry

The Government has tasked the Productivity Commission with a 12-month inquiry into the future direction of the Universal Service Obligation (USO). The Productivity Commission Inquiry is expected to end in April 2017 when it hands the final report to the Government.

The USO is a fundamental and vital ingredient in the Australian telecommunications market that needs to be revitalised to ensure that it remains relevant in coming decades and to take into account changes to infrastructure provision as the transition to the NBN occurs around the nation. The USO should be expanded to incorporate universal access to data as well as telephony and other digital services. It is also time for the Government to consider a universal access regime that ensures that Australians can remain “always connected”. Funding for a universal access regime should be provided by a broader telecommunications and Internet industry levy than that currently used to partially fund the USO.

A key aspect of the USO inquiry will be defining and measuring productivity outcomes associated with the USO. As with many issues surrounding telecommunications service provision today, the USO facilitates productivity outcomes that may be difficult to measure, and in particular access to telecommunications increases a nation’s wellbeing and happiness. How is this measured? Telecommunications is an essential service and it is about time the Australian Government formally recognised this.

For the Productivity Commission to complete this review it will need to grapple with the value of customer information to Government and business gained through telecommunications and broadband usage. Big Data has become a key to monetising customer information and the amount of data available is constantly growing.

Looking Forward

A student paper prize is available and students are encouraged to submit papers to be in the running for the opportunity to join with Telsoc members and key telecommunication industry executives at the Charles Todd Oration held in Sydney annually.

The key theme for the December 2016 issue will be *International Telecommunications Legislation and Regulations*. As the global digital economy evolves it is timely to consider the different telecommunications markets and how each is coping with the transition to next generation networks – the ‘gigabit race’ – and how competition is being fostered with the market.

Papers are invited for upcoming issues and with your contributions the Journal will continue to provide the readership with exciting and informative papers covering a range of local and international topics. The Editorial Board values input from our readership so please let us know what themes you would like to see in the coming year.

All papers related to telecommunications and the digital economy are welcome and will be considered for publication after a peer-review process.

Mark A Gregory

http://doi.org/10.18080/ajtde.v4n2.53

The NBN from 2009 to 2016 and Beyond

A Commentary on Mike Quigley's June 2016 Address to the Telecommunications Association

Leith H. Campbell
Honorary Fellow, Melbourne School of Engineering

Abstract: On 22 June 2016, Mike Quigley, the founding CEO of NBN Co, gave an address to TelSoc on his insights into, and predictions for, the Australian National Broadband Network (NBN). This article provides a brief summary of his presentation and a commentary on some of the issues raised. Mr Quigley contended that, if there had not been a hiatus and change of direction after the election of the Coalition government in 2013, the rollout of the NBN would have been completed by December 2021 within a peak funding of $45 billion, broadly in accord with NBN Co's plans from September 2013. A major part of the original plan was for fibre to 93% of existing premises within the fixed-line footprint of the NBN. He noted that the replacement of the fibre plan in 2013 with a multi-technology mix had slowed deployment. He showed that the Coalition's assertions while in opposition about the cost and take-up of the NBN had not proved true up to December 2015. Mr Quigley's critique also raised a number of issues about the future direction of the NBN, particularly with regard to a future upgrade of technology and greater capacity needs.

Introduction

On 22 June 2016, Mike Quigley, the founding CEO of the NBN Company (NBN Co) from July 2009 to September 2013, gave an address at the University of Melbourne sponsored by TelSoc and the Melbourne Networked Society Institute on 'The NBN: 2009 to 2016 and Beyond'. For many in the audience, his presentation provided a devastating critique of the Coalition government's mishandling of the National Broadband Network (NBN) and the disinformation campaign that had accompanied the changes in technology direction for the NBN. The media presented the talk as an intervention in the Federal Election (Knott, 2016; Adhikari, 2016).

http://doi.org/10.18080/ajtde.v4n2.58

This article is a summary of Mr Quigley's presentation. His full speaking notes have been published elsewhere (Delimiter, 2016). The emphasis and the commentary here, however, are the present author's own. Mr Quigley's talk raised a number of issues about the current state and future direction of the NBN that should be further pursued.

Nation-Building or Not?

Mr Quigley believed that, when he was CEO of NBN Co, he was 'managing a nation-building public project'. (All unattributed quotations are Mr Quigley's words.) He quoted Felix Rohatyn (Rohatyn, 2011) on the US experience and asserted that 'public entities … can efficiently build economically and socially valuable infrastructure for the public good'. He emphasised that many of the staff in NBN Co were inspired by this vision and worked hard and innovatively to achieve it. He claimed he was approached by people who were willing to work without pay to support the NBN.

While nation-building was clearly a driver of the original NBN concept in 2009, it was not part of the Liberal Party's view. When the Liberal Party came to power in September 2013 as the senior partner of the Coalition Government, it decided to continue with a less capable NBN that could give a nudge to broadband availability in Australia, while leaving any future heavy lifting to competitive pressures. This was in line with Telstra's original proposal to the Government to co-invest in a fibre-to-the-node broadband network. The difference in attitude to the NBN between the main political parties has been, and remains, a contentious issue in the telecommunications industry and federal politics.

The Liberal Party's attitude to the NBN was accompanied by a disinformation campaign about the benefits, costs and timetable of the NBN. Much of Mr Quigley's speech was directed to countering the misconceptions promulgated by this campaign with a point-by-point examination of actual outcomes. He noted, however, that the campaign had been pervasively effective.

Mr Quigley told of visiting 'a very senior public servant in Canberra' after 'NBN Co had been running for a few years' (presumably 2012 or 2013). The public servant had asked why the NBN was 'so over budget'. At that time, according to Mr Quigley, the operating costs, capital costs and peak funding were 'virtually unchanged from the original projections'. The 'senior public servant' had been misled by the disinformation campaign.

NBN Technology

The NBN access technology plan that Mr Quigley was working to consisted of three major parts:

- Fibre-to-the-Premises (FTTP) for most homes and business premises (93%) in Australia;
- Fixed Wireless access for a small proportion of premises (4%) in regional areas;
- Satellite access via some purpose-built satellites for premises (3%) in remote areas.

The vast majority of the access build was FTTP. Mr Quigley described it as having two parts: a 'greenfields FTTP' for newly built premises; and a 'brownfields FTTP' replacing the current telecommunications networks to existing premises. He claimed that the greenfields FTTP solution was, in 2013, 'running below the budgeted cost and was keeping up with the growing demand from housing developers'. His main emphasis in the talk was on 'brownfields FTTP', as this had been the most contentious issue regarding technology.

Mr Quigley noted that, in addition to the access portion of the NBN, other essential technology successfully delivered during his time as CEO included:

- The transit network (consisting of 'more than 65,000 km of fibre links and about 1,000 access nodes') that connects the NBN access networks to the Points of Interconnection (PoIs);
- The required IT systems, that 'never became a bottleneck to deployment';
- A National Test Facility;
- A Network Operations Centre.

Mr Quigley's charts showed that, by September 2013, about 78 PoIs had been integrated (out of the 121 mandated by the ACCC), about 45,000 Fixed Wireless premises had been covered, about 40,000 satellite premises had been activated and more than 60,000 new premises in greenfields areas had been passed by FTTP. This represented solid progress in the NBN rollout.

The FTTP Rollout in Brownfields Areas

The 'brownfields FTTP' rollout has been the most contentious area of the NBN plan. It is the future rollout of this part of the NBN that has been replaced, after the NBN Strategic Review (NBN, 2013), with a mix of reusing the current Hybrid Fibre-Coax (HFC) networks, built by Telstra and Optus in the 1990s, and a new build of Fibre to the Node (FTTN), which reuses Telstra's copper distribution network. The debate over cost will be described in the next section, while here we discuss progress in the rollout itself.

Mr Quigley presented a chart of the numbers of premises passed by brownfields FTTP during his time as CEO. He noted, firstly, that they had set ambitious targets in the first Corporate

Plan in 2010. They were 'perhaps … too ambitious' and were not achieved for brownfields FTTP. There were some trials in 2011, but the volume rollout did not begin until early 2012.

A major cause of the delay was the time taken to conclude a deal with Telstra for access to its ducts and other access infrastructure. This deal, including its approval by the ACCC, took longer than had been anticipated and caused a delay of 9 months in the schedule. Mr Quigley was silent on why the deal had taken longer to finalise than had been planned, but he outlined the complexity of it. He noted that a 'mandatory requirement in that original deal was Telstra taking responsibility for ensuring everything they provided to NBN Co was fit for purpose'. In other words, Telstra was required to take on some of the project risk from NBN Co.

The rollout volumes rose from the start of 2013 and reached a peak of about 90,000 premises passed in the June quarter. After that, volumes declined again when a problem of asbestos in Telstra pits was discovered, leading to less than 50,000 premises passed in the December quarter. Telstra resolved the asbestos issue during the second half of 2013, but by September the Coalition Government had been elected and was de-emphasising FTTP.

While there was some pickup in the rollout in the March quarter of 2014, rollout volumes for the remainder of 2014 were below 60,000 premises passed as the NBN was replanned. With a new plan in place and a renewed emphasis on FTTP until the alternative solutions were ready, the brownfields rollout grew again in 2015, reaching a peak of 150,000 premises passed in the June quarter, before declining again as FTTN started to be rolled out.

Given the stop-start nature of this history, it is perhaps hard to predict what the future would have held if the FTTP rollout had continued. Mr Quigley noted that NBN Co would have needed only to double the peak rate of 150,000 premises passed per quarter in order to complete the rollout by June 2022, about six months later than forecast in 2013. He believed this improved rate could have been achieved and sustained.

During the question and answer segment at the end of the formal talk, one questioner asked for comment on the enormous difficulties in cost and schedule experienced by the construction companies engaged by NBN Co to build the brownfields FTTP. The questioner noted that all the companies had lost money. Mr Quigley's answer was enlightening. He suggested that the NBN was 'not a typical construction project', more 'like a distributed factory'. That is, one should treat the rollout like a production line, learning over time how to optimize the construction processes. He felt that the construction companies would have learnt how to do this but they were stopped before they became good at it.

What of the alternative technologies? The FTTN rollout has now started to ramp up (Mr Quigley's chart suggesting at a greater rate than was achieved with FTTP), passing about

300,000 premises by the March quarter of 2016 (and about 100,000 in the quarter itself). Under a Coalition Government, this rollout will continue, presumably with higher volumes each quarter for some months. The Labor Party alternative would see the FTTN rollout phased out and the FTTP rollout ramped up again, leading eventually to about 2 million premises passed by FTTP. Mr Quigley believed that a transition back to FTTP could be achieved with careful management.

Either government would reuse the HFC networks, both now to be transferred to NBN Co. The HFC transformation was not present in the March 2016 quarter figures, so the future trajectory of this rollout is very uncertain. Mr Quigley noted that the decision in 2010 to overbuild the HFC networks with FTTP was taken with awareness of 'just how much effort it would have taken to use this older infrastructure both in hardware upgrades and IT development'.

In order to include the HFC networks in the NBN, NBN Co has renegotiated its arrangements with Telstra. Mr Quigley noted that this has diluted the protections for NBN Co while reducing the cost exposure of Telstra. The cost and risk consequences of this will only become apparent in future years as the HFC is transformed. Telstra has been given a contract worth $1.6 billion for planning and designing the HFC portion of the NBN.

The Cost and Funding of the NBN

The cost of the NBN has been contentious since it was first mooted but the debate became seriously distorted when the Coalition, then in opposition, proposed a new model based on a multi-technology mix (MTM) in April 2013. This proposal would have peak funding of $29.5 billion (as against NBN Co's estimate of $45 billion) and would deliver at least 50 Mb/s to 90% of fixed-line premises by the end of 2019. This was fully two years earlier than under the then-current plan. But Mr Quigley noted that 'as we now know, those original MTM estimates were fiction'.

NBN Co's estimated completion date is now the end of 2020 and the peak funding is projected to be below $56 billion, with a target of $49 billion. Mr Quigley stressed that the cost and schedule changes were all due to the costs and timing of the FTTN and HFC rollouts, not due to the original FTTP costs. Indeed, the peak funding estimates had only risen from $43 billion (the Labor Government estimate in April 2009) to $45 billion by NBN Co's estimate in September 2013. Most of the funding increase, Mr Quigley claimed, was due to the inclusion of a deal with Optus for its HFC network closure, a change that improved the internal rate of return for the NBN project.

As part of its campaign to discredit the FTTP rollout and to justify a change of plan, the Coalition and the replacement NBN Co management put out a variety of estimates for the peak funding of an FTTP-based NBN. These ranged from an unlikely $94 billion in April 2013 to $64-$73 billion in the *Strategic Plan* (NBN, 2013) of December 2013. There was also an estimate of $74-$84 billion in August 2015, but this turned out to be the cost of returning to the original FTTP plan after some years by replacing the FTTN build and the rejuvenated HFC. This variety of estimates, as Mr Quigley hinted, has sown confusion in the minds of many.

Based on current data, what should be believed about the peak funding estimate for the NBN? Mr Quigley believes the original NBN plan could have been delivered with peak funding of $45 billion (the September 2013 estimate from NBN Co). His argument rests on analysing the three contributors to peak funding: cost, timing and revenue. We have already discussed timing in the previous section: a delay of one year to the original plan makes only a small difference to the cost of the ten-year project.

The cost per premises passed for the FTTP is critical. Mr Quigley noted that NBN Co's latest estimate of capital expenditure for brownfields FTTP is $3,700 per premises. The Government has implied that this is $2,000 more than planned, but the comparison is complicated by changes to accounting standards. NBN Co now reports costs differently from when Mr Quigley was in charge. His estimate is that the difference is more like $500 per premises, which, if sustained, would lead to a blowout of $5 billion. However, he believed that capital costs would decline. He noted that trials of 'skinny fibre' in Ballarat and Karingal had reduced costs by 12%. In addition to technology changes, there would also be operational improvements: he noted that Verizon in the US had reduced its FTTP costs by 38% in the years 2004-2006. Cost improvements are common in well managed network rollouts.

If the costs can be controlled, what of the revenue? The prices that NBN Co charges Retail Service Providers are set by a Special Access Undertaking approved by the Australian Competition and Consumer Commission (the Australian competition regulator). In June 2015, NBN Co reported Average Revenue Per User (ARPU) of $40, which is higher than the $39 predicted for the same date by Mr Quigley's NBN Co in 2013. ARPU in December 2015 was $43. The actual figures are substantially higher than the estimates made by the Coalition in April 2013 when in opposition.

Take-up rates are less certain but are holding up. Mr Quigley believed that take-up in early FTTP sites had been over 70%. The NBN Corporate Plan now assumes a long-term take-up rate of 73% (for, Mr Quigley pointed out, an offering less attractive than FTTP), not much

http://doi.org/10.18080/ajtde.v4n2.58

different from the 2013 estimate of 74%. Again, these numbers are higher than the 64% suggested by the Coalition in opposition.

One can conclude, therefore, that revenues would have held up in the FTTP version of the NBN, which, together with cost reductions for premises passed, would lead to a peak funding commitment of $45 billion, as planned. Whether this would have come to pass we will now never know.

For the current, MTM-based NBN, the peak funding target is $49 billion. The great imponderable in this is the integration and upgrade of the existing HFC facilities. The costs are still to be fully worked out as detailed design work progresses. The history of NBN costing would suggest that the costs have been underestimated. This could be material to the overall cost, as the HFC is a significant component of the current NBN, with about 3 million premises passed out of a total of 10 or 11 million.

The NBN Satellites

The number of satellites to be launched to provide service to outer regional and remote premises has also been a matter of contention. Mr Quigley recalled 'hours spent in Joint Parliamentary committees defending NBN Co's decision to design and launch two satellites'. This was due to the then Opposition's assertion that they would not be fully utilised and were too expensive. In the event, however, the NBN Corporate Plan from August 2015 has confirmed that at least two satellites would be needed.

In answer to a question, Mr Quigley noted that the satellites, although 'very sophisticated machines', have a limited capacity. It was always expected that some spot beams would become exhausted. Mr Quigley suggested that, as the NBN is 'a huge cash-generating machine', NBN Co could eventually extend the footprint of the Fixed Wireless access to relieve some of this congestion.

What the Future Holds

Whichever party is in government, Australia now will be provided with an NBN with a much lower proportion of FTTP than was originally envisaged. Whatever the technology, completing the full rollout by 2020 would be 'heroic'. Mr Quigley's estimate, given the current uncertainties surrounding the HFC component, is a completion date some time in 2022.

The rollout will probably continue to accelerate for some time to come and revenues for NBN Co will continue to increase. Capital costs of deployment per premises passed will eventually fall. Operating cash flows will be less than would have been achieved with the FTTP plan because maintenance costs for the FTTN and HFC will be greater than for FTTP.

The current NBN, as Mr Quigley noted, does not 'allow for any significant growth in … demand over the next 10 or 20 years', which is 'incredibly short-sighted'. He claimed that the revised technology plan 'has turned out to be short-sighted, expensive and backward looking'. Meanwhile, others are turning away from FTTN in order to accommodate growth. He cited the examples of AT&T, which is facing demand in the US for faster broadband speeds than can be delivered with FTTN, and BT, which is under pressure from the British regulator, Ofcom, to take a 10-year perspective on fibre access. If the long-term vision for the NBN is 'a future-proof FTTP solution', it is 'now going to happen over a longer period and at a greater cost to taxpayers' than was envisaged in 2009.

The effective disinformation campaign – or, if one prefers, the NBN estimates put forward in good faith but which later largely proved misleading – mounted by the Coalition will continue to colour perceptions of the NBN, no matter how well it performs and how efficiently NBN Co executes the plan. The nation-building vision of the NBN, whereby Australia would have been equipped with modern, high-speed Internet infrastructure, almost certainly has been lost.

One aspect of this sorry saga that will continue to have repercussions, but was not mentioned by Mr Quigley, is the *ad hominem* attacks made on his reputation by the Coalition. Mr Quigley rose in Alcatel to be one of the most influential Australians ever in the global telecommunications industry. That his reputation was attacked in the pursuit of political advantage is to be deprecated. It can only be hoped that other, well experienced Australians will not be deterred by his experience from contributing their knowledge and leadership to future Government projects.

References

Adhikari, Supratim. 2016, June 23. NBN chief Quigley questions Turnbull's 'bet' on old copper. *The Australian*. Retrieved from http://www.theaustralian.com.au/federal-election-2016/exnbn-chief-quigley-questions--turnbulls-bet-on-old-copper/news-story/904d503bdca4854a3ec68d386d422c7e .

Delimiter. 2016, June 22. 'Read in full'. Retrieved from https://11217-presscdn-0-50-pagely.netdna-ssl.com/wp-content/uploads/2016/06/MNSI_Telsoc_Text_Final.pdf .

Knott, Matthew. 2016, June 23. 'Short-sighted, expensive and backward looking': NBN boss blasts Turnbull's plan. *The Age*. Retrieved from http://www.smh.com.au/federal-politics/federal-election-2016/shortsighted-expensive-and-backward-looking-exnbn-boss-blasts-turnbulls-plan-20160622-gpozid.html .

NBN Co Limited. 2013. *Strategic Review*. Issued 12 December 2013.

Rohatyn, Felix G. 2011. *Bold Endeavors: How Our Government Built America, and Why It Must Rebuild Now*. New York: Simon & Schuster.

http://doi.org/10.18080/ajtde.v4n2.58

Some Thoughts about Australian Telecoms

Timothy E. Nulty
Visiting Scholar, University of New South Wales

Leslie E. Nulty
Visiting Scholar, University of New South Wales

Abstract: Australia is facing numerous challenges in its attempt to upgrade its telecom infrastructure. This paper summarises the little-known and even less understood history of telecom development in the USA. The authors believe this may provide useful ideas for Australian telecom policy and development that have not yet been considered.

Introduction

As newly-arrived observers of the Australian telecom sector, we see a prosperous nation that looks out on and trades heavily with the most advanced telecom systems in the world in East Asia, the US and Europe. Unfortunately, Australia's own telecom systems lag well behind the rest of the industrialised world (Akamai 2015, p.30) raising the question of how much of a drag this will put on future economic prosperity. Two different Australian political regimes have attempted to address this issue. From what we have seen neither has been effective. Australia's telecom sector is rapidly sinking in global ranking.

We believe there are alternatives to the approaches taken by both the current and former governments that would be both less costly and more effective. To appreciate these it is necessary to acknowledge the dramatic changes impacting telecoms everywhere. Central is the fact that accelerating technology is revolutionising not only operations but the fundamental role of telecoms in every aspect of society. Key aspects of this technical revolution are:

a. Greatly reduced, if not eliminated, economies of scale in most parts of the network

b. Greatly reduced need for central control, and elimination of any need at all for central ownership to manage national networks;

c. Radically changed nature, scope and cost of telecom services;

d. Consequent massive explosion in demand that threatens to overwhelm traditional network capability;

6http://doi.org/10.18080/ajtde.v4n2.52

e. Deep penetration of new telecom services into every aspect of economic, cultural and social life, such that failure to accommodate demand will hamstring economic performance.

Taken together, these factors have rendered many of the old telecom paradigms not only obsolete but obstructive. The technical telecom revolution is creating fabulous opportunities. But they are also destroying many of the traditional "truths" that have underpinned the industry for over a century. In this new world, industry structures and public policies that seek to preserve the "old ways," impose a serious risk to economic prosperity and social advancement. Ultimately they will fail – the forces unleashed by the new telecom are far too powerful to be held back.

Brief History of the Telecom Industry and Its Structure

To appreciate what is happening, a brief review of the history of the telecom sector may suggest lessons for Australia's current challenges . . . and suggest some ways out of the current impasse.

During the first century of its existence, the "telecom sector", worldwide, was effectively synonymous with the *telephone* industry. "Telephone" shared many attributes with other "public utility" industries, e.g. power, water, sewage etc.:

a) a single product: ordinary voice telephone calls (analogous to kilowatt hours, gallons of potable water, gallons of disposed waste, etc.);
b) a need for a reliable supply for what was considered a civilised standard of living;
c) a relatively slow rate of technical progress; and
d) a perceived "natural monopoly".

Items "a" through "c" were clearly accurate. Item "d", natural monopoly, while widely considered true, in fact, was not. However, the near universal perception that it *was* true, was enough to "make it true" from the perspective of national policy in virtually every country of the world.

The characteristics which define "natural monopoly" to economists are:

i) Very low marginal cost to produce an extra single unit of output (which gives an established incumbent a large pricing advantage vs. new competitors);
ii) High intrinsic (as opposed to artificially created) barriers to entry
iii) Large economies of scale in general, including large minimum size for efficient operation;
iv) Key inputs that are not generally available in a market environment; and

v) Necessity of reliable supply to the population with no or few substitute products or services

Modern broadband telecom does exhibit characteristics (i) and (v) – negligible marginal costs for an incremental unit of output, and high degree of necessity for modern life. But it does not exhibit (ii) through (iv).

On the contrary, modern broadband telecom systems have minimal intrinsic barriers to entry, minimal economies of scale, and few or no key inputs that are not available in the market. Taken together, the actual characteristics of modern telecom systems do not define a natural monopoly. Indeed today telecom shares most of its characteristics with sectors like food, clothing, and transport, with a wide range of essential services riding on basic distributional infrastructure. Like those sectors, the technical and economic basics favour competitive provision. However, all of these necessities for civilised life, including telecoms, **do** call for, and require, public oversight to ensure universal affordable availability, safety and quality standards, prevention of monopoly abuse, etc.

However, whether correctly or not, historically the telephone industry was perceived to be a "natural monopoly" and as a consequence, in virtually every country in the world, telephone service was provided by a single entity. In 1985, at the peak of the "telephone era", the telecommunications sector of virtually every member country of the International Telecommunications Union not only was dominated by – it almost entirely ***consisted of*** – a single "Post Telephone and Telegraph" (PTT) monopoly company, typically 100% government owned. In only three countries was this not the case in any meaningful degree: Finland, Canada and the USA.

Of these three, the USA was by far the largest, most important and most radically different from the rest of the world. It also had, by common acknowledgement at the time, one of the best telephone networks in the world as measured in virtually all dimensions: technical, operational, economic and, perhaps most remarkable, extent of coverage. (International Telecommunications Union, various years). Coverage is perhaps the most impressive: although an extremely large country with a huge, sparse and scattered rural population, by the end of the 1960s, coverage, at 96%, was effectively universal. The next highest country, Sweden, had reached 89% (International Telecommunications Union, various years). Much of that, in the USA, had been achieved as a result of the 1950s expansion of the New Deal's Rural Electrification Administration to include telephone. But the framework was created well before that and coverage was approaching universal by WWII. By 1970 in the USA, virtually every person with a fixed abode who wanted a telephone could get one and more than 96% of the population actually did. (Mueller 2013).

Elsewhere in the world, there was a perception that the high quality of the US telephone network was the sole achievement of the Bell system which was generally, and incorrectly, viewed as "just another PTT – except privately owned". AT&T was, indeed, privately owned, but in most other respects it was emphatically ***not*** like the "usual" PTT. More important, it operated in a very different environment from typical PTTs in other countries. Specifically, although the biggest US telecom company, it only served about 70-75% of the connected population (U.S. Census various years) and covered only about 25% of the land area. As such it was definitely not a legally-authorised monopoly for the whole country, as PTTs usually were. Nor was it ever the main force driving universality. On the contrary, the US telephone system was built by literally thousands of independent telephone companies of all sorts and sizes (including very small ones) operating under a system that combined elements of voluntary co-operation, regulatory oversight and competition which, though unusual in its structure, was effective in its outcome. As discussed below, the competitive element can be shown to be a major factor in the achievement of the system's superior results.

Despite the mythology of "economies of scale" there was absolutely no correlation between the economic efficiency of these companies as measured by any of the standard telephony metrics of economic and technical efficiency (Galbi 2010). The "top twenty" best-performing US telcos, including ATT, contained examples from every size, right down to some with only a few thousand subscribers and up to those with millions. Similarly, at the other end of the performance spectrum, the "bottom twenty" also contained examples from every size. In short, in the only country where a meaningful cross-section sample existed, there was absolutely no relationship between economic or technical performance and size.

Significant indicators of quality of service include:

- percentage of faults cleared within 24 hours,
- percentage of calls that fail during the busy hour,
- number of faults per annum per x number of subscribers.

The most common measure of operational efficiency is the number of Full Time Equivalent employees per 1000 subscribers. For mature companies that are not growing rapidly, this number is a reasonably consistent metric, both within countries and between countries. Numbers below 5 are generally considered to be very good and down near 3 to be excellent. Most of the former "Baby Bells" were in the 3 – 4 range as were the Nordic PTT's and a few others. The very lowest numbers were associated with some of the small US Telcos. (ITU, various years).

In the USA, development of this unique sector structure is largely due to historical accident: the telephone was invented in the USA in 1876 by Alexander Graham Bell. He immediately set about building companies to utilise his invention. Thus the telephone sector in the USA, from its very inception, was privately owned and developed. Bell's company, ATT, grew and prospered and by the time his patent expired in 1894 had penetrated the major cities and built a long-distance system connecting them.

He had not, however, made any significant effort to wire the immense rural areas where the majority of Americans still lived. As a result, when his patents expired a rash of new companies sprang up to build telephone systems in rural areas. By 1900 there were over 6000 of these. In the early 1900s Theodore Vail, CEO of ATT, approached JP Morgan with a scheme to buy up these independent companies and create a unified national monopoly — which they promptly set about doing. In keeping with the "robber baron" ethics of the time, this process was not gentle. A major lever used by Vail to pressure small companies to succumb, was to disconnect them from – or refuse to connect them to — ATT's long distance system.

These tactics produced a strong political backlash that led to pressure from the Federal Government for ATT to "back off" (per the then relatively new Sherman Anti-Trust Act). The outcome was the "Kingsbury Agreement" in 1913, the core of which was ATT's commitment to stop acquiring small companies and to connect any company that so requested to the long distance system. At first ATT continued to skirt the edges of the intent of "Kingsbury" but by the early 1920s it had come into compliance and the map of the US telephone industry was largely drawn. That map consisted of a complex patchwork quilt of independent companies interspersed with areas where ATT had purchased companies prior to 1913. That map remained the basis of the US telephone industry up to the present day (Mueller 2013).

As the map "congealed," a regulatory structure evolved that matched the realities of that map, existing regulatory systems for other utilities, and the facts of the US system of State v. Federal system of governance. In this system, long distance telephony was regulated by the Federal Government and was largely (though not entirely) operated by ATT. Local telephony was regulated by the states and operated by the local telcos, including ATT's local operations. Committees nominated by participant companies and convened under the combined auspices of the state regulatory commissions and federal regulators coordinated the interface between the two.

Each telephone company had its designated territory — mostly an artefact of where they happened to be operating at the time that the regulations came into being in each state. Inside its territory each company had a nominal monopoly but, in turn, was subject to rate and QOS regulation and a mandatory obligation to provide service on a non-discriminatory basis to anyone who wanted it. Despite the apparent "local monopoly", the reality was that this system had several dimensions in which each licensed telephone company faced meaningful de-facto competition:

a) The proximity of other telcos meant that customers were aware of what nearby companies were offering, the quality of their services, prices etc. Thus, they could, and frequently did, petition state regulators to force their own company to match the best practices of other nearby ones.
b) In extremis, groups of customers — even whole towns — could petition the state regulator to move them to the district of another company which had better, cheaper services. Even a single customer could say, for example, that their business required a particular service, or better technology in order to survive/prosper and therefore they wanted to receive service from another, better, company — even if that company was some distance away. Although such petitions were usually not granted, sometimes they were . . . and the fact that they ***could*** be, forced companies to pay attention to their customers in order to head off such petitions. This created a constant pressure on telcos to stay abreast of their neighboring companies. This pressure applied not only to quality of service and prices for existing telephone customers but was even stronger in cases where a local telco failed to serve a part of its territory. The un-served customers could petition to be moved to another company's district — and, not infrequently, convince their neighbors, even "served" neighbors, to join them. This applied to all telcos, big and small.

While hardly "pure competition," the fact was that all local telephone areas in the US were "contestable markets" to a meaningful extent.

Even ATT faced the above pressure. Further, unlike its PTT counterparts elsewhere, ATT, although dominant on the national and international level, was explicitly NOT a legal monopoly on the national level. On the contrary, ATT was highly exposed to regular and serious anti-trust actions brought against it both by competitors and by the US Government. These were an important part of the US telecom landscape throughout the 20th century — up to and including the final anti-trust suit that led to the break-up and de-facto dissolution of ATT. We have already mentioned the Kingsbury Agreement, but there were numerous others. In most cases, they were settled before they went to court, but such settlements (both formal and informal) resulted in significant changes in structure and behaviour. Examples include ATT's agreement to exit the radio field and to sell most of its international interests. In 1956 one of the most important such changes was the agreement by ATT to stay out of the computer and data processing industry. (This seminal agreement is discussed further below).

Despite the continuous competitive tension between and among the many thousands of telcos in the US, the whole system operated, technically, extremely well. It was coordinated through a series of industry-named committees that operated under the auspices and oversight of both the State Utility Commissions (through their national organisation the National Association of Regulatory Utility Commissioners, "NARUC," and federal regulators (after 1934, this was the Federal Communications Commission, "FCC"). These committees dealt with everything including numbering plans, signal protocols, dB loss standards, division of revenues etc. Although ATT was the biggest player in this system, and certainly carried the most weight, it was not a "dictator": there were counter-weights in the form other large technically sophisticated players such as GTE, United and Continental (each larger than most national PTTs), the political power of the rural independents, and the gimlet eyes of state and federal regulators watching from the edge of the room but not participating in the negotiations themselves unless there was an impasse or perceived abuse. The system worked very well indeed. Indeed, according to the quality of service and efficiency indicators cited earlier, it worked as well or better than the vast majority (and, arguably, all) of national networks that were centrally owned and controlled by a single monopoly and for which data are available. This flies directly in the face of the standard myth that central control and ownership are essential for effective operation of even traditional telephone networks.

In summary therefore:

The US telephone system was based on unique mixture of elements:

a) a large number of telco participants who, while nominal monopolies in their assigned areas, were also subject to a constrained but significant degree of de-facto "quasi-competition";

b) a regulatory framework that focused on pricing, QOS and coverage; and

c) voluntary co-operation, monitored but not directed by regulators, which coordinated the overall operation of the network.

The successful operation of this system proved that several characteristics of "natural monopoly" did not, in fact, apply to telephony. In particular: the US telephony sector demonstrated that:

i) there were no significant economies of scale in the sector;

ii) successful technical co-ordination did not require central dictatorship let alone central ownership. (NB: the successful operation of the global telephone network, which was also managed co-operatively by independent national PTTs under the auspices of the ITU, is further evidence of this fact).

Telecom Sector Transformation

In the USA the system came apart fairly rapidly beginning in the 1970's due to two central forces:

a) the accelerated development of technologies that permitted non-members of the "telco club" to bypass the system entirely; and

b) the adoption of new rules and laws that resulted in different industries competing in the same economic market under different legal rules.

The first was natural and unavoidable, the second was unwise and a clear mistake.

Technological disruption

The first disrupter was microwave transmission, which enabled non-traditional players (especially pipelines and railroads who had long stretches of their own rights-of-way) to "by-pass" the telephone industry's transmission infrastructure and offer services to large companies by utilising spare capacity in the formers' internal networks. The second was introduction of better peripheral devices (keyed handsets, etc.). Initially such devices were "dumb" and legalisation of their connection to the network in the 70's was thought to be "benign". However, "dumb" devices quickly became a lot more "intelligent" and interconnection of non-telco CPE quickly expanded to include sophisticated electronic network intelligence, such as powerful PBX's, which could be located just "outside" the "edge" of the telephone network and substitute for functions previously performed by the "central" intelligence owned by the telcos.

Together these developments enabled competitors, often including large customers, to create complete telecom networks that could use or by-pass the main network as and when it was convenient and profitable to do so. These "new" non-telco networks offered cheaper, more flexible services than the "orthodox" telcos were able or willing to provide. The pressure from major corporate telecom users for cheaper, more flexible services generated a long series of regulatory and court battles, all of which the telcos lost. Ultimately the concept of "interconnection" of non-telco "devices" to the network expanded to include the interconnection of entire, free-standing competitive telecom networks.

The first arena in which this occurred was long-distance telephony, because that was where the integrated telephone industry had traditionally chosen to accumulate a large part of its surpluses. But with the entry of competitive long distance, these surpluses were quickly eliminated and competition moved to the local area. Most of the political and legal war was fought between big business on one side and the telephone industry on the other. Ordinary citizens were not much involved and initially cared little. Nevertheless the war was fierce and continued over a period of nearly 20 years starting in the mid/late '70s and finally ending with the passage of the *Telecommunications Act* of 1996, which ended the last vestiges of monopoly, even in the local telco areas.

The reason the telcos could not possibly win in the end was the simple fact that the new technologies were so flexible that it was impossible to "solve" the telephone industry's dilemma by simply moving the regulatory definition of the boundary of the "monopoly network." No matter where the regulatory system defined the "boundary" of the "monopoly network" to be, competitors could design and build alternative networks just "outside" this boundary, tap into the network to reach customers, bring their traffic "outside", transmit or otherwise manipulate it, then tap back into the network at the same or different point to deliver the message or "product". As this process advanced, the entire foundation of the telephone system in the USA – and ultimately worldwide – was irreversibly undermined. As we shall see, this technological and economic process has continued and accelerated in the modern environment of IP, packet switching and software-defined "edge" intelligence.

Public policy disruption and asymmetry

The second great force eroding the old telephone system was the creation of different legal regimes for different companies competing in the same telecom space. The first of these was that as a result of the 1956 federal anti-trust settlement between ATT and the Federal Government and a number of other subsequent decisions, it became US policy that data services, including transmission of data and, ultimately, the Internet, were "computer services," and not "telecommunications" in the meaning of Title II of the Communications Act of 1934 and, hence, were not subject to regulation. Since ATT had agreed in 1956 to stay out of "unregulated data services" it was excluded from these vast and expanding markets. (U.S. Court of Appeals 1995).

Although originally thought to be a minor matter, over time this became a severe restriction as the "computer and data" market expanded. This was a bitter pill because ATT considered itself the founder and pre-eminent computer company in the world (with good reason – considering that it invented the transistor, did by far the most basic research in the field, held the most patents and, in the form of telephone switches was, in fact, the largest computer producer in the world). Exclusion from the exploding "data" market plus the erosion of its own telephone market prompted it in 1982 to settle another federal anti-trust suit with a "deal" that freed it from its exclusion from the computer and data industries – but at the cost of breaking up the Bell network into approximately 30 components.

The majority of the resulting entities were local telcos, the "Baby Bells". These, along with the independent telephone companies, municipals and co-ops continued to be regulated as "common carriers" subject to price regulation, obligation to serve, quality standards, etc. at both the federal and state levels. They also now faced the obligation to provide non-discriminatory interconnection to any and all long-distance companies – not just ATT Long Lines.

The second major public policy event was passage of the Cable Act in 1985. *(*47 U.S.C. Chapter 5, Sub-Chapter V-A). When the Cable industry was young it consisted primarily of small rural communities where TV coverage was poor. It responded by building "community" towers on the highest nearby hill in order to bring in distant signals and "pipe" them down their towns, hence the standard nickname for the industry "CATV", meaning "Community Antenna TV". In view of this origin and nature, Congress and the FCC were generally supportive and regulation in the early years was light and benign. However, the industry rapidly "grew up" during the '70s as aggregators bought up the majority of small operators. Eventually a few major players came to dominate what became a very aggressive oligopoly and by providing business data transfer and voice communications it began competing in the same market space but without the same obligations required of telecom "Title II" common carriers.

The telcos objected to the asymmetric treatment of the Cable companies compared to themselves and vigorously campaigned for either classification of cable companies under Title II or release of telcos from Title II regulations. They argued that either option would create a "level playing field" but the then current situation patently did not. This unleashed a huge political battle that ultimately involved a large part of the US electorate – a battle in which nearly all groups (telcos, local and state officials, unions, consumer groups, etc.) were on one side and the cable companies were on the other. But despite what looked like a political mismatch, the cable companies won hands down and got a special law governing their industry which was, to say the least, "highly favourable," and which gave them a substantial regulatory advantage vis-a-vis their main competitor, the telephone industry.

With this in their pocket, cable companies were able to attract major financing and attack the telcos effectively in the most lucrative markets. This assault became even more effective with the rise of the Internet because the latter was deemed to be "data service" and anything distributed over it was exempt from regulation, which includes, of course, VOIP telephone service. VOIP enabled cable to compete effectively in the very heart of the telephone industry's main market without being subject to similar regulation. As the Internet grew in importance, cablecos were at a technical advantage as well because cable networks are, inherently, able to offer greater speeds more easily than traditional "twisted pair" telephone

http://doi.org/10.18080/ajtde.v4n2.52

networks — even when the latter are upgraded to DSL, ADSL etc. As a result, the telcos, especially the Baby Bells who were concentrated in the dense markets that the cablecos most wanted to penetrate, found themselves at a competitive disadvantage.

From the break-up of ATT and the passage of the cable Act in 1985, to the end of the century, the US telecom sector was characterised by a titanic struggle between “Big Telcos” (primarily Baby Bells) and “Big Cablecos”. Due the major regulatory advantages created by the legal distinction between “data” and “telecom” and the effective de-regulation of cable companies, the latter gradually dominated the struggle. In response the two largest remaining Bells, Verizon and ATT, initially reduced their commitment to wireline telecommunications and concentrated on wireless. Most recently, however, these large former telcos have become active in overbuilding portions of their networks with fibre-to-the-premises (see below).

Although some of the US history is unique, it still holds lessons for others — especially regarding the folly of creating a situation in which different companies compete in the same space under different rules. No other country has quite the same arrangement for cable as the USA but the “data” vs “telecom” is not unlike the “services” vs. “infrastructure” issue that most countries, including Australia, are struggling with: how to design and establish a regulatory boundary between two industries that, in fact, operate very close to each other, without creating an unfair and ultimately destabilising dual legal regime, is not an easy task. What at first may seem intellectually obvious becomes very murky over time as the players utilise advancing technology to “game” the system. Ultimately, the result can be an irrational, unfair and unsustainable regime, which defeats the original purpose.

Although these issues are profoundly complex and the technical and economic foundations are changing all the time, the mists are beginning to clear and the real outlines of a sound policy framework are beginning to emerge. This is especially true in the USA and Europe.

In this new world, many of the characteristics of the traditional telephone industry which were enumerated at the beginning of this paper clearly do not hold:

a) The services offered are now extremely diverse. Instead of “Plain Old Telephone Service” (POTS) i.e. black telephone and voice calls, we have an immense variety of video, data, and voice services; a variety which is growing and changing almost every day;
b) The need for centralised network co-ordination (never as strong as alleged) has been radically undercut by IP-software-defined distributed intelligence, and packet switching. The Internet, in particular, now, by far the most important telecommunications medium, needs little coordination at all beyond codifying and

registering "addresses" (the analogue to old phone numbers) and updating the protocols for sending messages (primarily IP and its derivatives)

c) Economies of scale, to the extent they ever existed, continue to erode;

d) The capacity of modern telecom networks (especially optical fibre-based ones) is now beyond enormous — indeed, in principle, virtually infinite.

e) Technological change has accelerated. The growth of "services" and the demands they place on the underlying infrastructure are growing exponentially.

f) The capacity of regulation, by itself, to protect public interest is limited. On the contrary, powerful monopolies *create a powerful tendency toward "regulatory capture"*. This is especially true for sectors like telecom that are both critical to the entire economy and highly technical. Further, this holds true regardless of whether such monopolies are "publicly" or "privately" owned and regardless of the professed ideology of the government or regulators in question. *One of the most important lessons emerging from recent USA telecom history, is that to be effective in bending powerful carriers toward the public good, regulation should be combined with meaningful competition.*

Nowhere, including in the USA, has the legal/regulatory environment fully caught up with technological and structural changes in the industry. That said, some countries are clearly further along in this important task than others!

Barriers to Progress

The struggle in the USA (which is by no means over!) to find a rational and sustainable legal regime that balances society's interests with the realities of technology and economics, is instructive because of its history of having developed the only telecom sector based on a combination of significant competition among a large number of players and a regulatory framework that focused on managing that competition rather than abolishing it. The fact that the system produced one of the best telephone systems in the world is a very important lesson for the future.

Since the end of the "telephone world", the USA has not handled the subsequent changes nearly as well as it did the "telephone age" — largely, we would argue, because of the irrational asymmetries introduced by the unique (and, in our view, unwise) Cable Act and the crude distinction between "data" and "telecom" developed by a number of judicial and regulatory decisions. As a result the USA fell from being the clear leader in the old telephone world to its current rank somewhere between 15th and 20th.

In addition, the USA has strayed from its historical preference for multiple entrants and allowed the major incumbent cable and telco oligopolies to collude in order to prevent newcomers from challenging their combined "club". For much of the period from 1985 to 2000 these efforts were largely successful.

However, the USA is too open, diverse and dynamic for the restrictive actions of the main incumbents to succeed forever. In fact, new players are now entering the sector and are beginning to succeed at rates that are starting to make a real difference. In this process, Fibre-to-the-Premises (FTTP) is playing a major role because, once in place, it trumps all other current technologies. In principle, a single strand of modern optical fibre can carry an almost infinite amount of traffic. Actual traffic capacity in any specific case is, of course, limited by the electronics on the ends of the fibre. But the cost of such electronics is relatively low and falling – making it easy and cost-effective to upgrade fibre networks as and when demand justifies it.

No other technology comes close to the capability, durability and low cost of "fibre everywhere" (another word for "FTTP", "FTTH" or "FTTX"). Despite rhetoric that may assert otherwise, this is what telecom companies actually do with their own money wherever they have to make decisions in the open market without government subsidies or protections. Indeed, it is a pretty good rule of thumb that, if one observes actual new investment by a telecom company in obsolete copper-based assets, then that constitutes *prima facie* evidence that the company in question is either:

a) benefiting from uneconomic legal protection of one sort or another (usually from the government); or
b) investing the taxpayers' money rather than their own.

Circumstantial evidence of the gradual erosion of both of those supports for investment in copper is the fact that the most recent global data show that copper-based connections fell by 18.7% in Q4 2015 while FTTH and FTTX connections increased by 60.6% and 14.7% respectively (point-topic.com 2016). Australians should think about this when considering the fact that Telstra and NBN are investing sizeable amounts of money in new copper infrastructure — possibly the only major telco in any advanced country where that is occurring.

When incumbents resist fibre it is usually for two reasons:

a) it destroys the basis of the traditional telecom monopoly, the need to bundle services together with infrastructure; and
b) it renders their legacy copper networks obsolete and uncompetitive — thereby destroying their value.

Thus they will often oppose competitors' deployment of fibre even in "under-served" areas where they do not expect to invest in new infrastructure. This is exactly how the major telco and cableco incumbents have behaved in the USA and in many other countries including Australia. The methods used have often been ruthless and political. In the US they include impeding access to utility poles and conduits, lobbying for laws that restrict or prohibit new entrants, discriminatory access and pricing practices — and many others. However, the market's desire for better service has not evaporated; indeed, it is accelerating. As a result, a new process of industry restructuring has begun.

Currently in the USA we are seeing a change from the oligopolistic rivalry that followed the Bell breakup and passage of the 1995 Communications Act to a process that is analogous but not identical to that which occurred in the early part of the 20th century regarding telephony. Typically, the ex-Bells wanted nothing to do with FTTP, preferring to milk their still very profitable legacy copper networks to deliver whatever limited connectivity they could manage. To this end they were vociferous in denying the need or desirability of universal fibre, calling it: "unnecessary", "wasteful", "inappropriate" etc. and classifying as "broadband" anything that was better than dial-up service. Their hand was forced, however, by the aggressive expansion of Big Cable, whose Coax and HFC networks could more easily be re-engineered to sustain much higher speeds over longer distances than could be managed with the Baby Bells' preferred "Band-Aid broadband over twisted copper wire" retrofit technology: DSL.

Big Cable has moved to consolidate its position in parts of the metropolitan portions of the Bell areas. However, FTTP trumps both cable and DSL whenever/wherever it is installed. The worst fears of both Bell telcos and major cablecos were aroused when Google, a company whose financial, technical and political weight matches that of the incumbent telcos and cablecos, launched ambitious FTTP networks directly in the heart of some of the most attractive "metropolitan turf". This has clearly rattled the Bells and the cablecos who have suddenly acquired a new-found enthusiasm for fibre and are responding with aggressive FTTP programs in these same core areas. ATT started out with a fibre-to-the-node service but is now upgrading those to FTTP. But, just like its telco and cableco rivals, Google has shown no appetite for going into Bell rural areas. It is these areas that have seen the biggest rash of "unconventional" competitive start-ups: municipalities, other local governments, new co-ops, Public/Private Partnerships, etc. (Broadband Communities Magazine 2016).

Another important development in "Bell" rural areas is the growing trend of the major Bells to vacate these areas altogether by selling them off to various independent telcos. This has let loose a dynamic merger and acquisition scramble in those areas. M&A in this arena is not

http://doi.org/10.18080/ajtde.v4n2.52

entirely new — that is why there are now 1200 or so ”independent” telcos, instead of the 6000 that existed before WWII and approximately 3500 that existed in 1975.

But the large amount of territory coming on the market as ATT and Verizon exit non-metropolitan areas has introduced a whole new dimension to this process, as other companies who are more willing to invest in rural fibre purchase those former Bell properties. Frontier Communications is an example: it started life as a local power company (Citizens Utility in Connecticut), began moving into telecom about 20 years ago when GTE sold a group of rural exchanges in the process of merging with NYNEX (one of the spun-off “Baby Bells”) and they have been "rolling up" rural telecom properties ever since. Some of these properties are traditional independent telcos and some are rural properties of former Bell companies, which the latter wants to sell off. Today Frontier is the sixth largest local exchange company in the USA with approximately 9 million access lines – primarily concentrated in rural areas. They acquired significant rural territory from Verizon and ATT and are now aggressively seeking to partner with local governments to extend FTTP further.

Another example is TDS, based in Madison, Wisconsin. It started as a local independent, bought a number of similar companies and now has some 108 subsidiaries – mostly rural – all over the USA and is the seventh largest local exchange company in the US (approximately 6 million lines). TDS has been aggressively rolling out FTTP for the last 7 to 8 years. Last year it stated that it expects to have FTTP in place on 25% of all its access lines by the end of 2016. (NB: Because many of the subsidiaries of these and other local telecom conglomerates still operate under their original local name, outside observers may not realise that they are part of a larger entity).

There are at least a score or more of other similar "conglomerates" ranging gradually down the size scale to some who only own a few subsidiaries. These companies are, due to their historic roots, much more comfortable with rural areas and much more inclined to invest in new FTTP infrastructure there. There are also “failures”. The whole of Hawaii was sold off to a non-telecom consortium headed by Carlyle Group, which subsequently went bankrupt. Verizon sold all of its northern New England properties to a mid-level independent conglomerate, FairPoint Communications of North Carolina, which also went bankrupt. Both subsequently came out of bankruptcy and remain in operation but are much weakened and do not have the resources to pursue aggressive conversion to fibre.

In those rural areas where there are no private competitors willing to enter the market in competition with the large telcos and/or cableco incumbent, numerous communities have turned to their local governments to build fibre networks as public utilities. This movement started in the mid-90's and at first faced tough going against ferocious opposition from "Big Cable" and "Big Telcos".

This opposition succeeded in having such projects outlawed entirely in 19 states and severely hamstrung in a number of others. In addition, at that time FTTP technology was not yet quite ripe for easy, mass deployment. This further hampered the "muni FTTP" movement. By the turn of the millennium, some 10 or 15 had been established and were succeeding. The movement began to accelerate with another 20 or so starting up between 2000 and 2005. The response from the Big Incumbents was to escalate the battle on the political front, as described earlier, rather than to respond by building better networks. But the competitive movement has continued to grow. By 2010 there were approximately 100 FTTP projects up and running throughout the country and there are now over 450 such projects, with new ones being announced almost every week. (Institute for Local Self-Reliance 2015).

As the growing viability of FTTP is demonstrated by these diverse and successful initiatives, Federal government policy has finally moved toward active support (after initial negativity), partly through grant and loan funding to both private and public entities, partly by upgrading the definition of broadband to a *minimum* of 25Mbps down/5Mbps up as a requirement for anyone building network with Federal funds, by requiring "open access" and "non-discriminatory interconnection" (which incumbent telcos and cablecos consider anathema), by overturning state prohibitions on municipal telecom development, and by re-purposing the former "high cost" telephone fund to help defray the cost of Internet delivery in hard-to-reach areas, among others. Most recently the FCC has ruled that it has Title II (regulatory) jurisdiction over the provision of Internet access. This will enable it to apply more equitable regulatory conditions to all carriers. Finally, the palpable success of fibre projects among the 1000+ independent telcos and the 200+ local government projects is finally convincing new purely commercial players to enter the market.

Thus, in the USA competition in telecom — almost exclusively with FTTP technology – is now spreading rapidly and widely, to rural as well as metropolitan areas. As this proceeds there is also an emerging general awareness — and even a nascent consensus – that the right telecom policy for the 21st century consists of three main elements:

i) A national telecom infrastructure consisting of "universal FTTP on the ground plus universal wireless cloud above resting on the universal fibre foundation below" is the right one for the 21st century;

ii) The viability, efficiency, flexibility and "future-proofness" of the broadband-based telecom system requires that competition be an essential ingredient and driver of the modern telecom sector.

iv) However, telecom is so critical to the economy and social concerns are so important that competition must be managed in such a way as to prevent the emergence of monopolistic practices and abuses, must support adequate technical co-ordination and must ensure universal affordable availability.

Most important it is becoming clear that such a regime is not only optimal — it is practical, realistic and achievable.

This broad realisation is spreading in other countries as well, most of which do not have the long history of “managed competition” in telecom as has been the case in the USA.

Which countries first reach the goal of “universal future-proof fibre foundation plus universal wireless cloud based on the fibre foundation” is not easily predicted at this point. As of the beginning of 2014, the leaders in the percentage of connections that were fibre were Japan, Korea, Singapore, Holland, Belgium, Canada and the USA — but things can change. What is virtually certain is that those countries that get there first will have an advantage in the “new economy.”

Implications for Australia

Australia appears to be quite far back in the pack. According to Akamai’s latest report Australia now ranks 48th in the world in terms of average connection speed and 60th in terms of peak speeds. (Akamai 2015). Nor does there appear to be a convincing path forward. The sector is dominated by a semi-official duopoly between NBN and Telstra. It is difficult not to see this as, *de facto*, a mechanism for transferring money from the Federal Treasury to Telstra and a few large construction companies to build a self-serving patchwork network composed largely of obsolescent copper and Band-Aid additions like satellite. FTTP appears to play a minor role in NBN/Telstra plans according to its roll-out map/plan.

As one would expect in a tightly monopolised market, costs appear to be greatly inflated compared to competitive international norms and performance standards are astonishingly low for such wealthy a country. There are few private players who are able or permitted to enter, and those that have been grandfathered-in suffer substantial regulatory handicaps. Early attempts at innovation and local initiative in wireline seem to have largely atrophied. In effect Government has re-imposed a regime from the world of 50 years ago. Most astonishing is the degree to which both main parties appear to be committed to this approach. True, Labor wants this archaic duopoly “bus” to be driven toward “FTTH” street while the Liberals have told the driver to head toward “MTM” street. But which destination is preferred pales compared the inappropriateness and dysfunctionality of the bus itself.

This is not auspicious for Australia's position in the new global economy in which the most dynamic driving force is the Internet and all that rides upon it. Economic success in the 21st century without world class Internet services is hard to imagine. And it is even harder to imagine how current Australian policy can ever produce a world-class telecom and internet system.

What to do? – Conclusions and Recommendations

The first challenge Australia faces is reflected in the old adage: "you can't fix a problem you don't first admit you have!" That said, with the "fools walk in…." temerity of a newcomers, we feel it may be worth talking about possible remedies. That requires acceptance of the lessons to be drawn from the history described above; i.e.:

1. There are no appreciable economies of scale in today's telecom.
2. There is no need for central ownership or central direction in order to make today's telecom networks work in synchrony with each other.
3. Technology of telecom networks themselves and of the services that utilise them is advancing at exponential rates. Thus, all systems must be flexible and capable of rapid adaptation. No single vision, regardless of how brilliant and "far sighted", will remain applicable and optimal for long. "Future-proof" – meaning the ability to adapt easily to change in any dimension (organisational and economic as well as technical) – must be a central goal of public policy.
4. Government's role is twofold: to enforce a level competitive playing field; and to ensure universal affordable availability of these basic services. That role does not require, nor is it aided by, monopoly of any kind, including any owned and operated by the government itself.

Based on these principles the following actions should be considered:

i) Open the long and medium distance wholesale backhaul market to any and all who want to enter . . . and loosen licence requirements for such entrants

ii) Open up access to undersea cables

iii) Encourage construction of more undersea cables to open up international access for more domestic carriers

iv) Permit development of "carrier hotels" by anyone who is willing and able to develop them where long haul carriers can co-locate and offer services to anyone who builds connecting network into the "hotel"

v) Remove constraints on access to poles and conduits

vi) Encourage new entrants in rural and other underserved/difficult areas with public money being made available *only as a last resort* and, even then, via

http://doi.org/10.18080/ajtde.v4n2.52

revolving loan funds and loan guarantees rather than via grants or discriminatory “protections” against competition;

vii) Determine what legal barriers may exist to innovative forms of finance for new entrants in underserved areas (such as crowd-funding, public sector revenue bonding, etc.);

viii) Determine how best to reduce or eliminate such barriers and what constraints or regulatory oversight may be required to enable efficient use of such financing mechanisms

viii) Encourage/facilitate joint ventures involving both public and private sector entities and including co-operatives;

ix) Restructure the provision of subsidies to disadvantaged areas and groups so that they go directly to the recipients and thereby provide the capacity to pay for infrastructure and services themselves, rather than being dependent on monopolies who are far away and care little. This is **both** less costly to the public purse **and** more effective for target areas and groups.

POSTSCRIPT……and prognosis

Unfortunately, our near-term prognosis is mostly gloomy. We truly wish we could say otherwise. In our assessment, the current Australian telecom situation is at a dysfunctional impasse. It has retrogressed to the darker days of the old telecom monopoly system – something no other industrialised country in the world has done as far as we are aware. In this climate we are not sanguine that a program like that outlined above is politically likely in the near or medium term.

Despite this gloomy short-term forecast, there are opportunities to begin untangling the knot. One place to start is by explicitly encouraging and enabling independent local FTTP networks to be built in those rural areas designated for non-FTTP development under the NBN. Such networks should be encouraged in any way available—mostly regulatory relaxation—but ***not*** with government grants. We predict that, if pursued aggressively, this will stimulate a significant number of such networks in non-metropolitan areas that, frankly, need high quality broadband the most. Government grants should be considered only in extremis and in only those areas where it is clear that there is no other way.

We make this suggestion because we have built and operated such networks ourselves in much more challenging environments than those in Australia. We have looked closely at a number of possible sites for such networks here — including in the far northern sections of Western Australia. So far we have not seen anywhere that a viable commercial FTTP local network could not be built and operated. The key issues are very mundane:

i) access to poles where these exist, or Rights of Way for burying cable where there are no poles— in both cases at fair, cost-based rates that do not include deliberate non-cost barriers to entry;

ii) non-discriminatory access to wholesale back-haul at prices that reflect costs and do not include monopoly overcharging;

iii) protection from deliberate predatory actions by monopolies seeking to kill newcomers in order to “set an example”;

iv) if outside retail service providers do not come forward on reasonable terms then the local network must be allowed to provide retail services itself.

We believe that government has the power to ensure those conditions — and without costing a penny of taxpayer money.

References

Akamai. 2015. Akamai, Inc., State of the Internet Connectivity Report, 4th quarter 2015

Broadband Communities Magazine. 2016. Seven Models for Community Broadband, http://bbcmag.epubxp.com/i/686592-may-jun-2016

FTTH Council. 2015. “FTTH Success Stories,” retrieved from http://bbcmag.epubxp.com/i/622360-nov-dec-2015

Galbi, Douglas. 2010. Diseconomies in Communications Networks, http://www.purplemotes.net/2010/04/25/economies-and-dis-economies-in-communications-networks/

Institute for Local Self-Reliance. 2015. Available at www.ilsr.org/community-broadband-map-fact-sheet/ January, 2015.

International Telecommunications Union Historical Statistics, various years

Mueller, Milton L. 2013. *Competition, Interconnection and Monopoly in the Making of the American Telephone System*, Syracuse, 2013

Point-topic.com. 2016. Available at http://point-topic.com/services/global-broadband-statistics/

U.S. Bureau of the Census. Various years. Available at: www.census.gov

U.S. Court of Appeals, District of Columbia. 1995. U.S. versus Western Electric, Case #94-5252, February 17, 1995.

http://doi.org/10.18080/ajtde.v4n2.52

The National Broadband Network Brownfields Debate

Valuing FTTN and FTTP

Richard Ferrers
Monash University

Abstract: This paper analyses the value of FTTN and FTTP along financial and non-financial dimensions. It reports on an open, public, dynamic 'value model' of FTTN and FTTP, and showcases two visual tools to enable assessment of their multiple, competing, emerging and slippery 'value dimensions'. The paper reports and compares empirically-derived FTTN and FTTP value dimensions from recent Ministerial Speeches at CommsDay Summit 2016 and Government expert reports with the value model.

Introduction

This paper examines, analyses and values Fibre to the Node (FTTN) and Fibre to the Premises (FTTP) in the context of the Australian National Broadband Network (NBN). A comparison of the two needs to take into account multiple 'dimensions of value'. For instance, while FTTN is cheaper to install, offers 'good enough' speed in the short term, and is faster to roll out, FTTP is seen, by some, to be better value, due to its length of useful life, lower maintenance costs, and faster maximum speeds.

This analysis of FTTN and FTTP uses value theory (see Appendix 2), which sees innovations, like the NBN, as complex, dynamic systems. That is, the value of the NBN is multi-dimensional, shifting with new information that appears often, and in quantity. Value theory suggests that analysis needs to use dynamic and flexible approaches, rather than the static and partitioned (public/private) approaches, for instance, of Vertigan (2014), the Liberal's NBN cost-benefit analysis, or the ALP's McKinsey NBN Implementation Study (2010).

This paper reports the results of the public dynamic model of the value of FTTN and FTTP (Ferrers 2016a, 2016b) and encourages the reader to play with the model's assumptions and come to their own conclusions. This model is a dynamic approach to understanding value, but it has some weaknesses. Two alternative models are presented which address some of these weaknesses. The first model allows multiple FTTN and FTTP value dimensions to be visualised. The second model takes into account the relative importance of multiple value

http://doi.org/10.18080/ajtde.v4n2.55

dimensions, for example: time, price, need for speed, reliability, equity (see Appendix 3). All of these models are available for public use.

Through examining these models, this paper seeks to:

(1) add information to potentially shift the NBN value assessment for two key audiences,

(2) add to the long list of FTTN and FTTP pros and cons (see Appendix 4), and

(3) add the cost to replace FTTN with FTTP into the debate (Appendix 7).

The first audience that this analysis is aimed at is the NBN politicians. These include the Prime Minister, the Leader of the Opposition, the Communications Minister, the Shadow Communications Minister and relevant Innovation Ministers. The second audience is voters, who may have the NBN on their minds when they go to vote. So, the analysis attempts to be reasonably comprehensive for the first group but simple enough for the second group.

The Problem of valuing FTTN and FTTP

Two views have developed about which is the best way to roll out the Australian NBN. The current plan is to roll out FTTN to 3.7M (million) homes over the next two years (by 30.06.2018) at an installation cost of $6.3B (billion) (Table 1, Appendix 6). However the alternative view is that this $6.3B is a waste of money, since FTTN is a "technically inferior" (LeMay 2015a) system to the preferred FTTP system. In this view, FTTN will have to be upgraded soon to FTTP, since FTTN is close to the end of its useful life, and very little of the $6.3B will be of use in an upgraded FTTP system. By the government's own analysis, only 20% of the $6.3B would be re-useable in an upgrade to FTTP (Vertigan 2014), and some analysts believe, far less. So, this is close to a $6.3B problem for FTTP proponents. For FTTN supporters, if the 3.7B homes were rolled out with FTTP at a cost of $16B, this is a waste of $10B, when FTTN installation costs are substantially less (Table 1).

But, different types of analysis can give different results (Table 1, 2). A more comprehensive analysis of the best approach to implementing the NBN would include consideration of Hybrid Fibre/Coaxial (HFC) and Fibre To The Curb (FTTC), (which is briefly analysed in Appendix 1), but these are excluded from the main analysis for simplicity. Similarly FTTP, in this analysis, means brownfield existing homes, rather than greenfield new estates, which are for the first time installing phone and internet.

Table 1 – FTTN vs FTTP: The Cost Perspective

	FTTN	FTTP
Install Cost $ per household	$2,100	$4,400
Install Cost for 3.7M households	$6.3B	$16.3B
Install Cost per household in other countries; Government Investment (see Appendix 8)	UK: <£100 Germany: €138 NZ: $1,062	NZ: $1,700 SG: $438
Operating Costs (350,000 premises) (LeMay 2015a)	$150M pa	$125M pa
Revenue (350,000 premises) (LeMay 2015a)	$175M pa	$275M pa
Total Revenue – Operating costs (roughly 10 times 350,000 premises) = NBN Co. Cash Profit	$250M pa	$1,500M pa
Time to payback installation costs	Approx. 27 years	Approx. 11 years
Useful life	5-20 years	20-40 years

What Table 1 shows, is that while FTTN is significantly cheaper to install, it generates far less profit for NBN Co., and takes a lot longer to pay back the initial investment. FTTP pays back the extra installation cost investment ($10B) in around 6.5 years, with NBN Co profits projected to be $1,500M per annum. But, for every year that FTTN remains in operation, over $1B is sacrificed through foregone revenue and lower operating costs. These figures suggest, even if FTTN is installed, that a quick upgrade to FTTP is financially attractive. The operating costs and revenue numbers come from leaked NBN Co. documents (LeMay 2015a). NBN Co. were asked to comment on these figures and they said: "the figures used as the basis for this analysis are from draft documents in early 2015 – not endorsed by our executive" (Johnston 2016).

While these figures are unconfirmed, they do add an interesting alternative slant to the focus only on installation costs. To the extent the operating costs and revenue numbers are correct, they shift the value of FTTP and FTTN, towards favouring FTTP.

Table 2 – FTTN vs FTTP: The Return on Investment (ROI) Perspective

Return on Investment	**FTTN**	**FTTN**	**FTTN**	**FTTP**	**FTTP**	**FTTP**
	Investment	Return pa	ROI	Investment	Return pa	ROI
NBN Co.	$6.3B	$250M	4% pa	$16B	$1,500M	9% pa
GDP Revenue Operating$ NBN Profit	$6.3B	$1,750M $1,500M $250M	56% pa	$16B	$2,750M $1,250M $1,500M	34% pa

What Table 2 shows is that taking installation costs, operating costs and revenue into account, the GDP return for FTTN (56% pa) is significantly greater than for FTTP (34% pa). Both returns are extraordinarily high, and generated every year during the life of the asset, assuming revenue levels are maintained over time. The FTTN asset life is however much shorter than the FTTP life. The GDP benefit per year is the sum of NBN revenue, operating costs and NBN Co profit. While the profits for NBN Co. are greater for FTTP, the return on investment for FTTN is much greater, given its lower installation costs. Indeed, each year FTTN (once completed) generates close to 30% of its installation costs as revenue, whereas FTTP only generates a little under 20% given its substantially larger installation costs, though FTTP generates 50% more revenue per year.

These returns on investment again shift the value of FTTP and FTTN more towards favouring FTTN, at least in the short term. Thus either FTTP (using gross return or time to pay back investment) or FTTN (using return on investment) can be preferred depending on the type of analysis. The Ferrers (2016a) model uses this GDP calculation to analyse and value FTTN and FTTP (plus depreciation).

In the next section, I will discuss the background to the NBN, including the magic of optic fibre. Then, I will analyse the value dimensions of the NBN by looking at two speeches from the CommsDay Summit 2016 by Minister Fifield and Shadow Minister Clare, and contrast the value dimensions mentioned there with external reports from Vertigan (2014) and McKinsey (2010), supporting the alternative positions.

Then, I will introduce my proposed solution to the value problem, a dynamic value model of FTTN and FTTP, and compare its value dimensions against those discovered in the speeches and reports. Lastly, two data visualisations will show the multi-dimensional and changing nature of the value of FTTN and FTTP.

The Background

Optic fibre is the magical technology which combines lasers and glass fibre tubes to transmit digital data over long distances. Optic fibre is special because not only can the signal reach for many kilometres without power, and with amplifiers cross the oceans, bringing data around the world at the speed of light, but also by changing the laser boxes at each end, data capacity can be doubled for around 5% of the cost of installing the cable. Over the last forty years, this change in laser boxes has brought a million-fold increase in bandwidth that has enabled the bandwidth explosion and the falling price of data globally.

The NBN in Australia seeks to bring the fibre optic cable closer to homes, and thus improve data speeds which are currently limited by bringing fibre only to the telephone exchange, and using copper phone lines for the connection into homes. See further NBN history at Whirlpool (2016).

Fibre To The Node

FTTN uses optic fibre from the telephone exchange to a distribution box called a node, up to a few hundred metres from homes and then uses copper phone lines to reach into houses. This approach allows for download speeds approaching 100Mbps, but the speeds vary with the distance from the distribution box. Some benefits of this approach are: less construction on the last few hundred metres for millions of households, so the rollout proceeds more quickly (less digging up gardens), and at considerably less cost – in the order of $2,000 per household (Table 1).

A more exhaustive list of pros (10) and cons (8) of FTTN is provided in Appendix 4.

Fibre To The Premises

FTTP runs fibre all the way from the telephone exchange to the side of each house, but the fibre cable must be hauled down every street, either on power poles or through ducts, and across or under lawns to reach homes. Some benefits of this approach are that download speeds of 1,000 Mbps are available immediately (if rarely in practice), with virtually unlimited bandwidth in the future, as the laser boxes are switched inside the exchanges. (In the lab, tests have shown fibre optic cables are capable of moving over 10,000 times more data than current available products, but laser boxes capable of these speeds are many years away from being affordable.) However, the cable has a long lifetime, and low maintenance, so is likely to remain useable for decades, with future upgrades to laser boxes providing significant regular improvements to fibre capacity. As capacity improves, it is likely to result in significant drops in price per unit of data transported.

A more exhaustive list of FTTP pros (11) and cons (7) is provided in Appendix 4.

There is no comparison in an FTTN FTTP speed test. Since 1975, FTTP has had a million-fold improvement in speed on a single fibre, from 45 Mbps in 1975 to 100,000,000 Mbps or 100 Terabits per second in 2016 (Wikipedia 2016a). For more speed, a bundle of up to 12 fibres adds 12 times the data capacity (Wikipedia 2016a). In contrast, FTTN has seen a thousand-fold improvement in FTTN, from 6Mbps in 1993 (Gilder 1993) to 8,000Mbps (Palmer 2016) in the lab in 2016.

Table 3 – FTTN vs FTTP: The Time Test

	FTTN	FTTP
Time to install	3.7M households in 2 years	10M households in 8-10 years, (per NBN 2016, p.18, 39)
Life of Asset	5-20 years	20-40 years

Table 4 – FTTN vs FTTP: The Goal and Opponent comments

	FTTN	FTTP
ALP Goal		"Do it once, Do it right, Do it with fibre." Tony Windsor in 2010 (Taylor 2014) NBN Co Statement of Expectations (Wong & Conroy 2010) "provide access to high-speed broadband to all Australian premises... connect 93% of Australian homes, businesses and schools to FTTP... up to 100Mbps"
ALP supporter comment	"Technically inferior" (LeMay 2015a)	
Coalition Goal	"Deliver fast, affordable and reliable broadband years sooner" (Liberal Party 2012: 6) "...ensuring all Australians have access to very fast broadband as soon as possible, at affordable prices, and at least cost to taxpayers... at least 50Mbps to 90% of fixed line premises... upgrade paths are available as required" NBN Co Government expectations (Turnbull & Cormann 2014, 1-2)	

Coalition comment	"we will get the network completed six to eight years sooner [FTTN] than it would be under [FTTP]… and $30 billion cheaper or at less expense to the Government, which makes broadband more affordable" (ABC 2015; NBN 2016, 18, 39)	"…wasting money on the greatest white elephant this country has ever seen, the National Broadband Network" Prime Minister Abbott (Abbott 2012). "…no evidence consumers are willing to pay higher charges for 100 megabits per second" (Liberal Party 2012, 5).

In Tables 3 and 4, the battle lines are drawn between two versions of the NBN. On the one hand, FTTN is rolled out years faster, giving "all Australians … access to very fast broadband as soon as possible, at affordable prices… at least cost to taxpayers… at least 50Mbps…[with an] upgrade path" (Turnbull and Cormann 2014, Table 4). On the other hand, the all-fibre FTTP has long-term cost advantages, from the rapid improvement in data carrying capacity, as shown by the million-fold improvement in the last forty years, though it is slower to install at a national level. The decision is between cheaper/affordable now (FTTN Table 1), cheaper later (FTTP Table 1), fast enough now, or very fast later. But, there are more value dimensions to FTTN and FTTP than just price, speed and timing.

A value analysis of FTTN and FTTP – a multi-dimensional dynamic comparison

This section makes a value analysis of FTTN and FTTP. Firstly, I report on value dimensions of FTTP and FTTN discovered through examining two documentary sources:

(1) recent speeches of Minister Fifield and Shadow Minister Clare, at the recent CommsDay Summit (Fifield 2016; Clare 2016, Appendix 9), and

(2) expert reports to support the alternative FTTN FTTP positions; Vertigan (2014) and McKinsey (2010) (Appendix 10).

I summarise below the value dimensions found, and compare them to a dynamic financial value model to assess the value of FTTN and FTTP. Then, I compare the dynamic model to the empirically derived value dimensions, to test its adequacy, and then make some suggestions to improve the model for unaccounted value dimensions.

Summary of Value Dimensions – Empirically derived

The analysis of Ministers' speeches (Appendix 9) shows a strong divergence in what Ministers Fifield and Clare value from FTTN and FTTP. Minister Fifield pushes the FTTN agenda of a faster, lower-cost rollout with good enough speeds, and the flexibility of the multi-technology approach. Clare prefers to mainly criticise the FTTN approach (rising costs, delays, congestion), but suggests FTTC is an improvement without committing to this approach. Both Ministers argue their approaches are in line with international comparisons, FTTN to improve international rankings and FTTP to follow the AT&T's lead. Many other FTTN and FTTP value dimensions are not mentioned by either Minister (see Appendix 9).

The analysis of expert reports (Appendix 10) shows a divergence in value dimensions between FTTN and FTTP. McKinsey emphasises affordability and maximising usage, including social benefits, whereas Vertigan emphasises willingness to pay, and places far less emphasis on business or public benefits. Table 5 below combines the results of the analysis of Ministers' Speeches (Appendix 9) and expert reports (Appendix 10).

Table 5 – FTTN vs FTTP: Summary of Value Dimensions found in Minister Speeches and Expert Reports

	FTTN	FTTP
Value dimensions found	• Flexible on which tech (MTM) • Fast enough services to meet current needs, but congestion • Fastest rollout to reach users quickly • Lower cost rollout • No new (future) needs/apps • No WTP for highest speeds • Rising costs, delay FTTN • New tech increasing speed for users (FTTC)	• Equity of access • Social/national benefits • High use of data • Fastest services / use • Reliability of FTTP to deliver advertised speeds • More services competition

In the next section, I present a financial dynamic value model which captures some of the value dimensions derived above. In the following section, I consider improvement to the value model to account for further value dimensions, including non-financial ones, such as equity or reliability of service.

A Dynamic Value model of FTTN and FTTP

To create a dynamic model to include all the value dimensions found in the previous section is challenging. A dynamic value model was constructed (Ferrers 2016b, Appendix 5), which takes account of:

- time to market / cost of delay (based on GDP impact of delay), and so captures benefits of early installation (cost, time)
- revenue, build and running costs of FTTN and FTTP (Table 1; NBN 2016; LeMay 2015a), and so captures current (but not future) benefits of higher speeds on FTTP, benefits of lower expected maintenance costs in the longer term on FTTP, current expected cost of FTTN maintenance
- cost of capital (cost of spending/revenue at different times)
- GDP impact on households of early install of FTTN (at lower and upper bounds of potential impact)
- replacement of FTTN with FTTP at year 20.

However, the dynamic model is not capable of accounting for all the value dimensions noted in Table 5 above. For instance, delays in rolling out FTTN, congestion on FTTN, flexibility of technology and new technology in the form of FTTC could not be captured.

This model uses a net present value (NPV) calculation (Appendix 5). NPV uses interest rates (the discount rate) to convert future cash flows to a present day equivalent. If the result of the calculation is a positive number, this indicates that a profit will be made, taking into account the revenue and expenses that are incurred at a future time. The GDP calculation simulates the NBN impact on a single household, compressing 20 years of installation costs, revenue, and operating costs to a single profit-like figure. You can see the derivation and development of the model at Ferrers (2015). The analysis assumes FTTN remains in place over the coming 20 years.

The model calculates NPV under a number of different scenarios. Under each of these scenarios, sometimes FTTN has a higher result and sometimes FTTP has a higher result. The model tests three variables:

1. delays in FTTP rollout from zero to eight years, shown in two year increments
2. discount rates, ranging from 0% to 10%
3. impact on $70,000 household income of early use of FTTN, ranging from 0% to 2%.

So, there are sixty different combinations of assumptions modelled in Tables 6a to 6c below. What the analysis shows is that under certain assumptions, FTTN is preferred (Table 6 in white), while under others, FTTP is preferred (Table 6 in grey). Replacement of FTTN cost (but not rollout time) is also modelled (Appendix 7) and where this extra expense changes the result from a pro-FTTN to a pro-FTTP result, the cells are highlighted (Table 6 in pink).

Table 6a – Comparing FTTN and FTTP impact on a household over 20 years; where early FTTN gives 0% boost to household GDP.

Years delay FTTP	0 yr	2 yr	4 yr	6 yr	8 yr
	$'000	$'000	$'000	$'000	$'000
10% discount rate	7	3.5	1	1.5	3
5% discount rate	9	6	3	0	2
3% discount rate	10	7	4	1	2
0% discount rate	12	9	6	3	0

Table 6b – Comparing FTTN and FTTP impact on a household over 20 years; where early FTTN gives 1% p.a. boost to household GDP.

Years delay FTTP	0 yr	2 yr	4 yr	6 yr	8 yr
	$'000	$'000	$'000	$'000	$'000
10% discount rate	7	1	4	7.5	11
5% discount rate	9	3	2	7	11
3% discount rate	10	4	1	6	11.5
0% discount rate	12	6.5	1	5	11

Table 6c – Comparing FTTN and FTTP impact on a household over 20 years; where early FTTN gives 2% p.a. boost to household GDP.

Years delay FTTP	0 yr	2 yr	4 yr	6 yr	8 yr
	$'000	$'000	$'000	$'000	$'000
10% discount rate	7	1	8	14	18
5% discount rate	9	0	7	14	20.5
3% discount rate	10	1.5	6.5	14	21
0% discount rate	12	4	5	14	22.5

What is apparent from Tables 6a to 6c and Figure 1 is that:

- at 2% p.a. impact on household GDP, FTTN is preferred (shown in white), even with short delays, except at low discount rates.
- at 1% p.a. impact on household GDP, FTTN is preferred (shown in white), , so long as delay to install FTTP is four years or more.
- at 0% impact on household GDP, FTTP is preferred (shown in grey), at up to six years delay at low discount rates, and at four years delay at any discount rate.
- the boundary is only slightly changed when you take into account replacement of FTTN with FTTP (shown in pink).

In Appendix 5, the NPV for FTTP and FTTN, individually, are both shown. Since these figures in Appendix 5 are all positive, it shows that FTTP and FTTN projects are worth pursuing in their own right, regardless of comparison.

The reliability of these assessments is based on the validity of the financial costs, operating costs and revenue still making sense over the next 20 years. There is large uncertainty over whether FTTN revenue could be sustained over 20 years without significant loss of customer satisfaction, as FTTP speeds would likely have increased significantly beyond what FTTN is capable of.

Visualising FTTN and FTTP impact on a household over 20 years

Figure 1 below shows a data visualisation of the sixty combinations modelled in Tables 6a to 6c, some which show a higher result for FTTN (in blue) and others which show a higher result for FTTP (in orange).

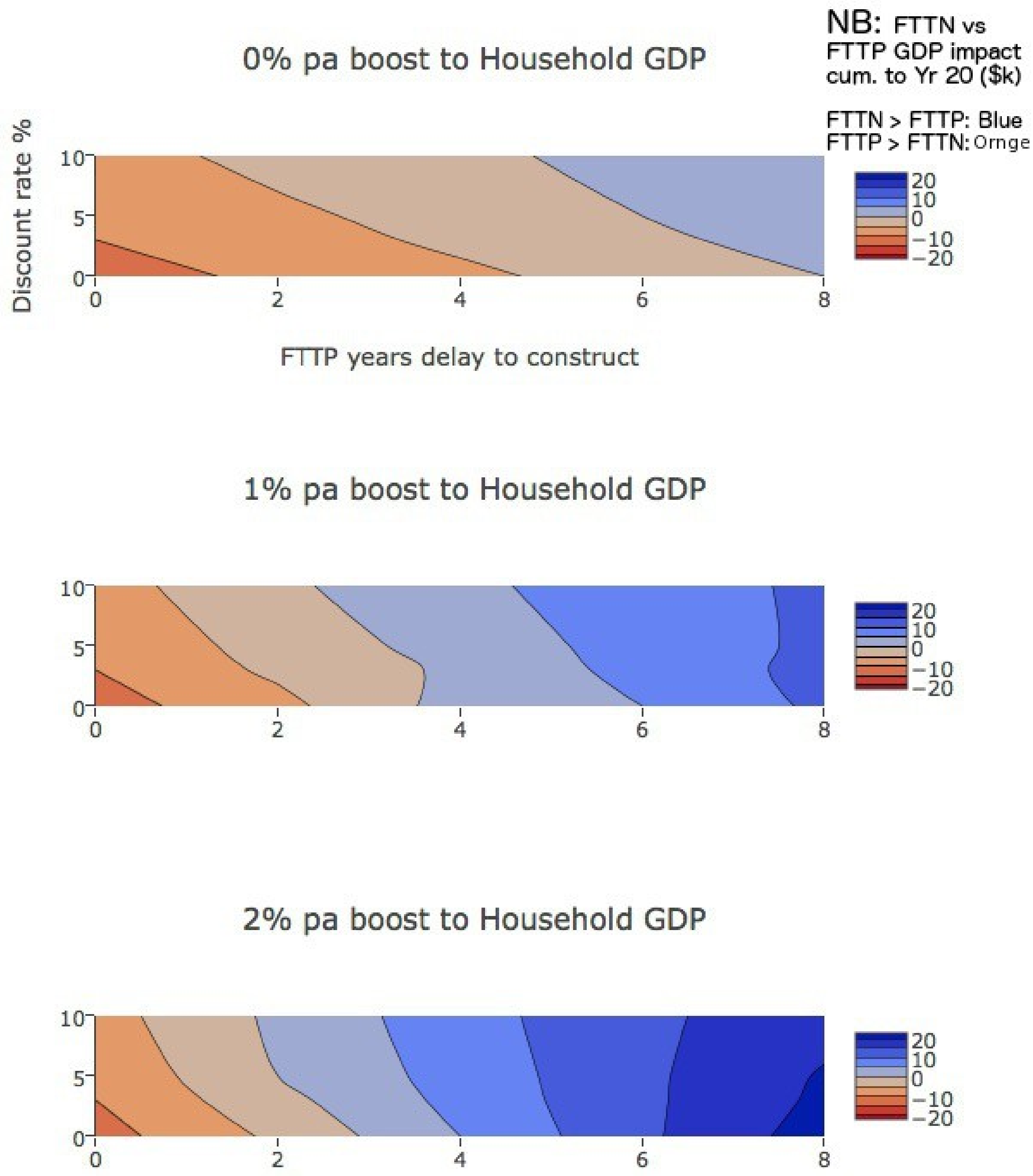


Figure 1 – Heatmap showing assumptions preferring FTTN (blue) and FTTP (orange) – Ferrers (2016a)

An updated heatmap diagram including cost of FTTN replacement with FTTP (per Appendix 7) is available at Ferrers (2016c).

Figure 1 above shows that assumptions can justify either FTTN (including replacement cost) or FTTP. This result seems to fly in the face of much analyst commentary, which focuses only on the technical advantages of FTTP.

The value model, as demonstrated, is openly available (Ferrers 2016b) for improvement or enhancement. One improvement might account for new applications possible on FTTP, and potential declining user satisfaction on slower FTTN services. In the next section, I seek to extend the value model with a tool that allows adding value dimensions, and to include different weights to the importance of those dimensions.

Extending a value model of FTTN and FTTP

This section proposes an enhancement to the above value model, taking into account a number of non-financial dimensions. Weightings are also given to dimensions to suggest their relative importance. Readers are invited to submit their further dimensions and weighting through an online survey. Such a survey could show how value dimensions for the FTTN and FTTP vary over time, and around Australia. I also provide a couple of visualisations that express the multi-dimensional models: through

(1) a radar chart which shows many dimensions; and
(2) an Aster chart, which also allows the weighting of dimensions.

Table 7 below indicates the author's assessment of several FTTN and FTTP value dimensions, and their relative importance. I also make an overall value assessment which seeks to state my overall value position towards FTTN and FTTP.

Table 7 – Comparing value of FTTN and FTTP on multiple value dimensions.

Note: Author's assessment and weighting of FTTN and FTTP value dimensions, and ratings noted as stars (* low to *** high value). More detail of dimensions – Appendix 3.

Value dimensions	Weight	FTTN	FTTP
Installation cost per household	25	$2,100	$4,400
Future capital expenditure (CAPEX) improvements	10	80% of $4,400 sometime (Vertigan 2014)	5% of $4, 400 for significant speed improvements (Senate Committee 2015)
Time to rollout	25	Quick (0-3 yrs)	Slow (+6-8 yrs)
Life of asset	25	Shortish	Long
Operating Costs (OPEX) (for 350,000 premises)	10	$150M pa	$125M pa
Revenue (for 350,000 premises)	10	$175M pa	$275M pa
Current Need	10	***	***+
Future Need	25	*	***
Reliability	25	**	***
Equity	10	**	***
Simplicity (new admin systems)	0	*	**
Beauty (digging up lawns)	5	**	*
Unknown Unknowns	25	**	*
Author's value assessment	Overall, even though FTTP has higher benefits logically to me, I value the quicker FTTN rollout to avoid the unknown unknowns, over the FTTP benefit of lower longer term costs. However, I am concerned that if the FTTN is left in place for a long time, its value will quickly diminish. So, I prefer FTTN, but subject to a commitment to switch to FTTP in a timely manner. However, my value assessment is subject to change with new information. Ideally, I prefer the disagreeing parties to agree on a joint plan to reduce risk, for instance implementing FTTC, or a commitment to retire FTTN progressively after 10 years.		

As can be seen from Table 7, FTTN and FTTP can be compared along multiple value dimensions. Many FTTN and FTTP value dimensions are non-financial dimensions. I use the example above of the author's value assessment, not to provide a correct answer, but to showcase two helpful tools to visualise the multiple dimensions of FTTN and FTTP. My value assessment is visually displayed in Figure 2 and Figure 3 below, where the differences between FTTN and FTTP become visible.

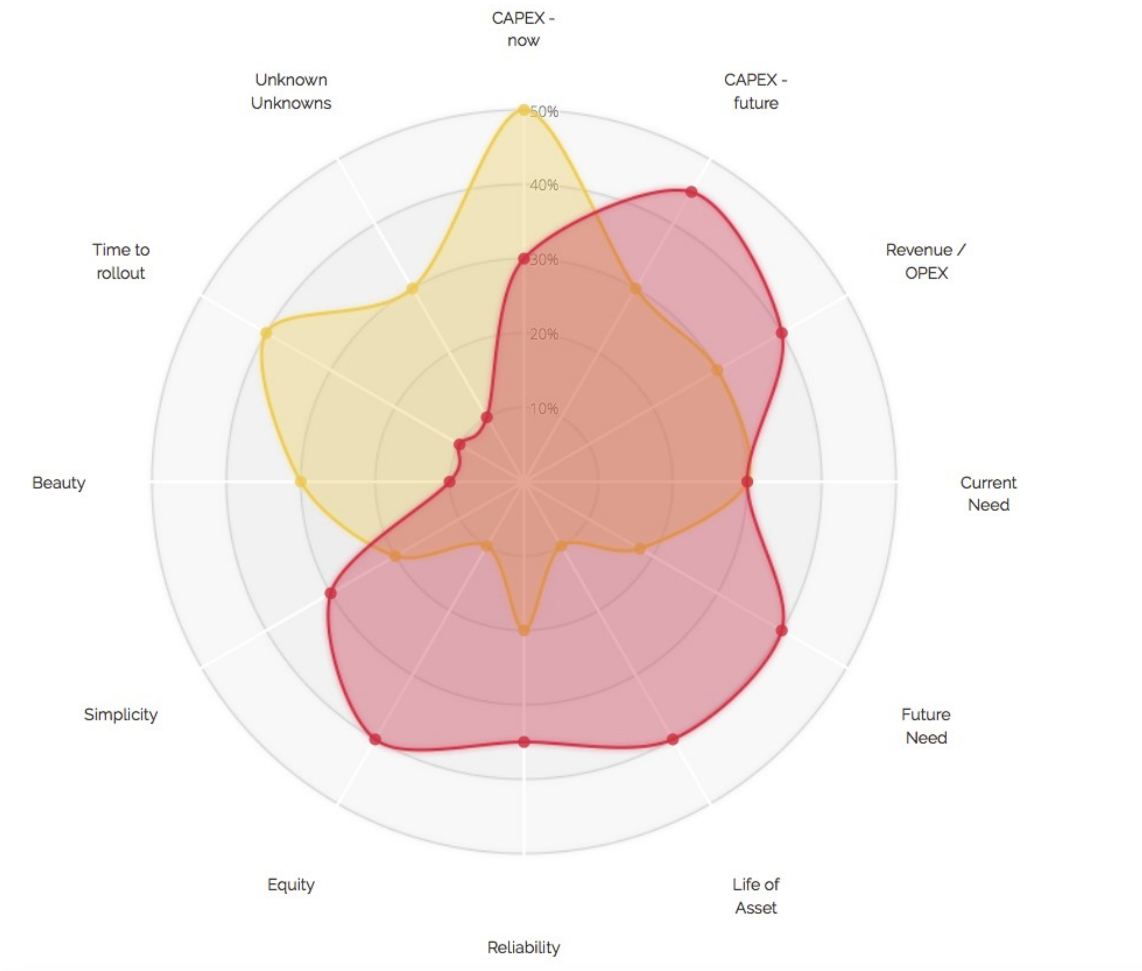


Figure 2 – Comparing FTTN and FTTP on multiple value dimensions (Radar Chart)

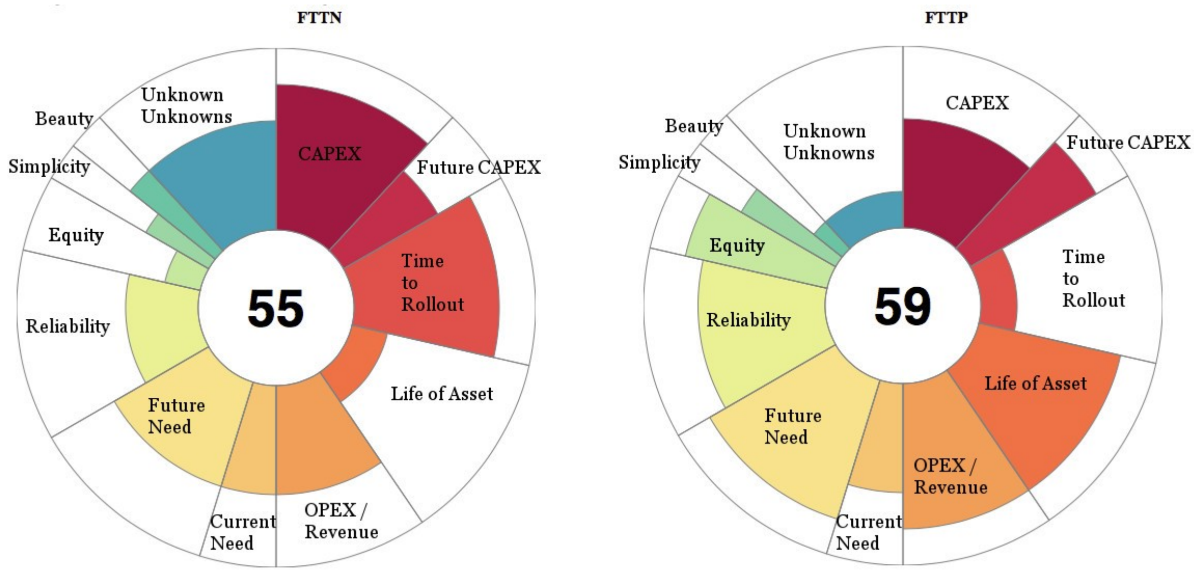
Note: Closer to edge indicates increased value. FTTN shown as Yellow, FTTP as Red.

Table 7 can be conveniently displayed as a Radar Plot (Ferrers 2016d). The plot shows on some dimensions FTTN is preferred (closer to edge) and on other dimensions FTTP is preferred. Assuming dimensions are weighted evenly, if FTTN or FTTP has a greater area on the chart, this means that it has a higher value. According to value theory, dimensions can be traded off, one against the other, but there is no rational basis for this, so it is done on an intuitive or emotional basis.

This is an 'apples and oranges' problem. Apples and oranges are measured on different scales, as are nearly all the dimensions on the radar plot (excepting revenue and CAPEX). Overall, you can see the pattern of contrasting value dimensions of FTTN and FTTP. A weakness of the Radar plot is that each dimension is given the same weighting. This, we fix in the second tool, shown in Figure 3.

An alternative to the Radar plot is the Aster plot (Ferrers et al. 2016), which enables a weighting for the value dimensions. In Figure 3, I use the weightings of Table 7, to display and contrast the value of FTTN (left side) and FTTP (right side). In the Aster chart, closer to the edge and a larger slice of pie, indicates higher value. The range of 12 value dimensions is indicated with different colours. Extra dimensions can easily be added, as well as weightings adjusted. It is easy to see how FTTN wins (larger piece of pie) on some dimensions, such as capital expenditure and time to rollout, while FTTP wins on other dimensions, such as life of asset and reliability. An overall value rating, shown in the centre of the Aster plot indicating overall value favours FTTP, but not by much.

A reader can download this chart from Ferrers (2016e) and add their own dimensions and weightings, to come to their own FTTN and FTTP value assessment. You can share your FTTN and FTTP value dimensions, and your weightings (including postcode) at Ferrers (2016f).



Key: Weight	Value Dimension
25	CAPEX: Installation costs
10	Future CAPEX: Improvements
25	Time to rollout
25	Life of Asset
20	Operating Costs / Revenue
10	Current need
25	Future need
25	Reliability
10	Equity
5	Simplicity
5	Beauty
25	Unknown Unknowns

Figure 3 – Aster plot of multi-dimensional weighted value dimensions of FTTN (left) and FTTP (right)

Conclusion

In this paper, I have analysed FTTN and FTTP using a value approach. A value approach assumes value shifts with new information, where many dimensions compete for importance, new dimensions may arise and weightings shift, giving rise to new attitudes. For instance, new techniques, such as NG-PON2 may massively increase FTTP data throughput and hence reduce cost per unit of data. This paper seeks to add a new value perspective to potentially shift the FTTN and FTTP value assessment for Ministers and voters. While Coalition Ministers prefer short term benefit and hence FTTN, ALP Ministers prefer long term benefit, and hence FTTP. Which is better, now or the future is a value question so the two views are 'incommensurable'. Figure 1 shows both FTTN and FTTP are financially justifiable at up to 20 years from now, though FTTN is much more limited in its technical capacity.

I have provided above two alternative dynamic approaches to valuing FTTN and FTTP. The first is a financial value model, open and public, where a user can amend the assumptions and explore or add to the financial dimensions. A second approach adds non-financial dimensions to the analysis, such as future needs, reliability, equity and unknown unknowns. The two data visualisations of the second approach allow a complex view of FTTN and FTTP to be visually presented and compared.

Ultimately the choice between FTTN and FTTP becomes a choice between which analysis variables that you, the reader, are prepared to commit to, set as a priority, and what weight you will give to each of these variables. You can share your weightings in an online survey at Ferrers (2016f). I urge you to use these tools to discover what you prefer, what you value more, and what value dimensions are of importance to you in regards to FTTN or FTTP.

Table 8 – Summary of significant FTTN FTTP value dimensions (more in Appendix 3)

Type of Value	**FTTN**	**FTTP**
Benefits	Cheaper in the short term Quicker to rollout Fast enough in short term	Faster by far Cheaper in the longer term Long lived asset
Problems / Risks	Needs to be replaced soon Higher maintenance and replacement costs	Not sure what to use speed for Slower to rollout
Overall value:	Quick wins Fast enough, cheaper now, sooner in use.	Build for the future Do it once, Do it right.

References

Abbott, T. 2012. 'Doorstop Interview'. [Internet], accessed at: http://www.wa.liberal.org.au/article/surf-life-saving-volunteers-pacific-highway-whaling-breast-implants-kevin-rudd-tony-abbott.

ABC. 2015. 'Malcolm Turnbull talks innovation, NBN, company tax, Mal Brough with Leigh Sales'. 7 December 2015. [Internet]. Available from: http://www.abc.net.au/7.30/content/2015/s4367704.htm.

CIA. 2016. The World Factbook. Accessed 10 June 2016. Available from: https://www.cia.gov/library/publications/resources/the-world-factbook/.

Clare, J. 2016. CommsDay Summit 2016. Speech. 'From Sonny Bill Williams to the Fonz - How Malcolm Turnbull made a mess of the NBN'. [Internet]. Available from at: http://www.jasonclare.com.au/media/speeches/2958-speech-from-sonny-bill-williams-to-the-fonz-how-malcolm-turnbull-made-a-mess-of-the-nbn-commsday-summit-sydney-

Crown Fibre Holdings Limited. 2016. 'Where and When is UFB being delivered?' [Internet]. Available from: http://www.crownfibre.govt.nz/getting-ufb/rollout-timetable/.

Ferrers, R; Best, B; Abercrombie, P; Regetz, J. 2016. 'Value Flower; a multi-dimensional dynamic value analysis tool'. [Internet]. Available from:

https://dx.doi.org/10.6084/m9.figshare.3425663.v1.

Ferrers, R. 2013. 'A Consumer Value Theory of Innovation in 3G Mobile Phones: a Grounded Theory Approach'. PhD Thesis. [Internet]. Available from: http://dx.doi.org/10.6084/m9.figshare.680002.

Ferrers, R. 2015. 'FTTP vs FTTN; When is spending $4400 better value than spending $2100?' [Internet]. Available from: http://www.valman.blogspot.com.au/2015/12/fttp-vs-fttn-when-is-spending-4400.html.

Ferrers, R. 2016a. 'FTTN vs FTTP 6: the graphical version'. [Internet]. Available from: http://www.valman.blogspot.com.au/2016/02/fttn-vs-fttp-6-graphical-version.html.

Ferrers, R. 2016b: 'Comparing FTTP and FTTN costs for NBN Australia'. Figshare. [Internet]. Available from: https://dx.doi.org/10.6084/m9.figshare.2008689.v8.

Ferrers, R. 2016c. 'FTTN FTTP Heat Map'. [Internet]. Available from: http://areff2000.github.io/2016/02/05/fttn-fttp-heat-map.html.

Ferrers, R. 2016d. 'Comparison of FTTN FTTP on multiple dimensions'. Radar Plot. [Internet]. Available from: https://github.com/areff2000/d3-bubble-plot/tree/gh-pages/radarPlot. Active version at: http://areff2000.github.io/2016/05/15/valuing-fttn-fttp-radar-map-comparison.html View source for data.

Ferrers, R. 2016e. 'Valuing FTTN FTTP - Aster Plot - multidimensional and weighted'. [Internet]. Available from: http://areff2000.github.io/2016/05/16/valuing-fttn-fttp-aster-plot-multidimensional-and-weighted.html.

Ferrers, R. 2016f. 'Valuing FTTN and FTTP; NBN Australia 2016'. Online Survey. [Internet]. Available from: https://t.co/dOCtl4b87D.

Ferrers, R. 2016g. 'FTTN vs FTTP (5): cheaper now or faster later; a clash of assumptions'. Table 2, 4. [Internet]. Available from: http://valman.blogspot.com.au/2016/01/fttn-vs-fttp-5-cheaper-now-or-faster.html Data at: https://dx.doi.org/10.6084/m9.figshare.2008689.v8.

Fifield, M. 2016. 'CommsDay Summit 2016'. Speech. [Internet]. Available from: http://www.mitchfifield.com/Media/Speeches/tabid/71/articleType/ArticleView/articleId/1136/SPEECH--CommsDay-Summit-2016.aspx.

Gilder, G. 1993. 'The Death of Telephony'. Economist, 11-17 Sept, 1993, [Internet]. Available from: http://web.archive.org/web/20070830094652/http://thejoie.com.au/gilder.htm.

Gregory, M. 2014. 'Why the NBN's cost-benefit analysis is flawed on arrival'. [Internet]. Available from: https://web.archive.org/web/20151111121046/http://www.businessspectator.com.au/article/2014/9/18/technology/why-nbns-cost-benefit-analysis-flawed-arrival.

Gregory, M. 2015. 'The Technology that could Turbocharge the NBN'. The Australian. 25 September, 2015. [Internet]. Available from: http://www.theaustralian.com.au/business/business-spectator/the-technology-that-could-turbocharge-the-nbn-/news-story/46e9e04f4809f56d928993e3826a0714.

Johnston, R. 2016. 'NBN Responds To Claims FTTP Is Better Value Than FTTN'. Gizmodo. 5 January 2016. [Internet]. Available from: http://www.gizmodo.com.au/2016/01/nbn-responds-to-claims-fttp-is-better-value-than-fttn/.

LeMay, R. 2014. 'Clare tables NBN petition in Parliament'. Delimiter. 14 February 2014. [Internet]. Available from: https://delimiter.com.au/2014/02/14/clare-tables-nbn-petition-parliament/.

LeMay, R. 2015a. 'NBN Co may overbuild the Optus HFC cable network it bought for $800 million'. Delimiter. 25 November 2015. [Internet]. Available from: https://delimiter.com.au/2015/11/25/nbn-co-may-overbuild-the-optus-hfc-cable-network-it-bought-for-800-million/. Data also at: http://bit.ly/1Xd2N84.

LeMay, R. 2015b. 'NBN Co delays FTTN rollout for further testing'. Delimiter. 24 August 2015. [Internet]. Available from: https://delimiter.com.au/2015/08/24/nbn-co-delays-fttn-rollout-for-further-testing/.

Liberal Party. 2012. 'Fast Broadband and an Affordable NBN'. [Internet]. Available from: http://www.liberal.org.au/fast-broadband-and-affordable-nbn. Also at: http://apo.org.au/node/33483.

McKinsey & Co. 2010. 'National Broadband Network Implementation Study'. [Internet]. Available from: http://apo.org.au/node/21219.

NBN. 2016. 'Corporate Plan 2016'. [Internet]. Available from: http://www.nbnco.com.au/content/dam/nbnco2/documents/nbn-corporate-plan-2016.pdf.

OECD. 2015a. 'Digital Economy Outlook'. [Internet]. Available from: http://dx.doi.org/10.1787/9789264232440-en.

OECD. 2015b. 'World Stats: Digital Economy Outlook'. Figure 2-24. [Internet]. Available from: http://dx.doi.org/10.1787/888933224587.

Palmer, D. 2016. '"Extraordinary innovation" happening in copper broadband, says Nokia chief'. Delimiter. 8 April 2016. [Internet]. Available from: https://delimiter.com.au/2016/04/08/extraordinary-innovation-happening-copper-broadband-says-nokia-chief/.

Senate Committee. 2015. 'The Cost-Benefit Analysis and Review of Regulation'. [Internet]. Available from: http://www.aph.gov.au/Parliamentary_Business/Committees/Senate/National_Broadband_Network/NBN/Second%20Interim%20Report/c04.

Taylor, J. 2014. "Abbott was unmovable on 'shocker' NBN Policy: Oakeshott". ZDnet. 26 May 2014. [Internet]. Available from: http://www.zdnet.com/article/abbott-was-unmovable-on-shocker-nbn-policy-oakeshott/.

Turnbull, M; Cormann, M. 2014. [Stakeholder Minister] 'Government Expectations'. [Internet]. Available from: https://www.communications.gov.au/sites/g/files/net301/f/SOE_Shareholder_Minister_letter.pdf.

Vertigan Committee. 2014. 'Independent cost-benefit analysis of broadband and review of regulation: Volume II – The costs and benefits of high speed broadband'. [Internet]. Available from: https://www.communications.gov.au/departmental-news/independent-cost-benefit-analysis-nbn. See also http://apo.org.au/node/41039. DOI: http://dx.doi.org/10.4225/50/570B2E5CA7F81.

Whirlpool. 2016. 'Knowledge Base: National Broadband Network 2007 – 2013'. Accessed 10 June 2106. Available from: http://whirlpool.net.au/wiki/NBN.

Wikipedia. 2016a. 'Fibre Optic Communication'. [Internet]. Accessed 10 June 2016. Available from: https://en.wikipedia.org/wiki/Fiber-optic_communication.

Wikipedia. 2016b. 'Present Value'. Accessed 10 June 2016. Available from: https://en.wikipedia.org/wiki/Present_value.

Wong, P; Conroy, S. 2010. [Shareholder Minister] 'Statement of Expectations'. [Internet]. Available from: http://www.nbnco.com.au/content/dam/nbnco/documents/statement-of-expectations.pdf.

Appendix 1: FTTN vs FTTP vs Skinny Fibre FTTC

Table A1 – Fibre to the Curb compared to FTTN FTTP

	FTTN	**FTTC**	**FTTP**
Fibre reaches to	Node	Curb	The home
Speed	Up to 100Mbps	Up to 1000Mbps	Up up up
Install cost	$2,100 per household	Unknown	$4,400 per household
Maintenance	Medium/uncertain	Low	Low
Revenue potential	Medium/Low	Medium/High	Medium/High
Reliability	Medium	High	High
Useful Life	Short/Medium	Medium / Long	Long
Ease to upgrade	Low	Medium	High
Cheap to upgrade	No	Middle	Yes

Note: According to the NBN Co CEO at Senate Enquiry in May 2016, while NBN Co has been trialling Fibre to the Curb for some twelve months, to date, there is only one working installation of the technology. This suggests Fibre to the Curb is quite some way from working at scale.

Appendix 2: What is a value theory of innovation?

A value theory of innovation was developed looking at consumers buying smartphones. Consumers expressed value in 80 different ways about their smartphones, and these value elements were expressed as 12 value dimensions. This analysis of the FTTN and FTTP tests these same 12 value dimensions in a new technology domain to provide confidence in the validity of these value dimensions. Other value dimensions may appear in different technologies.

Value in theory

- Value is subjective (though in other theories objective); personal, so depends on perspective. See an examination of the consumer value literature in Ferrers (2013) Section 7.6 and innovation value literature in Section 7.1.
- Value is dynamic; moves with new information.
- Value is complex; multi-dimensional (see Table 7).
- Value is financial, social, emotional, personal.
- Value is a trade-off between competing dimensions: time, cost, quality, future-proofing, function (speed), reliability. See Ferrers (2013), Appendix 5.
- Value is measurable, though it is unclear what units can compare competing dimensions. Emotion as a possible common currency of value.
- Value is simple. Regardless of underlying complexity, value is compressed into a vector showing strength and direction: strongly/weakly, negative/positive, and expressed as an attitude.
- Value is not comparable rationally across value dimensions, but can be compared and summarised emotionally as an overall attitude. See an example in Table 7. One cannot rationally compare beauty and power, time and cost, simplicity and emotion, novelty and community, or any of the other 60 combinations across 12 value dimensions.

Source: Ferrers (2013).

Appendix 3: FTTN and FTTP value dimensions – non-financial

Table A3 – FTTN and FTTP value dimensions – non financial

	FTTN	FTTP
Current / Future needs	Serve current needs well	Suitable for future applications
Time	The short term	The long term
Community	Liberal Coalition, Telcos	ALP, Academics, Technical Enthusiasts
Equity	Service depends on distance from exchange. Can be congested since shared medium.	Congestion only due to CVC provisioning. Distance does not impact service quality.
Reliability, Service	Moderate reliability Very easy to install. Potential for unreliability through water damage or age.	High reliability But challenges during installation, such as damaging cabling.
Novelty, Power	Faster	Fastest
Simplicity, Emotion	Simplicity: complex system for NBN to manage multi-network types, i.e. HFC, FTTN, FTTP	Simplicity: single system Emotion: petition 275,000 to Parliament to keep FTTP
Beauty	Invisible (using phone lines)	Underground (trenching), impact on gardens
Duty	At least 50Mbps to 90% of households with fixed lines as soon as possible	93% of households with fixed lines to get FTTP

Appendix 4: A more exhaustive list of Pros and Cons

Table A4 – A more exhaustive list of FTTN FTTP Pros and Cons

Type of Value	FTTN	FTTP
Benefits	• CAPEX less (NBN) "lowest cost" -> more affordable ($6.3B for 3.7M hh) $2100/hh. Net benefit $18B vs FTTP (Vertigan 2014). • Quicker to rollout (ABC 2015); "as soon as possible" (Turnbull & Cormann 2014); (6-8 yrs: NBN 2016, 18) • Provides option for upgrades (option value) • Sufficient for median demand at 2023; 15mbps. (Vertigan 2014) • Capable of 50-100mbps (20-50 mbps down), for 80% of premises. Good enough speed (Vertigan 2014) • FTTN should support 100mbps over short copper within a few years (Liberal Party 2012). • No need to dig across lawns. • Early GDP impact makes worthwhile at 0,1,2%/hh/yr • Good for Telstra to extend life of copper. • Users (> 50%) buying NBN at FTTN capable speeds currently (Vertigan 2014)	• Faster; more than 10x (or more) than FTTN eg NG-PON2 (Gregory 2015) • Future proof; longer lifetime use (N=30 yrs) • Cheap to upgrade speed (5% CAPEX) (Senate Committee 2015) • Cheaper OPEX (NBN) (LeMay 2015a) • More revenue (NBN) (LeMay 2015a) • Fairer, no slower speed on distance from exchange, all get same service • Countries aspire to FTTP speeds in plans. (OECD 2015a, 21-23) • Some countries fast rollout FTTP (NZ) • Carriers rolling out more FTTP (AT&T, Verizon, Google) • Petition; 270k supporters of FTTP to Parliament (LeMay 2014) • No power required between exchange and home (passive)

Type of Value	FTTN	FTTP
Problems	• Shorter life (perhaps less than 10yrs) - already obsolete • When/if replace with FTTP then only 20% of FTTN CAPEX reuseable on FTTP (Vertigan 2014) • Maintenance /remediation costs; higher/unknown • Contention, congestion at peak time • Power required at nodes, so slower to install and more expensive to run, more to maintain • Slower the further from exchange; 50% at 500m, 75% slower at 1000m. Impact on 20% of households. (Vertigan 2014, 46). • Slower upload speeds. • Countries replacing FTTN with FTTP eg NZ.	• Install costs more $4400/hh; (NBN 2016) • 6-8 years longer to rollout (NBN 2016) • No demonstrated apps for fastest speeds. (Liberal Party 2012) • No willingness to pay more for fastest speeds (>100Mbps) (Vertigan 2014) • Only 14 countries have more than 10% FTTP (OECD 2015b) • Need to dig up gardens to install. • Something better might come along - Telstra 4G at 1Gbps
Slogan	"deliver fast, affordable and reliable broadband years sooner" (Liberal Party 2012, 6) "ensuring all Australians have access to very fast broadband as soon as possible, at affordable prices, and at least cost to taxpayers... at least 50mbps to 90% of fixed line premises... upgrade paths as required" NBN Co Government expectations (Turnbull & Cormann 2014, 1-2)	"Do it once, do it right, do it with fibre" Tony Windsor 2010 (Taylor 2014)
International comparison (see Appendix 8)	NZ rolled out FTTN, switched to FTTP. Only two countries spending more (in total) than AU; US $45B over 10 yrs, Sth Korea $25B. But US has 321M population, Sth Korea has 49M population. No-one is spending more per household than Australia. Many countries (at 2014) rolling out FTTN; including Sth Korea, US, Germany, UK, Sweden. All countries except AU (FTTP) and Singapore allow infrastructure competition.	NZ rolled out FTTN, switched to FTTP.

Appendix 5: GDP NPV totals, shown net in Table 6a, b, c.

Table A5.1 – Comparing FTTN and FTTP impact on a household over 20 years; where early FTTN gives 0%, 1% or 2% boost. Discounted Interest at 0%.

Note: Shaded column indicates better outcome.

GDP	Delay = 0 yrs		2 yrs		4 yrs		6 yrs		8 yrs	
Yr20	FTTN	FTTP	FTTN	FTTP	FTTN	FTTP	FTTN	FTTP	FTTN	FTTP
	$'000	$'000	$'000	$'000	$'000	$'000	$'000	$'000	$'000	$'000
0%	20	32	20	29	20	26	20	23	20	20
1%	20	32	23	29	25	26	28	23	31	20
2%	20	32	25	29	31	26	37	23	42	20

Table A5.1 – Comparing FTTN and FTTP impact on a household over 20 years; where early FTTN gives 0%, 1% or 2% boost. Discounted Interest at 10%.

Note: Shaded column indicates better outcome.

GDP	Delay = 0yrs		2		4		6		8	
Yr 20	FTTN	FTTP	FTTN	FTTP	FTTN	FTTP	FTTN	FTTP	FTTN	FTTP
	$'000	$'000	$'000	$'000	$'000	$'000	$'000	$'000	$'000	$'000
0%	9	16	9	13	9	10	9	8	9	6
1%	9	16	12	13	14	10	15	8	17	6
2%	9	16	14	13	18	10	21	8	24	6

Source: Ferrers, R. (2016g).

Appendix 6: NBN by the figures

Table A6 – NBN Corporate Plan (NBN 2016) Summary, p.60, p.67.

Year	‘15	‘16	‘17	‘18	CAPEX ‘16-18	$CAPEX/hh** ‘16-18	$/hh p.67
Premises Passed	‘000	‘000	‘000	‘000	$B	$	$
FTTN	-	500	2,035	3,745	6.3	$1,682	$2,300
FTTP - brown	708	1,080	1,270	1,515	2.5	$3,097	$4,400
FTTP - green	189	260	370	505			
HFC	-	10	875	2,350	2.6	$1,106	
Other (eg Satellite/wireless)	316	782	892	947			
Total	1.2M	2.6M	5.4M	9M			

NB: CAPEX = installation cost; hh = households/premises; Passed = infrastructure in place, but not necessarily connected.

Note: ** Does not include Infrastructure lease costs, ie pits and pipes.

See Table 8 (p.67) in NBN Corporate Plan (NBN 2016), which shows FTTP at $3,700 per household, which suggests $0.5B spent in 2015 relates to 2016-18 connections, plus infrastructure lease ($700 per household); Total $4,400 per household.

Appendix 7: Cost of Replacing FTTN with FTTP (Yr 10, Yr 20)

The original analysis (Ferrers 2015) uses $4,400 as CAPEX for FTTP (and NBN 2016, p.67). Vertigan (2014) suggests 20% of FTTN investment could be reused for FTTP. A substantial portion (say 60%) of FTTP is a labour cost which could rise with inflation at 2, 3, or 5% pa. What would $4,400 spent in 10 or 20 years, adding in labour inflation, discounted (Wikipedia 2016b) to today's dollars at interest rates used in the above analysis, be worth now? Model at: https://dx.doi.org/10.6084/m9.figshare.2008689.v9

Table A7.1 – Cost to replace FTTN with FTTP at Yr 20, given Labour Inflation and Discount Rate

Note: A 20% saving on FTTP from FTTN reuse, per Vertigan (2014); $3500 CAPEX.

Labour Inflation	0%	2%	3%	5%	Median
Installation Cost	$'000	$'000	$'000	$'000	$'000
Discount Rate 10%	0.5	0.7	0.8	1.0	Say 1.0
5%	1.3	1.7	2.0	2.6	2.0
3%	1.9	2.5	2.9	3.9	3.0
0%	3.5	4.5	5.2	7.0	5.0

Table A7.2 not analysed in text, so is provided for information only.

Table A7.2 – Cost to replace FTTN with FTTP at Yr 10, given Labour Inflation and Discount Rate

Labour Inflation	0%	2%	3%	5%	Median
CAPEX	$'000	$'000	$'000	$'000	$'000
Discount Rate 10%	1.4	1.5	1.6	1.9	1.5
5%	2.2	2.4	2.6	3.0	2.5
3%	2.6	3.0	3.2	3.6	3.0
0%	3.5	4.0	4.2	4.8	4.0

Appendix 8: International Broadband Strategies

Table A8 – Comparison of International Broadband strategies including FTTN and FTTP

Who?	$Govt investment	$/hh*	Infrastructure Competition	Services Competition	FTTN	FTTP
High $ per household						
Aust: Labor	$30B	$3,125	N	Y	nil	93%
Aust: Coalition	$29.5B	$3,072	Y	Y	mainly	15-25%
Sth Korea	US$25B	US1,275	Y	Y	60%	40%
NZ	NZ $1.7B	NZ1,062	Y	Y	some	75-80%**
Medium						
France	EU12B	EU451	Y	n/a	SOME	mainly
Singapore	S$1B	S$438	N	Y	nil	100%
US	$45B 10yrs	$350	Y	n/a	34%	66%
Low						
Germany	EU4.5B	EU138	mainly	Y	63%	37%
Sweden	SEK250M	SEK63	Y	Y	44% FTTx	44% FTTx
Finland	EU132M	EU60	Y	Y	n/a	mainly
UK	GBP1.1B	GBP42	Y	Y	75%	25%
Others to include?						Canada China Indonesia

Source: Table G.1,G.2,G.3,P.158-164, Vertigan Report 2014; ** Crown Fibre Holdings Limited (2016).

Source: Population (CIA 2016): est '15: Germay 81M, Sweden 10M, Sth Korea 49M, US 321M, UK 64M, New Zealand 4M, Australia 24M, France 66.5M, Singapore 5.7M, Finland 5.5M.

NB:* Assumes 2.5 persons per HH (household). $/HH - Author calculation.

Notes:

1. Infrastructure competition everywhere, except Singapore, Labor NBN. (Orange exceptions)

2. High proportions of FTTN common.(indicated in Yellow)
3. Australia has highest per household government investment, by either party. (indicated in Blue)
4. Majority FTTP is approaching a majority eg Singapore, Finland, with much smaller investment, and recently New Zealand, US, France. (indicated in Purple)
5. Australian has highest government investment in world, except for US, South Korea, with in excess of 2-10 times Australia's population.

Appendix 9: Value Dimensions from Ministers' Speeches – CommsDay Summit 2016

Table A9 – FTTN vs FTTP: Value dimensions of Fifield and Clare Speeches (CommsDay 2016)

	Minister Fifield (Coalition)	Shadow Minister Clare (ALP)
Positives of their policy approach	• Affordable ie less installation costs • Ubiquity (all in rollout) • Flexible - Technology agnostic, so could take advantage of skinny fibre • Meeting current mainstream needs o 30 to 50% takeup of VDSL indicates “exceed mainstream needs” in Belmont NSW • Faster time to rollout • Improve Aust. performance in international rankings	• FTTC 10x FTTN speeds (New speed)
Negatives of alternative approach	• Slow to deploy (FTTP) • Expensive (FTTP) • Consumers not willing to pay for fastest speeds (>100Mbps) (MTM) o Most consumers choose 25Mbps or less (MTM) o Very few consumers paying for 1000Mbps - implication CVC problem • Inflexible FTTP technology approach	• Rising cost of FTTN (from $600 to $1600 per household) • Delays rolling out FTTN (from completed in three years(2016), to 30k premises active in three years, now due for completion 2020), due to: o Negotiating with Telstra o Power connections • Congestion on FTTN at peak times eg 100Mbps connection getting <1Mbps (reliability) • New tech (FTTC) speeds 10x FTTN; skinny fibre • AT&T switching from FTTN to FTTP (community) • Not prioritising underserved areas (equity)
Value dimensions not mentioned	• Asset Life of FTTN (time) • Future needs • Best speeds on FTTP • Simplicity of single system FTTP • Equity of service on FTTP (no congestion)	• Willingness to pay for faster speeds (function / price) • Impact of CVC on high speed services (price) • Likely rollout delays in FTTP • Higher CAPEX Cost to rollout FTTP • Other high FTTN rollouts (Appendix 8)

Value dimensions mentioned	• Flexible on which tech • Fast enough services to meet current needs • Fast rollout to reach users quickly • Lower cost rollout • Improve International Rankings	• Rising costs, delay • New tech increasing speed for users (FTTC) • Equity of access • Reliability of FTTP to deliver advertised speeds • International comparison (AT&T)

Source: Fifield (2016), Clare (2016).

Appendix 10: Value dimensions from Expert Reports

Table A10 – FTTN vs FTTP: Value Dimensions from Expert Reports

	FTTN	FTTP
Expert Report	Vertigan (2014)	McKinsey & Co (2010)
Focus	Cost / Benefit	Affordability (more use, p.110) Entry level price same as for ADSL (price, p.110) Maximise take-up; same price for twice the speed ie 25Mbps vs 12Mbps (more speed, p.110) Remove data caps (more data, p.260) Competition at services layer (more services, p.260) Extend FTTP to 93%
Strengths	Reasoned economic argument Cost Benefit analysis	Focuses on value creation, including affordability, reliability rather than up-front cost (CAPEX).

	FTTN	FTTP
Expert Report	Vertigan (2014)	McKinsey & Co (2010)
Weaknesses	Model calculations not provided, only totals. Some details removed because commercial in confidence. Business benefit estimate at 50% more than consumer benefit (p.78). (low benefit) Public benefit estimated at 5%, private benefit 95% ie willingness to pay (WTP, p.17) => Only upgrade to FTTP when private benefit (WTP) justifies replacement cost. Assumes compression improves at 9% pa, so more data without line speed increase (p.77) No benefits for 20% households without internet (p.69). (low benefit) 2% p.a. increase in demand for speed. (p.189) Panel estimates FTTP Operating cost 100% greater than NBN Co. (p.56-7), and removed $4B of NBN Co installation cost savings for FTTP (p.56-7). (high cost) Significant criticisms noted by Gregory (2014) and Senate Interim Report (Senate Committee 2015), Ch.4. Criticisms Include: the report is not fully independent, such as from the Productivity Commission, the panel includes strong NBN critic, such as Prof. Henry Ergas.	More on how than why Not a cost benefit analysis, so no financial forecasting, cashflows, or return on investment.
Key Uncertainty	Growth in demand for high speed broadband (p.13) Willingness to pay (WTP) for >50Mbps (p.17)	
Summary - value types	• Use years sooner • No new needs/apps • No WTP for highest speeds • Low business and public benefits	• Social/national benefits • High use of data • Faster use • More services (competition)

Vibration Measurements

Simon Moorhead
Ericsson Australia & New Zealand

Summary:

Two historic papers from the Journal in 1969 that provide unique examples of vibration measurements in the field, verify reality and discredit some conventional wisdoms in the field of cable installation.

Introduction

Technologists are spoilt today by the seemingly endless selection of technical papers and standards available to them on the world-wide-web. Not so long ago, technologists relied on their own practical experience and inventive skills to solve technical problems. This was particularly the case for Australia, with the tyranny of distance and harsh environmental conditions. It forced the development of better equipment and processes to improve the reliability of the telecommunications network.

Where knowledge or experience were lacking, technologists devised experiments and undertook empirical measurements to separate fact from fiction and understand the extent of the challenge. They then devised clever and cost-effective solutions which were regularly documented in this *Journal* and often received wider acknowledgment overseas.

The two historic papers by M F Lette, Engineer Class 2, Primary Works, Post Master General's Department from the *Telecommunications Journal of Australia* in June 1969 and October 1969 respectively are reproduced here. They provide details of experiments to determine the effects of vibration on telecommunication cable installations. The first paper (Lette 1969a) tests whether the installation of cables across existing bridges (rather than the preferred but much more expensive option of submerged river crossings) is possible and can achieve the desired reliability. The second paper (Lette 1969b) tests whether the use of explosives near co-axial cables will affect their performance.

It appears that in 1969, there was significant reluctance to use existing bridges as a means of carrying cables across rivers because of vibration concerns. The author suspects that this reluctance is based on rumour and contributed to by bad installation practices. The author undertakes the measurement of vibrations at a number of bridges in NSW and correlates his findings against cable failure records. A number of recommendations are made but

ISSN 2203-1693. copyright © 2016 The author(s). http://doi.org/10.7790/ajtde.v4n2.54

essentially cable crossings on bridges are much more economical and will be reliable, provided the vibration and exposure to temperature extremes is limited by proper installation.

In the second paper, the author finds (contrary to expectations) that reasonably-sized explosive charges may be detonated close to co-axial cables with little or no effect on transmission. This is timely knowledge, as other Authorities are required to use explosives near telecommunication cables and the potential effects were a concern, but largely unknown.

Both papers provide unique hands-on examples of the need for field measurements to verify reality and in these cases, to discredit some conventional wisdoms in the field of cable installation.

References

Lette M. F. 1969a. "Installation of Lead Sheathed Cable on Bridges", *Telecommunication Journal of Australia*, June 1969, pages 127-135.

Lette M. F. 1969b. "Use of Explosives near Co-axial Cables", *Telecommunication Journal of Australia*, October 1969, pages 231-235.

ISSN 2203-1693. copyright © 2016 The author(s). http://doi.org/10.7790/ajtde.v4n2.54

The historical paper

INSTALLATION OF LEAD SHEATHED CABLES ON BRIDGES

*M. F. LETTE, A.S.T.C., M.I.E. Aust.**

INTRODUCTION.

The failure of lead sheathed telephone cables on bridge structures has, in the past, received considerable publicity. The result of this is that over the years, a certain distrust has developed towards this type of construction, based mainly on rumour and contributed to by inadequate installation practices.

This article sets out to investigate whether this distrust is justified, what causes failures on bridges, and what constitutes good installation practices.

CABLE FAILURE MANIFESTATIONS.

The usual mode of failure of lead sheathed cables on bridges is for the integrity of the sheath to be impaired either at one point, or over a considerable area along the length of the cable. Where joints are installed on bridges, failures of the joints have also occurred. For cables not under pressure, sheath or joint failure allows moisture (or even water) to enter the cable destroying the insulating properties of the paper around the conductors. For cables under gas pressure, failure results in loss of pressure which is detected by pressure sensitive alarms so that repairs can usually be effected before moisture entry occurs.

The loss of sheath integrity and joint failures are usually a result of intercrystalline fracture of the lead. Such fractures occur where lead (and other metals) are called upon to withstand many cycles of varying stresses and strains.

Stress Variations in Cables On Bridges

Bridges vibrate in a variety of modes due to the impulsive effect of vehicle and wind loads and are also subject to considerable and often rapid temperature changes. Cables attached to bridges have these temperature changes and vibrations transmitted to them in a greater or lesser degree depending on the design and placement of the cable supports. In addition the cable structure itself, e.g. a rigid pipe supported at intervals, has a natural or resonant vibration frequency and may be subject to additional temperature change by virtue of exposure to the sun, rain or even water from waves or tides.

Both vibrations and temperature changes induce stresses into the cable sheaths and joints but the quantitative assessment of stress from vibration and temperature does not appear possible. However Ref. 1 indicates that the effects of vibration can be assessed adequately by determining, with instruments, the strain and the acceleration to which the cable is subjected. It indicates that provided the strain is below 30 x 10^{-6} and the acceleration is below 0.6 g (where g is the acceleration due to gravity) the cables should be 'safe', i.e. have an acceptable service life.

Other references (Ref. 2 to 6) dealing mainly with structures indicate that designs based on maximum accelerations of about 0.6 g are satisfactory provided a moderately high safety factor is used.

Relation between Vibration and Acceleration

The bridge vibrations and, through them, the cable vibrations, are a damped harmonic motion and therefore, for any cycle of a given amplitude and frequency the classical formulae of simple harmonic motion lead to the expression —

Acceleration $= Aw^2 \sin wt$ where A is the amplitude and w is 2π times the vibration frequency, and the acceleration is expressed in length units per second per second. To express the acceleration in terms of g the expression becomes —

$$a = \frac{4\pi f^2 A}{12\,g} \text{ where}$$

a is acceleration (in terms of g)

A is the amplitude in **inches.**

f is the frequency of vibration in cycles per second.

g is 32.2, the acceleration due to gravity in **feet** per sec. per sec.

Thus for any given amplitude and frequency there is a discrete value of 'a' and conversely for a set (or design) value of 'a' a graph of frequency versus amplitude can be plotted. The full line of Fig. 1 is such a graph for 'a' = 0.15.

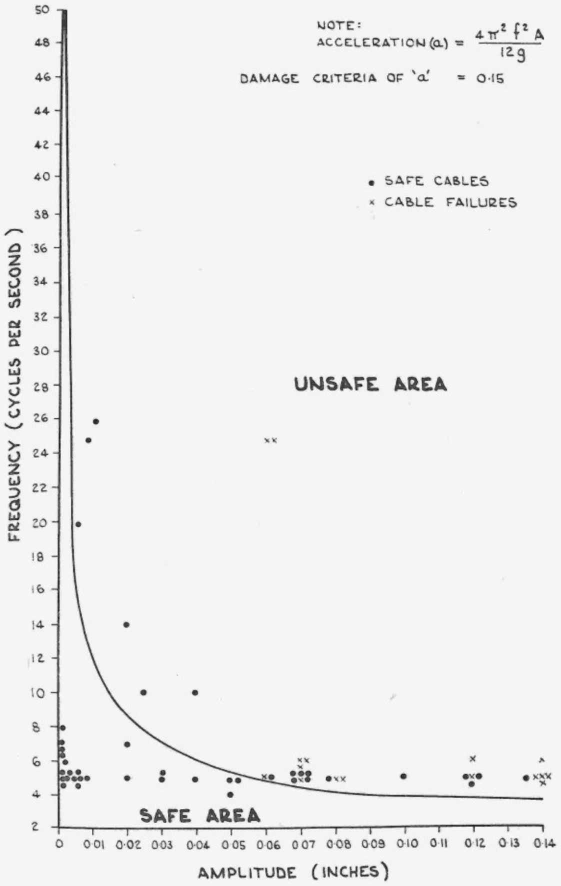


Fig. 1

* Mr. Lette is Engineer Class 2, Primary Works, Sydney.

LETTE — Cables on Bridges

ISSN 2203-1693. copyright © 2016 The author(s). http://doi.org/10.7790/ajtde.v4n2.54

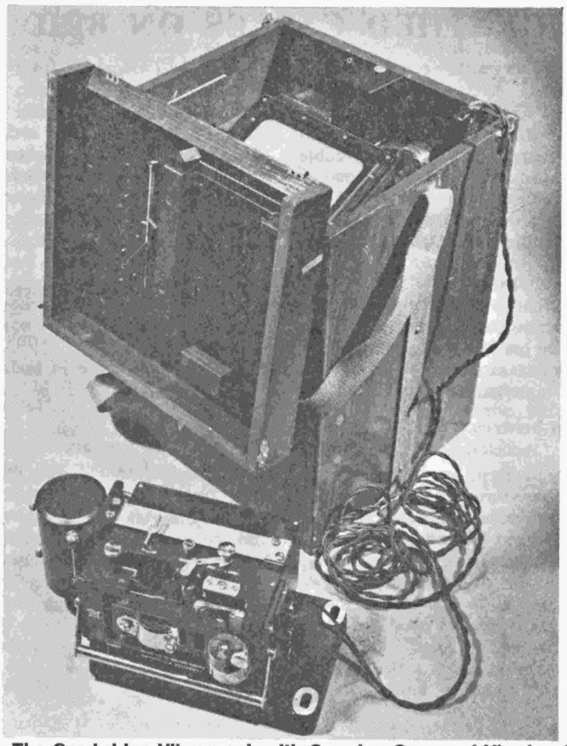


Fig. 2 — The Cambridge Vibrograph with Carrying Case and Viewing Screen.

INVESTIGATION PROCEDURE.

The investigation aimed to determine whether acceleration alone can explain the majority of past cable failures and of successful installations, thus providing a simple guide to future practices.

Instrument Used to Establish Vibration Amplitudes and Frequencies.

The instrument used in the investigation is a Cambridge Universal Vibrograph, which is best described as a stylus-on-celluloid recorder. Figs. 2 and 3 show this machine, while Fig. 4 is a typical recording. This machine can record either horizontal or vertical vibrations. In Fig. 2 it is shown set up to record vertical vibrations, and in Fig. 3 for horizontal vibrations. In all bridges measured, the vertical vibrations were larger than the horizontal vibrations.

RESULTS

Cases Where Cables Failed

Of all the bridges on which cable failures have occurred, only 16 are still in existence and available for vibration measurements. These bridges varied, but 14 of the 16 were of timber construction, and, of these, timber truss types were the most common. Figs. 5 and 6 show typical timber bridges on which these early cables were installed. N.S.W. Department of Main Roads statistics

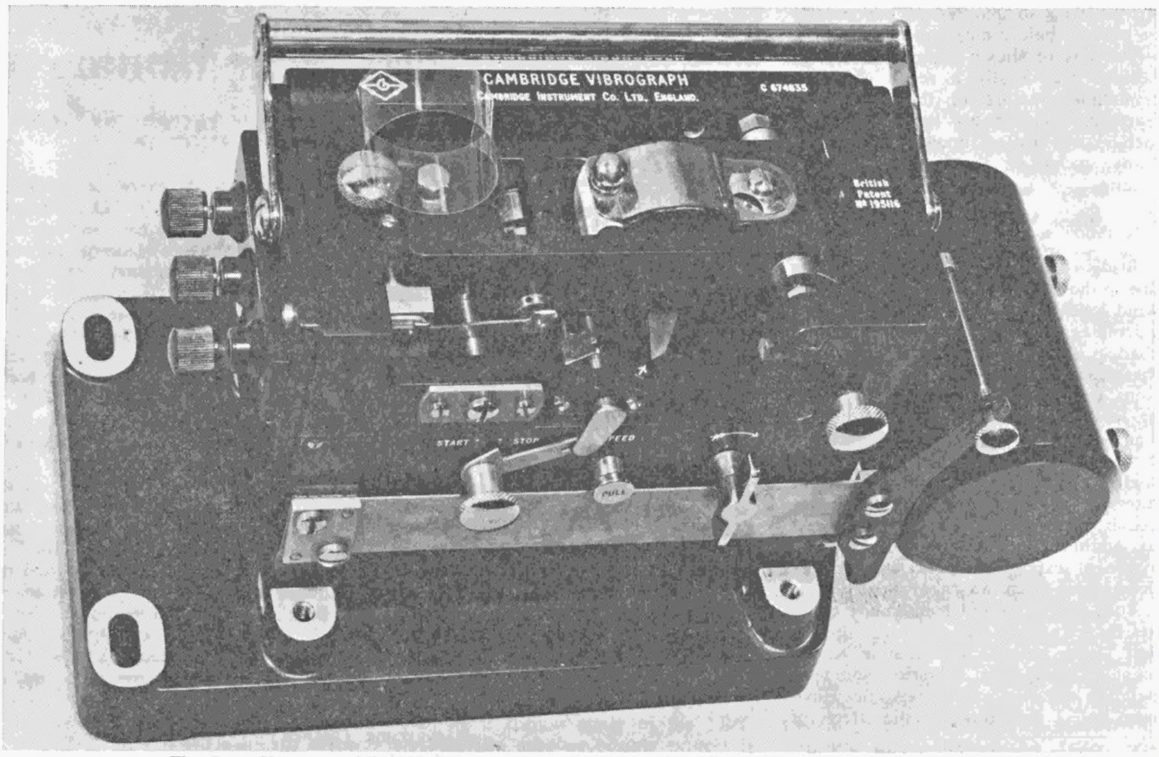


Fig. 3 — Close-up of the Vibrograph set up for Recording Vibrations in the Horizontal Plane.

Australian Journal of Telecommunications and the Digital Economy Volume 4 Number 2, June 2016
ISSN 2203-1693. copyright © 2016 The author(s). http://doi.org/10.7790/ajtde.v4n2.54

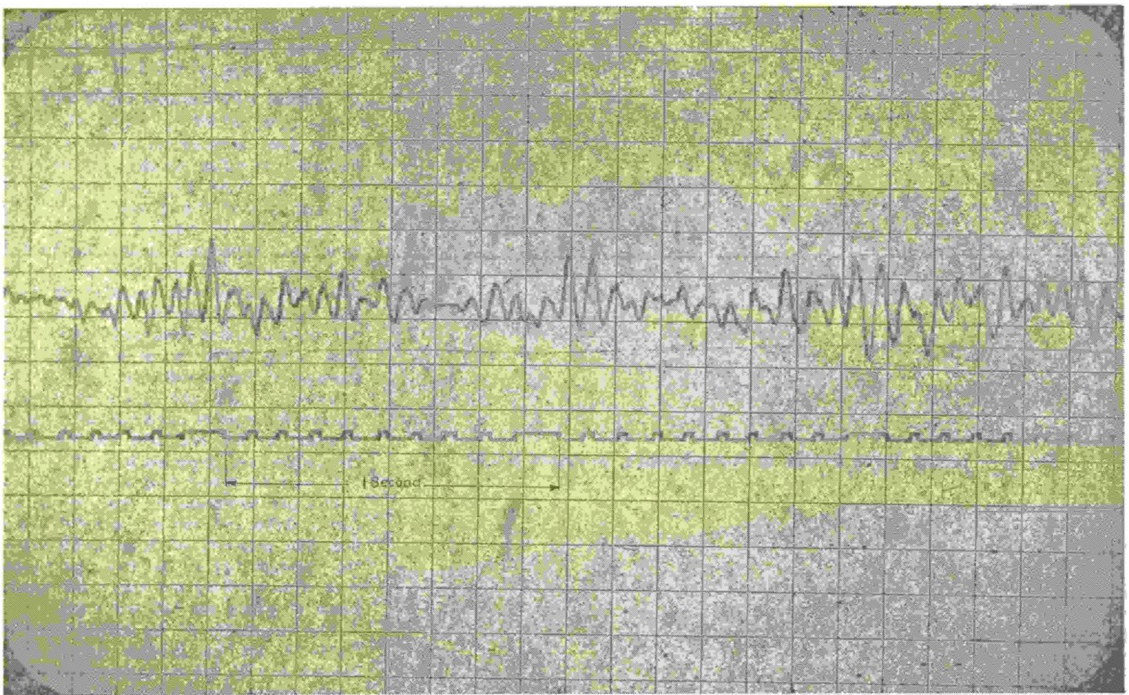


Fig. 4 — Photograph of a Recording on the Viewing Screen. The time base, recorded simultaneously with the vibration, is in tenths of a second. The grid represents 0.004 in.

TABLE 1 — YEARS OF SERVICE BEFORE FAILURE

Type of Construction	Vibration Amplitudes				
	0.060 in	0.070 in.	0.080 in.	0.120 in.	0.140 in.
Armoured Cable			*4 years*	15 years	*4 years* *1 year*
Armoured in Conduit				40 years	
Lead Sheath in Conduit	8 years *20 years* *11 years*	*18 years* *3 years* *23 years*	5 years		*20 years* 1 year *1 year*
Lead Sheath not in Conduits		20 years			

Note: Items in italics are for cables or conduits which are exposed to the sun, and may therefore be subjected to more rapid temperature changes.

show that out of its 4,000 bridges, over two-thirds are of timber construction. Although cables are placed on a very small percentage of these bridges, it is likely that the majority of cables on bridges are on timber bridges. Table 1 shows failure vibrations and types of cable construction.

The table shows that cables exposed to the sun have lasted from 1 to 22 years, and that cables not exposed to the sun have lasted from 1 to 40 years over similar vibration amplitudes.

Table 2 relates the diameter of cables, amplitudes and years of service before

TABLE 2 — DIAMETER OF CABLES AND YEARS OF SERVICE BEFORE FAILURE

Diameter of Cable (in.)	Years before Failure	Vibration Amplitude (in.)	Type of Cable	Exposed to the Sun
0.6	20	0.070	Lead Sheath	Yes
0.7	8	0.060	Lead Sheath in Pipe	No
0.8	18	0.070	,, ,, ,, ,,	Yes
0.8	20	0.140	,, ,, ,, ,,	No
0.8	40	0.120	Armoured in Pipe	No
1.0	15	0.120	Armoured	Yes
1.0	22	0.070	Lead Sheath in Pipe	Yes
1.0	4	0.080	Armoured	Yes
1.11	20	0.060 at 25 cps.	Lead Sheath in Pipe	Yes
1.5	1	0.140	,, ,, ,, ,,	No
2.02	5	0.080	,, ,, ,, ,,	Yes
2.32	11	0.060 at 25 cps.	,, ,, ,, ,,	Yes

Notes: (1) All frequencies are 5-6 cycles per second unless otherwise stated.
(2) Four cables are not listed in this table as their diameters were not recorded on replacement.

Australian Journal of Telecommunications and the Digital Economy Volume 4 Number 2, June 2016
ISSN 2203-1693. copyright © 2016 The author(s). http://doi.org/10.7790/ajtde.v4n2.54

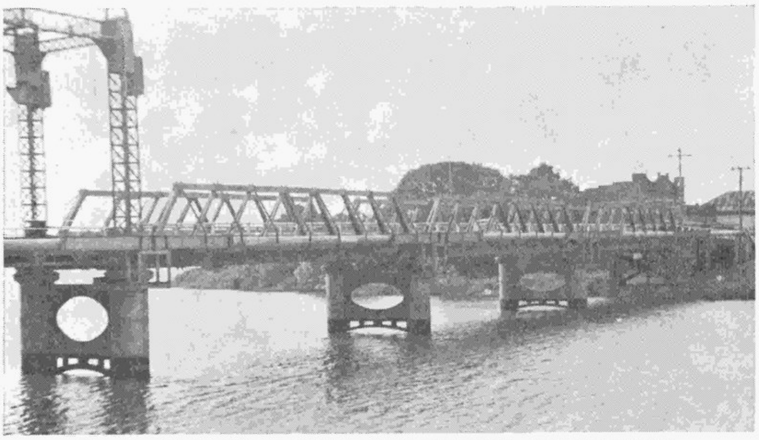


Fig. 5 — Timber Truss Bridge at Murwillumbah, Northern N.S.W.

Fig. 6 — Timber Beam Bridge at Gundagai, Southern N.S.W.

failure. This shows that the smaller diameter cables appear to survive the longest.

Longest Service to Date Before Failure.

The cable which lasted the longest before failure was at Gladstone on the N.S.W. North Coast. The bridge is across the Belmore River on the main road between Kempsey and Gladstone. The cable was wire armoured and was installed in a G.I. pipe well clamped to the underside of the bridge every 8 feet, and consequently was not exposed to the sun. The cable lasted 40 years before failure, and was subjected to vibrations of 0.120 in. at 6 cps. It is significant to note that this cable which lasted so well was armoured, and may have had alloy 'B' lead sheath.

On the graph (Fig. 1), the known failures have been ploted as 'X'. It can be seen at a glance that all the plots full above the a = 0.15 line i.e. all failures have occurred on cables subjected to accelerations in excess of 0.15 g. On the same curve, the results from the investigation of 'safe' bridges have been plotted as '•'.

Cases where Cables have not Failed

The safe bridges measured are those on which cables have been in situ for at least nine years, and are still in service without any failures. A total of 48 bridges were examined in various parts of N.S.W. including the Sydney Metropolitan area. The 'safe' bridges were of all types, and included the longest steel truss span in the State (the Pacific Highway Bridge over the Hawkesbury River, 30 miles North of Sydney), which has two main spans of 452 feet each.

Bridge with Longest Cable Life

The cable which has lasted the longest to date (without failure) is at Murrurundi (50 miles South of Tamworth) where the New England Highway is bridged across the Pages River. The cable is a 216/10 installed in a 4 in. iron pipe well supported under the bridge, and consequently not exposed to the sun. The cable was installed in 1931 and is still in service. The bridge is subjected to continuous traffic, the vibration being 0.070 in. at 6 cps on the passage of heavy vehicles.

Table 3 lists the years of service against the type of construction, whether exposed to the sun, and the vibration the cables are experiencing.

It will be noted that many of these cables are subjected to small vibrations (up to 0.006 in.), but are exposed to the sun. The majority of these 'small vibration bridges' are in the Riverina Irrigation Area crossing the numerous canals, some of which are 100 feet wide.

The remainder of the cables listed in Table 3 are on bridges spread over eastern N.S.W., all on highways or main roads; measurements were not taken on bridges on lesser roads where traffic was light. The majority were on three highways, namely Newell, New England and Pacific Highways. Fig. 7 indicates these Highways, and the location of all the measured bridges.

Summary of Vibration Data

Comparing Tables 1 and 3, it is noted that failures occurred between vibration readings of 0.060 in. and 0.140 in. (the limit of the Cambridge Vibrograph) at 5 cps. On the other hand safe bridges recorded vibrations of up to 0.120 in. at 5 cps. Thus it is apparent that factors other than vibration play a significant part. However, most 'safe' cables are subject to accelerations less than 0.15g leading to the tentative conclusion that this may be a safe limit. This limit as shown by Fig. 1 is 0.070 in. at 5 cps. A reservation must be placed on this limit, as the data available has referred mainly to cables less than 1 in. in diameter.

Effect of Temperature

Temperature changes need consideration as they impose stress variations on the lead sheath, which may add to the effects of vibration induced variations to an unknown extent. Failures attributable to temperature change are described below.

Case 1: A cable in a 4 in. G.I. pipe on the approaches to Glebe Island Bridge in Sydney. The conduit was installed only a few inches below the surface of the footpath, which was black bitumen. During the summer months,

LETTE — Cables on Bridges

ISSN 2203-1693. copyright © 2016 The author(s). http://doi.org/10.7790/ajtde.v4n2.54

TABLE 3 — DIAMETER OF CABLES ON 'SAFE' BRIDGES

Diameter (in.)	Years in Service	Vibration		Whether Exposed to Sun	Type of Construction
		Amp. (in.)	Freq. (cps)		
0.5	9	0.120	5	No	Lead sheath in iron pipe.
0.5	15	0.006	5	No	,, ,, ,, ,, ,, *
0.5	14	0.100	7	Yes	,, ,, ,, ,, ,,
0.5	11	0.030	5	Yes	Armoured.
0.5	15	0.030	5	Yes	Armoured.
0.5	14	0.006	20	Yes	Lead sheath in iron pipe
0.5	15	0.001	15	Yes	,, ,, ,, ,, ,,
0.5	12	0.001	20	Yes	,, ,, ,, ,, ,,
0.5	8	0.070	5	No	,, ,, ,, ,, ,,
0.6	22	0.040	5	Yes	,, ,, ,, ,, ,,
0.6	17	0.120	5	No	,, ,, ,, ,, ,,
0.6	10	0.020	7	Yes	Armoured.
0.6	15	0.006	5	No	Lead sheath in iron pipe
0.6	10	0.120	5	Yes	,, ,, ,, ,, ,,
0.6	20	0.008	5	No	Armoured.
0.6	10	0.002	15	Yes	Lead sheath in iron pipe
0.6	25	0.009	25	Yes	,, ,, ,, ,, ,,
0.6	11	0.001	5	Yes	,, ,, ,, ,, ,,
0.6	8	0.001	5	Yes	,, ,, ,, ,, ,,
0.7	11	0.070	5	No	Armoured cable in troughing.
0.7	10	0.020	14	Yes	Armoured.
0.7	9	0.060	5	Yes	,,
0.7	16	0.140	5	Yes	,,
0.7	24	0.002	5	Yes	Lead sheath in iron pipe
0.7	15	0.006	5	No	,, ,, ,, ,, ,,
0.9	10	0.020	5	No	,, ,, ,, ,, ,, (4 cables).
0.8	20	0.001	5	Yes	,, ,, ,, ,, ,,
1.0	17	0.025	10	No	,, ,, ,, ,, ,,
1.0	15	0.070	5	No	,, ,, ,, ,, ,,
1.0	25	0.001	5	Yes	,, ,, ,, ,, ,,
1.0	12	0.003	5	Yes	,, ,, ,, ,, ,,
1.1	13	0.050	5	No	,, ,, ,, ,, ,,
1.1	11	0.070	5	No	,, ,, ,, ,, ,,
1.2	15	0.050	4	Yes	Armoured.
1.2	34	0.070	5	No	Lead sheath in iron pipe
1.4	9	0.001	5	Yes	Lead sheath in iron pipe
1.7	15	0.004	5	No	,, ,, ,, ,, ,,
1.7	15	0.004	5	No	,, ,, ,, ,, ,,
1.7	8	0.080	5	No	,, ,, ,, ,, ,,
2.0	15	0.004	5	No	,, ,, ,, ,, ,,
2.0	17	0.040	10	No	,, ,, ,, ,, ,,
2.67	25	0.001	5	Yes	,, ,, ,, ,, ,,
2.67	25	0.001	5	Yes	,, ,, ,, ,, ,,
2.67	25	0.001	5	Yes	,, ,, ,, ,, ,,
2.67	25	0.001	5	Yes	,, ,, ,, ,, ,,

Note: * Bridge at Peats Ferry, Hawkesbury River. The longest truss span road bridge in N.S.W.

the footpath temperature went over 100°F, and it is quite likely that the conduit temperature was similar. When the cable failed, and was withdrawn, the lead sheath where it had been in the pipe was literally falling apart due to inter-crystalline fracture. Vibration readings were taken on the site, but proved to be negligible.

Case 2: This occurred in the foothills of the Blue Mountains, where the Western trunk cable passed through a short exposed length of 4 in. G.I. pipe approximately 10 feet long. After about 8 years service, the cable failed and was withdrawn. On examination it was found to have inter-crystalline fracture, but only over the short section of cable that was in the pipe; the balance of the sheathing was sound. Again, vibration measurements were taken, but were negligible. In this area temperatures drop below freezing in the Winter and rise above 100°F in the Summer, consequently daily variations in temperatures of up to 40°F are not uncommon. The pipe was exposed to the sun for most of the day.

Case 3: This involved a submarine cable across Georges River, Sydney, between Oatley and Como. When the cable failed it was found that the wire armouring had rusted away between the low and high water marks, and over this section the sheathing had inter-crystalline fracture. The sheathing was checked at other locations and was found to be sound. The cable at the water line, after the armouring had rusted away, would be subjected to the cooling effect of the rising tide, and then heating due to the sun after the tide fell. The cable was checked for vibrations, but again the results were negligible.

The question which should now be asked is, "Why haven't cables in other areas failed through temperature cycl-

ISSN 2203-1693. copyright © 2016 The author(s). http://doi.org/10.7790/ajtde.v4n2.54

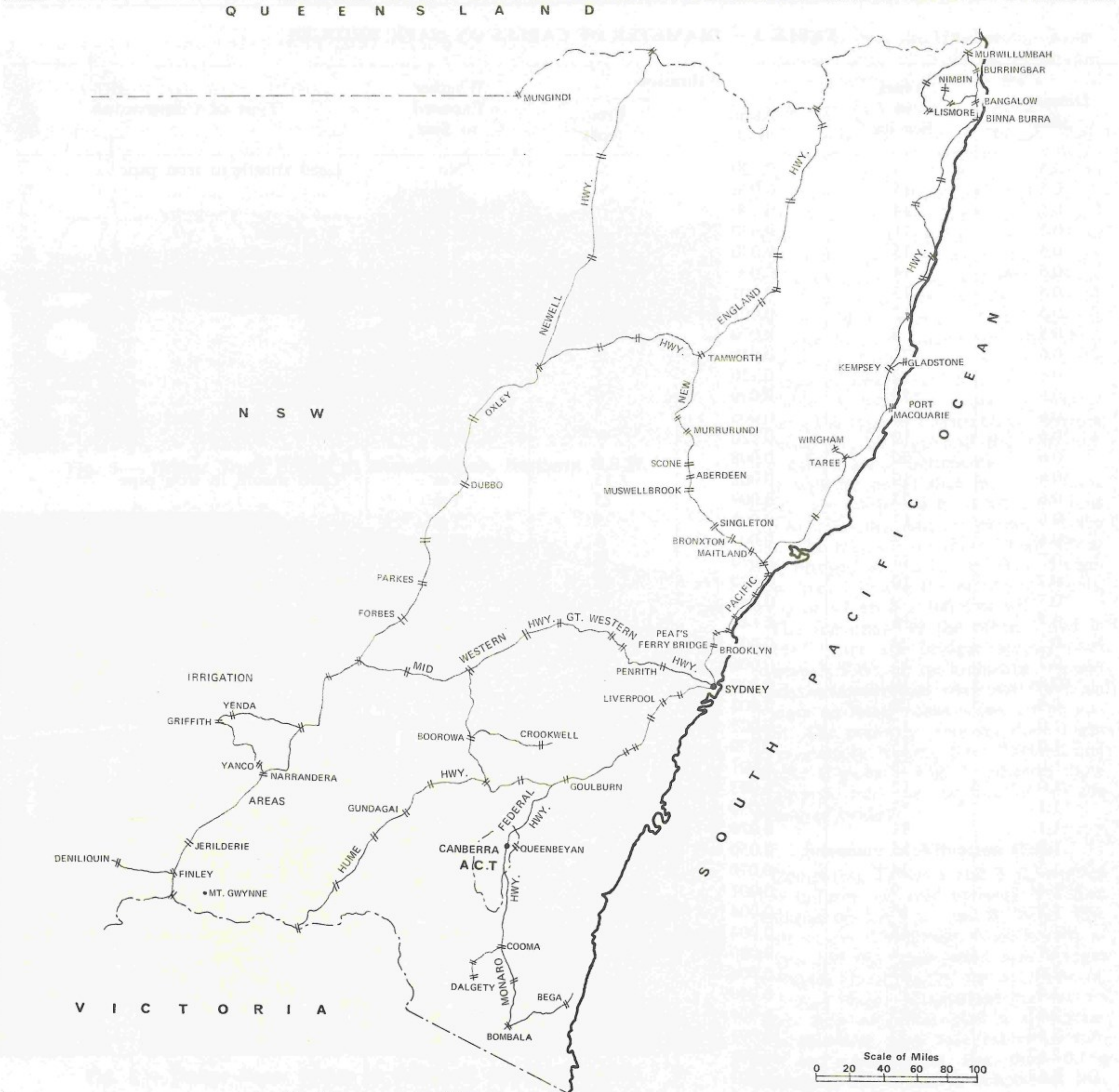


Fig. 7 — Location Map.

ing?" As considerable data was available for cables installed in the Riverina Irrigation Area, it was decided to compare temperature variations in this area with the greater Sydney area. Griffith was selected as representing the Irrigation Area and Parramatta for the Sydney Area. The Bureau of Meteorology supplied temperature records for the last 30 years. Table 4 shows the average maximum and average minimum for each month.

As shown by Table 4, the temperature variations in the two areas are similar and the two regions are very much alike as regards average maximum and minimum temperatures.

TABLE 4 — TEMPERATURE DIFFERENCE BETWEEN GRIFFITH AND PARRAMATTA IN °F

Month	GRIFFITH			PARRAMATTA		
	Max.	Min.	Diff.	Max.	Min.	Diff.
Jan.	89.2	61.8	27.4	83.2	62.1	21.1
Feb.	89.2	62.2	27.0	82.3	61.4	20.9
March	83.7	57.6	26.1	79.9	58.4	21.5
April	72.9	50.8	22.1	74.7	52.6	22.1
May	65.5	43.3	22.2	69.0	46.7	22.3
June	58.3	39.7	18.6	64.0	42.0	22.0
July	57.8	38.4	19.4	62.7	40.5	22.2
Aug.	61.0	40.0	21.0	66.2	41.6	24.6
Sept.	67.7	43.6	24.1	71.3	46.3	25.0
Oct.	74.7	49.1	25.6	75.4	51.5	23.9
Nov.	81.6	54.7	26.9	78.8	56.3	22.5
Dec.	86.3	59.7	26.6	82.1	60.4	21.7
	Average Difference 23.9			Average Difference 22.5		

ISSN 2203-1693. copyright © 2016 The author(s). http://doi.org/10.7790/ajtde.v4n2.54

A significant difference between the areas could be the rate at which this variation occurs. The Metropolitan area is subjected to very rapid changes in temperature when the cooling Southerlies sweep up the coast. Griffith, however, being surrounded by very large land masses cools slowly during the night, and is not subjected to the cooling Southerly winds so prevalent along the coast. Generally, the Griffith area would start heating from just after sun rise to, say, about 2 p.m., then it would commence cooling, and would cool until about sun rise. In the hottest month, February, the heating would take place over 8 hours, and the cooling over about 16 hours, but as the average difference is only 27°, both the cooling rate and heating rate would be very gradual. In the Sydney area it is not uncommon to have several cold Southerly changes in a week, particularly in the summer months. During these changes the temperature may drop 15 — 20°F in 30 minutes, which would produce stresses in a lead sheath. In addition to this, daily oscillations in temperature occur due to the cooling effect of the sea breezes.

EFFECT OF SHEATH STRESS DUE TO G.P.A. SYSTEMS

When cables are placed under gas pressure alarm (G.P.A.) systems, the sheath is subjected to an additional stress. Data on past cable failures and on successful installations on bridges is not sufficient to allow conclusions to be drawn regarding the importance of the adverse effect on lead sheaths, of the additional stress when superimposed on the stress due to vibration.

EFFECT OF CABLE SIZE

In N.S.W. the cables installed on bridges have been of relatively small size and little data is available in respect of larger cables. Theoretically it appears that the effect of vibration on large cables will be worse than on smaller cables on two counts —

(a) The force required to cause a given acceleration is proportional to the mass being accelerated. Thus force which is transmitted via the cable sheath, is larger for heavier cables.

(b) For a cable to remain in contact with a duct vibrating between two supports, the cable must flex. Such flexing will induce stresses in the sheath and the magnitude of the stresses is proportional to cable diameter.

Of these (b) may control and accordingly Table 5 has been prepared to show suggested design limits (at 5 cps) for cables up to 3 in. diameter.

TABLE 5 — TABLE OF CABLE DIAMETERS AND VIBRATION LIMITS

Cable Diameter (in.)	AMPLITUDE OF VIBRATION LIMITS (in.) (Notes 1 and 2)
0 – 1.0	0 – 0.070
1.0 – 1.5	0 – 0.060
1.5 – 2.0	0 – 0.040 0.040 – 0.070 if split into 2 cables.
2.0 – 2.5	0 – 0.30 0.030 – 0.060 if split into 2 cables.
2.5 – 3.0	0 – 0.20 0.020 – 0.030 if split into 2 cables. 0.030 – 0.050 if split into 3 cables.

Notes: 1. Assuming alloy 'B' sheath and polythene jacket.
2. These limits are for vibration frequencies of up to 5 cps. For bridges which vibrate at higher frequencies, the limits are lowered accordingly.

TABLE 6 — COPPER PAIR CABLES AND COAXIAL CABLE WEIGHTS

Copper Cables		Coaxial Cables (Non Layer Polythene jacket)	
Dia. (in.)	Av. Weight per Yard (lbs.)	Size (No. of Tubes)	Weight per Yd. (lbs.)
1	5.6	4	7.2
1½	9.5	6	11.6
2	17.0	8	14.0
2½	24	12	23.0
3	32.5		

TABLE 7 — TABLE OF VIBRATION LIMITS FOR NON LAYER POLYTHENE JACKET COAXIAL CABLES

Cable Size (No. of Tubes)	Amplitude of Vibration Limits Assuming Alloy 'B' Sheathing (in.)
4	0 – 0.060.
6 & 8	0 – 0.040. 0.040 – 0.060 split into 2 cables.
12	0 – 0.030. 0.030 – 0.040 split into 2 cables. 0.040 – 0.060 split into 3 cables.

Note: These limits are for vibration frequencies of 5 cps. For bridges which vibrate at higher frequencies, these limits are lowered accordingly.

COAXIAL CABLE

Coaxial cables are from 4 to 20% lighter than copper conductor cables of equivalent diameter (Table 6), and therefore if the limits based on Table 5 are applied to them, the design will be slightly more conservative. As this is desirable for such important cables, Table 7 has been prepared accordingly.

NEW DEVELOPMENTS

Cables

Installations of two new types of cables are currently being carried out in the various States. These cables have moisture barrier sheaths and are available with either paper or polyethylene insulated conductors. The moisture barrier sheathing is essentially a polyethy-

Australian Journal of Telecommunications and the Digital Economy Volume 4 Number 2, June 2016
ISSN 2203-1693. copyright © 2016 The author(s). http://doi.org/10.7790/ajtde.v4n2.54

lene sheathing with a thin layer of aluminium firmly bonded to its inner surface. This sheathing can withstand much higher vibrations than lead sheathing and is ideally suited for placing on bridges, provided that in the case of paper insulated conductors a suitable gas protection system is available.

The jointing on both these cables is carried out using epoxy resin and auxiliary lead sleeves, which also means that they may be readily plumbed onto existing lead sheathed cables; but special precautions would still be necessary for any joints on the bridge.

Bridges

Many present types of stressed and reinforced concrete bridges being built offer very good platforms for cables. Fig. 8 shows a good example of this type. This is a photograph of the Commonwealth Avenue Bridge across Lake Burley Griffin at Canberra. This bridge consists of five spans varying between 185 feet and 240, and the maximum vibration recorded was 0.010 in. at 5 cps.

Examples of other modern concrete bridges are listed below:

(a) Cook's River Bridge, Princes Highway at Tempe, Sydney, spans of 130 feet, maximum vibration 0.010 in. at 5 cps.
(b) King's Bridge across Lake Burley Griffin at Canberra, 7 spans ranging from 95 feet to 154 feet, maximum vibration 0.006 in at 5 cps.
(c) Captain Cook Bridge across Georges River in Sydney, 7 spans ranging from 184 feet to 250 feet. Maximum vibration 0.005 in at 4 cps.
(d) Gladesville Bridge across the Parramatta River, 1 main span of 1000 feet. Maximum vibration 0.001 in at 4 cps. (This bridge has the roadway on top of a 1000 feet span concrete arch).

CONCLUSION

There is no doubt that more bridges could be used to carry cables, and that Engineers should weigh carefully the following advantages and economies of construction on bridges before deciding on a river crossing:

(a) Expensive excavation in river beds is avoided.
(b) The cable costs less and is more readily available than the armoured cables required for installation in the river bed.
(c) Cables are readily accessible and may be withdrawn.
(d) Cables on a bridge are unlikely to be affected by floods, particularly on the downstream side.
(e) The cable if damaged, may be repaired in situ, or, if this is not possible, can easily be replaced. Actually in some situations it may be more economical to allow for the cable to fail on a bridge, say every 10 years, than to construct an expensive river crossing, particularly if a G.P.A. system is available to ensure that the sheath failure does not cause service interruptions.
(f) Approaches to bridges are generally sound.

The following design and installation practices are recommended:

(a) Bridges should be used in preference to a submarine cable crossing, where the bridge is suitably sited and vibration readings confirm that the amplitudes are lower than the

Fig. 8 — Commonwealth Avenue Bridge, Canberra, A.C.T.

LETTE — Cables on Bridges

ISSN 2203-1693. copyright © 2016 The author(s). http://doi.org/10.7790/ajtde.v4n2.54

limits of Tables 5 and 7 appropriately adjusted for frequency.

(b) All cables installed on bridges should be sheathed using Alloy 'B', and be jacketed with polythene, unless moisture barrier cable is used.

(c) Large size cables should be split into smaller diameter cables in accordance with Tables 5 and 7 if single cable is outside limits.

(d) All cables and conduits should be shaded from the direct rays of the sun. If this is not possible, a sunshade should be installed over the conduits; and painted with aluminium paint.

(e) Special precautions should be taken where duct (or supports) cross expansion joints in the bridge so that stress concentrations do not occur in the cable sheath.

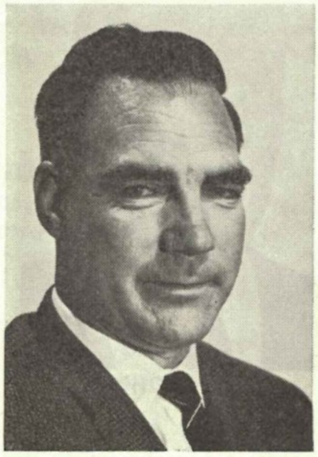
(f) Particular care should be taken with any cable joints on the bridge itself. Ideally these should be at nodes in the bridge vibration pattern, i.e. usually immediately above piers.

ACKNOWLEDGMENT

The Author wishes to acknowledge the assistance of many colleagues in New South Wales who so willingly supplied the information and assistance required to complete the investigatory work.

REFERENCES

1. MASAO Totruku and Takao Koniski 'Anti-Vibration Measures for Cables Fixed to Bridges'; Japan Telecommunication Review 1963.
2. Leonard Obert, Report E-35 No. 3 1960, 'Bureau of Mines, Applied Physics Research Laboratory Maryland'.
3. A. T. Edwards and T. D. Northwood, 'Experimental Studies of Effects of Blasting on Structures'; The Engineer, September, 1960.
4. F. J. Crandell, 'Ground Vibrations and its Effects Upon Structures'; Boston Society of Civil Engineers Publication, 1949.
5. H. Westerberg and B. Kilstrom, 'Ground Vibrations in Blasting'; Water Power, September, October, November, 1958.
6. J. R. Thoenem and S. L. Windes, 'Seismic Effect of Quarry Blasting'; U.S. Bureau of Mines Bulletin 442.



M. F. LETTE

M. F. LETTE, author of the article, 'Installation of Lead Sheathed Cables on Bridges', joined the Department in 1947 as a Cadet Draftsman. After qualifying as a Draftsman in 1951 he spent five years in the Equipment and Survey Sections. In 1956 he qualified as an Electrical Engineer and took up an appointment as Grade 1 Engineer, No. 2 Primary Works in 1957. He was promoted in 1958 to the position of Group Engineer, District Works and was later transferred as Group Engineer, Primary Works.

In 1961 when installing ducts and cables for the COMPAC Cables project Mr. Lette became interested in the problem of damage as a result of blasting operations in built up areas and undertook formal studies in this field at the Sydney Technical College in 1962.

Mr. Lette is a Member of the Institution of Engineers, Australia.

★

ISSN 2203-1693. copyright © 2016 The author(s). http://doi.org/10.7790/ajtde.v4n2.54

USE OF EXPLOSIVES NEAR COAXIAL CABLES

M. F. LETTE, A.S.T.C., M.I.E. Aust. *

INTRODUCTION

With the increasing use of coaxial cables, cases are arising where other Utilities, Authorities and private contractors seek advice on, or require to use explosives in the vicinity of coaxial cables.

This paper describes a field investigation on the use of explosives near a coaxial cable. Since coaxial cables are by their construction less robust and more liable to damage than conventional cable, it follows that the conclusions at the end of this paper could be applied to conventional cables.

DAMAGE CRITERION

When this problem was first investigated it was thought that amplitude and frequency of vibration, recorded by the Cambridge Vibrograph up to the failure of any tube would be a satisfactory damage criterion.

However recent developments overseas have indicated that this instrument cannot record the high frequencies (from the Civil Engineer's viewpoint), in the order of 100-1000 c.p.s. found in close proximity to a blast, and the modern technique is to use geophones coupled with oscilloscopes. As the shock waves pass through the ground the geophones record the velocity of the ground movement (hereafter called particle velocity), and by using this arrangement the threshold for particle velocity could be determined below which cables would not be damaged.

The N.S.W. Department of Mines agreed to supply their equipment for the test and it consisted of the following:

(i) One vertical recording geophone
(ii) One horizontal (longitudinal) recording geophone
(iii) One horizontal (transverse) recording geophone
(iv) Four (4) channel oscilloscope equipped with a polaroid camera to record all results.

Figs. 1 and 2 show the above equipment.

TEST PROCEDURE

All formulae used in determining the possible damage effect of explosives on structures are empirical. Consequently the only way to achieve results for coaxial cable was to carry out actual field trials on a typical cable. As the cable was proposed to be tested to destruction, working cable could not be used, so it was necessary to install a suitable length of non-working cable in a trench excavated in rock.

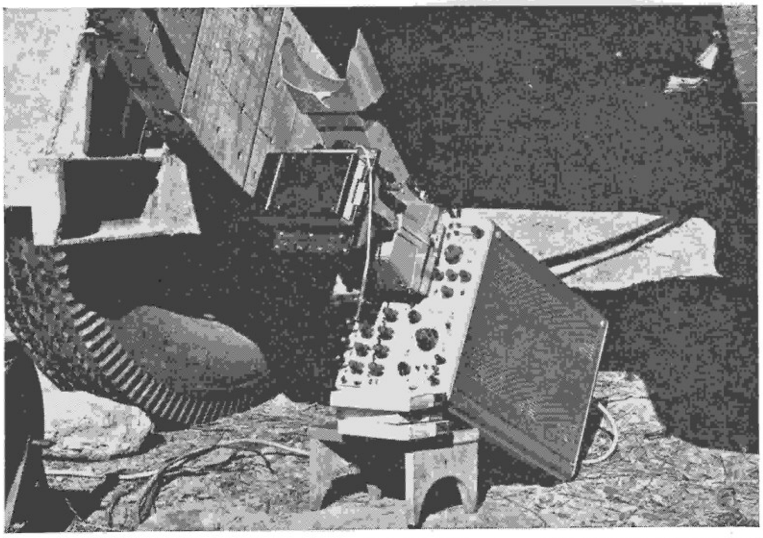


Fig. 1. — Tektronix Type 564 Cathode Ray Oscilloscope with Storage Screen and Polaroid Camera. Screened leads in bottom L.H. corner connect the C.R.O. to the geophones.

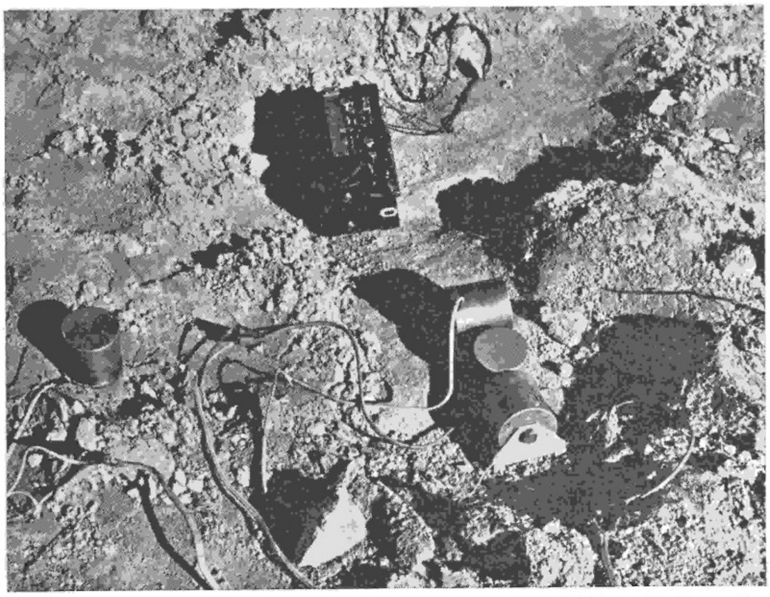


Fig. 2 — Four Taxco Geophone Transducers 2 Vertical, 2 Horizontal. Recording unit on the left used to trigger the C.R.O. Cambridge Vibrograph in the background.

* Mr. Lette is Engineer Class 3, Primary Works, Sydney. See Vol. 19, No. 2, P. 175.

Australian Journal of Telecommunications and the Digital Economy Volume 4 Number 2, June 2016
ISSN 2203-1693. copyright © 2016 The author(s). http://doi.org/10.7790/ajtde.v4n2.54

Fig. 3. — L. to R. Centre, Backfilled Excavation; L. of Centre, Geophones and Vibrograph. Holes already drilled indicated by wooden plugs.

A spare 63 yard length of 8 tube non layer plastic jacketed coaxial cable was installed in a 4 feet deep trench excavated at Bargo in the vicinity of the Sydney-Melbourne co-axial cable crossing of the Nepean River. The cable was surrounded by 6 in. cover of sand and then backfilled using the excavated material. The backfill was watered and well rammed and the top of the trench was sanded for easier identification (see Fig. 3). The cable ends were then removed and the cable tested with the pulse echo tester and the high voltage tester. After testing, each tube was placed across a High Voltage Tester and remained there for the duration of the investigation.

At right angles to the trench, holes were drilled at distances ranging from 5 feet to 50 feet from the cable. These holes were later charged with explosives varying from 1/6 lb to 2 lb of AN"60" and detonated individually.

The three geophones were placed on the rock at the side of the trench (see Fig. 4), and testing commenced using 1/6 lb of AN"60" at a distance of 5 feet, a count down preceded each blast and at 10 seconds before the detonation, the eight high voltage testers were energised to 4000 volts, with one operator to every two machines. These operators then observed the H.V. testers until a few seconds after the blast, and reported to the testing officer any fluctuations in the voltage readings.

EXPLOSIVES

The generally accepted definition of an explosive is as follows:

"A solid or liquid substance or mixture which on the application of a suitable stimulus to a small portion of the mass, is converted in a very short interval of time into another more stable substance, largely or entirely gaseous, with the development of heat and high pressure."

Blasting powder has been mainly superceded by the gelatinous type of high explosive, for general small scale excavation work. The gelatinous type of explosive is supplied as a wrapped waxed paper cartridge and is available in either the

(a) sodium nitrate or

(b) ammonium nitrate grades.

The sodium nitrate grades are classified according to the percentage of nitroglycerine they contain. For example, SN 60% is a sodium nitrate gelignite containing 60 % nitroglycerine.

Ammonium nitrate on the other hand contains much less nitroglycerine and the strength is made up by the ammonium nitrate which is itself an explosive. Ammonium nitrate grades are classified according to their strength equivalent to the sodium nitrate grades. For example AN"60" is an ammonium nitrate gelignite which, although it only contains 32% nitroglycerine, is equivalent in strength to SN 60% which contains 60% nitroglycerine.

As the ammonium nitrate grades contain much less nitroglycerine they are much cheaper than the sodium nitrate grades consequently the ammonium nitrate grades are the most commonly used.

Of the AN grades AN"60" is the one most used on general excavation work and is characterised by high strength, high density and good water resistance properties.

The cartridge size used during the test at Bargo was 1 in. diameter by 8 in. long, each stick weighing approximately 5 ozs. Consequently 1/6 lb represents approximately $\frac{1}{2}$ of one of the sticks, and 1/3 lb represents 1 stick.

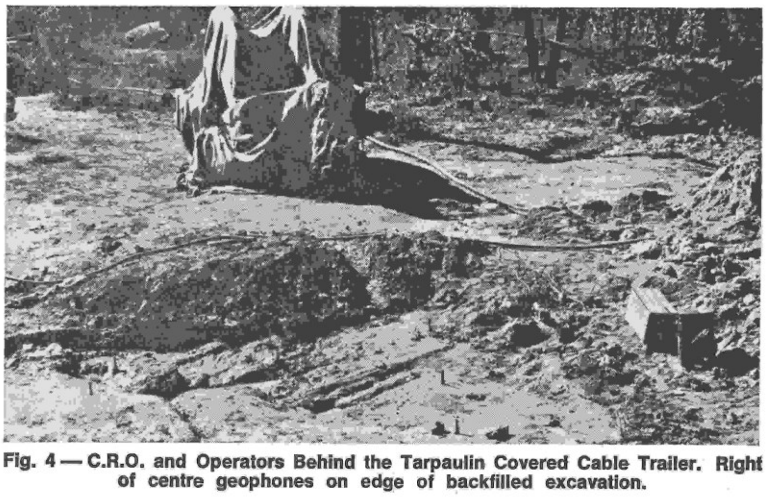


Fig. 4 — C.R.O. and Operators Behind the Tarpaulin Covered Cable Trailer. Right of centre geophones on edge of backfilled excavation.

LETTE — Explosives Near Cables

ISSN 2203-1693. copyright © 2016 The author(s). http://doi.org/10.7790/ajtde.v4n2.54

TABLE 1: EXPLOSIVE CHARGE — DISTANCE — RESULTANT PARTICLE VELOCITY

Test No.	Explosive Charge (lbs.)	Distance (Feet)	C.R.O. Sensitivity (Volts/cm)	Component Voltages			Resultant Voltage (Volts)	Resultant Velocity (in./sec.)
				V_I (Volt)	H_T (Volt)	H_L (Volt)		
1	⅙	25	0.2	0.214	0.1	0.12	0.26	0.7
2	⅙	15	1.0	0.20	0.08	0.16	0.27	0.73
3	⅙	10	1.0	1.1	0.24	0.28	1.12	3.02
4	⅙	5	10.0	8.8	0.4	0.4	8.82	23.8*
5	⅓	23.3	1.0	1.0	0.04	0.4	1.04	2.8
6	⅓	13	5.0	4.75	0.05	4.95	6.86	18.5*
7	⅓	8	10.0	15.0	0.1	0.1	15.0	40.5*
8	⅓	3.3	10.0	20.0	1.2	0.4	20.1	54.2*
9	½	23.5	5.0	5.0	0.2	0.2	5.1	13.8*
10	½	13.5	10.0	25.0	0.8	3.2	25.3	68.5*
11	½	8.5	10.0	40.0	—	—	40.0	108.0*
12	½	4	10.0	10.0	—	—	10.0	27.1*
13	⅙	50	0.2	0.4	0.078	0.08	0.41	1.1
14	⅙	40	0.5	0.65	0.06	0.195	0.68	1.84
15	⅙	30	2.0	0.16	0.08	0.4	0.44	1.19
16	⅙	20	5.0	0.1	0.1	0.4	0.42	1.13
17	⅙	19	2.0	0.04	0.12	0.1	0.16	0.43
18	⅙	10	5.0	6.5	0.2	0.45	6.51	17.6*
19	⅔	50	5.0	0.05	0.1	0.15	0.19	0.53
20	⅔	40	1.0	0.4	0.22	0.3	0.55	1.48
21	⅔	31	—					
22	⅔	20	2.0	0.54	1.0	0.24	1.13	3.05
23	⅔	16	5.0	0.4	1.0	0.4	1.23	3.32
24	1	13.5	10.0	1.4	1.0	2.5	3.04	8.21
25	1	50	1.0	0.08	0.2	0.45	0.46	1.24
26	1	40	1.0	0.65	0.4	0.35	0.84	2.27
27	1	30	5.0	2.0	0.2	0.2	2.02	5.5
28	1	25	10.0	0.3	0.3	0.3	0.52	1.4
29	1	21	5.0	0.4	0.4	0.1	0.58	1.57
30	2	50	1.0	0.2	0.35	0.69	0.86	2.32
31	2	40	1.0	1.55	0.47	0.36	1.66	4.5
32	2	31	10.0	0.6	2.0	0.4	2.12	5.72
8A	⅓	23	2.0	0.22	0.8	0.2	0.85	2.29
12A	½	30	2.0	0.16	0.16	0.32	0.39	1.05
19A	⅔	50	1.0	0.08	0.12	0.28	0.31	0.84
12B	½	21	5.0	0.15	0.5	0.25	0.58	1.56
18A	⅙	15	2.0	0.1	0.4	0.06	0.41	1.11
21A	⅔	25	2.0	0.2	0.2	0.4	0.41	1.11

* Geophones bounced

Australian Journal of Telecommunications and the Digital Economy Volume 4 Number 2, June 2016
ISSN 2203-1693. copyright © 2016 The author(s). http://doi.org/10.7790/ajtde.v4n2.54

TEST SITE

The requirements for a site were:

(i) That it be isolated because of the noise problem.

(ii) That it be accessible.

(iii) That the rock be a continuous sheet for at least 60 feet on each side of the cable trench.

The site at Bargo fulfilled all these requirements as well as being within a few hundred feet of a manhole on the Sydney-Melbourne coaxial cable. By utilizing the local order wire in the manhole, a communications set-up was established which simplified logistic support.

Rock Analysis

A sample of the rock was forwarded to the N.S.W. Department of Mines who reported as follows:

"The sample of rock from Bargo submitted for examination has the following composition. Quartz arenite (sandstone) consisting essentially of rounded to sub-rounded grains of quartz in a matrix of clay and iron oxide. Secondary overgrowth of quartz grains is common, in some cases resulting in the fusing of adjacent grains. Average grainsize is approximately 0.3 m.m. The specimen examined indicates that the rock is fairly friable."

The rock from the above analysis is a soft type. Soft rock will transmit shock waves much further than does hard rock, consequently any recommendations based on this rock may be used safely for harder types of rock.

TEST RESULTS

The first important result was that a charge of $\frac{1}{2}$ lb at 5 feet from the cable created a split in the rock with a permanent displacement of ground into the cable trench. No damage resulted to the cable but obviously $\frac{1}{2}$ lb at 5 feet is dangerous, not from ground velocity but from physical displacement. As no displacement occurred when $\frac{1}{3}$ lb. was fired 5 feet from the cable the critical charge is somewhere between $\frac{1}{3}$ lb and $\frac{1}{2}$ lb. Taking the lower limit of $\frac{1}{3}$ lb and using a safety factor of 3 a safe charge of $\frac{1}{9}$ lb 5 feet from the cable can be deduced. The balance of the testing continued without incident and Table 1 shows the test results.

After the programme was completed the cable still had not recorded any damage. It was intended to test the cable to destruction but as the large charges were exceeding the limits of the testing instruments at close range, there was no point in increasing the charges further until the cable failed, for it would be impossible to know at what particular velocity failure occurred.

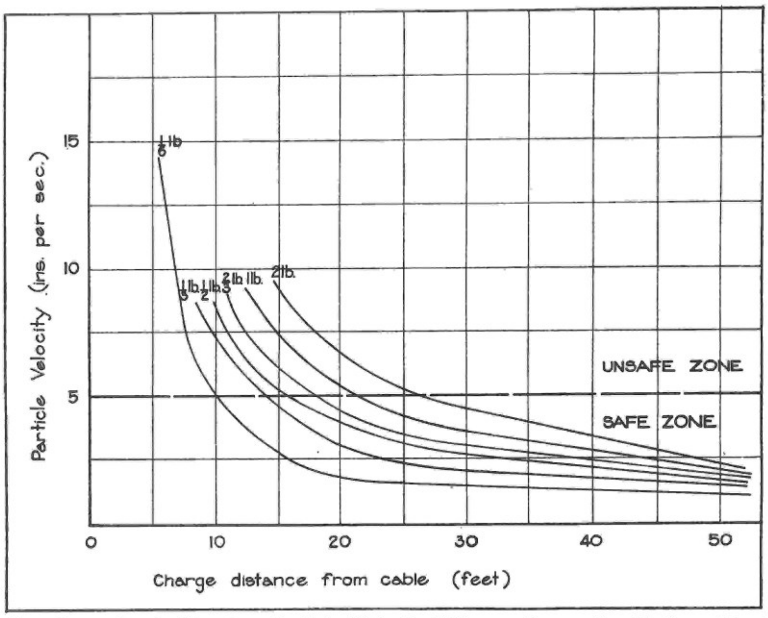


Fig. 5 — Graph Showing Particle Velocity-Distance Curves for Various Sized Explosive Charges.

The cable was subsequently withdrawn and examined. It was sound with no visible marks or indentations. After final electrical tests on the tubes it was resealed and transported back to the store.

The graph in Fig. 5 was produced in conjunction with the Mines Department of N.S.W. and represents Particle Velocity—distance curves for various size charges, based on the results from the oscilloscope readings.

The highest particle velocity recorded at the cable was 8.21 inches/second which not only did not effect the tubes but left the cable sheath unmarked. Obviously the threshold for a damaging ground velocity would be higher than 8.21 ins./sec. However in the interests of safety to the cable a lower limit should be adopted and in accordance with this reasoning a limit of 5.0 ins./sec has been selected. It is freely admitted that there is not sufficient evidence to arrive at a soundly based statistical figure. This would require many weeks of testing in a variety of locations, and was beyond the scope of this initial investigation. However until further work is done a particle velocity limit of 5.0 ins./sec. is regarded as reasonable. This limit is undoubtedly conservative but should be a safe one and also a practical one in that the size of charge permitted is of sufficient weight for it to be effective.

S.A.A. Recommendations

If blasting operations are to be carried out near both coaxial cables and structures, care will need to be exercised in adopting the correct upper limit. The Standards Association of Australia (CA 23, 1967), have recommended that structures be subjected to particle velocity values not greater than 0.75 ins./sec. Consequently when blasting under these conditions the size of the charge should be such that any building or structure will not be subjected to particle velocities in excess of 0.75 ins./sec., which is, and this must be emphasised, a comfort level and not a damage threshold.

Subsequent Tests

Further tests were carried out at Balmain in November, 1967, and at Mona Vale in March, 1968. These results verify the figures obtained at Bargo.

RESULTS USING VIBROGRAPH

Comparison checks were made with the Cambridge Vibrograph and its results were checked against the oscilloscope geophone combination. Within 20 feet of a one pound charge the vibrograph results did not correspond with the oscilloscope readings, also the stylus on film recordings produced by the vibrograph were nearly impossible to read due to the high frequencies present. However, beyond 20 feet

Australian Journal of Telecommunications and the Digital Economy Volume 4 Number 2, June 2016
ISSN 2203-1693. copyright © 2016 The author(s). http://doi.org/10.7790/ajtde.v4n2.54

the recordings were decipherable and there is no doubt that this instrument would be satisfactory under certain conditions, as illustrated by the following example.

At Goulburn N.S.W., in June 1969 a series of vibration readings were taken with the vibrograph, for charges ranging up to 60 pounds of explosives. At 150 feet from the 60 lb charge the recordings were easily read, typical results being vertical vibration 0.002 inches at 50 c.p.s., horizontal longitudinal vibration 0.002 inches at 50 c.p.s. and horizontal transverse vibration 0.004 inches at 50 c.p.s. The resultant vibration was calculated to be 0.005 inches at 50 c.p.s. By reference to the nomogram shown as Fig. 6 this vibration is shown to be equivalent to a particle velocity of 1.5 inches/second.

A description of the Cambridge Universal Vibrograph and a typical example of a recording has already been given in the Telecommunication Journal of Australia, Vol. 19, No. 2, June 1969 (Ref.1).

CONCLUSION

The tests proved that reasonably sized explosive charges may be detonated, with safety, near coaxial cables, subject to the following safeguards:

(i) No explosive should be detonated within 5 feet of the nearest edge of the cable trench. Between 5 feet to 10 feet the charge should not exceed 1/9 lb of AN"60". At 10 feet from the edge of the cable trench the charge size should not exceed 1/4 lb. of AN"60" or its equivalent.

(ii) The particle velocity curves shown as Fig. 5 should be used to determine a safe explosive weight. (This weight only refers to the instantaneous charge, and if millisecond delay detonators are used a number of charges each 2/3 the weight of the instantaneous charge may be detonated at the same time. The number of charges is limited only by the number of detonators in the range).

(iii) Notwithstanding (i) and (ii) the cable is in hazard if any rock, part rock or soil is permanently displaced into the cable trench (termed "cratering"), the charge size must then be reduced. ("Cratering" is also a possibility on the bottom of the cable trench if the charge is within 10 feet of the cable trench and is deeper than the cable trench. The top surface of the cable trench should be carefully observed for indications that "cratering" may be occurring.)

(iv) In other than built up areas the upper limit for particle velocity, at the cable, of 5.0 ins./sec. is not to be exceeded.

(v) In built up areas no structures or buildings to be subjected to particle velocities in excess of 0.75 ins./sec. (As laid down in the S.A.A. Explosives Code, Australian Standard CA23-1967 Section 10.)

(vi) The rock at the test site was a continuous sheet without faults. If faults exist and run between the cable trench and the explosive location, care will need to be exercised and the weight of charge may need to be reduced.

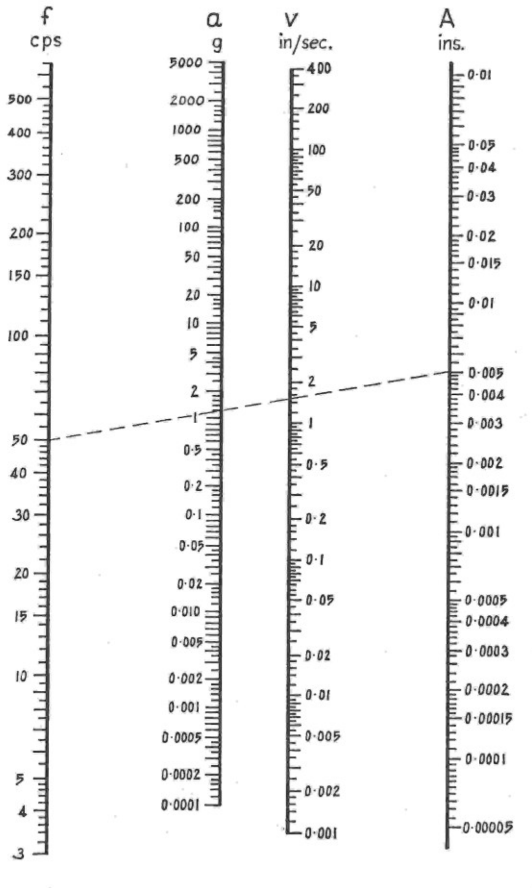


Fig. 6. — Nomogram Showing the Relationship Between Frequency (f), Acceleration (a), Ground Velocity (v), and Ampitude of Vibration (A). The example indicates that a vibration of A = 0.005 inches at a frequency of f = 50 c.p.s. is equivalent to a particle velocity of v = 1.5 inches/second.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the valuable assistance given to him by the Supervising Engineer, Primary Works Sydney, Divisional Engineer Goulburn Regional Works and Services and Divisional Engineer, Transmission Planning (Measurements).

REFERENCE

1. M. F. Lette, 'Installation of Lead Sheathed Cables on Bridges'; Telecom. Journal of Aust., June 1969, Vol. 19, No. 2, P. 127.

A Next Generation Wholesaler's View of the NBN

How Retail Service Providers can succeed in an NBN world

Sarah Branson
Brand Manager, the MNF Group

Rene Sugo
CEO, the MNF Group

Abstract: The MNF Group has been operating in the Australian telecommunications market since 2004. The author of this paper is an employee of the MNF Group and the opinions expressed are those of the author and do not necessarily represent those of the MNF Group.

Upgrading the infrastructure of an entire country is a huge undertaking and was deemed necessary with Government intervention in Australia. Had this task been left to private companies, the likelihood is that Australia would continue to experience a huge gap in the cost and availability of high quality, fast speed broadband services between metro and rural regions. The NBN rollout is several years into the project; a recently released report from the ACCC has given insights into the wholesale market and initial market indicators show that the market is becoming less competitive. This paper examines the costs of interconnecting with the NBN and demonstrates why the NBN has not achieved its goal of providing a level playing field for all telecommunication companies. By looking at the true cost of providing NBN services to NBN users, it is shown that the NBN pricing model is flawed and will affect the quality of service being provided to Australians. To succeed in the telecommunications industry, it is suggested that smaller RSPs will need to work hard to differentiate their brand and provide added value to consumers through additional service offerings. Selling NBN services alone will not be enough to enable smaller RSPs to survive in this tough market. It can be expected that there will be further RSP consolidation within the telecommunications industry as the smaller RSPs won't be able to compete with the Big Four dominating the market.

Introduction

This paper examines whether four or five large companies operating in the telecommunications market is providing enough competition, taking into consideration how the telecommunications industry looked five years ago, how it looks now and what the purpose of the National Broadband Network (NBN) rollout project was in relation to competition.

6http://doi.org/10.18080/ajtde.v4n2.59

For the purposes of this paper, when competition is examined, it refers to competition seen at a retail level i.e. the competition between organisations that benefits consumers when they make a choice about which telecommunications provider they will buy their broadband service from.

A recent report (ACCC 2016b) released by the Australian Competition and Consumer Commission (the ACCC) provides some insights into the current marketplace and demonstrates that there is a lack of competition. When we examine the multiple acquisitions that have taken place in the telecommunications industry and the high barriers to entry created by the NBN we can see why competition is being reduced.

This paper sets out the true cost to a company of providing an NBN plan to a residential user, showing that the pricing model for NBN is flawed and suggests that alternative technologies will further damage the business case for NBN in Australia.

The paper provides some insight into the NBN from a wholesale provider's point of view as well as exploring the challenges for Retail Service Providers (RSPs), making suggestions as to how an RSP can compete in the market.

Unless otherwise indicated, prices are taken from the current NBN price list, version 2.9, issued 16th June 2016, which is publicly available on the NBN website. (NBNCo 2016b).

NBN and the Australian Telecommunications market

There are several large telecommunication companies that operate in the telecommunications market at both a retail and a wholesale level. What is meant by this is that they sell services directly to consumers via their own retail channels and they also sell their services on a wholesale basis to Retail service Providers (RSPs) who then on-sell these services to the same retail consumer market.

Not all wholesale business models look the same. The way a company operates may be largely dependent on their obligations to their shareholders, the amount of money they have invested in legacy infrastructure and their marketing strategy for their retail brand.

Consider the incumbent telecommunications provider in Australia, Telstra, before the NBN was conceived and how they would achieve the best Return on Investment (ROI) for their shareholders. It could be said that due to their large investment in their copper network, prioritising sales of their copper services at a retail and wholesale level, over investing in new technologies would provide the best ROI and a best result for their shareholders. There would be a lack of incentive to innovate even if this would provide a better experience or cost benefit to the consumer.

This scenario demonstrates why it would be difficult for multiple telecommunication providers in a country to invest in new technology and achieve the objectives that the NBN has been put in place to achieve: a nationwide rollout of new technology to all premises across Australia with no service delivery price differentiation based on geographical location.

Even if an NBN rollout had been attempted by private companies, it would most likely have resulted in preferential outcomes for metro-based consumers as this would represent a more profitable market. This is especially true in Australia where there are large geographical distances between consumers and the cost of providing services to regional consumers has always been more expensive.

By creating a Government-run corporation tasked with implementing a nationwide rollout of modern broadband services at wholesale prices fixed for all consumers regardless of location, the NBN should achieve what private companies were unlikely to ever achieve.

Insights into the NBN market

In April 2016, the ACCC released its first report on the NBN wholesale market ("NBN Wholesale Market Indicators Report" (ACCC 2016b).

The statistics contained in the report were alarming to many across the industry, as it clearly shows market dominance by four large players.

Market share

The report from the ACCC showed that Telstra had around 48% market share across the three fixed technology types: Fibre to the Premises, Fibre to the Node and Fibre to the Basement (FTTP, FTTN and FTTB); this figure is higher if only the newer technology types FTTN and FTTB are considered.

Telstra's average retail market share for fixed DSL broadband services was an average of 41% from 2011-2015 (ACCC 2016a). Given that the NBN was supposed to reduce Telstra's monopoly power, it has proved counter-productive in that Telstra has gained a higher market share of the NBN market than they previously held in the DSL broadband market.

http://doi.org/10.18080/ajtde.v4n2.59

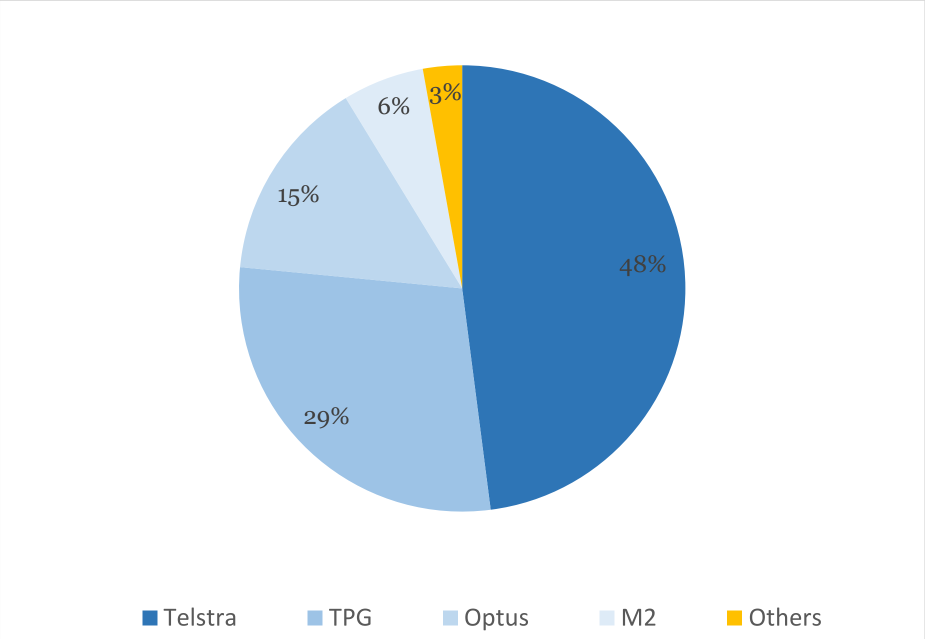


Figure 1 – NBN market share of current connections by Network Access Seeker for FTTP, FTTB and FTTN. Source: "NBN Wholesale Market Indicators Report" 2016

Number of providers at the POIs

The NBN Wholesale Market Indicators Report from the ACCC (ACCC 2016b) also showed that 71 Points of Interconnect (POIs) had just four Access Seekers (telecommunication companies) connected directly to them and providing services within the POI area.

The data also shows us that the maximum number of providers at any POI was 10, and that just 5% of POIs had more than 7 providers directly connected and providing NBN services.

The NBN website RSP list (List of NBN service providers, 2016) shows that there are currently 133 RSPs who are reselling NBN services to consumers, which means that even if hypothetically all 121 POIs had 10 providers directly connected to them, this would represent just 7.5% of RSPs.

The significance of being able to directly connect to NBN's 121 POIs will be examined later in this paper.

CVC Bandwidth

Another insight from the ACCC report (ACCC 2016b) was an indication of the amount of Connectivity Virtual Circuit (CVC) bandwidth which was being purchased by Access Seekers in order to service end users.

In the report, for Service Class 4, Table 2 showed that total contracted CVC is 952,561 Mbps. Table 1 showed that the total number of Fixed NBN services (FTTP, FTTB and FTTN) for Service Class 4 is 805,396 services in operation (SIO).

Taking the total CVC and dividing it by the number of SIOs, gives an average CVC bandwidth per service of 1.18Mbps. This calculation does not take into account the different plans that services are assigned to, nor the fact that CVC has to be purchased in minimum blocks; however it does give a very approximate indication of the CVC that is being provided to NBN end users.

Whilst this amount of CVC bandwidth might not cause immediate concerns for industry or end users, consider when an end user requires 5Mbps to watch High Definition Television (HD TV), and to support multiple devices being connected to the same service in a household. This amount of bandwidth would result in buffering, slow speeds and a poor end user experience.

Creating competition or creating barriers?

Since 2010, we have seen the fixed market (that is, voice and broadband but not considering mobile services) consolidate from around 16 separate companies to just four large companies dominating the market[1].

Whilst this is not as a result of the NBN rollout, it is market consolidation at a wholesale level that has been approved by the ACCC, a Government organisation that is supposed to promote competition and fair trading.

Acquisitions

TPG acquired iiNet in 2015 after the purchase was approved by the ACCC; with ACCC chairman Rod Sims even stating that they expected this acquisition to lessen competition in the fixed broadband market in the short term (ACCC 2015a).

At the time, Sims gave the impression that the ACCC would be "much tougher on any further consolidation of the telecommunications sector, especially if the deal involved Telstra, Optus, TPG or M2" (Sadauskas 2015). However, three months after approving this acquisition, the ACCC approved another when Vocus acquired M2 ("ACCC will not oppose" ACCC 2015b).

The ACCC stated that in this case, the merged firm will face competition from Optus, Telstra and TPG and therefore it was approved.

As a result there are now several large companies operating in the industry, which satisfies the requirement for competition, but does not take into consideration the effect of the acquisitions on the market.

The reality is that these companies are all very similar, and there is very little incentive for them to innovate or to support RSPs whilst they also own and operate large retail brands themselves.

Barrier to entry

One of the initial objectives of the NBN stated in the NBN Corporate Plan of 2010 (NBN 2010) was to create a level playing field for all Access Seekers. This objective was expected to be achieved partly by separating Telstra from its network assets, and partly by the decision to use Uniform National Wholesale Pricing (UNWP) so that all Access Seekers would pay the same wholesale price for a service from NBN.

When considering the cost of interconnecting directly with the NBN, we can understand why this objective cannot be achieved. The 121 Points of Interconnect model used for the NBN rollout means that there are many RSPs that are not able to interconnect directly and therefore cannot access NBN services at the UNWP fixed prices.

There are both upfront and ongoing costs to connect directly to an NBN POI. The upfront cost to connect to each POI is $1,000 per POI, based on the NNI 1000BaseLX Activation fee as per NBN's price list (NBN 2016b). Therefore, to connect to all 121 POIs would require a substantial upfront investment of $120,000.

The minimum ongoing monthly cost of being connected to a POI in order to provide NBN services is $1,775 per month. This figure is based on the minimum commitment for RSPs for a CVC which is 100Mbps at the current price of $15.75 per Mbps (based on industry average, price as at June 16), plus the minimum NNI cost of $200 (1 Gbps – 10 km range) ("Price List", NBN 2016b). When you multiply this by 121 POIs the total minimum monthly cost is $214,775 per month regardless of the number of end users that are being serviced.

NBN Co announced in April that they would introduce a Dimension Based Discount (DBD) model to reduce the CVC costs paid by RSPs, claiming that CVC costs could be reduced to $11.50 per Mbps (NBN 2016a). Since this was introduced, industry has seen the price reduce from $17.50 per Mbps to the current DBD price of $15.75. Even if we use the lowest theoretical cost of $11.50 in the same calculation, it would be $1,350 per POI and a minimum monthly commitment of $163,350 to interconnect directly with all 121 POIs.

It should be noted that these calculations do not include the cost of network backhaul to transport data to the RSP's core network Points of Presence (PoP), which adds further cost.

These high costs of interconnecting directly to the NBN have ruled out many companies from being able to compete at a Tier 1 level, resulting in a multi-tier market with price increases as

http://doi.org/10.18080/ajtde.v4n2.59

we move down each tier as the large companies sell to the next tier level, who then on sell to the RSPs.

Whilst this has always been the case in the telecommunications market, the reason that creating competition is so difficult now is due to the huge amount of consolidation we have seen in the industry. Consider that the main large companies who can afford to interconnect with NBN directly and to enjoy these fixed wholesale prices also have their own retail brands. Ultimately, this enables the big players to buy cheaply and sell cheaply direct to their retail consumers; making it harder for RSPs to compete in the same retail consumer market.

The cost of providing NBN services

When supplying an NBN service to an end user, there are several elements that make up the final cost of an NBN service:

- Access Virtual Circuit (AVC)
- Connectivity Virtual Circuit (CVC)
- Network backhaul
- Other costs (staff, overheads, marketing etc.)

To demonstrate why the current pricing model for NBN is flawed, detailed below is the true cost to a business of supplying an NBN service, based on the assumption that the service is supplied at a Tier 1 level – i.e. the provider is buying directly from NBN and is selling this to its own retail customers.

AVC

The Access Virtual Circuit (AVC) monthly access fee is the monthly price that a provider pays NBN to purchase a service from them. It is the port cost for the connection from the end user to the NBN network.

This AVC fixed price is only accessible to those who have directly interconnected with NBN. Anyone who is too small to connect will be buying at a higher price on a wholesale basis from a Tier 1 or Tier 2 provider.

The pricing detailed below is publicly available information from the NBN Price List 2016.

The entry level plan with NBN is 12/1Mbps and costs $24 Ex GST.

http://doi.org/10.18080/ajtde.v4n2.59

AVC TC-4 downstream Mbps (PIR)	AVC TC-4 upstream Mbps (PIR)	NBN Co Network	Recurring Charge
12	1	Fibre, FTTB, FTTN, HFC, Wireless and Satellite	$24.00
25	5	Fibre, FTTB, FTTN, Wireless, HFC and Satellite	$27.00
25	5 - 10	FTTB and FTTN	$30.00
25	10	Fibre and HFC	$30.00
25 - 50	5 - 20	FTTB, FTTN and Wireless	$34.00
50	20	Fibre and HFC	$34.00
25 - 100	5 - 40	FTTB and FTTN	$38.00
100	40	Fibre and HFC	$38.00
250	100	Fibre	$70.00
500	200	Fibre	$100.00
1000	400	Fibre	$150.00

Figure 2 - The recurring Charges per Billing Period for the AVC TC-4 and UNI bundle

Source: NBN Co Price List 2016.

CVC

The Connectivity Virtual Circuit (CVC) charge is the cost of aggregation from multiple households to the POI. It is effectively the bandwidth used by the end user and is currently set at $17.50 per 1Mbps of traffic (NBN 2016b).

To give some context to what the CVC charges might look like, take Netflix as an example of what consumer demands will be.

Netflix has provided on its website the recommended amount of bandwidth required for an Internet connection if an end user wishes to watch films and TV shows in High Definition (HD). The recommended bandwidth for viewing in HD is 5Mbps. (Netflix 2016b)

HD is already considered the standard in homes; in 2011 some 93% of households across Australia already had an HD integrated digital television (ACMA 2012).

Therefore, if an end user wants to watch TV or a movie in HD, they would need 5Mbps of bandwidth. If we apply the CVC charge of $17.50 per 1 Mbps then this equates to $87.50 for 5Mbps of bandwidth.

It is easy to see why currently on average only 1.18Mbps is being provided to end users for their NBN service. Whilst this might be acceptable for today's consumer needs, it is expected that within the next few years more Australians will consume TV and movies in Ultra HD (also known as 4K) with 40% of TVs expected to be 4K by 2020 (Player 2016).

Consider also that the number of Australians with Subscription Video on Demand (SVOD) services has now reached 2.7 million (Telsyte 2016) and is expected to more than double to

4.7 million subscriptions by the end of 2019 (Ovum 2015). This means the industry will see a higher number of Australians requiring a greater amount of data and demanding more bandwidth to deliver Ultra HD quality.

Given that Netflix recommend a connection providing 25Mbps bandwidth to watch ultra HD content, the cost of purchasing this bandwidth to provide this experience to the end user will be unsustainable for most RSPs.

It is perhaps not surprising that Presto, a Video on Demand (VOD) service, when it launched in Australia in 2015 postponed their offering of 4K content as they did not believe NBN would be able to provide the bandwidth required to watch 4K TV (Dudley-Nicholson 2015).

Network Backhaul

Backhaul put simply is the cost of transporting Internet data from a series of locations back to a more centralised location; i.e. from an NBN POI to a company's core network PoPs.

It is difficult to provide an estimate of the costs of backhaul due to commercial in confidence reasons; hence this cost has not been considered in the total cost of providing an NBN service.

Other

The document setting out the Coalition's plan for fast broadband and an affordable NBN stated that they assumed retail prices to include a margin of $28 as this is the current approximate figure (Federal Coalition 2013). Consider that this $28 should not only cover the costs of labour, overheads, marketing and other costs, but it should also provide some profit margin to the provider.

Total cost of providing an NBN service

A company will pay a monthly fee for an NBN plan (AVC), a charge for CVC bandwidth, and network backhaul costs to transport data.

If we take the entry level plan available from NBN – a 12/1Mbps plan priced at $24 ex GST – and add the 5Mbps of CVC bandwidth cost, but not including the backhaul cost, the total cost of that plan to an RSP is $111.50.

Note that this is based on a Tier 1 provider accessing NBNs UNWP pricing; any provider not directly connected with NBN buying from a Tier 2 provider will pay more than this.

Adding the $28 margin that NBN included in its document (Federal Coalition 2013) plus GST gives the final retail cost of an NBN service for an end user of $153.45.

http://doi.org/10.18080/ajtde.v4n2.59

AVC charge	$24
CVC charge (5Mbps)	$87.50
Backhaul costs	Not specified
Sub total	*$ 111.50*
Margin	$28
GST	$13.95
Total cost to end user	**$153.45**

Figure 3 – The total costs of providing a 12/1Mbps plan.

Looking at a selection of telecommunication providers in the marketplace, many companies are selling an entry level (12/1Mbps) unlimited NBN plan for around $60 to $70, including GST. This could indicate that providers are selling at a loss to gain market share, or they may be selling contended services which means there is likely to be congestion on the network at peak times.

One might wonder why we are not seeing prices already at the $153.45 price point if that is how much it is costing providers to supply that service to the end user. The reason for this is that companies are not currently providing consumers with 5Mbps of bandwidth as per their requirements; instead they are providing approximately 1.18Mbps. Whilst this means that the company can afford to provide the service and the end user can afford to buy it; in reality, the end user may experience some buffering and slow speeds, especially during peak times such as when most people are home and using their Internet connection in the evenings.

It should be noted that the CVC charge used in the calculation does not take into consideration the CVC rebate recently announced by the NBN (NBN 2016a). NBN Co claims that CVC costs could be reduced to $11.50 per Mbps; however, this reduction in price is dependent on the average CVC bandwidth that is provisioned to end users across the industry. Therefore the price that an RSP will pay for CVC bandwidth is determined by what the Tier 1 providers directly interconnected with the NBN are choosing to provision for their end users. Even if the calculations were based on the lowest CVC charge possible of $11.50, the total cost to the end user for the plan demonstrated would be $120.45.

It should also be noted that the new DBD pricing model has been put in place to "reward retailers with a discount (determined at an industry level) for delivering a better customer experience through the better allocation of CVC to end users." (NBN 2016a). This indicates that NBN Co are aware that services are being sold contended and that this will lead to a poor customer experience and ramifications for the success of the NBN project. The author is of the opinion that the new DBD pricing does not go far enough to address the issue of high CVC usage based charging.

NBN Business case under threat

A risk to the NBN business model is the threat from alternative broadband technologies such as wireless mobile phones and tablets, or alternative fibre access providers such as TPG and Lightning Broadband.

NBN itself has also highlighted this risk in its corporate plan: "competition could intensify from both wireless mobile service providers and alternative fixed providers" (NBN 2015).

Improvements in the speed of data downloads on wireless mobile devices are already positioning wireless access services as a viable alternative to the NBN. Mobile phone plans in the market are continually offering more data inclusions whilst maintaining current retail price points; this will ultimately make wireless mobile an affordable household alternative to an NBN service.

As demonstrated above, NBN plan charges at a retail level are likely to increase as demand for higher bandwidth and data consumption needs to be meet. The CVC pricing model means that theoretically NBN plan fees will become prohibitive and either consumers will not buy them, or RSPs will not offer them, resulting in consumer's choosing alternative technologies.

This will compound the issue of high NBN prices even further, as fewer consumers share the cost of the NBN, meaning that either retail prices will remain high, or the time it takes for the NBN to pay back its cost will be extended.

The MNF Group – A Wholesaler's View on the NBN

The MNF Group has been operating in the Australian telecommunications market since 2004 and was listed on the ASX exchange in 2006 (ASX:MNF).

The NBN rollout presents exciting opportunities for businesses across the industry as well as bringing a better digital future for the Australian population.

It is important that companies and individual advocates in the industry have a voice to lobby for change. When the NBN network model was being discussed in industry, companies were invited to submit their responses to the ACCC. Many in the industry understood that the large number of Points of Interconnect (POIs) that were being proposed would result in a market where only the largest companies would be able to afford the investment required to connect to all of the POIs around the country, as has been demonstrated above.

http://doi.org/10.18080/ajtde.v4n2.59

In addition, the majority of the proposed POIs were based in Telstra's existing infrastructure, giving Telstra immediate competitive advantage over other companies as they had the required infrastructure and backhaul in place already. This arrangement gave them a head start in the marketplace over others who would have taken time to set up these arrangements and agree commercials.

The next major challenge presented in the business case for the NBN was the change of Government and following on from that, the change to the technology types that would be used to deliver the NBN to Australians nationwide.

The change of technologies hasn't necessarily presented commercial challenges to RSPs but there are additional operational difficulties to overcome.

Using the existing copper means that the transition for an end user from DSL to NBN is likely to result in downtime (time without an Internet service) giving a poorer end user experience during the changeover. This is unlikely to be as much of an issue for Telstra who have full control over the copper network and the migration of services and can offer a more seamless experience. This provides another competitive advantage for the incumbent carrier.

It is now generally accepted that there is little to be gained from continuing to lobby against these challenges since the rollout is too far advanced, although former NBN CEO Mike Quigley has recently brought this issue back into the spotlight by "pleading for a return to the NBN to the FTTH (FTTP) model" (Communications Day 2016) and the Labor Party has revealed its plans for the NBN if it were to be voted into power in the recent election.

In addition to these challenges, there are still elements of the current business plan that continue to cause concern.

The NBN Co's approach to CVC pricing could seriously undermine the business case for the NBN and cause prohibitive and unsustainable pricing. In turn, this will lead to a strengthening of the case for alternative technologies (this is discussed further below).

The release of the pre-election budget presented an opportunity for the Government to write off some of the costs of the NBN network build, which would help to stabilise the future business model for the NBN rollout.

The write-off of some of the build cost would mean that NBN would not have to pay back so much in revenue, and a review of the way NBN services are priced could have been undertaken. Instead what we will see is prohibitive price increases as customers require more data.

http://doi.org/10.18080/ajtde.v4n2.59

The MNF Group - A Retail Experience

The MNF Group is a multi-tenanted business, owning a Tier 1 Voice over Internet Protocol (VoIP) network, several consumer retail brands, and on-sells wholesale services.

This range of service offerings gives a wide ranging and unique insight into the impact of the NBN across several different market disciplines.

The way telecommunication companies sell services

The Australian Bureau of Statistics (ABS) reports the average broadband downloads grew more than 33 per cent from December 2013 to December 2014 (ABS 2014). Perhaps even more impressive is that the amount Australians downloaded jumped 50% between December 2014 and December 2015 (ABS 2015).

This change in consumer data consumption will have been experienced by nearly all providers across the industry, especially since the introduction of Netflix in Australia. NBN has referenced this change in its corporate plan: "continued double-digit growth in volume through changed consumer behaviour (e.g. new subscription video services, 4K streaming, devices per household, etc.)" in the context that they expect this to contribute to higher CVC earnings for the NBN (NBN 2015).

Given that many companies in the industry have modelled their commercial offerings on a usage-based cost, this change in consumer behaviour will dramatically affect how DSL and NBN plans are sold and priced.

As an example, consider that an unlimited plan might have been sold in 2013 for $49.95 including GST, but the cost modelling for this plan would be based on the fact that the end user will probably only download around 45.6GB per month (ABS 2014). If the consumer increased their data usage in line with the statistics shown be the AVS, it is likely that three years later a provider would lose money on a plan modelled this way.

In 2015 the average data download on NBN was 112GB ("Half Year Results" NBN 2016c); – that is nearly 2.5 times the amount of data compared with the previous year. Consumer data consumption will continue to increase as VOD and other online services become more mainstream, and as technology such as 4K Ultra HD TVs enable the faster consumption of data.

http://doi.org/10.18080/ajtde.v4n2.59

Consumer Expectations

There are several things that influence consumer expectations when it comes to determining what they expect from a broadband service and what they expect to pay for it, particularly when it comes to the NBN:

- The market
- Politicians
- Netflix effect

The Market

Consumers have long been able to access cheap, unlimited broadband plans thanks to the pricing strategy described above and the lowering cost of data on DSL services.

Prices for unlimited DSL prices are fairly stable at around $40-$50. The cheapest prices for NBN entry level plans (12/1Mbps) have settled in the market at around $50-$60, although as demonstrated above, customers are most likely only receiving 1.18Mbps based on the current contracted CVC and number of subscribers.

Politicians

The Parties on both sides of politics have been promising to deliver fast and affordable broadband for all Australians. The Coalition Party even specified a price point in their plan for fast broadband and an affordable NBN policy document of $66 (Federal Coalition 2013).

The Netflix Effect

The Netflix effect is a term adopted to describe the shift in consumer consumption of TV and movies since the introduction of Video on Demand (VOD) services such as Netflix, Stan, Presto and others. Netflix even ranks RSPs based on how good their download speeds are (https://ispspeedindex.netflix.com/).

The burgeoning Video on Demand industry has allowed consumers to watch content through their TV, meaning that they are consuming more data than ever before and yet they would have seen no change to the price of the broadband plan (assuming they are on an unlimited plan) as their RSP would bear the cost as a result of the cost modelling described above.

http://doi.org/10.18080/ajtde.v4n2.59

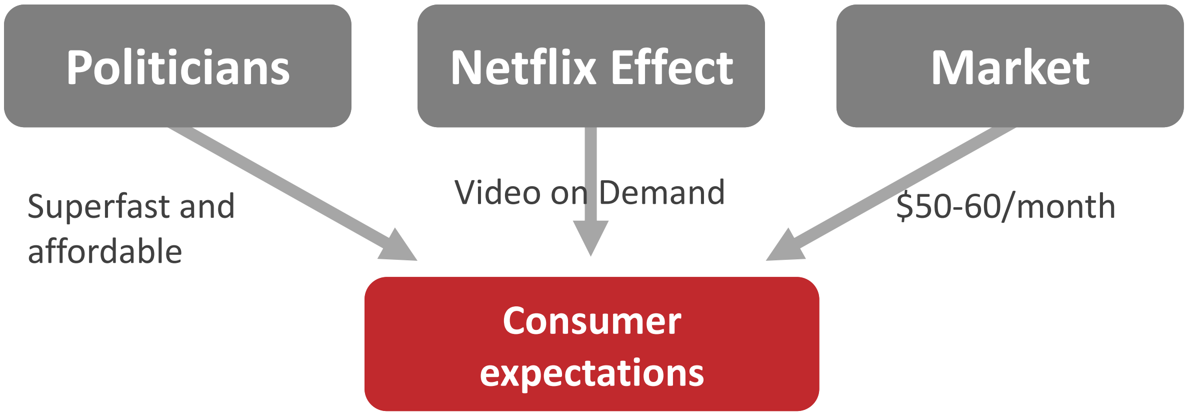


Figure 4- the different influences on consumer expectations.

Resulting Expectations

Considering these influences, it is easy to understand why the consumer expectation is that they should be able to buy an unlimited Internet plan, regardless of technology type, and be able to watch Netflix and other Video Services on Demand (VSOD) as much as they like in HD for around $66.

For many RSPs this means that they are selling NBN services at a price point to meet consumer expectations with minimal if any margin. It is likely that RSPs are selling at break-even pricing (or below) with the intention of gaining market share and making their profit from other services that they can offer.

Whilst this paints a somewhat gloomy picture for telecommunication companies trying to compete, it also presents opportunities and forces companies to find new ways to differentiate themselves.

How to succeed as an RSP

Fixed wholesale pricing in the NBN model was intended to deliver fair pricing for all providers and to remove the ability to be able to compete on price. With a multi-tier industry, where the smaller RSPs are not able to buy directly from NBN, price competition hasn't been removed, and it is more difficult to offer the cheapest plan if you are not a Tier 1 company.

Price is not the only factor that a company considers when differentiating itself from its competitors. In an industry where everyone is selling the same underlying service, RSPs must look for other points of difference to give them a competitive edge.

http://doi.org/10.18080/ajtde.v4n2.59

Pricing

Whilst many providers offer very cheap pricing for an entry level plan, it has also been proven that you don't have to be the cheapest to be able to sell NBN services. Telstra is not the cheapest provider and yet they have gained the largest market share.

The important thing is to ensure that you are not the most expensive either, which may be challenging for some providers who have very low margins. Therefore, being able to obtain revenue and profit margin from other avenues and products is important.

Value proposition

Aside from pricing, there are other ways that an RSP can ensure they offer differentiation in the marketplace. This paper does not explore marketing theories in depth, however it will demonstrate a Company's point of view which is specific to the telecommunications industry.

A value proposition is made up of multiple facets which enable a company to provide additional perceived value to their end user. Sometimes this additional value is quantifiable, for example a promise to answer calls in a certain amount of time can be measured by both an organisation and a consumer. An example of a non-quantifiable benefit would be the quality of the customer service that a company provides to their end user.

Service and systems

Within the MNF Group, iBoss is a Tier 2 wholesaler that provides wholesale services (such as NBN); these services are ordered, provisioned and managed via an online portal.

By offering a wholesale customer (the RSP) superior and intuitive systems that are easy to use to, iBoss is able to differentiate itself from its competitors. In turn, the benefit to the RSP is efficient systems that reduce their manual workload and the amount of operational staff required. The RSP will be able to operate more leanly, which will provide cost benefits in the form of lower operational overheads.

An RSP will also usually use a billing system to bill their end user and to provide the end user with the capability to manage their service and billing account. An RSP is able to leverage iBoss' billing systems to provide automated ordering solutions to their end users, meaning that the end user can have control over ordering their service and managing it. Invoicing and billing is also integrated and automated, enabling the RSP to effectively run their businesses with minimal human input.

Superior software systems will provide an enhanced customer experience, and ultimately can reduce the overhead costs for an RSP.

http://doi.org/10.18080/ajtde.v4n2.59

Support

The quality of customer service and technical support that an RSP provides to its end users will provide a non-quantifiable customer benefit. Providing a quality and knowledgeable support service to the end user is an important part of a service offering in telecommunications as services can often present technical complications.

The way an RSP can achieve this is by providing high quality training to their customer support team. Implementing procedures to ensure that customer complaints or technical issues are escalated in the correct way and are resolved in a timely manner is an important element of customer service and relates back to the systems an RSP uses to manage their business.

Quality

When it comes to quality of service, it might seem difficult to differentiate on the quality of an NBN service being provided to an end user, since the underlying infrastructure and product is the same for all providers. However, RSPs can differentiate on quality by purchasing more CVC bandwidth for their end users, which would provide a better download experience and reduced likelihood of buffering. This will be difficult for any RSP that is not a Tier 1 provider interconnected directly with the NBN, as they will not have control over the amount of bandwidth that is being purchased for its end users.

So whilst it is difficult to compete on the quality of the service being provided, it does come into play when you consider that RSPs could be selling a service that is buffering and hence provides a poorer customer experience.

Netflix itself provides a rating system on its website to show the RSP that it says is performing the best in providing download speeds (see: https://ispspeedindex.netflix.com/)

This makes RSPs accountable for the quality of service that they offer, and will ultimately apply pressure to ensure providers at all tier levels do not sell contended services. This adds weight to the argument that CVC costs are not sustainable and need to be reviewed in order to provide end users with the experience they expect at a price they can afford to pay.

Add-ons

Telecommunication providers will need to look for innovative solutions and products that they can add-on to an NBN service to provide a point of difference to their competitors. An example of an add-on that would provide extra perceived value would be including a voice service with calls as part of a bundle offer, or providing free Netflix or another similar VOD service.

Niche suppliers

The rollout of the NBN has offered new opportunities to geographical and niche suppliers. Small local providers have been able to capitalise on the opportunity presented by the mass switch-on of fibre services in their local area. This has provided a competitive edge as they have captured the early adopters who wanted to migrate to the NBN network as soon as it was available. The vast amount of data available from NBN on rollout areas and estimated switch-on dates has enabled specific targeting of customers in specific areas. This unique opportunity will become much less relevant once the rollout is complete.

Conclusions/Recommendations

Early market indicators from the telecommunications industry show some worrying trends. The NBN market is dominated by four large players, and it is expected that small RSPs will exit the market as they find it too difficult to compete; this will lead to more consolidation and less choice for consumers.

There are widespread concerns across industry about the pricing model for NBN which has been proven to be flawed. By examining the challenges posed by the pricing model, the author has demonstrated that the quality of the service being provided to consumers is diminished.

The author predicts that without modification of this pricing model, not only will this result in reduced competition, but consumer adoption of the NBN is likely to falter as alternative technologies pave a faster, more affordable path to high quality, fast speed data connections.

The NBN rollout is expected to be completed in 2020 by which time the data demands from households will be much higher than we see today; without change to the pricing model consumer perception will be that the NBN rollout has been a failure.

References

Australian Bureau of Statistics. 2014. "Internet Activity, Australia, December 2014". Available at: http://www.abs.gov.au/AUSSTATS/abs@.nsf/Previousproducts/8153.0Main%20Features5December%202014?opendocument&tabname=Summary&prodno=8153.0&issue=December%202014&num=&view=

Australian Bureau of Statistics. 2015. "Internet Activity, Australia, December 2015". Available at: http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8153.0Main%20Features4December%202015?opendocument&tabname=Summary&prodno=8153.0&issue=December%202015&num=&view=

Australian Coalition Parties. 2013. "The Coalition's plan for fast broadband and an affordable NBN". Available at: http://lpa.webcontent.s3.amazonaws.com/NBN/The%20Coalition%E2%80%99s%20Plan%20for%20Fast%20Broadband%20and%20an%20Affordable%20NBN.pdf

Australian Communications and Media Authority. 2012. "Television sets in Australian households 2011". Available at: http://www.acma.gov.au/~/media/Research%20and%20Analysis/Research/pdf/Television%20sets%20in%20Australian%20households%202011.PDF

http://doi.org/10.18080/ajtde.v4n2.59

Australian Competition and Consumer Commission. 2015a. "ACCC to not oppose acquisition of iiNet by TPG". Available at: https://www.accc.gov.au/media-release/accc-to-not-oppose-acquisition-of-iinet-by-tpg

Australian Competition and Consumer Commission. 2015b. "ACCC will not oppose Vocus' proposed acquisition of M2". Available at: https://www.accc.gov.au/media-release/accc-will-not-oppose-vocus%E2%80%99s-proposed-acquisition-of-m2

Australian Competition and Consumer Commission. 2016a."Competition in the Australian Telecommunications Sector". Available at: https://www.accc.gov.au/system/files/ACCC%20Telecommunications%20reports%202014%E2%80%9315_Div%2011%20and%2012_web_FA.pdf

Australian Competition and Consumer Commission. 2016b. April 29. "NBN Wholesale Market Indicators Report". Available at: https://www.accc.gov.au/regulated-infrastructure/communications/national-broadband-network-nbn/nbn-wholesale-market-indicators-report/initial-report

Communications Day. 2016. "Quigley makes another election campaign plea for pervasive FTTH". Issue 5155. June 2016

Dudley-Nicholson, J. 2015. *News Corp Australian Network*, August 31. "Presto says Australia's internet speeds too slow for 4K content and blames new NBN." Available at: http://www.news.com.au/technology/presto-says-australias-internet-speeds-too-slow-for-4k-content-and-blames-new-nbn/news-story/f08d9845d708bdaa0556ddc3e7251f6f

NBN Co. 2010. Corporate Plan 2011 – 2013. Available at: http://www.nbnco.com.au/content/dam/nbnco/documents/nbn-co-3-year-gbe-corporate-plan-final-17-dec-10.pdf

NBN Co. 2015. NBN Corporate Plan 2016. Available at: http://www.nbnco.com.au/content/dam/nbnco2/documents/nbn-corporate-plan-2016.pdf

NBN Co. 2016a. "New discount-based pricing to encourage enhanced broadband experience." Available at: http://www.nbnco.com.au/corporate-information/media-centre/media-releases/New-discount-based-pricing-to-encourage-enhanced-broadband-experience.html

NBN Co. 2016b. Price List, Wholesale Broadband Agreement. Available at: http://www.nbnco.com.au/content/dam/nbnco2/documents/sfaa-wba2-product-catalogue-price-list_20160616.pdf

NBN Co. 2016c. Half Year Results 2016. Available at: http://www.nbnco.com.au/content/dam/nbnco2/documents/nbn%20half%20year%20financial%20results%202016%20-%20presentation.pdf

NBN Co.2016d. "List of NBN service providers. 2016". Available at: http://www.nbnco.com.au/connect-home-or-business/information-for-home/whats-involved-in-getting-connected/service-provider-list.html

Netflix Australia. 2016a. ISP Leaderboard, May 2016. Available at: https://ispspeedindex.netflix.com/country/australia/ (accessed 24th June).

Netflix Inc. 2016b. "Internet Connection Speed Recommendations". Available at: https://help.netflix.com/en/node/306

Ovum. 2015. "Australian OTT Video – Creating a New TV Market." Available from: http://www.nbnco.com.au/content/dam/nbnco2/documents/ott-video-in-australia-creating-a-new-market.pdf

Player, C. 2016. *ARN* June 20. "Cisco internet traffic forecasts expose further flaws in Govt's NBN rollout". Available at: http://www.arnnet.com.au/article/602027/internet-traffic-forecasts-expose-further-flaws-government-nbn/?utm_campaign=daily-pm-edition-2016-06-20&utm_medium=newsletter&eid=-4152&utm_source=daily-pm-edition

Sadauskas, A. 2015. *itnews*, September 1, 2016. "ACCC defends approval of TPG/iiNet merger". Available at: http://www.itnews.com.au/news/accc-defends-approval-of-tpg-iinet-merger-408744

Telsyte. 2016. *Telsyte News*, June 27 2016. "Strong SVOD growth create opportunities for content providers and resellers in Australia". Available at: http://www.telsyte.com.au/announcements/2016/6/27/strong-svod-growth-create-opportunities-for-content-providers-and-resellers-in-australia

Endnotes

[1] Examples of mergers and acquisitions in the telecommunications market between 2010 and 2016:

1. iiNet acquired AAPTs consumer division in 2010 https://aapt.com.au/aapt/about-aapt
2. iiNet acquired internode in 2011 http://www.internode.on.net/news/2011/12/259.php
3. iiNet acquired TransACT in 2011 http://www.iinet.net.au/about/history/
4. iiNet acquired Adam internet in 2013 http://www.iinet.net.au/about/history/
5. iiNet acquired 60% of Tech2 in 2014 http://tech2home.com.au/
6. TPG acquired AAPT in 2014 https://aapt.com.au/aapt/about-aapt
7. TPG acquired iiNet in 2015 https://www.tpg.com.au/about/profile.php
8. M2 acquired Primus in 2012 http://www.iprimus.com.au/legal/about-us/
9. M2 acquired dodo and Eftel in 2013 (https://en.wikipedia.org/wiki/M2_Group
10. Vocus acquired Amcom in 2015 http://www.vocus.com.au/news/vocus-and-amcom-faqs
11. Vocus acquired M2 in 2015 http://www.vocus.com.au/news/vocus-and-m2-merger-approved

http://doi.org/10.18080/ajtde.v4n2.59