Journal of Telecommunications and the Digital Economy

Volume 7 Issue 4
December 2019

Publisher: Telecommunications Association Inc.

ISSN 2203-1693

JTDE Volume 7, Number 4, December 2019

Table of Contents

Editorial

Public Policy Discussion

Industry Case Study

Articles

History of Australian Telecommunications

Market Upheaval, Fires and What's Next for the NBN

Editorial

Mark A. Gregory
RMIT University

Abstract: Papers in the December 2019 issue of the *Journal* include discussion on the future of the $51 billion National Broadband Network (NBN), Benefiting from Asia's Technology Revolution and the relationship between the use of the Darwin-based coastal High Frequency radio service and the development of social capital in the Northern Territory. The Telecommunications Association is hosting public forums on the future of the NBN in 2020 at RMIT University in Melbourne. A recent decision by the Federal Court has cleared the way for the merger of Vodafone Hutchison and TPG to proceed. It is time for more robust telecommunications infrastructure as the recent devastating bushfires found telecommunications services wanting. The *Journal* welcomes contributions on telecommunications and the digital economy.

In This Issue

In this issue of the *Journal* papers cover public policy related to the National Broadband Network (NBN), Asia's technology revolution, HF radio inspired social capital and a historical look at a digital radio concentrator system.

The NBN Futures Forum: Realising the User Potential of the NBN presents a summary of the second NBN Futures Forum.

Promoting Digital Inclusion Through the NBN provides a guide on how to include all Australians with access to the NBN through more affordable pricing and improved reliability of access.

Competition and Mobile Network Operator's Investment Relationship: A Firm Level Empirical Evidence for Developing Countries investigates the effect of competition on investment and how this indicates the existence of a competition intensity that maximises mobile network operator investment.

http://doi.org/10.18080/jtde.v7n4.245

The NBN Futures Project background and aims are explained in this paper. Building consensus and common ground are the basis for the public policy discussion on the future of the NBN.

Benefiting from Asia's Technology Revolution is an invited paper, the Charles Todd Oration 2019, that covers how Australia might benefit from Asia's technology revolution.

'This is VJY, Over' provides a discussion on how the Darwin-based HF coastal radio service was instrumental in the development of social capital in the Northern Territory.

The Digital Radio Concentrator System provides a historical look at the design and development of the digital radio concentrator system deployed by Telstra to provide automatic telephone services through regional and remote Australia.

Market Upheaval, Fires and What's Next for the NBN

The recent decision by the Federal Court to overturn the 2019 decision by the Australian Competition and Consumer Commission (ACCC) to block the merger of Vodafone Hutchison and TPG will have major ramifications for the Australian telecommunications market, albeit slowly and initially with a stronger entrant moving into the 5G market.

For regional and remote Australians, a larger third carrier should be expected to turn its attention to competing with Telstra and Optus outside the major urban centres. Whilst this is not anticipated to be a panacea for competition in the bush, it could see a changing dynamic that improves access and pricing over time.

The ongoing debate about infrastructure competition is likely to return to prominence as the ACCC considers whether to require that all carriers declare and provide the details of all publicly co-funded or fully funded infrastructure. There should be no hesitation for this to occur: it is time that all publicly co-funded or fully funded infrastructure be identified and a publicly accessible register made available.

The devastating 2019/2020 bushfire season has raised several issues regarding telecommunications infrastructure resilience and the robustness of telecommunication networks in regional and remote Australia. It is vital that a review be carried out from technical, social and business perspectives to identify ways to improve telecommunications resilience when confronted by unexpected fires and floods.

The Telecommunications Association is hosting forums on the future of the NBN at RMIT University in Melbourne throughout 2020. More details can be found on the *telsoc.org* website.

The NBN is Australia's largest Government-funded infrastructure project that is anticipated to cost the taxpayer about $51 billion by the time it is built and fully operational in 2022. The NBN is about the future, vital infrastructure that will underpin the nation's future participation in the global digital economy. For the younger generations, the NBN is a key Government contribution towards successful careers, innovation and wealth creation.

Get involved, learn about the potential future for the NBN and have your say on this vital national project.

The *Journal*, Looking Forward

The *Journal* welcomes papers on telecommunications and the digital economy, including, theory, public policy and case studies.

Technological change is happening at a rapid rate and consumers anticipate that governments and industry will keep pace to ensure that the benefits can be fully utilised. The *Journal* is calling for papers on how new technologies will affect Australian telecommunications consumers.

The topics of *International Telecommunications Legislation and Regulations* and *International Mobile Cellular Regulation and Competition* are set to continue for some time, as the opportunity to attract papers from around the globe continues. We encourage papers that reflect on where the global telecommunications market is now, how it got to where it is, and what is going to happen next.

Papers are invited for upcoming issues. With your contributions, the *Journal* will continue to provide readers with exciting and informative papers covering a range of local and international topics. The Editorial Advisory Board also 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 the double-blind peer-review process.

Mark A. Gregory

http://doi.org/10.18080/jtde.v7n4.245

The NBN Futures Forum

Realising the User Potential of the NBN

Leith H. Campbell
Honorary Fellow, School of Engineering, University of Melbourne

Abstract: On 22 October 2019, TelSoc held its second NBN Futures Forum in Melbourne on the theme of realising the user potential of Australia's National Broadband Network. Four speakers discussed various aspects of usage, including digital inclusion, access and affordability, broadband-enabled services, and service pricing. While the NBN has increased access to broadband, affordability remains an issue and the evidence suggests that gaps in digital inclusion are not being closed. The New Zealand experience suggests that demand for high-speed broadband will continue to grow if wholesale and retail prices are appropriately set. The cost of the NBN rollout remains a challenge for wholesale prices. Various improvements in affordability, including direct subsidies for low-income households, were canvassed.

Keywords: NBN, public policy

Introduction

TelSoc (the Telecommunications Association Inc, publisher of this *Journal*) is organizing a series of public forums under the title NBN Futures to encourage debate, and potentially to build consensus, about the future of Australia's National Broadband Network (NBN) now that the initial rollout is nearing completion. The first forum was held in July 2019 and is summarized in Campbell & Milner (2019).

The second forum, held on 22 October 2019 in Melbourne and online, had the theme of "Realising the User Potential of the NBN". Four speakers addressed various aspects of this theme in short presentations of no longer than 10 minutes. Discussion from the audience and online followed, teasing out lessons to be learnt from the user experience to date. The speakers were then invited to make closing remarks.

http://doi.org/10.18080/jtde.v7n4.228

The NBN Futures Forum

The Forum was opened by Mr John Burke, who chaired the event. In his brief opening remarks, he noted that one aim had been "building the NBN for all Australians". The NBN was to have social and economic benefits. He then invited the four speakers to address the theme of "realising the user potential of the NBN".

Teresa Corbin: Australian communications consumers

Ms Teresa Corbin is CEO of the Australian Communications Consumer Action Network (ACCAN). She remarked first that the issues of NBN availability and affordability had been brought to public attention once again in the last week through the chairman's remarks at the Telstra AGM and the ACCC's inquiry into wholesale access pricing.

Ms Corbin indicated that, for ACCAN, the issues related to the NBN were threefold: the future of NBN pricing; ensuring reliability of telecommunications service; and the evolution of the Universal Service Obligation (USO).

On NBN pricing, the Australian Digital Inclusion Index had identified a growing share of household income devoted to internet services, indicating the potential for increasing financial stress for some households. Ms Corbin claimed that NBN services are simply unaffordable for some people. About 2.5M Australian residents are not currently online. Without greater affordability, there will be a digital divide. Meanwhile, the Internet has become an essential service, with governments pursuing a digital-first strategy for access to government services and many businesses promoting online access.

As part of its strategy to address affordability, ACCAN had signed up for NBN Co's product development forum. Ms Corbin regretted that its deliberations were confidential, with only one discussion paper on pricing having been made public. She called for greater transparency in the deliberations on NBN service pricing.

Of particular concern was the 12/1 (that is, 12 Mbps downstream; 1 Mbps upstream) entry-level service, which would replace telephone-only service. Ms Corbin feared that it might not be widely taken up by the NBN Retail Service Providers. She indicated that ACCAN believes an effective charge of $22.50 per month for this service would make it more attractive.

For the popular 50 Mbps service, ACCAN has proposed a wholesale price with unlimited data of $20 per month for low-income families receiving government income support. This would lead to a retail cost of approximately $30 per month, about half the current price. In a whole-of-government approach, these discounts could be seen as revenue neutral, since the digital-first strategy is estimated to provide $25M annual savings for the Federal Government.

http://doi.org/10.18080/jtde.v7n4.228

Ms Corbin noted that reliability is also important. As the end of the initial rollout nears, it is important to improve the reliability of the NBN. She described an area near the ACT where ADSL had been delivered reliably and consistently, while the alternative NBN service, Sky Muster (the satellite access service), was less reliable and with higher prices. This would affect both families and small businesses.

For the future of the USO, Ms Corbin indicated that a key priority for ACCAN was the implementation of the proposed telecommunications reform package, which had lapsed in Parliament several times. This would see NBN Co as the infrastructure provider of last resort. Currently, there is no guarantee of broadband availability (defined as 25 Mbps and above). The Department of Communications had determined to continue the current USO for telephony and payphones to 2032. ACCAN believes that a better long-term Universal Service Guarantee including broadband access is required. Ms Corbin foreshadowed that there would be significant debate in the development of this Guarantee.

Ms Corbin has expanded on her speech in a more detailed article, published elsewhere in this issue (Corbin, 2019).

Chris Wilson: Australian digital inclusion

Dr Chris Wilson described what could be learnt about the impact of fixed (NBN) and mobile broadband infrastructure development on digital inclusion from the Australian Digital Inclusion Index (ADII). The ADII can be used to track the nature and level of digital inclusion in Australia from 2014 to 2019.

The ADII looks at three aspects of digital inclusion: access, affordability and digital ability. Overall Index scores have been steadily rising, from 54.0 points in 2014 to 61.9 points in 2019. This rise has been primarily driven by improved access (underpinned by public uptake of broadband services and increased data allowances). Dr Wilson suggested that the effect of the NBN on digital inclusion has been threefold: firstly, notwithstanding specific cases of poor performance and consumer complaints, the NBN provides a higher quality broadband service than most pre-NBN alternatives; secondly, it has encouraged some people to take-up home broadband services; and, thirdly, in forcing the transition of households from legacy broadband plans, it has contributed to a rise in the average data allowances available to households.

The period 2017-2018 was a particularly interesting year in Tasmania, where there was a surge in NBN take-up, from about 30% of the population to nearly 60%. This corresponded with the completion of the Tasmanian NBN rollout and the closing of the 18-month legacy network switch-off window in many Tasmanian locations. As a result, the gap in overall ADII scores between Tasmania and the rest of Australia was reduced, but the gap has not been closed. Between 2018 and 2019, ADII results in Tasmania were flat, suggesting the beneficial impact of the NBN may be mainly a one-off.

While broadband infrastructure investments have improved some aspects of digital inclusion in Australia, Dr Wilson noted that substantial digital inequalities persist. ADII scores clearly track with socio-economic factors: for instance, rising with income and level of education and declining for those aged over 50. In many cases, the level of inequality is not falling. The digital inclusion gap between those aged 65+ and those aged 25-34 has widened slightly since 2014, while the gap between those in the top 20% income bracket and those in the bottom 20% has not changed. The gap between those with tertiary qualifications and those not completing high school has narrowed only slightly.

Affordability remains a key concern. Dr Wilson noted that, while the cost of data has fallen, people are spending more on internet services. The increase in expenditure has been greater than income growth, indicating that households now dedicate a higher proportion of their income to internet services. This is a substantial issue for those on low incomes.

A more detailed description of the Australian Digital Inclusion Index was published in a previous issue of this *Journal* (Wilson, Thomas & Barraket, 2019).

Murray Milner: New Zealand broadband market experience

Dr Murray Milner addressed the issue of what could be learnt from the New Zealand experience. He noted that the aim of the New Zealand Ultrafast Broadband (UFB) project was to provide 50 Mbps downstream or better to 99.8% of the population. Of this, 87% would be Fibre to the Premises (FTTP), with the remainder on wireless technologies. At June 2019, FTTP was at 78%. The target completion date is 2022.

Dr Milner noted that the take-up was market driven only, with no compulsion to change (unlike in Australia). Take-up, however, had been double expectations, with overall take-up being above 45% by 2018. UFB take-up in the top 10 towns and cities where the build was complete was all around 60%. Not even the experts predicted this level of take-up so quickly at the launch of the UFB initiative.

The product mix has also continued to evolve. A 50/20 (50 Mbps downstream; 20 Mbps upstream) offering has been available since 2015. The GPON-based 100/50 service, non-contended, has also been popular. Now, a 1000/500 service has been growing in popularity, from 3% of take-up in 2016 to 9% today. Chorus is currently testing a 10 Gbps service, prior to commercial release.

Retail offers have also continued to improve. A 1000 Mbps service now costs about NZD 100 per month, down from around NZD 150 at launch, with growth at 1% of connections each quarter.

Use cases also have continued to expand. There are now more than 2,000 schools with FTTP. For many small businesses, upload speed is a driver, with upload speeds of 50 Mbps or greater being required. Dr Milner highlighted one high-resolution design business that was able to be in a “lifestyle” location but whose designs, through high upload capability, could be sent to printers in the city where they were required.

Dr Milner suggested that a typical small business in New Zealand would now take a 200/200 symmetrical service; and a typical residential service would be 100/50. He reiterated, however, that 1 Gbps service was growing in popularity, now at almost 10% of take-up.

Bob James: Improving Australia’s broadband ranking

Mr Robert James examined the actions that would be required in order to improve the outcomes of the NBN project and to provide a sustainable, competitive path for the future. The current result had seen Australia slip down the fixed broadband rankings: Australia’s average download speed of 42.1 Mbps, as measured by Speedtest (2019), put it at 61st in the world. He suggested affordability of fixed broadband was poor and take-up uncertain. After an expenditure of about $50B, Australia would be worse off after completion of the NBN rollout than in 2009 when it began.

He noted that Australia was falling behind, with average speed growing at 30% per annum, while in the rest of the world the annual growth was 40%. Australia was far behind New Zealand (with an average download speed of 98 Mbps). He suggested that, to start to catch up, NBN Co should reduce the wholesale price of the 100 Mbps service to the 50 Mbps price and remove increases in wholesale usage charges. He agreed with the Telstra chairman’s reported remarks that, without the NBN, Australia would have had 100 Mbps service to much of the population by now through competition between telcos.

Mr James outlined the global broadband improvement model, which he characterized as: “Pay the same or less year by year; get more”. He gave the example of Telstra mobile broadband, in which the data component had increased by 10,000 times over 17 years at 12% lower cost (without accounting for inflation). He extrapolated that in 2023 $60 per month would buy a minimum of 500 GB and 160 Mbps wireless broadband. This change is achieved by reducing costs to grow earnings while revenues remain flat. He noted that, in Europe and North America, revenues from fixed broadband were flat or declining.

It was unrealistic, he suggested, for NBN Co to plan to raise wholesale prices until 2040 and beyond. He noted that a flat ARPU of $75 per month was needed to make a positive return. The chosen model of first matching existing prices and then increasing ARPU progressively to $100 at 2040, as outlined in the 2012-2015 plan, would handicap Australian adoption relative to other countries for the next 20 years. The underlying problem, he maintained, was that NBN Co had spent too much – twice the cost per premises than New Zealand and much more than others. He suggested that a plausible scenario would be that revenue would stall at a rate that would not allow a return on the government equity of $30B. If take-up in 2023 were lower by 10% and ARPU was held down at around 2019 figures by 4G and 5G competition, then revenues would not even cover the interest on NBN Co's loans of $20B.

He noted that, in the rest of the world, there was a convergence between fibre and wireless access to create a converged broadband service. A structurally separated fixed network was an architectural dead end.

Mr James considered that the government had changed the aims of the NBN project to just getting the initial rollout completed and minimizing the losses, without considering the impact on consumers and network investors. He urged the government to recommit to the consumer goals of fast, affordable broadband with high take-up. It would be necessary, he said, to end the financial misery by accepting write-downs on the value of NBN Co. In addition, he believed that NBN Co should be sold off as quickly as possible to limit the damage from an unsuitable architectural choice.

Questions and discussion

Questions and discussion from those attending in person and online followed the speeches.

The government and consumer institutions, such as banks, now prefer online communications. How can this be addressed?

> Ms Corbin noted that the current focus was on fixed broadband but that low-income families were choosing mobile broadband. There was already much government support for broadband: Ms Corbin cited the mobile blackspots program, the annual cost of the NBN, and the USO costs. For some users, such as those in rural communities or people with disabilities, online access may be preferred to face-to-face interaction. However, it was preferable to have a choice of face-to-face or online, something that Service NSW has now recognized.
>
> Dr Milner remarked that the alternative in New Zealand was that some institutions such as banks are paying for their customers to access online services; the end user pays nothing for usage and a low connection fee. There is essentially no charge for

http://doi.org/10.18080/jtde.v7n4.228

access to essential services by the end user. This approach is in its infancy but is showing positive trends.

Should a future USO mandate at least 50 Mbps downstream?

Ms Corbin thought it would be good to have but noted that Sky Muster does not support 50 Mbps downstream, so the service could not be universal.

The unpredictability of the growth of broadband has been mentioned. In Tasmania, there were high expectations of being able to be employed and stay in Tasmania to enjoy the lifestyle. Have expectations played an important role?

Dr Milner replied that expectations changed over time in New Zealand. The market changed dramatically as the rollout continued for both end users and investors. The expectations of investors in the UFB public-private partnerships have also changed, with the investors buying out the government in some locations as they recognized the return on investment that can be realised.

Mr James suggested there was an expectation on price. In Japan and Australia, the market moved from dial-up to DSL when the prices were the same and, in Japan, the market moved from DSL to fibre again when the prices were the same. He characterized it as a crazy world where NBN was forcing customers to pay more.

Dr Wilson noted that the rapid take-up in Tasmania had been caused by the switch-off of alternative access networks. Growth after the transition had not been maintained.

The price comparison should not be between DSL alone and broadband but DSL plus telephone, which cost about $60 per month, the same as current NBN-based retail plans. Comment?

Mr James considered that, at that price point, mobile broadband would take off in the market. Ms Corbin noted that customers on Sky Muster or Fixed Wireless were keeping their separate telephone connection if they could.

What is the one thing we have done wrong in Australia?

Ms Corbin suggested that it was moving first, ahead of the market. Dr Milner considered that a strength of the New Zealand case was the public-private partnership model of investment, which led to a learning environment, with tight control of incentives to perform. Then, the network provision can adapt as the market develops.

Even if a premium is allowed for the sparse geography of Australia, it seems that the government has invested too much in the NBN yet is unwilling to write down the value of NBN Co. This could be seen as a "Mexican standoff". Is this, at base, a political problem?

http://doi.org/10.18080/jtde.v7n4.228

Mr James agreed it was a political problem. The government has spent $50B because of a lack of initial cooperation from Telstra. In other cases, governments have leant on operators to get what they want. New Zealand spent about the upper limit of what should be spent per premises. The solution is to sell NBN Co so that the government is out of the market. However, a write-down of the value would be required and is not possible because of budget issues.

Dr Milner suggested that, without political interference, the market could develop and evolve over time. In New Zealand, the original plans included FTTP only for urban areas. However, as the rollout developed, this was extended to 87% of the population (from 75%) based solely on the economics of building, given that the wholesale service providers had learnt how to deploy the network at a reasonable cost per premises.

Ms Corbin remarked that Telstra did not initially put its best foot forward and then the major policy goal became the structural separation of Telstra. With the advent of the hung parliament, this became *very* political.

Was there an institutional model that was critical to success in New Zealand?

Dr Milner believed there were two critical factors: structural separation and competition. Telecom New Zealand had been operationally separated from 2006 but, when the UFB project was started, structural separation was required of participants. Thus, Chorus and Spark were created, permitting Chorus to access government support through a public-private partnership. There were three other wholesale providers, providing competition to Chorus, thus holding down the cost of provision. Any cost over-run was attributed to the wholesale providers, as the government contribution was fixed, which, combined with competition, provided a strong incentive for efficient deployment.

Gavin Williams, Executive General Manager, Products, at NBN Co, gave a speech at the recent ACCAN conference in which he addressed digital inclusion and, for example, connecting those with more transient lifestyles, such as renters. Can NBN Co be the company to do this?

Ms Corbin noted that NBN Co has created NBN Local to consult with communities. This is a recognition that NBN Co must understand the needs of end users. NBN Co has a role in understanding need, but it will require government to subsidize some users.

Dr Wilson remarked that switching off alternative access networks causes some people to miss out. If this caused exclusion of some identifiable groups, then it would not look good from a political point of view.

> Dr Milner described how the New Zealand government was finding innovative ways to pay for online access, for example by promoting clusters to grow around schools in low-income areas. This permitted customers to connect to schools and other institutions at low cost to the end users.

Could it be that two steps to improving the situation would be to stop turning off alternative access networks and to encourage others, such as hospitals and education institutions, to pay for broadband access for their clients?

> Ms Corbin considered that it was too late to change the turn-off provisions. Instead, competition with mobile broadband, as, for example, by what Optus is doing with 5G fixed wireless service, will be beneficial. She noted that in several States the Education Departments were helping to pay for Sky Muster in order to provide broadband connections for schools.

Closing remarks

Mr Burke invited the panellists to make some closing remarks.

Dr Milner noted that digital inclusion was a key theme in New Zealand. For example, to address the challenge of broadband access in regional and rural areas, the three retail mobile service providers had banded together to deploy shared cellular infrastructure. This was a way of reducing costs in low usage areas with challenging economics, while ensuring that coverage is still provided for all customers. This is an example of rational market behaviour given the right incentives.

Dr Wilson considered that the isolation of digital inclusion from digital transformation in the Australian government was a problem. In New Zealand, both aspects were the responsibility of one department. In Australia, health policy, for example, was not connected to telecommunications policy. A holistic approach was required.

Mr James suggested that satellite and fixed wireless were not good choices for fringe urban areas where they have their greatest application. They will not be competitive with mobile broadband in such areas. For uneconomic areas, one wireless network delivering both fixed and mobile services would have much better economics (as New Zealand chose with its Rural Broadband Initiative).

Ms Corbin noted that, with 50% of the rollout achieved already and completion of the NBN rollout in the next year (together with a further 18-month transition period), there would be a large changeover of customers in the near term. It is necessary to address the issue of affordability now. ACCAN modelling suggests that adding low-income customers at subsidised rates actually improves NBN Co's income.

http://doi.org/10.18080/jtde.v7n4.228

Conclusion

This was the second of a planned series of forums on the topic of the future of the NBN. There was general agreement that the current situation was not desirable nor sustainable. While the NBN has increased access to fixed broadband, affordability remains an issue, especially for low-income households, and the evident gaps in digital inclusion are not being closed.

The $50B cost of the NBN rollout has become a barrier to market development, with high wholesale prices discouraging both end-user take-up and commercial opportunities for retail service providers. Projected increases in ARPU to support returns to NBN Co would suppress demand and drive an increase in mobile-only households. Low-income households are already opting for mobile broadband, leading potentially to differences in digital inclusion.

A write-down of NBN Co value is politically unattractive but affordability can be addressed, at least in part, by other means. ACCAN has proposed a direct subsidy for broadband access for families receiving government income support. This could stimulate demand for fixed broadband, improving NBN Co's finances, while being revenue-neutral if a whole-of-government accounting approach were adopted. A significant reduction in wholesale prices would stimulate greater take-up but the actual price elasticity in the Australian market is uncertain.

The New Zealand experience suggests that, with appropriate wholesale and retail pricing, there would be developing demand for fixed broadband services with increasing speeds over time, including services at or above 1 Gbps. Upload speeds are also important for many small businesses. The market experience in New Zealand was not easily predicted but, rather, has evolved through natural end-user innovation, combined with market-based encouragement.

The initial aim of "building the NBN for all Australians" has not yet been achieved. As the transition to the NBN for fixed broadband reaches its final stages, change will be required but the final shape of this change has not yet been determined. TelSoc will organize future NBN Futures Forums to assist public discussion of issues related to the NBN and to help build consensus on the future changes that are required.

References

Campbell, L. H., & Milner, M. (2019). The NBN Futures Forum: Discussing the future ownership of Australia's National Broadband Network, *Journal of Telecommunications and the Digital Economy*, *7*(3), 1-9. https://doi.org/10.18080/jtde.v7n3.202

Corbin, T. (2019). Promoting Digital Inclusion Through the NBN, *Journal of Telecommunications and the Digital Economy*, *7*(4), 12-16. https://doi.org/10.18080/jtde.v7n4.236

Speedtest. (2019). Speedtest Global Index, Australia, September 2019. Available at: https://www.speedtest.net/global-index/australia

Wilson, C. K., Thomas, J., & Barraket, J. (2019). Measuring Digital Inequality in Australia: the Australian Digital Inclusion Index. *Journal of Telecommunications and the Digital Economy*, *7*(2), 102-120. https://doi.org/10.18080/jtde.v7n2.187

Promoting Digital Inclusion Through the NBN

Teresa Corbin
CEO, Australian Communications Consumer Action Network

Abstract:

This is the speech given by Ms Corbin at the TelSoc NBN Futures forum held in Melbourne on 22 October 2019. She spoke on how to include all Australians in the National Broadband Network through more affordable pricing of services, continued and improving reliability of access, and an evolution of the Universal Service Obligation.

Keywords: NBN, public policy, digital inclusion

Introduction

Before I begin, I would like to take this opportunity to acknowledge the traditional custodians of this land, the Wurundjeri peoples of the Kulin Nation, and pay my respects to the Elders past, present and emerging.

While life in telco could rarely be described as uneventful, the last few weeks have seen a number of shakeups that have ensured that telco issues remain at the forefront of the national conversation. From Telstra's fiery comments about the NBN (Letts, 2019) at their AGM, to the ACCC's newly announced inquiry into NBN access pricing (ACCC, 2019), there's been one question on everyone's lips: what is the future of the NBN? This ambitious national infrastructure project is nearing the end of its initial roll-out, but what does this mean for the everyday Australian?

This afternoon, I'd like to share ACCAN's perspective on this important issue by examining three key points:

- The future of NBN pricing;
- Ensuring reliability in telco services;
- The evolution of the Universal Service Obligation.

http://doi.org/10.18080/jtde.v7n4.236

The Future of NBN Pricing

We've seen the conversation around NBN pricing shift quite dramatically since the beginning of 2019. It is now a commonly accepted fact by industry, regulators and everyday Australians that NBN broadband is simply unaffordable for some people.

Just last month, the 2019 Australian Digital Inclusion Index (ADII) (Wilson, Thomas & Barraket, 2019) revealed that, while the cost of internet has decreased since 2014, the percentage of household income that is devoted to internet services has increased – up from 1.00% in 2014 to 1.18% in 2019. This is a serious red flag, especially considering that economic modelling (Breunig & McCarthy, 2019) shows that the more that a household spends on communications as a proportion of their income, the higher the likelihood that these households are experiencing financial stress. If this trend continues, we're going to see more and more Australian families facing financial stress as they struggle to find the funds to pay for this modern-day essential service. Despite aiming to 'connect Australia and bridge the digital divide [so that] Australians have access to fast broadband as soon as possible, at affordable prices, and at least cost' (NBN Co, 2016), the simple fact is that, if the affordability issues of the NBN are not addressed, we will see the digital divide between the connected and the unconnected in Australia deepen. The latest ABS data shows that over two and a half million Australians are not online (ABS, 2018); this is an issue not just for these individuals or their families, but for the nation. When we have a nation that is digitally divided, we are missing out on the full economic potential of the NBN: increasing average incomes, creating new businesses, and increasing tax revenues through higher economic activity, and reduced unemployment

Thankfully, NBN Co has acknowledged that there are issues with the affordability of their services. In September, they released a wholesale pricing review (NBN Co, 2019) which promised significant discounts from entry-level to high-speed wholesale tiers in an effort to lift take-up of NBN services. Significantly, this was the very first time that such a consultation paper has been made public. ACCAN has been calling for greater transparency from NBN Co on their consultation process for some time now, so this was a very welcome change. This new openness also means that we're able to share a few key take outs from our submission with you here this afternoon.

When it comes to NBN Co's proposed changes to the 12/1 Entry Level Bundle discount, ACCAN is supportive of NBN's efforts to refine the existing Entry Level Bundle pricing arrangements to allow it to be used as an alternative to ADSL services. However, we're concerned that the proposed structure of the service means that there won't be widespread take-up by RSPs. We're proposing that increasing the CVC inclusion for the Entry Level Bundle to 1 Mbps and

http://doi.org/10.18080/jtde.v7n4.236

setting an effective charge of $22.50 would make the service more feasible as a combined data and voice service.

We were pleased to see that our call for a concessional broadband product had been heard by NBN Co, as shown by the inclusion of a question in this consultation paper about targeted solutions for low income households.

We'd like to see NBN offer a reduction of $20 per month on a 50 Mbps service to households receiving financial support from government. We estimate that providing this concession to the 1 million plus households on the lowest incomes can be Federal budget neutral, and help to fulfil the initial vision of the NBN in closing the digital divide. We want consultation on this targeted solution to commence as soon as possible, with a view to implementing this new product, with funding allocated in the 2020 Federal Budget.

Ensuring Reliability in Telco Services

The issue of reliability is also an important piece of the puzzle when it comes to the future of the NBN. So much of the conversation around the NBN has focused on the end of the roll-out in 2020. But this date does not mark the beginning of the end; it marks the end of the beginning. It's important to remember that Australians will still have 18 months after the NBN arrives in their area to make the switchover. This means that we will need to ensure that there is a timeline and proper community consultation about the future of ADSL.

On hearing that I would be speaking with you today, one of our members actually reached out to share their story about their reliance on ADSL. The Wamboin Communications Action Group is a volunteer group located roughly 20 km east of the ACT. Most people in their area rely on ADSL. While some do use mobile broadband, they have many blackspots in the region. They find ADSL reliable and consistent; however, they say that those who have made the switch to the NBN services in their area (provided over SkyMuster) have no such reliability. With smaller data allowance, inconsistent and unpredictable speeds and considerably higher prices than other NBN solutions, these community members are frustrated and worried. They want to keep their ADSL service, rather than switch over to SkyMuster. It is these communities of families and small businesses that we must keep in mind beyond the 2020 deadline of the NBN rollout.

As NBN becomes entwined in our daily lives, it's vital that there are adequate safeguards in place to ensure that Australians are guaranteed reliable telecommunications services. One of the key priorities must be passing the Telecommunication Reform Package. This piece of legislation is due to be re-introduced to Parliament in the coming months after it lapsed at the end of the last sitting. This legislation would make NBN Co the default 'infrastructure provider

http://doi.org/10.18080/jtde.v7n4.236

of last resort' for all of Australia after the NBN is declared built and fully operational, and would bring with it a raft of important consumer protections – from having to offer a standard broadband service with peak speeds of at least 25 Mbps download and 5 Mbps upload, to supporting voice services for consumers on fixed-line and fixed wireless networks. The Telecommunication Reform Package would also allow the Minister for Communications to make standards, rules and benchmarks that could set out more detailed requirements, such as timeframes for providing access and rectifying faults. These are key powers to ensure that consumers are guaranteed access to reliable communications through the NBN.

The Telecommunication Reform Package also includes a provision to establish a Regional Broadband Scheme (RBS) to ensure there are long-term sustainable funding arrangements in place to provide broadband services to Australians in regional and remote areas. In our work with the Regional, Rural and Remote Communications Coalition, we know that there is still much work to be done in connecting our regions.

The latest ADII report showed that despite improvements in access to connectivity, those outside of our metropolitan areas are still less likely to be digitally included than their city counterparts. Without affordable, reliable communications, the digital divide between city and country will only deepen.

The Evolution of the Universal Service Obligation

Finally this afternoon, I'd like to quickly discuss the Universal Service Obligation and how this needs to evolve in a post-NBN-rollout Australia.

Currently, Telstra is contracted to ensure everyone has access to a standard voice service regardless of where they live or work. This is very important for consumers and businesses across the country, as it means they can take advantage of safeguards included under the agreement, including 24-hour free access to emergency service numbers, access to the Customer Service Guarantee (CSG), and priority assistance.

In November last year, the Department of Communications and the Arts released a report into Development of the Universal Service Guarantee (USG) (Communications, 2018) – an evolution of the USO for a post-NBN-rollout world. One of the key conclusions of this report found that, while the existing USO contract should continue until 2032 for voice services and payphones, we need to consider a better long-term USG model.

At the moment, Telstra supports approximately 235,000 ADSL broadband customers on their network outside the NBN fixed-line footprint. If Telstra were to decommission its copper network, NBN Co would need to invest in additional capacity in their fixed wireless and satellite networks in order to service these additional customers. This is a significant number

http://doi.org/10.18080/jtde.v7n4.236

of services to consider, and it is important that these consumers are not left behind. Further planning is needed by the Government and relevant stakeholders to ensure that Australians across the country are guaranteed robust voice services and access to broadband moving forward.

Conclusion

We will not be short of new challenges to face in the future. The telco industry has a strong responsibility to ensure that consumers are not mis-sold new technologies and that reliability and affordability for consumers are kept at the heart of our conversations.

References

ABS [Australian Bureau of Statistics]. (2018). Household Use of Information Technology 2016-17. Available at https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8146.02016-17?OpenDocument

ACCC [Australian Competition & Consumer Commission]. (2019). Inquiry into NBN access pricing, *Discussion Paper*, 14 October. Available at https://www.accc.gov.au/regulated-infrastructure/communications/national-broadband-network-nbn/inquiry-into-nbn-access-pricing

Breunig, R. & McCarthy, O. (2019). Household telecommunications expenditure in Australia, Telecommunications Policy, July. https://doi.org/10.1016/j.telpol.2019.101837

Communications & the Arts, Department of. (2018). Development of the Universal Service Guarantee, Summary Report, November. Available at https://www.communications.gov.au/documents/development-universal-service-guarantee-summary-report

Letts, S. (2019). Telstra chair savages NBN as unfair monopoly sending retailers broke, *ABC News*, online, 15 October. Available at https://www.abc.net.au/news/2019-10-15/telstra-chair-savages-nbn-as-unfair-and-a-waste-of-resources/11603756

NBN Co. (2016). About NBN Co, NBN Co online, 24 August. Available at https://www.nbnco.com.au/corporate-information/about-nbn-co

NBN Co. (2019). NBN Co confirms new wholesale discounts and annual data capacity increases to meet customer demand, NBN Co online, 26 November. Available at https://www.nbnco.com.au/corporate-information/media-centre/media-statements/nbn-confirms-new-wholesale-discount

Wilson, C. K., Thomas, J. & Barraket, J. (2019). Measuring Digital Inequality in Australia: the Australian Digital Inclusion Index, *Journal of Telecommunications and the Digital Economy*, *7*(2), 102-120. https://doi.org/10.18080/jtde.v7n2.187

Competition and Mobile Network Operator's Investment Relationship: A Firm Level Empirical Evidence for Developing Countries

Kasmad Ariansyah
R&D Center for Posts and Informatics, MCIT, Indonesia

Chaikal Nuryakin
Faculty of Economics and Business, Universitas Indonesia, Indonesia

Abstract: Policymakers have reformed the telecommunications market structure for several decades, from a monopoly to a more competitive market. They believed that the competitive market structure would be able to overcome the limitations of investment required to develop the industry and to provide equitable access. However, the advance of mobile broadband technology has triggered the emergence and proliferation of over-the-top (OTT) services that have considerably changed the competition landscape. First, in addition to acting as new competitors, the availability of OTT services also helps Mobile Network Operators (MNOs) to acquire more subscribers. Second, the competition has broadened to cross geographical boundaries. This paper aims to investigate the effect of the competition intensity on MNOs' investment behaviour in the most recent context and focus only on MNOs in developing countries. The results show that competition intensity and MNO's investment behaviour have an inverted U-shaped relationship with a turning point of 0.61. This points to the existence of competition intensity that maximizes the MNO's investment. The empirical results also show the cumulative impact of the competition intensity on investment is 12.5 times of the immediate impact.

Keywords: Competition intensity, Investment, Mobile Network Operator, Digital age

Introduction

The reform of the telecommunications market structure, from a monopoly to a pro-competitive market structure, began almost four decades ago. This reform was based on the premise that competition can encourage investment and innovation (Lestage *et al.*, 2013).

However, the introduction and the fast advancement of mobile broadband technology has triggered the emergence and proliferation of over-the-top (OTT) services that considerably changed the competition landscape in several ways. First, OTT service providers act as new competitors for MNOs, since they offer substitutions for conventional voice and message services. In this case, the OTT service providers have the same effect as existing competitors (other MNOs), i.e., threaten an MNO's revenue. However, OTT service providers are different in that they also provide advantages for MNOs by enriching existing services offered to the MNO's consumers. This helps MNOs to acquire new consumers as well as to encourage existing consumers to consume more bandwidth, which means more revenue for MNOs (Bilbil, 2018; Sujata *et al.*, 2015). Second, the broadband technology also has broadened the competition field, fading geographical boundaries. OTT service providers can serve their consumers from any location in the world and harm MNOs' profitability. Their services present to the MNO's consumers as soon as the MNO launches its own broadband services.

At the same time, MNOs are encouraged to sustainably improve their network performance. As predicted by Cisco, there will be a threefold IP-based traffic increase in the period 2017 to 2022 and is expected to keep increasing (Cisco, 2018), requiring higher network capacity. In addition, future applications such as smart grids, intelligent transportation, disaster emergency, tele-health, industry 4.0-based production systems, etc., require higher reliability as well as higher security levels of the networks. The networks are also required to be able to serve not only humans but also a large number of objects, which will amount to around 25 billion by 2025 (GSMA, 2018). To meet those requirements, MNOs are required to innovate and invest sustainably.

The change in the competitive landscape, as well as the increase of the demand for investment, must be taken seriously. The failure to define proper competition policy could lead to the inability to encourage MNOs to invest in their networks continuously. Further, it will cause failure in providing required network performance. As the role of the communication network is increasingly substantial in the digital age (GSMA, 2016; WEForum, 2017), it is difficult to grasp any opportunity offered at this age.

Unfortunately, there are different theoretical views on the competition and investment relationship. A sceptical view from Schumpeter (1942) states that there are many situations where a concentrated market structure is an optimal market structure. The first reason is the economic scale of the market causes the market to consist of only a few companies. The second and most important reason is the desire of companies to occupy a monopoly position in the future, so that encourages them to invest or innovate today (Schumpeter, 1942). In other words, because a monopolist is a price maker, they have large enough financial reserves and financial adequacy to keep investing. On the contrary, Arrow (1962) has conveyed the opposite view. According to him, a company in a competitive market has a greater tendency to innovate than a monopolist. This phenomenon is called an escape-competition effect. This effect is related to the profits obtained by a company in the competitive market when the company becomes a pioneer in new technology (Arrow, 1962). We can also view the Arrow effect as a replacement effect, namely a low incentive for monopoly companies to replace old technology with new ones because of the profitability of current technology (Tirole, 1988). Similarly, previous works also found diverse findings. Some of them focused on the fixed network broadband market. A study by Grajek and Röller (2009) found that competition caused by regulations requiring incumbent companies to share access with new entrants had a negative impact on investment. Bacache, Bourreau, and Gaudin (2014) concluded that access regulation did not have a significant impact on the investment of new entrants to the fixed broadband market. Meanwhile, in the mobile telecommunications industry, most of them focus on competition and investment relationships in developed countries (Elixmann *et al.*, 2015; Garrone & Zaccagnino, 2015; Jeanjean & Houngbonon, 2017; Lestage *et al.*, 2013). Although there are several studies on developing countries, such as those conducted by Kang *et al.* (2012) and Mutinda (2016), they focused on the industry level. The study on the industry level is only appropriate if the objective of competition policy is the industry performance in general. However, in this case, it will be difficult to define a more detailed strategy to increase or decrease competition intensity. For example, if a policymaker intends to decrease the competition intensity through company consolidation, the policymaker does not have enough information on which companies should be encouraged to consolidate. Another study by Houngbonon & Jeanjean (2016) has scrutinized the competition-investment relationship on the firm level for developed as well as developing countries. However, their findings only reflect the relationship for MNOs with positive earnings before interest, tax, depreciation, amortization (EBITDA) margin. Therefore, the present study tries to fill the gaps by analyzing the firm-level data and including not only MNOs with positive EBITDA margin but also those with negative EBITDA margin. In addition, this study only focuses on developing countries as these countries rely more on mobile networks than developed countries (ITU, 2017).

Method

Data

The data consists of the following: i.) total capital expenditure, Ebitda margin, and cashflow of MNOs obtained from the Thomson Reuters database; ii) GDP per capita and population figures from the World Bank; iii) the penetration rate of fixed broadband services from the International Telecommunication Union (ITU); and iv) check and balance and stability as proxy of political institutions obtained from the Inter-American Development Bank (IADB). Some data is only available annually, so that the quarterly period in the same year is averaged, under the assumption that it is constant throughout the year. Financial report data is at the company level, while other data is at the country level, so that companies residing in the same country will have the same value.

Sample

The sample consists of MNOs operating in developing countries, with the exclusion of virtual operators (MVNOs). Twenty-three MNOs from the following developing countries were selected: 1 from India; 3 from Thailand, 1 from Mexico, 3 from Malaysia, 2 from Egypt, 2 from Philippines, 4 from Indonesia, 1 from Bangladesh, 2 from Turkey, 1 from Kazakhstan, 1 from Sri Lanka, 1 from Russia and 1 from Sudan. The data form panel data with a maximum time span starting from quarter 1 in 2009 to quarter 4 in 2017.

Empirical model

The empirical model illustrates the relationship between MNO's investment and the intensity of competition experienced by the MNO. The basic model in this study is presented in equation (1). The hypothesis is that there is coexistence between the Schumpeter effect and the Arrow effect, which causes a nonlinear relationship between competition and investment. This relationship can be in the form of an inverted U curve as shown by Aghion *et al.* (2005) or U-shaped as shown by Sacco & Schmutzler (2011).

$$I_{it} = \mathrm{f}(I_{i(t-1)}, \Phi_{it}, \Phi_{it}^2) \quad (1)$$

I_{it} is the dependent variable, i.e. investment of operator i in period t. It is measured by the accumulated expenditures of fixed assets and expenditure on intangible assets of operator i in quarter t. $I_{i(t-1)}$ is operator investment i in the previous period *(t-1)*. The reason for the inclusion of $I_{i(t-1)}$ in the model is because: (1) adjustments to capital expenditure occur slowly in response to changes in other factors; (2) MNOs are likely to have a long-term investment plan: therefore there is a possibility of investment dependence between periods (Frontier, 2015). Another reason for using this lagged dependent variable is the possibility of the gradual impact of an independent variable on the dependent variable (Lestage *et al.*, 2013). It is possible to include a larger lag. However, several similar studies confirm that investment does not depend on a larger lag (Alesina *et al.*, 2005). Φ and Φ^2 are competition and square of competition variables. The level of competition is measured based on the Lerner index. According to Aghion *et al.* (2005), the Lerner index is better at measuring the level of competition compared to the market share or Herfindahl-Hirschman Index (HHI) because both are very dependent on the accuracy of geographical and product definitions that are very difficult to do, especially in the digital age where data and information flows are no longer limited by geographical boundaries. This makes market concentration that is only measured by data in one region or country susceptible to bias. The Lerner index of a company is the ratio of the gap of product price (P) and marginal cost (MC) to the price of the product (P) (Pindyck & Rubinfeld, 2013). Companies with higher competitiveness have better ability to minimize costs (C) and to determine the selling price (P) of their products so that they can maximize revenue. Because the Lerner index is calculated based on corporate financial data, it is more flexible to use since every change in the competition intensity, whoever causes the change (including by the emergence of the OTT), will be reflected in the corporate financials. Theoretically, the Lerner index, denoted by L, ranges from 0 to 1. If L is equal to 0, the company is operating in a perfectly competitive market where P = MC. L value of 1 indicates that the company has a high market power. P and MC are difficult to obtain. Therefore, service prices (P) are replaced by revenue, while marginal cost (MC) is replaced by total operational cost. Revenue is an accumulation of the selling of voice, data, roaming, international calls, and interconnection services. The difference between revenue and marginal cost is called Earnings before interest, tax, depreciation and amortization (EBITDA). Therefore, the intensity of competition can be calculated by equation (2).

$$\Phi_{it} = 1 - \frac{ebitda_{it}}{revenue_{it}} = 1 - EBITDA\,margin \tag{2}$$

Estimation strategy

The use of lagged investment variables as one of the explanatory variables in the panel data structure is a characteristic of dynamic panel data. The best way to overcome the bias in a dynamic panel is to use least square dummy variable (LSDV) estimation (Kiviet, 1995). However, we cannot apply this approach to an unbalanced data panel. Besides, LSDV cannot overcome the problem of endogeneity (Roodman, 2009). A variable is said to be endogenous if the value of the variable is determined in the context of an econometric model. Endogeneity also describes a condition in which one or several variables have a relationship with the error term (Wooldridge, 2002). This study uses a dynamic panel model with unbalanced data panels and there is a possibility of simultaneity bias of competition and lagged investments to the contemporaneous investment, so that LSDV estimation is not appropriate to be applied in this study.

According to Wooldridge (2002), there are three causes of endogeneity, namely: 1) omitted variable bias; 2) measurement error; and 3) the possibility of a two-way relationship between independent variables and the dependent variable (simultaneity). The existence of these biases in the model causes inconsistency of estimation results and inaccuracy of conclusions. This study takes several anticipatory steps to minimize these biases as follows.

1) omitted variables bias

We mitigate this bias by including several control variables into the basic econometric model. The addition of control variables into the base model can also be useful as a robustness check (Lu & White, 2014). Equation 3 is the complete model after the inclusion of control variables.

$$I_{it} = \beta_0 + \beta_1 \Phi_{it} + \beta_2 \Phi_{it}^2 + \gamma I_{i(t-1)} + \sum_{n=1}^{N} \vartheta_n X_{nit} + \varepsilon_{it} \quad (3)$$

$\beta_0, \beta_1, \beta_2, \gamma$ and ϑ_n are the parameters to be estimated, and ε_{it} is a random error with zero mean and constant variance that satisfies the classical assumptions of homoskedasticity and the absence of serial correlation. X is a vector of control variables; n points to the nth control variable. N is the number of control variables. The control variables in this study consisted of operator cash flow in the previous period, the number of the population, gross domestic product (GDP) per capita, political institutions, and time effects. Positive cash flow is one of the company's financing sources that can be used to finance investment projects, especially in the case of capital market imperfections and asymmetric information (Garrone & Zaccagnino, 2015). Although in fact some or all investment projects are debt-funded, high cash flows illustrate the company's ability to pay the debt instalments. The population and GDP per capita illustrate the market size and market demand. Logically, large markets offer higher profit opportunities that encourage companies to innovate and to invest so that they can attract more potential customers. According to Dixit & Pindyck (1994), uncertainty is one of the characteristics of an investment project, and poor political institutions are one of the causes of uncertainty. Poor political institutions will discourage companies to invest, as the government may arbitrarily change current policies and cause losses to the investor (Stasavage, 2002). This explains the importance of good political institutions, which are characterized by the existence of checks and balances in fostering a conducive climate for investment (North & Weingast, 1989). This study also includes political stability variables that illustrate the change in power in a political system. The time effect serves to capture the possibility of investment trends in addition to capturing the effects of the adoption of new technology. Dummy variables for quarter and year are used to capture the time effects. Each dummy variable has value of 1 in the corresponding quarter or year and 0 for the others. To avoid collinearity, we do not include the first quarter and the first year in the model and treat them as reference variables.

2) measurement error

A measurement error problem occurs when an independent variable is clearly defined, but the data used as a measure of the variable contains errors (Wooldridge, 2002). In this study it is very difficult to avoid measurement errors considering the use of secondary data. It is difficult to obtain access to primary data to validate the data.

3) simultaneity

In practice, researchers often overcome simultaneity by replacing an endogenous variable with its lagged variable. This will, however, not be able to eliminate the bias. Alternatively, lagged endogenous variables are used as instrument variables in two-stage least square estimate (2SLS), in generalized method of moments (GMM) estimate, or in limited information maximum likelihood (LIML) estimate (Reed, 2015). According to Hansen, 2SLS has a weakness compared to GMM especially when heteroscedasticity and autocorrelation problems exist (Hansen, Heaton & Yaron, 1996). Likewise, LIML requires homoscedasticity (Baum, Schaffer & Stillman, 2003). Therefore, the Generalized Method of Moments (GMM) is considered as the most suitable approach for this study. In addition to its ability to handle dynamic panel data, GMM also has the ability to overcome endogenous problems by using lagged variables as instrument variables (Cameron & Trivedi, 2005). A good instrument variable is able to meet the requirements of validity and strength. An instrument is valid if it does not have a correlation with errors, while its strength is measured by how strong the relationship is with its endogenous variable. To avoid the possibility of correlation between the first lagged variable (*t-1*) with errors, this study uses the second lagged variable (*t-2*) as the instrument variable of each endogenous variable.

Results and Discussions

Descriptive statistics

Table 1 shows descriptive statistics of the variables used in the estimation. Investment ranges from 0.014 billion USD to 4.7 billion USD. The range is quite large and usually relates to a company's market size. As discussed in the methodology, this study uses EBITDA margin as a measure of the Lerner index (L). Theoretically, the Lerner index ranges between 0 and 1. However, as presented in Table 1, 1-Lerner has a maximum value of 1.967 which means there are Lerner indexes, represented by EBITDA margin, that are less than 0. This is an indication that the company's total income is unable to cover the company's operating costs.

Table 1. Descriptive statistics

Variables	Observations	Means	Std Dev	Min	Max
Investment (billion USD)	814	284.225	504.191	0.014	4,746.9
(1-Lerner)	814	0.635	0.178	0.004	1.967
$(1\text{-Lerner})^2$	814	0.435	0.331	0.000	3.869
Cashflow (million USD)	814	0.004	0.593	-6.620	6.769
Population (million)	814	159	253	16.800	1,340

Variables	Observations	Means	Std Dev	Min	Max
GDP per capita (USD)	814	5,783.14	3883.88	726	14,936
Stability	814	0.118	0.237	0	1
Check and balance	814	3.091	1.451	1	17
Fixed broadband subscribers (million)	814	5,288	5,448	0	31,100
Quarter	814			Q1 2009	Q4 2017

Source: Thomson Reuters (2019), ITU-D (2019), IADB (Scartascini, Cruz & Keefer, 2018), and World Bank (2019b, 2019a)

Estimation results

In the estimation process, several variables are converted to logarithmic values. This aims to reduce the bias caused by heteroscedasticity. To avoid error and negative values, logarithmic operation is only applied to variables having values that are positive, continuous, and more than 1. Therefore, cash flow, 1-Lerner, and dummy variables are excluded from the conversion. This study uses GMM estimation method with instrument variables (IV GMM) to confirm the causal relationship between the intensity of competition and the investment behaviour of MNOs. This study only uses internal instrument variables, namely the two-period lagged variables (*t-2*) of $I_{(t-1)}$, Φ_t and Φ_t^2. According to Reed (2015), internal instruments are capable of providing consistent and valid estimation results.

We carry out a robustness check to test the estimation consistency by modifying the basic model specification by adding one or several independent variables (Lu & White, 2014). In this study, the robustness check is done by developing 6 model specifications. Model specification 1 is the basic model, which only consists of the main variables, while model specification 6 is the most complex model. The results of each model specification are then compared with each other to see the consistency of the sign, the significance level and coefficients of the competition intensity (Φ_t), the square of the competition intensity (Φ_t^2), and the lagged investment variable ($I_{(t-1)}$). Table 2 displays the estimation results of all models.

Before looking further at the estimation results, it is necessary to first look at the level of validity and the strength of the instrument variables. The non-existence or weak correlation between the instruments and idiosyncratic error indicates the validity of the instruments (Murray, 2006). The Sargan and Hansen tests are generally used to test the validity of an instrument variable. Both tests have a null hypothesis that the instrument is valid. Table 2 shows all p-values of the two tests are higher than 0.05, so that we cannot reject the null hypothesis: i.e. all instrument variables are valid. In addition to the Sargan and Hansen tests, Arrelano and Bond also developed another test to detect the validity of internal instrument variables, i.e. the autocorrelation test on idiosyncratic errors (Roodman, 2009). An estimation result that uses lagged variables as the instrument will lose its consistency when its errors are serially correlated (Arellano & Bond, 1991). In this test, the lagged variable is considered to be a valid instrument if it does not cause serial correlation on idiosyncratic errors. Because this study uses 2-period lagged variables as instrument variables, the autocorrelation test is carried out in order of 2, AR(2). The results show that the six models have p-values of AR(2) higher than 0.05. These indicate the absence of serial correlation on idiosyncratic errors. The next test is to examine the strength of the instruments. We perform this test by looking at the correlation between endogenous variables each with their instrument. The test results show that all internal instrument variables have a significance level of 1%. From all tests, we conclude that all instrument variables are valid and highly correlated with each endogenous variable.

The estimation results in Table 1 show that the variables of interest as a whole have a fairly good level of consistency in terms of significance, sign, and coefficient. In all model specifications, the lagged investment variable ($I_{(t-1)}$) is statistically significant at the level of 1% and 5% with a coefficient value of 0.791 in the model specification 2 and 0.921 in the model specification 6. Similarly, the estimation results of competition intensity (Φ) and the square of competition intensity (Φ^2) are also consistent. The variable Φ has significance levels that vary between 5% and 10%, while significant levels of Φ^2 are consistent at the 5%. However, Φ and Φ^2 consistently show the opposite sign, i.e., positive and negative, respectively. Φ has values that vary between 8.28 in the specification model 4 and 12.43 in the model specification 5. Meanwhile, the coefficients of Φ^2 are in the range of -7.030 in the model specification 4 to -9.543 in the model specification 6. Some control variables are also empirically proved to have a significant effect on investment, which can be seen from the significance level, which varies from 1% to 10%. Those variables are log of population, political stability and quarterly time effects.

Table 2. Estimates

	Model specification					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variable of interest						
Log $I_{(t-1)}$	0.811***	0.791***	0.801***	0.788***	0.860***	0.921**
	(0.144)	(0.157)	(0.173)	(0.182)	(0.182)	(0.430)
Φ	10.08**	10.14**	8.785**	8.280*	12.43**	11.64*
	(4.786)	(4.431)	(4.122)	(4.489)	(5.550)	(6.682)
Φ^2	-7.864**	-7.956**	-7.320**	-7.030**	-9.184**	-9.543**
	(3.059)	(2.917)	(2.779)	(3.058)	(3.487)	(4.492)
Control variables						
Cashflow $_{(t-1)}$		-0.443	-0.415	-0.382	-0.212	-0.0080
		(0.515)	(0.478)	(0.409)	(0.493)	(0.124)
Log of population			0.245*	0.261**	0.410***	0.359*
			(0.124)	(0.122)	(0.140)	(0.175)
Log of GDP per capita			0.111	0.138	0.302***	0.252
			(0.160)	(0.168)	(0.0944)	(0.189)

	Model specification					
	(1)	(2)	(3)	(4)	(5)	(6)
Stability				0.261*	0.322***	0.330**
				(0.143)	(0.0960)	(0.158)
Check and balance				-0.0310	-0.0338	-0.0904
				(0.0324)	(0.0324)	(0.0784)
Log FBB subscribers					-0.175	-0.139
					(0.128)	(0.187)
Quarter 2						0.634*
						(0.315)
Quarter 3						0.502**
						(0.228)
Quarter 4						0.872**
						(0.320)
Year effect						√
Constants	0.530	0.908	-4.108**	-4.130**	-8.660***	-8.428**
	(2.085)	(2.054)	(1.584)	(1.769)	(2.995)	(4.064)
N	783	783	783	783	783	783
F test (p-val)	0.000	0.000	0.000	0.000	0.000	0.000
AR2 (p-val)	0.444	0.430	0.417	0.407	0.528	0.782
Hansen-J (p-val)						
Log $I_{(t-3)}$	0.886	0.946	0.936	0.934	0.891	1.000
$\Phi_{(t-2)}$	0.896	0.957	0.916	0.948	0.834	1.000
$\Phi^2_{(t-2)}$	0.865	0.978	0.957	0.984	0.761	1.000
Sargan (p-val)	0.978	0.998	0.998	0.999	0.998	0.462

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Short-run effect (SRE) of competition on investment

Model specification 6 is the most complex. It has the most control variables so as to minimize omitted variable bias. We will use this model specification in the further discussions. Refer to equation (3), $\beta 1$ and $\beta 2$ are coefficients of competition intensity and square of competition intensity variables. According to model specification 6, they have values of 11.64 and -9.543, respectively. The short-run effect of an independent variable on the dependent variable is the partial derivative of an estimation against the independent variable (Gujarati, 2003). Thus, the short-run effect (SRE) of competition on investment is a partial derivative of the estimation of investment against competition. Equation (4) is a mathematical expression of the relationship.

$$SRE(\Phi) = \frac{dE(I)}{d\Phi} = \beta_1 + 2\beta_2\Phi = 10.64 - 19.086\Phi \quad (4)$$

The SRE is essentially the marginal effect of the change in the competition intensity on investment. As we observe in equation (4), SRE contains Φ, which means the marginal effect of competition on investment is not linear but depends on the competition level experienced by a company.

Investment maximizing by competition intensity

The difference in the sign between the coefficient of competition variable ($\beta 1$) and the coefficient of square competition variable ($\beta 2$), where $\beta 1$ is positive and $\beta 2$ is negative, indicates a nonlinear relationship between the intensity of competition and investment of an MNO. A quadratic function with a negative quadratic coefficient implies the relationship is inverted-U shaped. In addition to showing nonlinearities, the estimation results also indicate the existence of a point of competition intensity that maximizes investment. We can obtain the value of the point by setting the right-hand side of equation (4) to zero, and we get Φ equal to 0.61. Because competition intensity equals 1-EBITDA margin, the value is equivalent to EBITDA margin of 0.39 or 39%. The interpretation is that initially the increase of competition intensity will encourage MNOs to keep investing. This condition holds until the intensity reaches a point of 0.61 or EBITDA margin at the level of 39%. After this point, MNOs respond negatively to the increase in competition by reducing their level of investment.

Long-run effect (LRE) of competition on investment

Referring to the specification of model 6, the lagged investment variable ($I_{(t-1)}$) has a coefficient of 0.921 and is significant at the level of 1%. The coefficient is less than 1 and more than 0. This implies the adjustment of an investment converges over times. We can use equation 5 to obtain the long-run effect (LRE) and we find that the cumulative impact of competition on investment is 12.5 times that of the short-run.

$$LRE(\Phi) = \frac{1}{(1-\gamma)} SRE(\Phi) = \frac{1}{(1-0.921)} SRE(\Phi) = 12.5\, SRE(\Phi) \quad (5)$$

Discussion

Overall, the findings indicate the coexistence of an escape-competition effect (Arrow Effect) and Schumpeter effect. The escape-competition effect is an attempt by a company to get out of the competition by investing or innovating. In the empirical results above, this effect is shown by companies that experience competition intensity of less than 0.61 or have an EBITDA margin of more than 0.39 (as competition intensity equals 1-EBITDA margin) or 39%. Those companies respond to intense competition by increasing their investment. Meanwhile, the Schumpeter effect is presented by companies having an EBITDA margin of less than 39%. This group faces budget constraints, so that an increase in competition will drive them to reduce their investment.

The findings of this study are in line with that of a study by Mutinda (2016). Mutinda (2016) carried out a study on developing countries at the industry level and used the Herfindahl-

Hirschman Index (HHI) as a measure of competition intensity. The author found an inverted U-curve relationship between competition and investment. Thus, we can conclude that studies at the firm level and at the industry level provide relatively the same results.

The results of this study also complement the study results of Houngbonon & Jeanjean (2016) in two ways. First, Houngbonon & Jeanjean (2016) only included MNOs with positive EBITDA margin, while this study also includes MNOs with negative EBITDA margin. Second, the Houngbonon & Jeanjean (2016) study covers the period 2005 to 2012, when mobile networks were dominated by 2G and 3G technology with very small 4G penetration (eMarketer, 2018). Meanwhile, this study encompasses the period 2009 to 2017. In this time span, mobile broadband technology, as an enabler for OTT services, increased sharply from teledensity of 3 to 53.3 (ITU, 2018), which is expected to give higher and different pressure of competition to the MNOs. However, empirically, the findings of this study and that of Houngbonon & Jeanjean (2016) are very similar, especially in terms of short-run impact. Houngbonon & Jeanjean (2016) also found an inverted U-curve relationship between competition and investment. The EBITDA margin that maximizes investment in this study is in the range obtained in the study of Houngbonon & Jeanjean (2016), which is 37%-40%. This signifies consistent investment behaviour from telecommunications companies in responding to changes in competition intensity. Technological developments do not necessarily change their short-run investment behaviour. However, there is considerably different behaviour of investment in the long run. While Houngbonon & Jeanjean (2016) found the cumulative long-run impact of competition on investment was 3-4 times the short-run, this study finds the impact increases to 12.5 times. This finding is inseparable from the increasingly important role of MNOs in the digital era, which drives mobile network operators to have much longer investment plans than before (GSMA, 2016; WEForum, 2017). Although the digital era causes the massive emergence of OTT service providers that pose threats to MNOs' profitability, as some of them offer substitutions for conventional communication services, the digital era also offers new opportunities in the future. Another justification is that the greater network burden, which is caused by the proliferation of OTT services in the 4G era, has forced telecommunication companies to develop longer-term strategy.

Conclusion

The estimation results show that the intensity of competition has a significant short-run effect on an MNO's investment behaviour. The effect is not linear, but it forms an inverted U curve, which indicates the existence of competition intensity that maximizes investment. We found that the intensity is at the level of 0.61 or when a company has an EBITDA margin of 0.39 or 39%. It means there is a different investment behaviour between companies having EBITDA

http://doi.org/10.18080/jtde.v7n4.205

margins of less than and more than 39% in response to the change in competition intensity. Those whose margin is less than 39% respond to an increase in the competition intensity by reducing their investment. Meanwhile, operators with an EBITDA margin of more than 39% respond in the opposite way. The empirical results also show the cumulative impact of the intensity of competition on investment in the long-run is 12.5 times of the short-run. These results in some respects have shown very similar results as previous works, especially for short-run impact.

Acknowledgements

The authors gratefully appreciate the financial support from Human Resources Research and Development Agency, Ministry of Communication and Informatics of the Republic of Indonesia. The authors also thank Vid Adrison, Ph.D., and Muhammad Hanri, Ph.D., for useful discussion and helpful comments on this paper. Last but not least, the authors also thank the anonymous reviewers for very valuable comments.

References

Aghion, P., Bloom, N., Blundell, R., Griffith, R., & Howitt, P. (2005). Competition and Innovation: An Inverted-U Relationship. *The Quarterly Journal of Economics*, *120*(2), 701–728.

Alesina, A., Ardagna, S., Nicoletti, G., & Schiantarelli, F. (2005). Regulation and Investment. *Journal of the European Economic Association*, *3*(4), 791–825. https://doi.org/10.1162/1542476054430834

Arellano, M., & Bond, S. (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *The Review of Economic Studies*, *58*(2), 277. https://doi.org/10.2307/2297968

Arrow, K. (1962). *Economic Welfare and the Allocation of Resources for Invention* (pp. 609–626) [NBER Chapters]. Retrieved from National Bureau of Economic Research, Inc website: https://econpapers.repec.org/bookchap/nbrnberch/2144.htm

Bacache, M., Bourreau, M., & Gaudin, G. (2014). Dynamic Entry and Investment in New Infrastructures: Empirical Evidence from the Fixed Broadband Industry. *Review of Industrial Organization*, *44*(2), 179–209. Retrieved from JSTOR.

Baum, C. F., Schaffer, M. E., & Stillman, S. (2003). Instrumental Variables and GMM: Estimation and Testing. *The Stata Journal: Promoting Communications on Statistics and Stata*, *3*(1), 1–31. https://doi.org/10.1177/1536867X0300300101

Bilbil, E. T. (2018). Methodology for the Regulation of Over-the-top (OTT) Services: The Need of A Multi-dimensional Perspective. *International Journal of Economics and Financial Issues*, *8*(1), 101–110.

Cameron, A. C., & Trivedi, P. K. (2005). *Microeconometrics: methods and applications*. Cambridge ; New York: Cambridge University Press.

Cisco. (2018). Cisco Visual Networking Index: Forecast and Trends, 2017–2022, November. Retrieved February 19, 2019, from: https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white-paper-c11-741490.html

Dixit, A. K., & Pindyck, R. S. (1994). *Investment under uncertainty*. Retrieved from http://www.dawsonera.com/depp/reader/protected/external/AbstractView/S9781400830176

Elixmann, D., Godlovitch, l., Henseler-Unger, I., Schwab, R., & Stumpf, U. (2015). *Competition & investment: An analysis of the drivers of investment and consumer welfare in mobile telecommunications*. Bad Honnef: Wik-Consult Report, Study for Ofcom.

eMarketer. (2018). 4G Mobile Connections in Asia-Pacific to Outnumber 3G, 2G by 2018. Retrieved June 25, 2019, from: https://www.emarketer.com/Article/4G-Mobile-Connections-Asia-Pacific-Outnumber-3G-2G-by-2018/1016129

Frontier. (2015). *Assessing the case for in-country mobile consolidation (A report prepared for the GSMA).* Retrieved from Frontier Economics, Ltd website: https://www.gsma.com/publicpolicy/wp-content/uploads/2015/05/Assessing_the_case_for_in-country_mobile_consolidation.pdf

Garrone, P., & Zaccagnino, M. (2015). Seeking the links between competition and telecommunications investments. *Telecommunications Policy*, *39*(5), 388–405. https://doi.org/10.1016/j.telpol.2015.03.002

Grajek, M., & Röller, L.-H. (2009). Regulation and Investment in Network Industries: Evidence from European Telecoms. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1448666

GSMA. (2016). *Competition Policy in the Digital Age*. Retrieved from GSMA website: https://www.gsma.com/publicpolicy/resources/competition-policy-digital-age-case-studies-asia-sub-saharan-africa

GSMA. (2018). The Mobile Economy 2018. Retrieved January 17, 2019, from Mobile Economy 2018 website: https://www.gsma.com/mobileeconomy/wp-content/uploads/2018/05/The-Mobile-Economy-2018.pdf

Gujarati, D. N. (2003). *Basic Econometrics* (Fourth Ed.). New York: McGraw-Hill.

Hansen, L. P., Heaton, J., & Yaron, A. (1996). Finite-Sample Properties of Some Alternative GMM Estimators. *Journal of Business & Economic Statistics*, *14*(3), 262–280. https://doi.org/10.2307/1392442

Houngbonon, G. V., & Jeanjean, F. (2016). What level of competition intensity maximises investment in the wireless industry? *Telecommunications Policy*, *40*(8), 774–790. https://doi.org/10.1016/j.telpol.2016.04.001

ITU. (2017). Spanning the Internet Divide to Drive Development. In *Aid for Trade at a Glance 2017 Promoting Trade, Inclusiveness and Connectivity for Sustainable Development*. https://doi.org/10.1787/aid_glance-2017-en

ITU. (2018). Key ICT indicators for developed and developing countries and the world (totals and penetration rates). Retrieved from: https://www.itu.int/en/ITU-D/Statistics

/Documents/statistics/2018/ITU_Key_2005-2018_ICT_data_with%20LDCs_rev27Nov2018.xls

ITU-D. (2019). Fixed-broadband subscriptions. Retrieved from https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2019/Fixed_broadband_2000-2018_Dec2019.xls

Jeanjean, F., & Houngbonon, G. V. (2017). Market structure and investment in the mobile industry. *Information Economics and Policy*, *38*, 12–22. https://doi.org/10.1016/j.infoecopol.2016.12.002

Kang, F., Hauge, J. A., & Lu, T.-J. (2012). Competition and mobile network investment in China's telecommunications industry. *Telecommunications Policy*, *36*(10), 901–913. https://doi.org/10.1016/j.telpol.2012.02.003

Kiviet, J. F. (1995). On bias, inconsistency, and efficiency of various estimators in dynamic panel data models. *Journal of Econometrics*, *68*(1), 53–78. https://doi.org/10.1016/0304-4076(94)01643-E

Lestage, R., Flacher, D., Kim, Y., Kim, J., & Kim, Y. (2013). Competition and investment in telecommunications: Does competition have the same impact on investment by private and state-owned firms? *Information Economics and Policy*, *25*(1), 41–50. https://doi.org/10.1016/j.infoecopol.2013.02.001

Lu, X., & White, H. (2014). Robustness checks and robustness tests in applied economics. *Journal of Econometrics*, *178*, 194–206. https://doi.org/10.1016/j.jeconom.2013.08.016

Murray, M. P. (2006). Avoiding Invalid Instruments and Coping with Weak Instruments. *The Journal of Economic Perspectives*, *20*(4), 111–132.

Mutinda, S. (2016). *Evaluating the impact of market structure in mobile telecommunications markets: panel data analysis for emerging economies*. M.Com Minor Dissertation, University of Cape Town, Cape Town. Available from https://open.uct.ac.za/handle/11427/23766

North, D. C., & Weingast, B. R. (1989). Constitutions and Commitment: The Evolution of Institutions Governing Public Choice in Seventeenth-Century England. *The Journal of Economic History*, *49*(4), 803–832. Retrieved from JSTOR.

Pindyck, R. S., & Rubinfeld, D. L. (2013). *Microeconomics* (8th ed.). New Jersey: Pearson Education, Inc.

Reed, W. R. (2015). On the Practice of Lagging Variables to Avoid Simultaneity. *Oxford Bulletin of Economics and Statistics*, *77*(6), 897–905. https://doi.org/10.1111/obes.12088

Roodman, D. (2009). How to do Xtabond2: An Introduction to Difference and System GMM in Stata. *The Stata Journal: Promoting Communications on Statistics and Stata*, *9*(1), 86–136. https://doi.org/10.1177/1536867X0900900106

Sacco, D., & Schmutzler, A. (2011). Is there a U-shaped relation between competition and investment? *International Journal of Industrial Organization*, *29*(1), 65–73. https://doi.org/10.1016/j.ijindorg.2009.09.003

Scartascini, C., Cruz, C., & Keefer, P. (2018). *The Database of Political Institutions 2017 (DPI2017)*. https://doi.org/10.18235/0001027

Schumpeter, J. A. (1942). *Capitalism, socialism and democracy* (1st ed.). New York ; London: Harper & Brothers.

Stasavage, D. (2002). Private Investment and Political Institutions. *Economics and Politics*, *14*(1), 41–63. https://doi.org/10.1111/1468-0343.00099

Sujata, J., Sohag, S., Tanu, D., Chintan, D., Shubham, P., & Sumit, G. (2015). Impact of Over the Top (OTT) Services on Telecom Service Providers. *Indian Journal of Science and Technology*, *8*(S4), 145-160–160. https://doi.org/10.17485/ijst/2015/v8iS4/62238

Thomson Reuters. (2019). Thomson Reuters Datastream. Retrieved from Thomson Reuters website: Subscription Service

Tirole, J. (1988). *The theory of industrial organization*. Cambridge, Mass: MIT Press.

WEForum. (2017). *Digital Transformation Initiative Telecommunications Industry*. Retrieved from World Economic Forum website: http://reports.weforum.org/digital-transformation/wp-content/blogs.dir/94/mp/files/pages/files/dti-telecommunications-industry-white-paper.pdf

Wooldridge, J. M. (2002). *Econometric analysis of cross section and panel data*. Cambridge, Mass: MIT Press.

World Bank. (2019a). GDP per capita (constant 2010 US$). Retrieved December 15, 2019, from World Bank website: https://data.worldbank.org/indicator/NY.GDP.PCAP.KD?name_desc=false

World Bank. (2019b). Population, total. Retrieved December 15, 2019, from World Bank website: https://data.worldbank.org/indicator/sp.pop.totl?name_desc=false

The NBN Futures Project

Jim Holmes
Incyte Consulting

Leith H. Campbell
Incyte Consulting

Abstract: Over the past 20 years the provision of broadband services in Australia has become a matter of contention. The National Broadband Network (NBN) and longer-term plans for the way in which it will be structured and operate into the future have been caught up in this. The potential sale by the government of NBN Co, the developer of the NBN, in the next few years has brought greater urgency to considering the longer-term future of the NBN.

An NBN Futures Project, whose aims are explained in this article, is promoting public and policy discussion through TelSoc (the Telecommunications Association) on the NBN and its future, with the aim of building consensus and common ground as a basis for developing public policy for the future. TelSoc's role is not to advocate particular policy positions, but to provide media and forums for ensuring that critical analysis and discussion does occur and is shared as widely as possible. The Project promotes articles in the *Journal of Telecommunications and the Digital Economy*, together with forums, talks and other events.

This article describes the NBN Futures Project and how it envisages that it will make a difference.

Keywords: National Broadband Network, public policy, digital inclusion, digital economy

Background

The provision of broadband services within Australia has been the subject of contention for at least the past 20 years and especially since the establishment of a Government-owned enterprise, the National Broadband Network Co ('NBN Co', now sometimes 'nbn') in 2009 to provide broadband access services nationally (e.g. Gerrand, 2010). Unfortunately, contention and lack of bipartisan political support characterise the complete range of issues associated with NBN Co and the national broadband network (the NBN), including the role of the public sector, funding, competition, technologies, development pathway, pricing and affordability, applications development, social and economic inclusion, universal service policy, digital leadership, and the quality of service and performance standards required now and into the foreseeable future.

NBN Co has over the past ten years executed the role that the Government of the day has required of it, and will likely, during 2020, have completed the rollout of the NBN past all residences and business locations in Australia. That is to say, by that time all business and residential premises will have access, should they require it, via a mix of technologies, to broadband services. This does not mean that Australia will have been transformed into a high broadband capacity society and economy – only that the journey has commenced. Critically, it does not mean that Australia will have a suitable and sustainable plan for identifying and meeting rapidly changing broadband needs into the future, and for ensuring that economic and social objectives, themselves also subject to change, will be met in future.

From the formation of NBN Co, it was planned that the company would remain in government ownership only for the shortest possible time – until soon after the completion of the initial rollout of the NBN – and that it would eventually be privatized. It was envisaged that the proceeds from the privatization would repay the expenditure on the NBN rollout. The potential sale of the NBN in the next few years gives greater urgency to considering how the NBN should be structured, operated and regulated in the future.

Short-Term Focus

In the process of the initial NBN rollout, the Government will have incurred substantial expenditure of up to $51 billion – described as a public equity funding commitment of $29.5 billion, a Commonwealth loan facility of up to $19.5 billion and up to $2 billion of private sector debt (Finance, 2019). Current government policy (which has received little attention in recent times) is to sell the enterprise, NBN Co, and pay back the expenditure from the proceeds.

The substantial public expenditure on the NBN has become a major focus for many shorter term considerations about what to do with it. Paying down public debt is a major policy concern in itself, but giving undue priority to that aspect of the NBN incurs substantial risks, including the risk that non-financial and medium-to-longer term issues associated with the NBN will not be fully considered or addressed, or will be considered to be too hard or too indeterminate to be dealt with at present.

Ideological preferences for certain types of outcomes can obscure or prevent analysis of all options. For example, a preference for private ownership of the NBN as a matter of course, or for maximising competition in all circumstances, could be examples of this. NBN policy may be better served by examining all options, including some that are possibly more nuanced than stark binary choices. (For example, at the first NBN Futures Forum (Campbell & Milner, 2019) it was suggested that parts of the NBN could be privatized while the rural and regional accesses implemented by fixed wireless or satellite links remain in government hands.)

NBN policy development and related infrastructure investment are a long-term undertaking. The consequences of the policy and plans that are adopted in this area cast long shadows on Australia's digital capability into the future. The way in which technologies, user needs and priorities will develop are not known with certainty, and that aspect of the challenge increases the further we look into the future. The risks of a short-term focus, or of rigidity in the sort of approach adopted for the NBN, are therefore both real and substantial.

Role of TelSoc

TelSoc is a membership-based voluntary association, concerned with the development of the telecommunications and information industries in Australia and globally. It organises and supports discussion, debate and research into issues associated with the sector, principally through its major publication, the *Journal of Telecommunications and the Digital Economy*.

TelSoc has no policy position to advocate in relation to broadband or the many other issues with which its members are concerned. The role of TelSoc is to facilitate discussion, debate and research into the issues and to engage with policy makers to ensure the sharing of information, concerns and considerations amongst all Australian stakeholders. Over many years, TelSoc and its predecessor organisations have promoted discussion and research into broadband themes through the *Journal*, supplemented by events programs.

The NBN Futures Project

In early 2019, an NBN Futures Project working group was formed to develop and concentrate attention on key issues as the NBN initial rollout draws to a conclusion and the Government is considering the future of NBN Co and the NBN. The initial focus was on the future ownership options for the NBN – including keeping the NBN in government ownership, at least for the time being; selling NBN Co, either as a single entity or in technology-based parts; and merging NBN Co with Telstra InfraCo (Telstra's wholesale network operator) – but this has led to wider consideration of what objectives should be set for the continuing NBN (whether in public or private hands) and how they could best be achieved.

The NBN Futures project has operated through working groups that are open to members and invited experts who wish to volunteer their time and expertise.

http://doi.org/10.18080/jtde.v7n4.238

Work to date

The Project has developed an issues slate to better identify and encourage analysis of the main considerations and relationships that should be taken into account in the development of a sustainable future broadband policy framework and NBN infrastructure in Australia. Key issues are set out below.

NBN development plan

The Project's initial examination of ownership options has suggested that a sale immediately following the completion of rollout is unlikely to occur, due to financial implications for the federal budget and the lack of readiness of the business for sale. This leads to increasing attention to the development of the NBN over the next 5 to 10 years, explicitly through an NBN Development Plan or similar. A major focus of the project is now to suggest the construction of such a plan, based on consideration of performance and technology objectives, financial considerations and enhancing social and economic value.

Vision and objectives

It is crucial for there to be a clear understanding and general agreement on the vision and objectives for the NBN if there is to be a sensible discussion of how they might be achieved, and, indeed, whether they have been achieved in any measure to date. Statements of vision and objectives are the key plank in the policy framework for ensuring that there can be meaningful discussion and engagement on the means employed to deliver broadband infrastructure and services efficiently, creatively and equitably.

Work on refining a statement of vision and objectives is continuing with a view to publication of further articles in the *Journal* in the early part of 2020. In the meantime, the Project has developed a working draft to guide discussion. The working draft is:

> *Australia's National Broadband Network needs periodic review and ongoing changes to its technologies, network structure and governance structure along with government regulation to ensure that it meets the following objectives:*
>
> - *International competitive advantage for Australian businesses;*
> - *Affordability, reliability and accessibility for Australian users across all ages, backgrounds, occupations, geographical locations and forms of social disadvantage;*
> - *A regulatory regime that ensures affordability, reliability and accessibility, as well as prompt action on customer complaints; and*

- *Synergies and support for complementary network technologies such as mobile networks and the service arrangements needed for emergency services.*

Infrastructure competition vs monopoly

Over the past 40 years, Australian economic policy has emphasised the importance of competition in markets at all levels to deliver services efficiently, at lowest sustainable cost and at quality levels that meet customers' expectations. Competition has been increasingly seen as critical for the generation of productivity and as a major contributor to global economic advantage and continued high standards of living. Industries such as telecommunications and energy services have been restructured to enable the dynamic forces of competition to be established and to drive sector development. Major infrastructure projects such as the NBN have been considered, at best, to benefit from *de facto* monopoly provision for the shortest possible time, notwithstanding the existence of natural monopoly characteristics, such as scale economics and the need for integrated networking on a national basis.

In public discourse, this issue is often linked with the issue of public vs private ownership, partly because of the historical links between public ownership and long-term infrastructure projects that might not be able to generate commercial returns in the shorter term or at all. While the Project recognises the link, it has attempted in its work so far to ensure that a clear distinction is maintained between competition and ownership concepts.

There is already a broad consensus that retail service provision should be competitive. The area that attracts more discussion and debate is whether a similar approach can and should be taken to infrastructure and wholesale services competition. The original conception was that NBN Co should be limited to the provision of infrastructure services at a wholesale level, and that its customers should be limited to licensed retail service providers. This view is already under challenge. It may be argued that NBN Co needs, in order to be commercially viable, to be able to deal directly with, for example, large corporate customers.

If infrastructure competition were to be promoted, what possible forms might it take? The Vertigan Report in November 2014 (Vertigan, 2014) promoted the idea that the NBN might be broken up on technology lines. The new entities established to manage the resulting parts might then be encouraged to compete with one other.

Another approach is that the NBN should not enjoy any form of special legislative protection, and thereby be subject to competitive entry and to contestability generally. This approach needs to be further explored in the light of possible cherry-picking (if any form of national uniform pricing is to be continued) or of possible affordability, inclusion and equity issues (if pricing becomes more cost-related, with potentially significant differences in access prices and service quality).

http://doi.org/10.18080/jtde.v7n4.238

Another approach is to accept that the NBN is currently an effective monopoly but that technological developments will erode this and lead to increasing network competition over time. Cellular mobile, including the emerging 5G standard, and a new generation of low Earth orbiting (LEO) satellite systems have been identified as candidate disruptive technologies. It could be envisaged that, whether or not a policy of monopoly provision of fixed broadband access in 2020 is adopted, technological erosion and disruption will occur.

Social and economic value

The Project working group believes that further work is needed to better understand and even to quantify the social value and broader economic value of the NBN and to ensure that these value considerations are taken into account when the costs and benefits of the NBN are under consideration. It is important that the Government does not restrict its assessment of the value of the NBN to simply its commercial or book value, i.e. to what it could be sold for. An important consideration with the NBN, as with all major infrastructure, is that there are significant externalities, because of the diverse economic and social behaviour and benefits that will depend on the use of that infrastructure. More analysis needs to be undertaken to understand these externalities, both in the case of the NBN and of broadband infrastructure generally.

For example, consider the *value* of the NBN. It is not just the revenues received by NBN Co in operating wholesale services on the NBN. There is also value from the NBN in enabling more efficient teleworking, telehealth and online government services, for example (Campbell & Suessspeck, 2015). Much of this value will accrue to the government, through greater productivity in the economy, as well as to business and service providers.

Other issues arise as a result of this analysis, including the notion of broadband applications leadership. Careful study of how broadband is being used by enterprises and by households, and the way in which this is changing – resulting in changing needs in terms of price expectations and service speeds (both uploading and downloading) – is required. In some countries — for example, Sweden (2016) – the Government is considered to have a prime leadership role, through the transformation of its own service delivery and transaction processes to benefit from broadband availability. But broadband leadership and innovation occur at many levels and whether, and how, this should be encouraged is an important area for further discussion.

Digital equality and inclusion

Digital equality means ensuring that all enterprises, households and individuals are treated equally in terms of access to Australia's digital resources and that they are not denied access because of location, affordability, age, ethnicity or language, or any other criteria. The result of meeting acceptable levels of equality should be to maximise social and economic inclusion of all enterprises, households and individuals. Experience in Australia and elsewhere strongly suggests (Wilson, Thomas & Barraket, 2019) that digital capacity and literacy should not be universally assumed: the availability of broadband will not be enough to ensure suitable levels of inclusion and engagement across all populations. More work is required to improve our understanding of the costs in economic and social terms of non-engagement and non-inclusion, and the costs of maintaining pre-digital or legacy means of delivering services in the broadband era.

Universal service and social pricing

Following the Universal Service review in 2017 the legacy telephone-centric universal service policy has been transformed into a universal service guarantee (USG) (Communications, 2018), which belatedly includes broadband service. The USG policy does not spell out service upgrade pathways that will enhance broadband service performance levels experienced in rural and regional Australia and reduce the gap with major urban centres.

Universal service policy development has been slow in Australia and reviews have been reluctant to move away from telephone-centric approaches and from legacy processes and concepts, especially compared to other countries, some of whom have similar high-cost, low-density areas to serve within their borders.

There is a need to recognise that long-term infrastructure investments with significant externalities require a corresponding long-term approach to pricing. Social pricing is to be contrasted with commercial pricing where price levels are set to achieve commercial returns on investment over relatively short periods. Pricing of services delivered by the NBN is an outstanding example of pricing that should also accommodate social requirements. For example, the government could choose to recover the cost of the NBN from greater productivity in the economy (leading to higher tax receipts) or from greater efficiency in the delivery of government services. Direct returns might never approach commercial levels or even become positive, when considered only within the constraints of an enterprise business model.

Discussions on whole-of-economy pricing need to take into account the broader economic benefits that the NBN will provide. Identifying and quantifying those benefits will require more research and analysis than has been undertaken to date. The Commonwealth needs to model the returns that it will achieve through taxes and other charges that increase with economic growth resulting from the NBN, rather than solely the direct returns through NBN Co revenues and the potential sale of the NBN.

Financial and budgetary considerations

The Project working group considers that some very basic questions need to be clearly answered to provide a basis for constructive dialogue about the NBN and its future. For example:

- Does the current legislation actually require sale of the NBN to be considered at any stage?
- The current Government policy requires a Productivity Commission enquiry prior to the potential sale of the NBN. What terms of reference should be given to the Productivity Commission for its enquiry? Can the enquiry consider the ownership options and issues identified in this project?
- What is the potential impact on government finances of an NBN sale being below the level of investment? (The levels of investment and of debt when construction is complete need to be confirmed.) How any subsequent shortfall in proceeds from an NBN sale would directly affect the long-term Commonwealth Budget needs to be established. Are the equity and debt components considered differently?
- Can the government write down the value of the investment in the NBN, and would such a write-down flow through to the budget?
- Are there consequences for the equity and debt arrangements of NBN Co staying in government ownership for a more extended period?

The answers to some of these questions may appear to be straightforward to Government insiders, but they need to be confirmed more broadly and the impacts of the conclusions further explored.

Regulatory framework

Arguably, there has been an implicit assumption in discussions around the NBN over the last decade that regulatory structures currently in place, including the strong preference for competition where it can be achieved, are suitable and appropriate for broadband, and for the NBN. Since these regulatory frameworks have been adjusted over time to recognise that the industry is changing, the implicit assumption is not without justification. Nevertheless, the Project working group believes that, whatever course Australia adopts on the NBN and broadband services in relation to the other issues listed in this article, an appropriate ongoing regulatory framework will need to be explored, with possible bespoke elements that reflect the unique combination of Australia's overall telecommunications and ICT regulatory regime and its approach to broadband infrastructure and services and social inclusion.

http://doi.org/10.18080/jtde.v7n4.238

NBN ownership options

This has been the starting point for the Project's work on NBN Futures. However, consideration of ownership options quickly morphs into discussions about many of the other issues and concepts that have been identified. We intend to return to the focus on the ownership options as we clarify these other issues, asking of each option:

- Why is the option proposed?
- How will it work in practice?
- How will it be put in place from the current situation?
- How will it meet criteria derived from national objectives and vision?

In any case, a key underlying consideration has always been that Australians have affordable access to broadband services that meet their needs and expectations well into the future.

Events to Date

TelSoc has hosted two seminars in the NBN Futures series.

The first related to NBN ownership options and was held on 31 July 2019. The presentations and discussion are documented in the *Journal*. Three main options were canvassed (Campbell & Milner, 2019): keeping the NBN in government ownership, at least for the time being (Holmes, 2019); selling NBN Co, either as a single entity or in technology-based parts; and merging NBN Co with InfraCo (Telstra's wholesale network division) (Gerrand, 2019).

The second was held on 22 October 2019 and focused on consumer and user needs for broadband and how they might be served in future. Again, the presentations and discussion at the event are documented in the *Journal* (Campbell, 2019; Corbin, 2019). A particular emphasis was on the pricing of NBN services: the effects of prices on digital inclusion and how it might be improved; comparison with prices in New Zealand; and whether full cost recovery through NBN prices is either achievable or desirable.

Forthcoming Work Program

During 2020, the working group intends to increase the tempo of its NBN Futures Project – partly because 2020 will be a critical year in which Australia should be planning the future of the NBN following the completion of the initial rollout scheduled by 2021.

The NBN Futures Project working group will continue its work on exploring the issues and the options for addressing them in more detail, and will continue to invite contributions from interested experts and others concerned with these issues.

The primary vehicle for disseminating information, research and considered views will continue to be the *Journal*, giving prominence to the NBN and broadband topics.

During 2020, it is hoped that TelSoc will continue to host NBN Futures forums that will create further opportunities for engagement and discussion of the issues. The program is yet to be confirmed but potentially will cover the future technology environment and the prospects for various forms of competition, especially infrastructure competition; pathways for NBN development; service affordability and digital inclusion issues; international experience, case studies and lessons; and more focussed attention to specific ownership and industry structure options.

In addition, a submission has been prepared to the Joint Parliamentary Standing Committee on the NBN.

Call to Action

The NBN is a major infrastructure project for Australia. It was conceived as a basic element for developing Australia's digital economy and, whatever competitive technological options emerge, it will remain a significant platform for broadband services for the next decade and beyond. As such, it deserves continuing public attention and debate. For the past five years, public attention has been largely directed towards the completion date of the initial rollout and on how effective the resulting broadband provision has been.

With the initial rollout coming to an end and the next steps for the NBN and NBN Co to be considered, now is the time for public debate to take up the issues described in this paper. If effective and sustainable public policy is to be developed in a timely manner, it will be essential to find bipartisan common ground as a foundation while embracing the needs of all stakeholders.

Some common ground *is* possible. For example, at the first NBN Futures Forum, there already appeared to be common agreement that NBN Co was not ready for sale and that it should be retained in public ownership for, probably, the next five years at least, to develop and grow the business. At the second NBN Futures Forum, there seemed to be common agreement that digital inclusion remains a worthy aim and that it can be stimulated by appropriate service pricing (but not necessarily NBN pricing only).

While these examples are limited, they demonstrate that, with good will, it will be possible to work through the many issues arising from the NBN to develop a new public policy that is supported by clear analysis. Importantly, it may also be feasible to lay out alternative futures for the NBN that may be preferable in certain prescribed circumstances.

We invite all members of TelSoc and other interested parties to contribute to the debate on NBN futures by attending the NBN Futures Forums in 2020, by writing articles for the *Journal*, or by assisting in planning the NBN Futures Project.

http://doi.org/10.18080/jtde.v7n4.238

Acknowledgements

The authors acknowledge the substantial work undertaken by the many contributors to the NBN Futures Project. While this article has benefitted from the comments of members of the Project working group, its final form is the responsibility of the authors alone.

References

Campbell, L. H. (2019). The NBN Futures Forum: Realising the User Potential of the NBN, *Journal of Telecommunications and the Digital Economy*, *7*(4), December, to appear.

Campbell, L. H., & Milner, M. (2019). The NBN Futures Forum: Discussing the future ownership of Australia's National Broadband Network, *Journal of Telecommunications and the Digital Economy*, *7*(3), September. DOI: 10.18080/jtde.v7n3.202

Campbell, L H., & Suessspeck, S. (2015). How the NBN could boost Australia's GDP by 2%, *The Conversation*, 8 October. Available at https://theconversation.com/how-the-nbn-could-boost-australias-gdp-by-2-48587

Communications, Department of. (2018). *Development of the Universal Service Guarantee: Summary Report*, November. Retrieved from https://www.communications.gov.au/documents/development-universal-service-guarantee-summary-report

Corbin, T. (2019). Promoting Digital Inclusion Through the NBN, *Journal of Telecommunications and the Digital Economy*, *7*(4), December, to appear.

Finance, Department of. (2019). *NBN Co Limited (nbn)*. Accessed at https://www.finance.gov.au/business/government-business-enterprises/nbn-co-limited-nbn

Gerrand, P. (2010). The National Broadband Network. The defining issue in Australian politics in 2010 [Editorial], *Telecommunications Journal of Australia*, 60(4), 52.1-52.4. DOI: 10.2104/tja10052

Gerrand, P. (2019). NBN Futures: The option of merging NBN Co with InfraCo, as a Benefit to the Digital Economy, *Journal of Telecommunications and the Digital Economy*, *7*(3), September. DOI: 10.18080/jtde.v7n3.198

Holmes, J. R. (2019). Getting the NBN Infrastructure We Need, *Journal of Telecommunications and the Digital Economy*, *7*(3), September. DOI: 10.18080/jtde.v7n3.199

Sweden, Ministry of Enterprise and Innovation. (2016). *A Completely Connected Sweden by 2025 – a Broadband Strategy*. Government Offices of Sweden. Retrieved from https://www.government.se/496173/contentassets/afe9f1cfeaac4e39abcdd3b82d9bee5d/sweden-completely-connected-by-2025-eng.pdf

Vertigan, M. (2014). *Independent cost-benefit analysis of broadband and review of regulation*. Department of Communications, 14 August. Retrieved from https://www.communications.gov.au/sites/g/files/net301/f/NBN-Market-and-Regulatory-Report.pdf

Wilson, C. K., Thomas, J., & Barraket, J. (2019). Measuring Digital Inequality in Australia: the Australian Digital Inclusion Index. *Journal of Telecommunications and the Digital Economy*, *7*(2), 102-120. https://doi.org/10.18080/jtde.v7n2.187

Benefiting from Asia's Technology Revolution

Invited Paper

John Lord
Huawei Technologies Australia

Abstract: An invited paper, the Charles Todd Oration 2019, delivered by Mr John Lord AM that covers how Australia might benefit from Asia's technology revolution.

Keywords: Asia, Technology, Policy, Telecommunications

Introduction

Good afternoon, ladies and gentlemen, and distinguished guests.

It is a pleasure to be here today delivering the TelSoc Charles Todd Oration. Many eminent people have delivered this oration over the years, so I am honoured to have been asked to deliver this today.

TelSoc plays such a valuable role in our local telecommunications industry in promoting the discussion around the development of the telecommunications industry here in Australia.

As we all know, the telecommunications industry has changed beyond comprehension from the days when Charles Todd and his team built that first telegraph line that connected Adelaide to Darwin, and Darwin to the rest of the world. That telegraph line connected Australia to the world and began to open up the pathway to an interconnected world which has helped create the hyper-connected 'Global Village' in which we now live.

The challenge now is not so much around connecting people to telecom networks – here in Australia almost everybody that wants to connect to either mobile or fixed broadband is able to do so.

The issue we are facing now, and the one which I will focus on today, is how we as Australians deal with the consequences of the connected world that Charles Todd helped to deliver. In particular, we need to deal with the impact that more and more of the technology that will

http://doi.org/10.18080/jtde.v7n4.235

drive this connected world is now coming out of Asia Pacific – especially China – rather than Europe and the US, the traditional countries.

How do we as a nation deal with this new reality of the technologies of the future being developed right on our doorstep? If we do not deal with it properly then we will only avail ourselves of 50% of the leading innovation and technology in the future.

The Rise of China

The plain fact of the matter is that China and the broader APAC region are emerging as key drivers of ICT technology and that poses clear challenges for Australia. I need hardly say that the issues that my own company have faced over the last 18 months on 5G are a pretty good demonstration of the challenge. We don't need to go into the details of all that here today but it does raise a very important point about how we as Australians see our regional partners and the ways in which we are prepared to trade with them and build trust in relationships.

As I am sure we are all aware, our country has long imported products from the rest of the region: we have brought in cars and electronics from Japan and Korea and, in recent years, we have imported a huge amount of Chinese-produced consumer goods.

But as we know and understand, the ICT sector is very different.

A few years ago, the Australia China Business Council (ACBC) reported (ACBC, 2014) that more than 50% of Australia's ICT imports were from China alone – more than the rest of the world combined.

Some of you may have seen this dilemma summed up rather neatly by Martin Parkinson, the outgoing secretary of the Department of Prime Minister and Cabinet, in an interview with the *Australian Financial Review* recently (Murray, 2019):

> "If China wants to be the world's largest producer of cheap consumer electronics, knock yourself out. I don't care. If, on the other hand, it's going to be the only supplier of quantum computing, or the only supplier of 5G, I've got a problem."

I don't seek an argument with a great and eminent Australian like Dr Parkinson but his comments on China do reflect the challenge that we as Australians are facing in the future.

Fergus Hanson of the Australian Strategic Policy Institute's cyber policy centre, speaking in support of Tobias Feakin, the Cyber Security Commissioner, reportedly said in India recently that, if India bans Huawei, it would represent a great success for western countries (Tillett, 2019). It is hard to see how it could be considered a good outcome if a country such as India could only access 50% of the best innovation and technology. I certainly don't think that

http://doi.org/10.18080/jtde.v7n4.235

Germany, the UK, France and the other twenty or so European countries that use Huawei technology would agree with him.

My key concern is that, if we are to gain all the benefits for our world in the future, we need to be open and embrace all the ideas, innovations and technological developments from all players irrespective of country or company of origin.

There is no doubt the United State of America will be a technological and innovation leader well into the future. It fosters an innovative environment in its society, encourages entrepreneurship, and with its large and dynamic economy has the resources to see innovation and entrepreneurship flourish.

Europe will also remain a key area for entrepreneurship and setting of international standards because of its multicultural and unified governance structures that, despite difficulties overall, do set standards, protocols and rules across many borders.

However, outcomes in life – as in politics – are driven by the simple laws of arithmetic – and the numbers we are dealing with here are pretty stark. According to official OECD figures, back in 2009 only around 30% of the global middle class was located in Asia with the remainder in the US and Europe. If you fast forward to 2030, then the OECD is forecasting that two-thirds of the global middle class will come from Asia (Pezzini, 2012).

To put that into simple numbers, the OECD is forecasting that the Asia-Pacific middle class will increase from 525 million people in 2009 to 3.2 billion in 2030 –nearly a six-fold increase over a twenty-year period.

On the back of this demographic sea change Asia will become the consumer powerhouse of the world. Also, its educational institutions will produce large numbers of talented people, its businesses will thrive and will invest more and more in research and development across all disciplines.

The numbers will win out in the end. The younger age of many of the countries, the growing GDPs, will see more and more innovation and technological advancements coming out of the Asian region. To be quite clear about it, the Huawei story of today will be a common story across Asia, not just in China, but in the many other countries that will grow and develop in coming years.

The reality of the situation is simply that the growing and better educated middle class emerging in Asia Pacific – especially China – is now capable of producing much more than cheap consumer electronics. Already Huawei is the undisputed world-leading vendor in 4G and 5G technology.

http://doi.org/10.18080/jtde.v7n4.235

The Asia-Pacific region is now capable of producing technologies as good as or even better than what is being produced in the western countries – and Australia cannot afford to turn its back on that kind of innovation.

Australians need to be smart about how we deal with this and we need to figure out how we can use this explosion of innovation taking place right on our doorstep as an opportunity and not a threat.

What Can Be Learnt from Huawei

This is where my company, Huawei and particularly Huawei Technologies Australia, is able to offer a unique perspective. We are one of the largest private companies in China, 100% owned by our employees with no Government involvement, and we are truly a global company with operations in over 170 countries around the world.

Australia's future prosperity depends very much on the strength of these kinds of business relationships like those that Huawei Australia has formed in the fifteen years it has operated here in Australia. Huawei has benefited from being in Australia but – just as importantly – we like to think that Australia has also benefited greatly from us being here too.

For example, here in Australia our 4G mobile networks are among the best in the world. This has been driven by strong competition between the three network vendor providers, which has driven innovation and kept costs down. Huawei is proud of the fact that it provides over 50% of Australia's mobile network.

The interesting thing is that there are clear historical parallels between what is happening now with the rise of Asia in the ICT sector and the situation that arose in the 1960s when the Japanese entered the commercial market here in Australia and globally.

In the 1960s, Australian's would not buy Seiko watches as they were thought to be copies, Toyota cars were thought to be highly inferior to European vehicles, and Japan was untrustworthy as we had fought a war against them. By the late 1990s, Seiko watches were considered to be as good as many Swiss watches, Toyota was the number one vehicle in Australia, and an ex-Prime Minister only a few years ago declared Japan our greatest friend in the Asia-Pacific area (SBS, 2013).

It is interesting to remember that the US tried to restrict Japan in the 1980s using the same kinds of tariffs and restrictions that Huawei is facing today.

I see Huawei and Chinese companies in a similar stage of development as those Japanese car companies were all those years ago; or more precisely entering and competing in the global environment.

http://doi.org/10.18080/jtde.v7n4.235

However, it's also important to note that it's not just about new competitors coming into the market, it's also about the pace of technological change. When I first commanded a vessel, I was using pretty much the same navigation equipment that had been used by Captain Cook in 1779 – very little had changed in maritime technology.

However, by the end of my career in 2000, I was using GPS satellites to position the vessel to metres of accuracy – something that would have been absolutely unimaginable at the start of my career and there will doubtless be more change ahead for the maritime industry.

So, to return to our theme, we want to get to a stage where our country is as comfortable with cutting-edge technology coming here from Asia as it is with cars and consumer goods.

At Huawei, we believe that localisation of Asian technology companies is the real key to doing this. In Australia, we have a local Board of three non-executive directors – Huawei's first local Board anywhere in the world – and we have over 700 local staff. It makes sense that we should be doing our utmost to ensure we have local technology suppliers also benefitting from – and contributing to – Huawei's success.

As part of this localisation drive, Huawei wants to promote an 'ecosystem of investment' between Australia and China. Already around half of our global R&D centres and Joint Innovation Centres are outside of China – but none have yet been located here in Australia. The importance of Australia capitalising on the unprecedented scale of technological innovation coming out of China – we cannot afford to miss out on what has been called 'the largest investment in Research and Development in human history' (Pearcey, 2015).

As a company of Chinese origins, many people imagine that our products are entirely produced in China from Chinese components and suppliers, but nothing could be further from the truth. Overall, 50% of our revenue is generated outside of China, and we source 70% of our materials from non-Chinese companies. The United States provided 30% of components ($11 billion); Taiwan, Japan and Korea provided 30%; Europe 10%; and Mainland China provides 30% of components. Although we know this is changing.

These components range from complex chipsets to the most basic nuts and bolts, and there are ample opportunities for Australian companies to play a far greater role in this supply chain. And Huawei is not unique. All of our competitors have similar supply chains, and Australia at this time participates well below its capability.

Australia cannot be a one-way street in terms of ICT industry trade with Asia. We cannot be taken by the mindset that we export our minerals to Asian countries and import hi-tech from them – Australia must benefit from Asia's innovation and technology boom.

If we get this right, then Asian global businesses can grow and succeed utilising Australia's strengths by being localised; and Australia broadens and increases its global revenues through joining large global supply chains and gaining access to innovations and leading-edge technologies.

The Challenges to Overcome

Hopefully you are becoming convinced that there are great benefits to be gained by Australia being more open and engaged with Asia in terms of technology innovation. I firmly believe that there is a potentially very bright future ahead of us with our neighbours but there are a number of areas we need to work on before we can benefit properly from Asian innovation.

The first of these is a pretty obvious one, our potential partners in Asia want certainty and stability from us if they are going to invest and engage in the longer-term. It hardly needs to be said that what we are seeing at the moment from an Asian perspective is exactly the opposite to the kind of business environment that we need to see in the markets in which Asian companies invest around the world. Too often the first call on an Asian investment proposal is to block it or insert more difficult criteria. Large Asian multi-nationals need to have certainty over what that future looks like because, if they don't, it is very hard to make the kind of investments that they need to make for our mutual benefit.

So, how do we get that certainty in terms of regulatory outcomes?

Well, to be quite clear about it, the number one thing we need to see established between Australia and the new emerging companies from Asia is trust. It is critically important. This is why Huawei has been working around the world with countries and international organisations to show that our products can be trusted and that we have nothing to hide.

We have been working with operators and government agencies in the UK for around ten years now to demonstrate to them the integrity of our kit and of our company. The results have been hugely positive for both Huawei and the UK. Our fixed broadband technology and equipment has helped make the UK the most advanced of the five major European countries in terms of high-speed broadband deployment.

Because we have been able to build a position of trust with the UK and its mobile operators, we have been able to help UK operators such as EE and Vodafone become some of the first in the world to launch 5G services, which are now rolling out across the UK.

It's been a similar story in mainland Europe where we have established our Cyber Security Centre in Brussels and – working with the European Union – we have been able to demonstrate to European countries that our products our safe and secure. That approach

http://doi.org/10.18080/jtde.v7n4.235

seems to be paying dividends for us because, of the 50 commercial 5G contracts that we have signed, over half are in European countries.

We could not have achieved any of that without building trust with all of those countries and a similar approach is needed here in Australia. We are not asking the Australian Government to trust us as a matter of blind faith. Security of critical infrastructure is a national imperative; security of data is essential.

However, the best Cyber-Security defence says:

1. Test all hardware and software;
2. Control all access to data;
3. Co-operate openly between business, industry and government.

We are saying to them that we are absolutely willing and open to have them test our products and technology to demonstrate that they are safe, secure and reliable.

There are two more things we need to see happen before we can move onto greener pastures.

Firstly, and I have already alluded to this earlier in my comments, Australia needs to change the way it sees Asia in terms of what the region can do for us. The fact is that Asia is no longer simply about mass producing cheap consumer goods, it is now moving to a different plane and is producing cutting-edge technology across a range of fields. As a country it is critically important that we understand that.

The final thing we need to ensure is that we are keeping up our part of the bargain in terms of producing the talent that can play an active and useful role in the mutually beneficial eco-system that we are talking about here. Asian companies producing cutting edge technologies will not invest here and will not be attracted here unless we are supplying young Australians who actually bring high-level expertise to the market.

The fact of the matter is that our Asian neighbours are producing staggering numbers of highly skilled engineers from their universities. The World Economic Forum reports that in 2016 China and India combined produced a staggering 7 million STEM graduates – by contrast the US and Japan produced a mere 800,000 (WEF, 2016).

As for us here in Australia, figures suggest that we have only around 800,000 STEM participants in our entire country – only a third of whom have post-graduate qualifications (Dobson, 2018).

If we want to have an impact on the world stage and create the kind of mutually beneficial environment that we are talking about, then we have to lift our game here and produce more STEM graduates that can add value to the global technology supply chain.

http://doi.org/10.18080/jtde.v7n4.235

Finally, to put it succinctly, we need to let our universities grow, not shackle them.

The Productivity Angle

When we talk about making the most of new technology, what we are really talking about is how we can make sure we get the productivity benefits that it brings and that we don't fall behind our competitors.

I am sure you will have heard many of our Federal politicians – including the Treasurer himself – recently discussing the fact that we need to lift productivity in this country. In a recent speech on August 26th to the Business Council of Australia (Frydenberg, 2019), the Treasurer pointed out that we are enjoying our 28th consecutive year of economic growth, adding that the Australian economy has grown on average by 3.1% per year – compared to an OECD average of 2.2%.

The Treasurer says that productivity has contributed 1.7 percentage points or over half of the 3.1% annual average growth with the productivity boost being at its greatest in the 1990s – but there are some areas of concern. In particular, labour productivity has increased over the last five years on average by 1.1% – below the long-term-run average of 1.5%.

Research from the OECD is suggesting that the benefits of technological innovation have not been spread as widely as we may have hoped and that some firms are still not benefiting like they could from new technologies that are available. Indeed, analysis from Treasury here in Australia (Cranston, 2019) alarmingly shows that the top five per cent of firms in Australia account for almost all of our productivity growth, so there is a clear gap between those at the frontier and the rest.

Why is this so important to those of us in the telecom industry? Well, there is pretty firm evidence to suggest that we are the ones that have the answers to this productivity problem being experienced here and around the world. After all, technology companies such as Huawei and network operators are the people most responsible for taking productivity enhancing technological innovation to, quite literally, billions of people all around the world.

This is particularly important when you think about where we are at right now in terms of 5G, which many people are saying will enable the 4th industrial revolution.

Many of you would have seen the recent research from AMTA and Deloitte Access Economics which said that the productivity benefits of mobile telecommunications with the arrival of 5G will be worth $65 billion to the Australian economy by 2023 – equivalent to 3.1% of GDP (Deloitte, 2019). This is equivalent to approximately $2,500 for every Australian and larger than the current entire contribution of the agricultural industry to Australia. The AMTA-

http://doi.org/10.18080/jtde.v7n4.235

Deloitte report demonstrates quite clearly the huge potential that technology has to shape and improve our lives and deliver better outcomes for everyone.

However, we must accept that the technologies of the future – including those from something like 5G – can come from anywhere in the world and we need to find ways to deal with that.

Conclusion

In conclusion, it is important to restate once again that we have far more to gain than to fear from the rise of our neighbours in Asia. Of course, there will be challenges that we have to overcome in the years ahead but the opportunities that will present themselves will far outweigh the challenges. As a country we need to aim for a scenario where we grow and benefit from the Asian tech revolution and don't see it as a zero-sum game.

Australia, a country of between 25 million and 30 million people, located at the bottom of the world, needs to have access to and to use all of the leading innovation and technology being produced globally. It needs to embrace solutions that address security, the economy and strategic relationships rather than solely the security perspective, which is presently being mischievously overplayed and which is unbalancing the debate on our national interests in the future.

The story of Huawei in Australia can hopefully be used as an example of how one of the biggest companies in Asia has come to this country and has not just taken out but has also put back in as well – all to our mutual benefit.

As a country we are incredibly fortunate to find ourselves in this position where our own region will become the technology powerhouse that drives much of the innovation that we will see over the next century.

We need to build trust and relationships.

It's a once in a generation opportunity and one that as a country we cannot afford to squander.

References

ACBC [Australia China Business Council]. (2014). *The 2014 Australia-China Trade Report*. Retrieved from http://acbc.com.au/admin/images/uploads/Copy2ACTradeReport_WEB_v4.pdf

Cranston, M. (2019). More investment is no productivity guarantee. *The Australia Financial Review*. 26 August. Available at https://www.afr.com/policy/economy/more-investment-is-no-productivity-guarantee-20190826-p52kqg

Deloitte. (2019). Mobile Nation 2019: The 5G Future, *Deloitte Access Economics, A report for Australian Mobile Telecommunications Association*. Retrieved from https://www2.deloitte.com/au/en/pages/economics/articles/mobile-nation.html

Dobson, I. R. (2018). STEM in Australia: The statistical patterns of university science and technology in the twenty-first century, *Australian Council of Deans of Science*. Available at http://www.acds.edu.au/wp-content/uploads/sites/6/2018/10/ACDS-STEM-in-Australia-Final28-10-18.pdf

Frydenberg, J. (2019). Making our own luck – Australia's productivity challenge. Address to the Business Council of Australia. 26 August. Available at https://ministers.treasury.gov.au/ministers/josh-frydenberg-2018/speeches/address-business-council-australia

Murray, L. (2019). Decision to ban Huawei from 5G 'was all ours', *Australian Financial Review*, 8 August. Available at https://www.afr.com/policy/foreign-affairs/decision-to-ban-huawei-from-5g-was-all-ours-20190808-p52f6w

Pearcey, L. (2015). A bold step along the new Silk Road, *Confucius Institute, UNSW*, 22 May. Retrieved from http://confuciusinstitute.unsw.edu.au/in-the-media/bold-step-along-new-silk-road/

Pezzini, M. (2012). An emerging middle class, *OECD Observer*. Retrieved from http://oecdobserver.org/news/fullstory.php/aid/3681/An_emerging_middle_class.html

SBS. (2013). Japan our best friend in Asia: Abbott, *SBS News*, 10 October. Retrieved from https://www.sbs.com.au/news/japan-our-best-friend-in-asia-abbott

Tillett, A. (2019). India seeks Australian input as it weighs Huawei ban, *Australian Financial Review*, 8 August. Available at https://www.afr.com/politics/federal/india-seeks-australian-input-as-it-weighs-huawei-ban-20190909-p52pie

WEF [World Economic Forum]. (2016). The Human Capital Report 2016, *World Economic Forum Insight Report*. Retrieved from http://www3.weforum.org/docs/HCR2016_Main_Report.pdf

'This is VJY, Over'

The Contribution of High Frequency Radio to the Social and Economic Development of the Northern Territory

Susan Bandias
Charles Darwin University

Elizabeth (Janie) Mason
Charles Darwin University

Abstract: This paper examines the relationship between the use of High Frequency (HF) radio and the development of social capital in the Northern Territory (NT) of Australia. Social capital is an elusive concept. It has its origin in a number of disciplines and, as a consequence, it is a mix of disparate and intangible concepts such as trust, reciprocity, norms and cooperation. It has been argued that there is a strong positive correlation between the acquisition of social capital and social and economic wellbeing. In order to determine if the use of HF radio promoted the development of social capital, qualitative data was collected from 32 NT self-identified HF radio users. Although manned operations of the Darwin-based HF coastal radio service ceased on 30 June 2002, the evidence indicates that HF radio was instrumental in the development of a sense of community amongst its widely dispersed and isolated users. The social capital outcomes of HF radio use that included social and economic well-being, engagement in participatory democracy and the acquisition of human capital were precipitated by the shared community concept of trust, informal and formal networks and cross-cutting ties.

Keywords: high frequency radio, social capital, Northern Territory, isolation, wellbeing

Introduction

The now obsolete Darwin Coastal Radio Service (DCRS) was, for many years, the only form of telecommunications access in the remote and very remote regions of the Northern Territory (NT) of Australia (Bandias & Mason, 2017; Bandias & Vemuri, 2005; IMG, 1980). It was initially established for the purpose of safeguarding the lives of seafarers and to guard the northern coastline of Australia (Hewitson, 2012). It eventually evolved into a service that not only met the commercial needs of the outback but also provided a mantle of physical, social and emotional safety for remote, isolated residents (Harte, 2002). However, little is known of the social capital benefits and the shared community concepts of trust, cooperation and values High Frequency (HF) radio engendered amongst its users. Consequently, this paper examines the relationship between the use of HF radio and the social and economic development of the NT. The research question this project sought to address was: 'Did High Frequency radio use contribute to the social capital of the Northern Territory?'

In order to provide a context for the research, the paper commences with a description of the NT. This is followed by a brief historical overview of the use of HF radio in the Territory. The paper then discusses the theoretical concept of social capital and the methodology employed in the data collection. An analysis of the data and a discussion of the social capital indicators, as defined by the Organisation for Economic Development and Cooperation (OECD), follows. The paper concludes with a summary of the qualitative data and a description of the social capital outcomes facilitated by HF radio use.

The Context and the History of Telecommunications Access in the NT

A review of the literature indicates that, apart from an historical timeline, little is known of the role of HF radio or the DCRS in building community capacity. This topic has been under-researched and is absent in the history, management, social science and Information Communications Technology (ICT) literature. Consequently, this paper will fill a significant gap in the literature by exploring the nexus between social capital and HF radio use in the NT.

The Northern Territory is situated in the far north region of Australia. It covers a geographic area of 1,349,290 sq km (Geoscience Australia, 2018). According to the Australian Bureau of Statistics (ABS), as at 2017 the total population of the NT was 246,105 and the population density was 0.2 people per sq km (ABS, 2017). More than 50 percent of the Territory population reside in Darwin, the capital city of the NT. The remainder reside in remote or very remote communities. Approximately 25 per cent of the population are of Indigenous descent (ABS, 2017). The provision of telecommunications access to the people of the NT has a long history (Bandias & Mason, 2017; Bandias & Vemuri, 2005; IMG, 1980; Legislative Assembly of the Northern Territory, 1985; Livingston, 1996; Moyle, 1984). It was, and is, complicated by remoteness, isolation and low population density.

Initial telecommunications access in the NT commenced in 1913 with the establishment of a coastal radio station in Darwin. It was established for the purpose of safe-guarding the lives of seafarers and to guard the Northern coastline of Australia (Hewitson, 2012). Although Darwin was connected to the national telephone network in 1942, the remote, underpopulated regions

http://doi.org/10.18080/jtde.v7n4.229

of the Territory remained isolated from the mainstream (Bandias, 2008; IMG, 1980; Moyle, 1984). Both distance and lack of telecommunications access contributed to the isolation.

In the ensuing years the Coastal Radio Service evolved into Darwin Costal Radio Service (DCRS), and eventually the Outpost Radio Service.[i] At the height of its operation, the DCRS was one of the busiest stations in the Coastal Radio Service and employed a staff of ten (Hewitson, 2012). Victor Juliet Yankee (VJY) was the call sign for the dedicated radio service for Health and Aero Medical Services in the Top End of the NT.[ii] As the role of the DCRS expanded, it eventually serviced the whole of the remote top end of Australia as the only communications network relaying medical, civil, legal and defence information between remote communities, pastoral stations and Darwin.[iii] Manned operations closed in June 1999 with the upgrading of all outposts to satellite communications and the station officially closed on 30 June 2002 along with other coastal radio stations (Northern Territory Police Historical Association, 2000).

Social Capital a Theoretical Perspective

Both the ABS and the OECD define social capital as "...networks, together with shared norms, values and understandings which facilitate cooperation within or among groups" (ABS, 2002, p. 4; OECD, 2002). The concept has its origin in a number of disciplines and, as a consequence, it is a mix of disparate ideas such as trust, reciprocity, norms and cooperation. It has been argued that there is a strong positive correlation between the acquisition of social capital and social and economic wellbeing at both the individual and community level (ABS, 2004; Coleman, 1988; Grootaert, 1998; OECD, 2002; Woolcock, 2000). Stone (2001) states that influential social capital theorists perceive the outcomes of social capital are concerned with "...social and economic well-being, democracy at the nation state level and the acquisition of human capital..." (p. 4).

The dimensions of social capital that emerged in the data gathering phase of the research were closely linked to the theoretical constructs that underpin the concept. Trust, networks, reciprocity and cross-cutting ties are common themes in the social capital literature. These themes correlate with the OECD recommended indicators of social capital (OECD, 2002). The indicators include community participation through organised groups, informal networks, trust, cross-cutting ties such as bonding (within groups) and bridging (across groups) and indicators of ICT-based networks.

Methodology

The research question, 'Did High Frequency radio use contribute to the social capital of the Northern Territory?' emerged as the project evolved. Consistent with a grounded theory research paradigm, this project employed a qualitative methodology (Carmichael & Cunningham, 2017; Loonam, 2014; Martin, 2018). According to Martin (2018), grounded theory is a deductive methodological study of "... culture, which sees the communication process as a means of production, created through the discourse of groups and individuals that is produced within particular political, historical, and cultural contexts" (p. 16).

The data was collected through a process of recording discreet interviews from 32 self-identified HF radio users. A request for volunteers to participate in the project was circulated via Charles Darwin University eNews letter, the NT Branch of the Australian Computer Society and Darwin's ABC radio. A number of participants also recommended other potential interviewees. All participants were self-identified HF radio users in the period between 1950 and 1990. Ethics approval was sought and obtained from the Charles Darwin University Human Ethics Committee in August 2016.

Fifteen of the participants were former nurses; three were medical practitioners; three were teachers; three were school boarders; two were wives/mothers; and the remainder included a construction worker, a pilot, a radio technician, a VJY operator, a tourist operator and a surveyor. Twenty-four of the thirty-two participants were female. This gender bias is a reflection of the then demographic of the HF radio users.

In the period between August 2016 and June 2017 two experienced researchers conducted face-to-face and telephone interviews. In order to provide a focus for the interviews, the participants were asked a number of stimulus questions. The interviews were subsequently transcribed and returned to the interviewees for verification and correction where necessary. In analysing the data a number of consistent themes emerged. The themes are discussed in the following section.

Consistent Themes

The vital role of HF radio

In recoding recollections of the interviewees, the vital role HF radio played in the lives of the outback inhabitants became apparent. In the absence of any other form of communication, DCRS was an essential means of accessing health and education services, maintaining social contact and facilitating commercial transactions. However, transmission and reception over HF radio was not without its vulnerabilities.

A core group of people worked behind the scenes to keep DCRS operational. They included technicians, telegraph operators and, in some instances, indigenous telegraph boys. They were, as one interviewee stated, the 'life blood' of the radio service. They monitored the three radio frequencies utilised by the DCRS and they kept VJY on air twenty-four hours a day, seven

http://doi.org/10.18080/jtde.v7n4.229

days a week. According to one interviewee: “The technicians did anything and everything that was required to keep VJY operational and the ‘community’ connected”.

The technicians and the ‘girls’ who were employed as telegraph operators were central to the effective operation of the DCRS. They connected outback users with vital medical services; relayed information on impending cyclones, floods and medical emergencies; facilitated commercial transactions; and assisted novice users, including medical staff, in taking calls.

A number of contributors acknowledged the high regard the outback community had for the operators. The operators were “…loved, feted and looked after” by the community they served. Regular VJY users often expressed their appreciation by providing the operators with boxes of mangoes, buffalo fillets, live crabs and crayfish.[iv]

Despite the instability of and issues inherent in HF radio transmission, it was a vital communication system. As one interviewee commented: “[HF Radio] was a lifeline for running daily life from getting in stores, listening for weather reports, schooling, social life, social contacts, to emergency and health care”. Children were educated, medical services were delivered, spiritual support was accessed and community activities all took place amid the static, unwelcome cross-frequency intruders and technology failures. It was acknowledged that, for many years, there was no other alternative.

Cross-cutting ties – bonding within and across groups

VJY was a public radio network. Everyone connected to the frequency could potentially hear every message that was sent and received. According to one interviewee: “There were no secrets in radio land”. Everyone knew the news that was vital to the fabric of community life – births, deaths, marriages, wives chasing recalcitrant husbands, who had paid their bills and even who was behind in their rent. Participants listened to evolving romances, funeral arrangements, people being informed of a death in the family, patient diagnosis, stations talking to employees, mechanics ordering parts and grader crews requesting supplies.

Medical services had priority use and a ‘sched’, which dictated their scheduled time and duration. However, the very public nature of the network ensured everyone was informed. As one contributor commented: “Everyone tuned into the same wavelength and got the run on each station’s medical problems!”

Everything in life and the bush was discussed. Everyone involved listened to and shared in the events that defined the life of their community. The loss, empathy, humour and love that regularly played out over the airwaves helped form a unique bond amongst the HF users, some of whom would never meet face to face.

http://doi.org/10.18080/jtde.v7n4.229

Whilst many interviewees lamented the lack of privacy over HF radio, they also acknowledged the vital role it played in building a sense of community. The pastoral care, medical support, social interaction and community engagement delivered over HF radio was a collective experience that enriched the lives of those who lived and worked in the isolation of the outback. As one interviewee recounted:

> I was always within earshot of the radio whilst at camp and I would listen to the morning chatter. People, all strangers ordering Vegemite, flour, beer and stores. I would listen to … the local mob from outstations talking to … the VJY Darwin operator, to the shop and to each other. Sometimes in Kriol, sometimes in that wonderful Arnhem Land accented English and often full local language. It filled my mornings and made me feel a part of the Northern Territory and this big community.

In the physical absence of immediate neighbours, extended family and access to essential services, radio users bonded over their shared experience lived through their 'life in radio land'. The depth of the bond was illustrated by one of the interviewees who, in 1988, was asked to make the final call on VJY on its transfer to St John Ambulance — a narrower more medically focused radio service. She emotionally described the final call as: "[It] was like saying goodbye to my family".

Informal and formal networks

The coastal radio service was a 'community' in every sense of the word. As the use of the DCRS evolved and grew, both formal and informal networks were established over the air. The Aero Medical Service, The Country Women's Association, The School of the Air and religious services held regular sessions that required an understanding and an adherence to schedules, protocol and etiquette. Those outback residents hungry for gossip and human contact could access what was euphemistically called the 'Cockatoo Service' and participate in a 'galah session'.[v] The galah sessions were open for general communication and social chit-chat.

For the women of the outback the DCRS filled a huge social void. Of an evening, after the business of the day had been transacted and children had completed their school-of-the-air sessions, the women would use the radio for social contact and to participate in clubs, groups and associations that had formed over the radio.

One club, a public speaking group for women, commenced in the early 1980s and fulfilled such an important social need that it continued until 2003 when the Internet had made HF radio all but redundant. Participants used the School-of-the-Air frequency and conducted their meeting from radios in Darwin, Humpty Doo and Katherine as well as pastoral stations in the remote areas of the Territory. The 'venue' covered a geographical area of over 800,000 square miles [2 million square kilometres] and 'meetings' occurred on a regular monthly basis. Such was the persistence of the group that, despite the static, the increasingly poor reception and the often cross-frequency interruptions by fishermen in the Arafura and Timor Seas, the group 'met' on-air for over twenty-three years. However, as one participant commented, the club served much more than a social need:

> These airborne [club members] of the outback stepped forward to become active members of organisations that were involved in their lives and business. I believe that, through their involvement, the Isolated Children and Parents Association became a powerful lobby voice to Government.

Trust

The DCRS operated on a basis of trust. Users trusted the DCRS to keep them connected, informed and provide access to vital essential services. They also trusted the relationships and bonds that had developed over the airwaves with the operators, technicians, medical staff and other VJY users. These bonds were often vital for the physical, social and emotional health of isolated outback users. As one interviewee stated: "If there was a problem somewhere, someone (on the DCRS network) would fix it".

There was a mutual understanding between the DCRS users of the necessity of providing assistance in a time of need. The vagaries of the DCRS and poor atmospheric conditions often meant that radio communication was difficult. An example of the cooperation and mutual trust that existed on the airwaves was highlighted by the following comment: "Everyone helped everyone else, and often unknown other users would help convey messages if we were having trouble sending or receiving".

The depth of the trust amongst HF users was often apparent in times of emergencies. In the absence of face-to-face medical assistance many lay people became primary caregivers:

> Radio consultations were usually between the doctor and a nurse. However, many calls were from women unqualified in medical matters, but all became skilled in presenting the patient symptoms. It was not uncommon for the doctor to ask the person at the other end their opinion regarding management and treatment. There was tremendous trust in the judgement of these rural people, nurses and others.

Users respected the priority of the medical schedules and they acknowledged the effort of the technicians and operators that kept VJY operational 24 hours a day. They trusted each other to co-operate in collective on-air public endeavours and they trusted the on-air community to provide them with often much needed support. In the words of one interviewee: "…everyone looked after everyone else. They gave support and comfort to each other. They had a better

http://doi.org/10.18080/jtde.v7n4.229

understanding of living in the outback and they provided a form of security for those living in remote locations”.

Discussion and Conclusion

As evidenced by the qualitative data, HF radio had a significant role in building the social capital of the Northern Territory. From its initial operation in 1913 until its closure in 2002, the DCRS was indispensable in developing the community of the outback. HF radio brought education to the children of the bush; it serviced the commercial, medical, social and spiritual needs of its inhabitants; and it gave comfort, solace and companionship to those isolated by distance and remoteness. HF radio was the glue that held the community together.

The VJY ‘girls’, technicians, medical staff, wives, mothers, entrepreneurs, teachers, missionaries and government employees shared their lives via the radio. They bonded over their collective experience. They formed groups, shared gossip, attended religious services and built a community based on trust, reciprocity and cooperation. They also endured the vagaries and problems inherent in using HF radio. Medical emergencies, cyclones, love, births, deaths – all the major life events occurred and were shared in the public domain of the DCRS.

HF radio was also instrumental in ensuring that isolated residents were part of the participatory democracy process. It enabled them to access and share information, to join community groups, to become effective advocates and to participate in the events that shaped their existence. The human capital of the outback was similarly enhanced through the provision of education, training and the opportunity for improved individual capability. These intangible social capital outcomes created economic and social value for individuals and the broader community. They also enabled the inhabitants of the outback to thrive in an otherwise harsh and isolated existence.

Although the researchers endeavoured to interview a cross-section of HF radio users there are a number of omissions and limitations to this study. The experience of indigenous people is notably absent from the data. However, photographic and anecdotal evidence indicates that indigenous people living in remote and very remote regions of the NT did use HF radio on a regular basis and for a variety of purposes. Similarly, the experience of male cattle station owners and managers is also missing from the data. Further research that incorporates a broader cross-section of HF radio users in the NT would enrich our understanding of the HF radio-social capital nexus.

The available evidence indicates that fifty years after these events the memories of life lived via the DCRS are still vivid and that the sense of ‘community’ has not diminished. The interview participants spoke fondly, with affection and admiration for their on-air

http://doi.org/10.18080/jtde.v7n4.229

companions. They also lamented the demise of the DCRS. As interviewees commented: "There was indeed a romance about VJY...we never realised one day it would be gone".

References

ABS. (2002). *Social Capital and Social Wellbeing* Canberra Retrieved from https://www.oecd.org/innovation/research/2380806.pdf.

ABS. (2004). *Information Paper Measuring Social Capital An Australian Framework and Indicators*. Retrieved from https://www.ausstats.abs.gov.au/Ausstats/free.nsf/Lookup/13C0688F6B98DD45CA256E360077D526/$File/13780_2004.pdf

ABS. (2017). *Australian Demographic Statistics, Sept 2017*. Retrieved from http://www.abs.gov.au/ausstats/abs@.nsf/mf/3101.0

Bandias, S. (2008). *The role of Telecommunications in the Sustainable Sustainable Development of Rural and remote communities in the NT*. (Doctor of Philosophy), Charles Darwin University, Darwin.

Bandias, S., & Mason, E. (2017). *Life in Radioland - Stories from the bush before the mobile phone*. Darwin: Historical Society of the Northern Territory.

Bandias, S., & Vemuri, S. R. (2005). Telecommunications infrastructure facilitating sustainable development of rural and remote communities in Northern Australia. *Telecommunications Policy, 29*(2), 237-249.

Carmichael, T., & Cunningham, N. (2017). Theoretical Data Collection and Data Analysis with Gerunds in a Constructivist Grounded Theory Study. *Electronic Journal of Business Research Methods, 15*(2), 59-73.

Coleman, J. S. (1988). Social Capital in the Creation of Human Capital. *American Journal of Sociology, 94*(s1), S95.

Geoscience Australia. (2018). Areas of Australia - States and territories Retrieved from http://www.ga.gov.au/scientific-topics/national-location-information/dimensions/area-of-australia-states-and-territories

Grootaert, C. (1998). *Social Capital: The missing link*. Retrieved from http://www.worldbank.org/poverty/scapital/wkrppr/sciwp3.pdf

Harte, B. (2002). *When radio was the cat's whiskers*. Dural, N.S.W: Rosenberg.

Hewitson, P. (2012). Australian MSC. Retrieved from http://coastradio.info/vid.html

IMG [Implementation and Management Group]. (1980). *A Study of Remote Area Telecommunications in the Northern Territory*. Sydney: The Group.

Legislative Assembly of the Northern Territory. (1985). *Report of the Select Committee On Communications Technology*. Retrieved from https://trove.nla.gov.au/version/46639633

Livingston, K. (1996). *The Wired Nation Continent*. Melbourne: Oxford University Press.

Loonam, J. (2014). Towards a Grounded Theory Methodology: Reflections for Management Scholars. *Irish Journal of Management, 33*(1), 49-72.

http://doi.org/10.18080/jtde.v7n4.229

Martin, V. (2018). Grounded Theory: Popular, Useful, and Misunderstood. *Journalism & Mass Communication Quarterly, 95*(1), 12-14. doi:10.1177/1077699018759676

McKay, F. (1995). *Traeger the Pedal Radio Man*. Moorooka Qld: Boolarong Press.

Moyle, A. (1984). *Clear Across Australia - A History of Telecommunications*. Melbourne: Thomas Nelson.

Northern Territory Police Historical Association. (2000). NT Police Museum. Retrieved from https://sites.google.com/site/ntpmhsociety/home/our-rich-history/equipment-1/communications

OECD. (2002). *Social Capital: The Challenge of International Measurement* Retrieved from London: http://www.oecd.org/innovation/research/2380584.pdf

Stone, W. (2001). Measuring Social Capital: Towards a theoretically informed measurement framework for researching social capital in family and communtiy life. Melbourne: Australian Institute of Family Services.

Woolcock, M. (2000). Social capital and its meanings. *Canberra Bulletin of Public Administration, 98*, 17-19.

Endnotes

---

[i] For the purpose of this article the various iterations of the Costal Radio Service will be referred to as Darwin Costal Radio Service (DCRS).

[ii] Voice communication was not initially part of the service offered to the outposts for personal traffic. This service was reserved for the Aero Medical Service only. Eventually, the VJY service evolved to a mix of telegrams and phone calls, all manually connected and relayed by the operators at VJY.

[iii] The Katherine School of the Air shared the Darwin Costal Radio Service frequency with the Aero Medical Service up until 1966 when increased demand necessitated they operate under a dedicated radio frequency.

[iv] In recognition of the vital role of the telegraph 'girls', a bark painting of "VJY Telephone Operators" by Brian Nyinawanga [1982], was presented by the Bawinanga Aboriginal Corporation of Maningrida to the VJY operators. The painting is currently held in the collection of the Museum and Art Gallery of NT. It is the only known bark painting depicting non-Indigenous women.

[v] Galah sessions were named in recognition of the flocks of screeching galahs that frequently descended on the radio aerials strung between the HF radio and the nearest tree (McKay. 1995)

http://doi.org/10.18080/jtde.v7n4.229

The Digital Radio Concentrator System

Simon Moorhead
Ericsson Australia and New Zealand

Abstract: A reprint of a technical paper from 1986 which details the design and development of the Digital Radio Concentrator System deployed by Telstra to provide automatic telephone services throughout outback Australia.

Keywords: Telecommunications, History, Digital Radio Concentrator System, Telecom Research Laboratories, National Rural and Remote Programme

Introduction

This historic paper (Martello, Lopes, Worsdell & Bannister, 1986) details the design and development of the Digital Radio Concentrator System (DRCS), which was deployed by Telstra's predecessor, Telecom Australia, to provide automatic telephone services to customers throughout outback Australia in the 1980s. Prior to DRCS, rural customers were connected to manual exchanges where operators physically connected calls and often relied on the vagaries of high frequency two-way radio.

Telecom's National Rural and Remote Programme at the time aimed to extend automatic telecommunication services to rural and remote areas by 1990. The DRCS was used to convert about 6,000 manual services and connect between 3,000 and 4,000 customers in remote areas.

The DRCS system was initially conceived by Telecom Research Laboratories and purposely designed to suit homestead-based customers and withstand Australian environmental extremes. The DRCS provided a connection from the local exchange to the customer using a pair of duplex, time-division-multiplexed, digital radio bearers. These bearers can carry 15 circuits and are shared between up to 127 customers via a concentrating switch at the exchange, hence the Digital Radio Concentrator name. The bearers are regenerated at repeaters typically 50 km apart, and there is a performance limit of around 13 repeaters in tandem, or a nominal range limit of about 600 km.

Notwithstanding these limitations, Telecom installed about 1,000 repeaters and covered 2.8 million square kilometres by the end of the programme. See the map from Brass (1993), originally published in *Australian Geographic*, reproduced at the end of this article.

http://doi.org/10.18080/jtde.v7n4.242

The significant distances encountered in remote Australia between telephone exchanges and subscribers essentially excludes cable connections due to the high cost of connection. This is why Telecom Research Laboratories specified a regenerative digital radio scheme with burst transmission to provide maximum system flexibility and minimal power consumption.

Telecom issued a worldwide tender for the DRCS equipment in 1980, including a staged development programme to industrialise the design and to demonstrate the equipment feasibility. NEC Australia was the successful tenderer; and extensive testing of prototypes and digital transmission studies were undertaken to prove performance. Telecom first trialled the DRCS in Western Australia at Meekatharra and Mt Magnet in 1985.

The paper provides readers with details of the digital frame structures and the switching and control arrangements. It also details the radio path surveys undertaken by helicopter to design the systems. The tower heights and system configurations are given, as well as the functions and responsibilities of the various Telecom installation groups who made this state-of-the-art project successful.

Solar power was provided at both the subscriber and repeater sites, ensuring the system continued to operate independently of the often-unreliable mains power. The DRCS systems operated for about 20 years and during that time went through an evolution to a higher capacity version. As recognition of its achievements in DRCS, Telecom was awarded the 1986 Engineering Excellence Award by the Institute of Engineers Australia, Queensland Division.

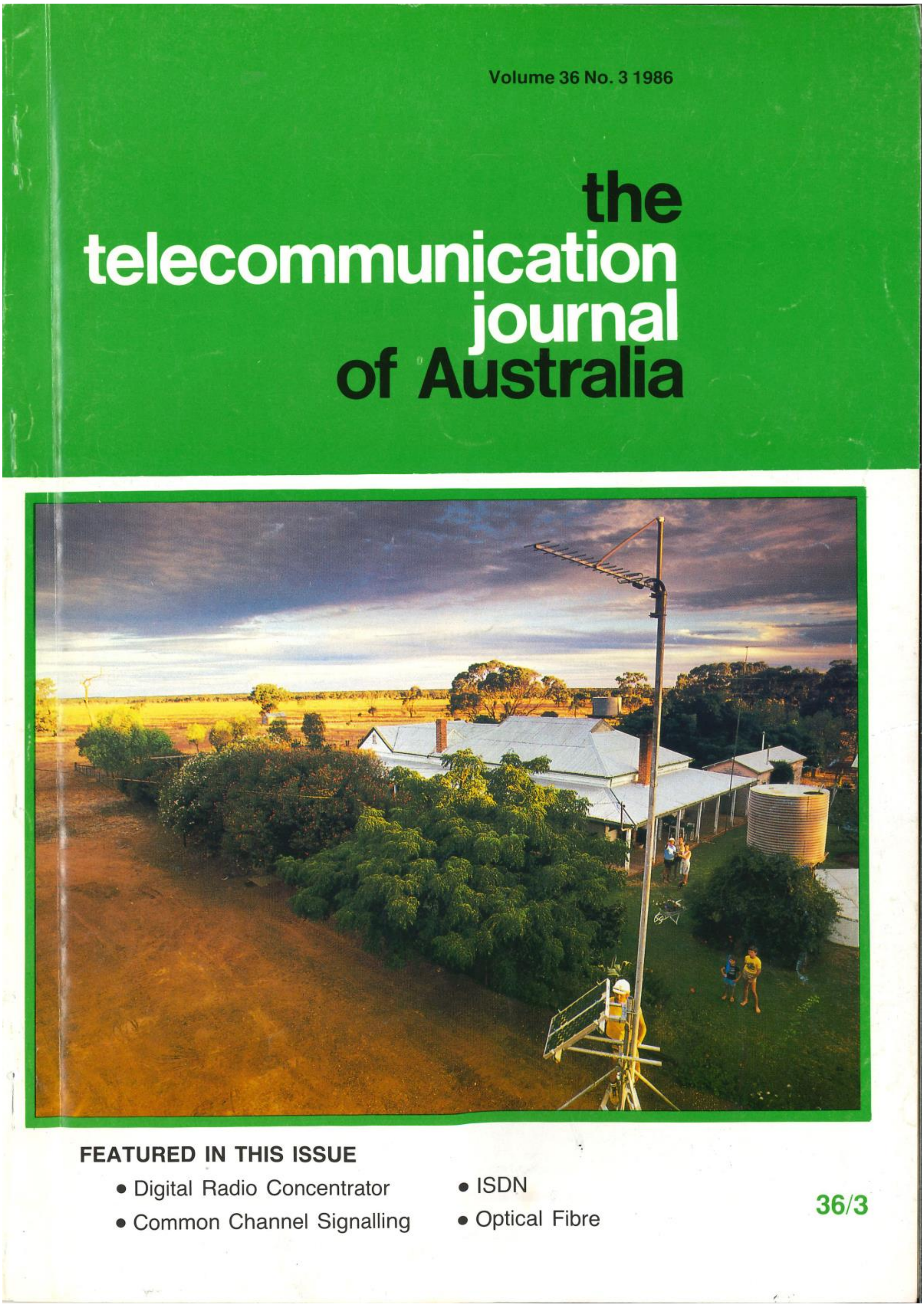
References

Martell, P. H., Lopes, P., Worsdell, G., & Bannister, G. P. (1986). The Digital Radio Concentrator System — DRCS, *Telecommunication Journal of Australia*, *36*(3), 3-22.

Brass, K. (1993). The phone goes bush, *Australian Geographic*, *29*, 56-75, January-March. The article was reproduced by Telstra and the Telstra reprint is available at http://www.coxhill.com/trlhistory/media/The%20Phone%20Goes%20Bush.pdf

The TJA Cover from March 1986

The cover of the *Journal* showed an outback family watching a DRCS installation.



The Historical Reprint

The Digital Radio Concentrator System — DRCS

P.H. MARTELL B.E. (Hons)
C. LOPES B.E.
G. WORSDELL A.I.T. (Comm Eng)
G.P. BANNISTER A.R.M.I.T.

The function of the DRCS is to form the basis of the local network for about 10 thousand of Telecom's existing and potential customers over much of Australia's habitable interior. The system is complex, employs new transmission techniques and is being used in a severe environment.

This paper describes the DRCS, its development and the installation of the first complete system.

INTRODUCTION

Telecom's National Rural and Remote Area Programme includes the extension of automatic telecommunications services to rural and remote areas so that all Australians will have access by 1990. The DRCS will be used for the conversion of about 6000 manual services in rural areas and the connection of the majority of 3000 to 4000 expected applicants in remote areas. About 850 DRCS Repeaters will be used to connect these customers and the area covered will be of the order of 3 million square km.

Initially conceived in Telecom's Research Laboratories, the DRCS has been designed specifically for the task. It is capable of providing the range of telecommunications facilities demanded by Telecom's customers, its configuration suits Australia's low density, homestead based population and it has been designed to withstand Australian environmental extremes.

GENERAL DESCRIPTION

The DRCS provides the connection from the local exchange MDF to the customer. It does this over a duplex pair of time division multiplexed digital radio bearers (refer to **Fig. 1)**. The bearers can carry 15 circuits, which are shared between up to 127 telephone/data users by way of a concentrating switch located in the exchange. Up to 28 telex services can also be provided on one of the 15 circuits in lieu of telephone/data use.

System range

The radio bearers are regenerated at Repeaters, which may be arranged in any branching configuration. There is a limit, however, of 13 tandem-connected DRCS Repeaters, giving the system a nominal range of 600 km. Each Repeater receives the bearer coming from the exchange direction, referred to as the downward bearer, and re-broadcasts to the next Repeater and to Subscriber units located at or near the customer's premises. Each Repeater also receives the upward going bearer from Subscriber or Repeater units and re-transmits back toward the exchange. Radio path lengths from Repeater to Repeater or from Repeater to Subscriber can be up to 70 km but are typically 50 km and 30 km respectively.

System Components

The basic system components and their main functions are:

- The Concentrator — A software controlled device switching and concentrating 127 telephone/data lines to 15 analog circuits **(Fig. 2)**.
- The TDM Controller or TDMC — Converts the analog signals on 15 trunks to a digital stream and modulates a radio bearer **(Fig. 3)**.
- Repeater Units — Regenerate the upward and downward digital streams and retransmit the bearer on an appropriate frequency **(Fig. 5)**.
- Subscriber Units — Receive and transmit the upward and downward bearers **(Fig. 5)**.
- Drop Out Units or DOUs — Demultiplex, convert the digital information to analog and interface with the customer's terminal equipment. A DOU provides one service and is located in every Repeater and Subscriber unit but can be added by way of DOU Shelves to provide up to 20 additional services at a Repeater or Subscriber unit.

Facilities

All Subscriber and Repeaters units can provide an access point to all 15 circuits as required.

A range of services and customer terminal equipment can be supported, including the following:

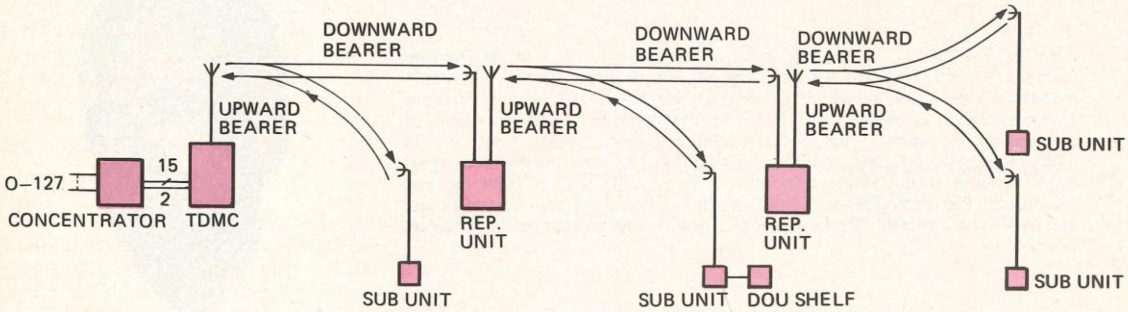
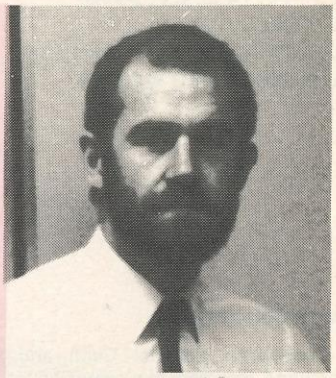


Fig. 1: System Upward and Downward Bearers

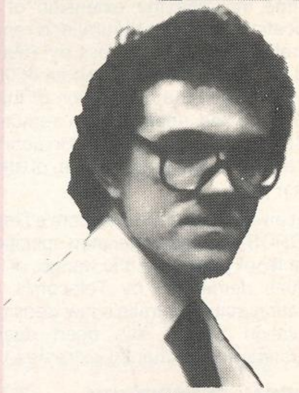
Journal of Telecommunications and the Digital Economy, ISSN 2203-1693, Volume 7 Number 4 December 2019

http://doi.org/10.18080/jtde.v7n4.242

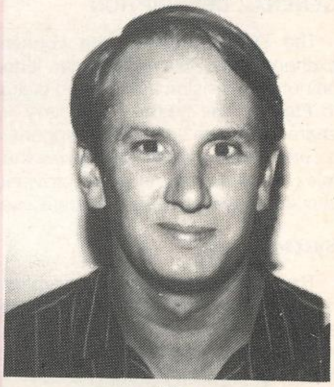
- All automatic telephone services such as Subscriber Trunk Dialling, International Subscriber Dialling, etc.
- All telephone instruments currently marketed by Telecom (although there are some limitations in the case of combinations of instruments and extension alarms).
- Telex



GREIG BANNISTER is an acting Supervising Engineer in the Radiocommunications Branch. He joined the PMG's Department as a Technical Assistant in 1969 and as an Engineer in 1971. He has been involved in system design, evaluation and provisioning of subscriber, small capacity, mobile and paging systems.



PHILIP MARTELL is a Senior Engineer in the Customer Section of the Radiocommunications Branch in Telecom Australia Headquarters. After graduating from the University of Melbourne with a Bachelor of Electrical Engineering (Hons), he joined Telecom in 1981. He has been involved with the design and provisioning of single channel subscriber radio systems and the field trial and volume production phases of the DRCS.



COLIN LOPES joined Telecom Australia as a cadet in 1973 and after graduation worked for 5 years in Traffic Engineering, carrying out computer program maintenance. During that time he also filled the Engineering Computer Co-Ordinator's position for a short period. After three years in Switching and Facilities (Metro), he moved to the HQ Switching Development and Support Branch, based in Sydney, in his present position of Technical Specialist.

GARY WORSDELL is currently a Senior Engineer in Commercial Projects Section of Country Region in Western Australia. He joined the PMG's Department in 1968 as a technician-in-training, received a traineeship in 1971 and graduated in Communications Engineering in 1974 from the Western Australian Institute of Technology. He spent 7 years in Radiocommunications Design, from 1977 to 1983, on projects including the Kimberley Microwave System and the Meekathara/Mt. Magnet Digital Radio Concentrator System design. In 1984 he was promoted to Project Engineer to co-ordinate installation of Western Australia's first two DRCS. He completed the special project role in 1985 and moved to his current position.

Journal of Telecommunications and the Digital Economy, ISSN 2203-1693, Volume 7 Number 4 December 2019

http://doi.org/10.18080/jtde.v7n4.242

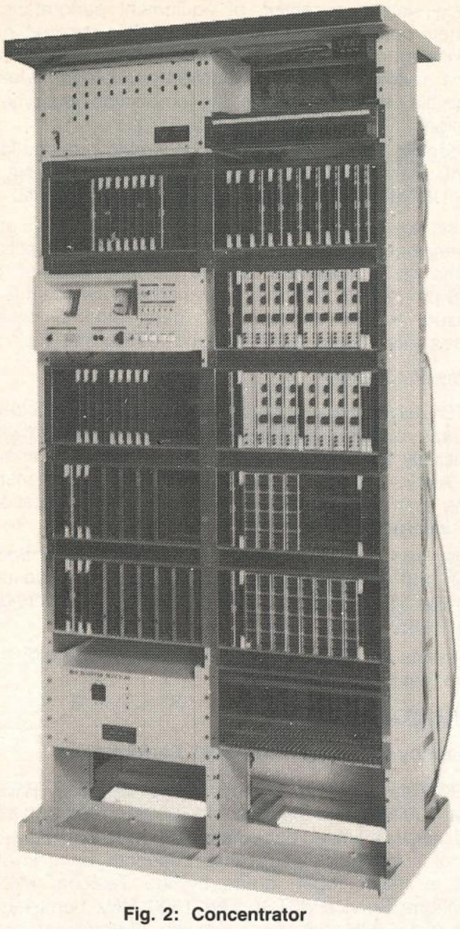


Fig. 2: Concentrator

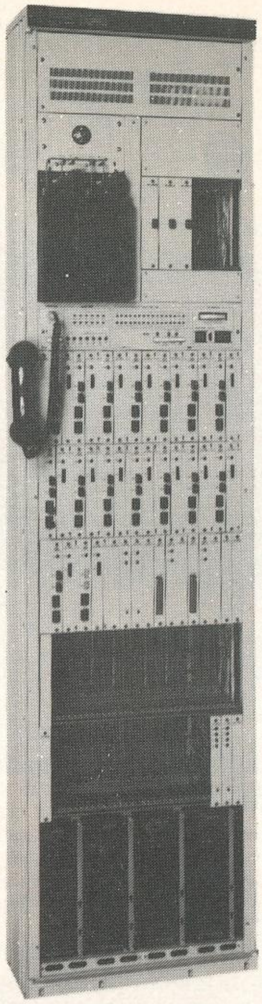


Fig. 3: TDM Controller

- Data connected through modems up to 2400 Kbit/s (2 wire through the switched network, 4 wire as a leased circuit) — enabling the provision of such services as Videotex and Telememo.
- Telecom's range of coin telephones
- Facsimile

Power source

The power consumption of Repeaters and particularly Subscriber units has been kept to a minimum thus allowing the economic use of solar power at most stations. Only at Repeater station sites where there is a nearby, reliable supply will mains power be considered. At Subscriber stations, as a general rule, solar power is preferred because home generating plants are notoriously unreliable and in those cases where mains power is available, special arrangements need to be made regarding connection and access.

DEVELOPMENT

Conception

In 1978, Telecom's Research Laboratories considered the problem of how Telecom might technically go about meeting it's commitment in rural and remote areas and in particular, those more difficult areas where the cost of connection using cable is high. There were, of course, existing means available using a range of technologies including a collection of Trunk, Small Capacity and Subscriber radio systems but an integrated and more economical system employing digital transmission, time division multiplexing and burst transmission was seen as most appropriate. These features enable Repeaters to regenerate indefinitely with negligible signal degradation, maximum system flexibility and minimal power consumption.

Design and Production

Following a feasibility study and facility specification, development and provisioning responsibilities passed to the Telecom's Development Division and in May 1980 a world wide request for tenders was prepared including a proposed development programme and detailed specification.

The successful tenderer was NEC Australia and the agreed development programme included the delivery of initially 3 field evaluation systems within two years and then after a further two years, the delivery of production equipment in bulk.

Field Evaluation

The field evaluation equipment was delivered in September, 1982, and installed in Telecom's Radiocom-

Journal of Telecommunications and the Digital Economy, ISSN 2203-1693, Volume 7 Number 4 December 2019
 http://doi.org/10.18080/jtde.v7n4.242

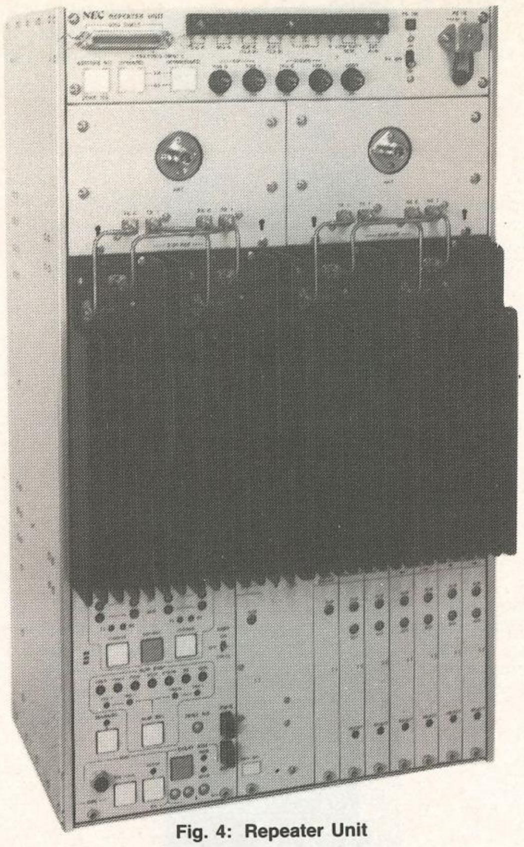


Fig. 4: Repeater Unit

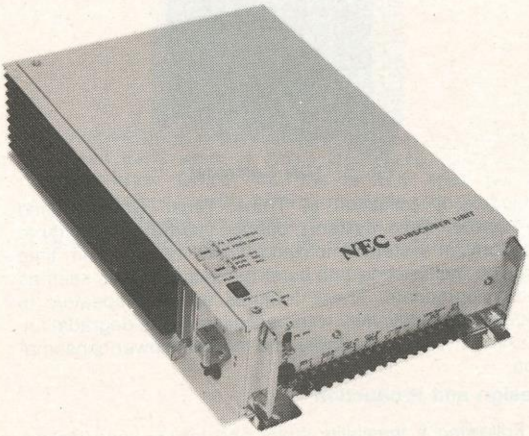


Fig. 5: Subscriber Unit

munications Laboratory, at Elliston in South Australia and at Charleville in Queensland. A fourth evaluation system was later installed at Berry Springs in the Northern Territory. All evaluation systems with the exception of the equipment installed in the Laboratory were used as working systems carrying customer traffic. In addition, propagation and equipment performance were extensively monitored at Charleville using equipment specially designed and constructed by Telecom's Research Department and Radiocommunications Laboratory.

There were two important aspects to Telecom's field evaluation programme:

- Firstly, intensive testing of equipment performance, system operation and new facilities. This resulted in a significant number of hardware and software modifications required in the evaluation equipment where possible, and changes in the production equipment design.
- Secondly, theoretical studies concerning propagation, particularly for potential interference paths inherent in the DRCS cellular frequency plan, were confirmed.

Masts, towers, shelters, antennas, power supplies and ancilliary equipment were also developed in conjunction with the radio equipment. Due to the magnitude of the DRCS programme and the remote areas in which it is to be used, special attention has been paid to design features that speed installation and reduce site visits.

Volume Production

NEC delivered the first production system in October 1984 and as in the case of the evaluation equipment was extensively tested in the Radiocommunications Laboratory. Again the equipment was subjected to intensive testing and both hardware and software modifications were incorporated by NEC.

The first installations were at Warren in New South Wales and at Meekatharra and Mt. Magnet in Western Australia. These systems were officially commissioned in June, 1985.

Systems are currently being ordered at the rate of over 50 per year.

TRANSMISSION ASPECTS

Frequency Planning and Radio Performance

DRCS systems can operate in two frequency bands, one at 500 MHz and the other at 1500 MHz. The 500 MHz band utilises a limited bandwidth of 30 MHz which gives a total of 7 frequency pairs. This frequency band is also used in major urban areas by the Telecom Mobile Telephone Service (MTS). The 1500 MHz band has a width of 100 MHz which can provide 22 frequency pairs. The full band, however, will not generally be available for DRCS. 13 frequency pairs have been set aside for normal use with the additional channels being set aside for special requirements.

Cellular Plan

In the areas of inland Australia for which the DRCS is intended there will be many systems, each having a number of repeating stations. As there are ony a limited number of frequencies to choose from, Repeater frequencies must be reused throughout the DRCS areas. This can be done by adopting a continuous cellular frequency plan in which frequencies are assigned to geographical zones on a repeating pattern. A Repeater or TDM Controller located in a particular zone must transmit on the frequency assigned to that zone. The determination of the cell pattern is governed by the interference between cells which have the same frequency. The DRCS cell plan and frequencies are shown in **Fig. 6.** Because the 1500 MHz band has more frequency pairs to choose from the distance between cells which have the same frequency is larger. This is an advantage in areas which have a high concentration of DCRS systems or are prone to the phenomenon of ducting which can allow interfering signals to travel large distances.

Antenna Radiation Patterns

In most cases, a Repeater will have two radiation patterns, one is generally circular or omnidirectional and is

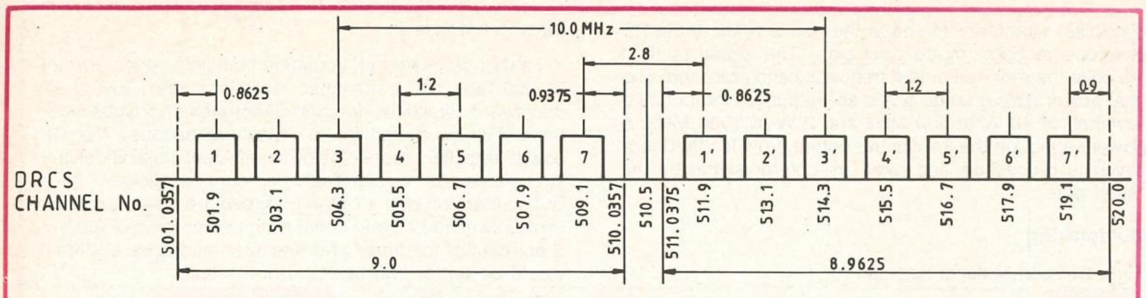


Fig. 6a: 500 MHz Frequency Plan

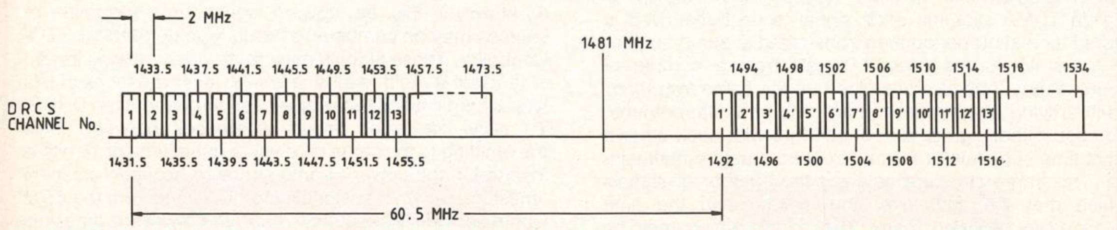


Fig. 6b: 1500 MHz Frequency Plan

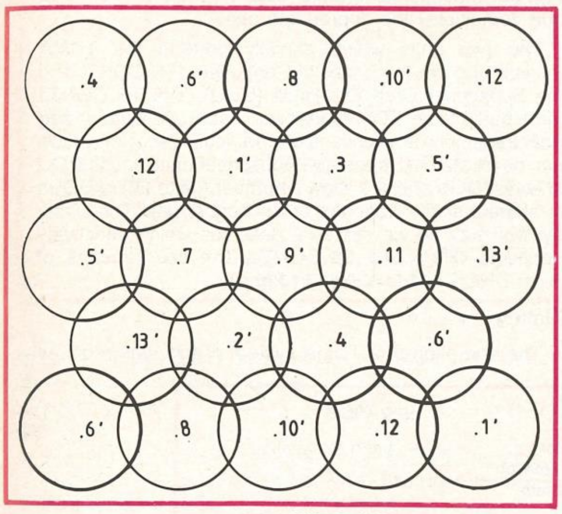


Fig. 6c: 1500 MHz Cell Plan

used to transmit to and receive from Subscriber stations in the surrounding cell and the next downward Repeater, the other is directional and is used to transmit to and receive from the preceeding Repeater. A Subscriber station's radiation pattern is directional to communicate with the appropriate Repeater.

Generally, the antennas used are commonly available or are adaptions of already developed antennas. In specifying DRCS antennas, special attention is paid to the need to minimise co-channel interference and to control wind loads, particularly on the structure located at the Subscriber station.

Both horizontal and vertical polarisation omnidirectional patterns are used so that cross polarisation protection can be used where required. All directional antennas can be adjusted to either polarisation.

In some cases where the propagation losses between adjacent Repeaters is high, it is advantageous to use a third radiation pattern at a Repeater. This is a narrow beam directed toward the downward Repeater. The signals transmitted and received are the same as those associated with the omnidirectional pattern and so, to avoid phase cancellation, the two antennas are cross polarised.

Performance Objective

The DRCS availability objective is 99.5 per cent of the year or better for each Subscriber. This corresponds to an unavailability of 44 hours in a year and includes equipment outages as well as unavailability due to anomolous propagation. Further objectives in terms of Bit Error Rate apply during the time the system is available to control transmission quality.

Digital Transmission

The radio bearers used in the DRCS have a data rate of 704 Kbit/s. The modulation scheme is two level Frequency Shift Keying (FSK) with discriminator detection. Binary FSK was chosen because it satisfied the cell pattern requirements, gave the simplest equipment realisation and allowed the use of efficient class C Radio Frequency (RF) power amplifiers. The use of simple modulation/demodulation techniques was of particular importance as it reduced the overall power consumption thus allowing the Subscriber and Repeater equipment to be solar powered.

The baseband Nyquist filtering for each hop is performed at the transmit end only. A simple digital filter is used. This approach has advantages in that a simpler filter can be used, no filtering is required at the receive end, emission bandwidth is slightly reduced and there is less manufacturing variation in the Bit Error Ratio (BER) performance.

Both 500 MHz and 1500 MHz receivers have Intermediate Frequencies (IFs) of 70 MHz and 2.1 MHz. The 500 MHz receiver has an additional IF of 10.7 MHz. Surface Accoustic Wave filters are used in the 70 MHz and 10.7 MHz IF circuits. A pulse count type discriminator is used.

Modulation in the DRCS transmitter section occurs at 80 MHz for the 500 MHz equipment and 130.5 MHz for the 1500 MHz equipment. The modulated signal passes through a "burst gate" which functions as a voltage

 http://doi.org/10.18080/jtde.v7n4.242

controlled attenuator to shape the rise and fall of the RF envelope in burst mode operation. The signal is then mixed to the required output frequency and amplified. The final power output stage gives an output (at the antenna terminal) of 10 W at 500 MHz and 2 W at 1500 MHz. A power sensor on the transmitter output provides feedback which is processed and used as control signal by the "burst gate".

Multiplexing

Time Division Multiple Access

The key transmission characteristic of the DRCS is its use of Time Division Multiple Access (TDMA) multiplexing. In TDMA systems each signal to be transmitted is stored for a short period then transmitted at some number of times its normal speed. Signals from a number of sources may thus be transmitted on the same frequency each arriving at the receiving antenna at a different time. To ensure that signals do not interfere with each other a strict time schedule or frame structure must be maintained. The frame structure sets out the number of signals which may be sent over the system and the time relationship between them. The period which may be occupied by a particular signal is referred to as a timeslot.

Frame Structure

In the DRCS frame structure each speech channel has a data rate of 32 Kbit/s and uses Adaptive Differential Pulse Code Modulation (ADPCM). ADPCM encodes only the differences between successive voice samples and continuously adjusts the quantising step size depending on the input voice signal level. Speech at 32 Kbit/s is stored for 4 ms then transmitted at 704 Kbit/s for 236 usec. There are 16 timeslots in the DRCS, 15 for speech and signalling and one, time slot 0 (TSO), for supervision and signalling. The signalling information associated with speech timeslots is sent either at the end of the timeslot or within the speech timeslot when speech is not being transmitted. **Table 1** lists the signal types and their position in the frame structure.

Burst Transmission

To reduce power consumption timeslots which are not in use are not transmitted in either the upward or downward directions for both Repeater and Subscriber units. This is a significant advantage because the RF power amplifier, despite being an efficient class C design, still consumes a significant amount of power. In a Subscriber unit with a call in progress the power amplifier is only switched on and consuming power for 236/4000 = 6 per cent of the time, whereas in an analogue system it would be on for 100 per cent of the time.

The frame structure for each of the two directions of transmission, upward and downward, are shown in **Fig. 7.** As shown in **Fig. 8a,** upward signals from a number of sources may be combined at each repeater and the TDM Controller. These signals may be at widely varying levels. To provide a rapid response time to level variations of this type a hard limiting receiver is used throughout the DRCS. To allow for small timing differences between sites transmitting to the same receiver, a guard time of 16 bits is inserted in the upward frame structure between adjacent timeslots. Downward signals are broadcast from the TDM Controller and Repeaters. Thus, all downward timeslots are available to all stations on the system, as shown in **Fig. 8b.** Stations using a particular timeslot simply select and demultiplex the appropriate one.

The two units which actually perform the TDMA multiplexing are the Timeslot Controllers (TS CONT) and the Subscriber Drop Out Units (DOU). The TS CONTs form part of the TDM Controller, each one supervising both transmission directions of a particular timeslot. DOUs can be located in Repeaters, Subscriber units and in DOU shelves. DOU shelves allow a number (up to 20) of DOUs to share a single Repeater or Subscriber unit. The whole system may be viewed as a data bus which effectively connects DOUs and TS CONTs. The bus structure of each DRCS unit is shown in **Fig. 9.**

Timing

The operation of a TDMA system of this type requires

TYPE	DOWNWARDS	UPWARDS
Timeslot 0	— Battery Saving Control — Terminating Call Information — Idle Timeslot Assignment — Orderwire Control — Delay Adjustment Information — Polling for Alarm Information	— Alarm Information
Speech Timeslot (Nos. 1-15)	— Page — Release — Originating Call Accept — Test Call — Delay Information — Remote Delay Check — Codec On — Disconnect — Orderwire Interrupt	— Page Response — Release Guard with Hook Information — Connect Request with Category Check — Originate — Line Lock Out Release
E&M (at end of speech timeslot)	— Metering Signal (Originating) — Ringing Control (Terminating)	— Dial Pulses (Originating) — Off Hook
INS (at end of speech TS)	— Polarity Reversal	

Table 1 — Signalling in the Frame Structure

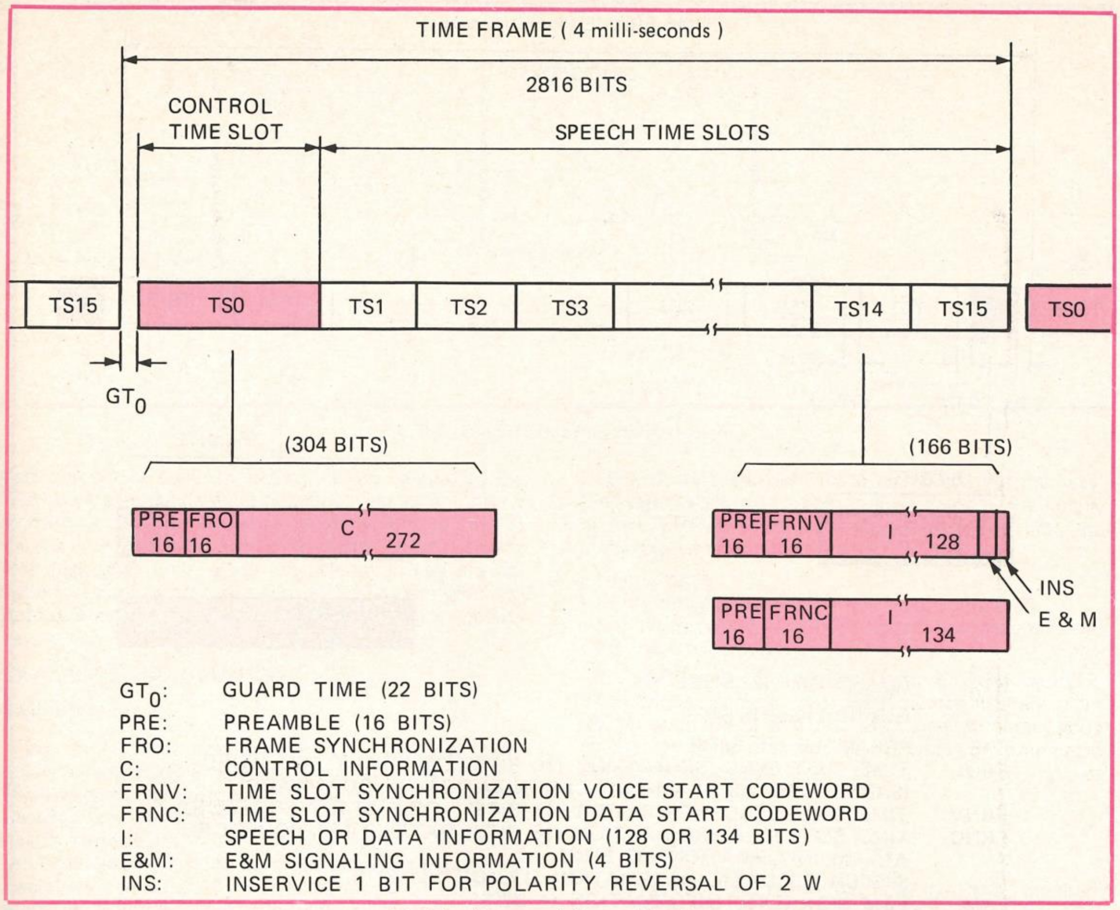


Fig. 7a: Downward Frame Structure

precise timing. Each radio unit must synchronise its internal frame clock to the rest of the system. The timing system chosen by NEC is based on the following principles:

- The TDM Controller is the master clock of the system. All units derive their timing from the synchronising word in downward TSO.
- The effective transmission time for each hop shall be the same.
- The addition of a new Subscriber or Repeater unit shall not require adjustment of the existing equipment.

Subscriber units may be any distance from 0 to 70 Km from their parent station (a Repeater or the TDM Controller). This corresponds to a propogation time variation of 122 us or approximately one complete timeslot. The DRCS gets over this problem by delaying the instant of transmission as a function of distance from the parent station. The closer in the station, the longer the delay and vice versa. Thus if a number of stations transmit on the same timeslot at the same time they will all arrive at the parent station at the same time because each unit will be delaying its transmission to allow for its distance from the parent station. Each unit must know the distance to its parent station to calculate the required delay. When a Repeater or Subscriber unit is installed this distance will be known, approximately, and this first guess is set in a distance switch on the radio unit. A system function known as a delay check is then initiated. A delay check request causes the radio unit to send a small RF pulse in the middle of an unoccupied timeslot. The TDM Controller then sends back a signal in the downward timeslot indicating whether the pulse arrived too early to too late. This is displayed in the radio unit by means of increase (INCR) and decrease (DECR) LEDS which prompt the person installing the unit to adjust the distance setting. This process enables the distance to be set to a resolution of 0.1 km with an overall accuracy of approximately 0.4 km.

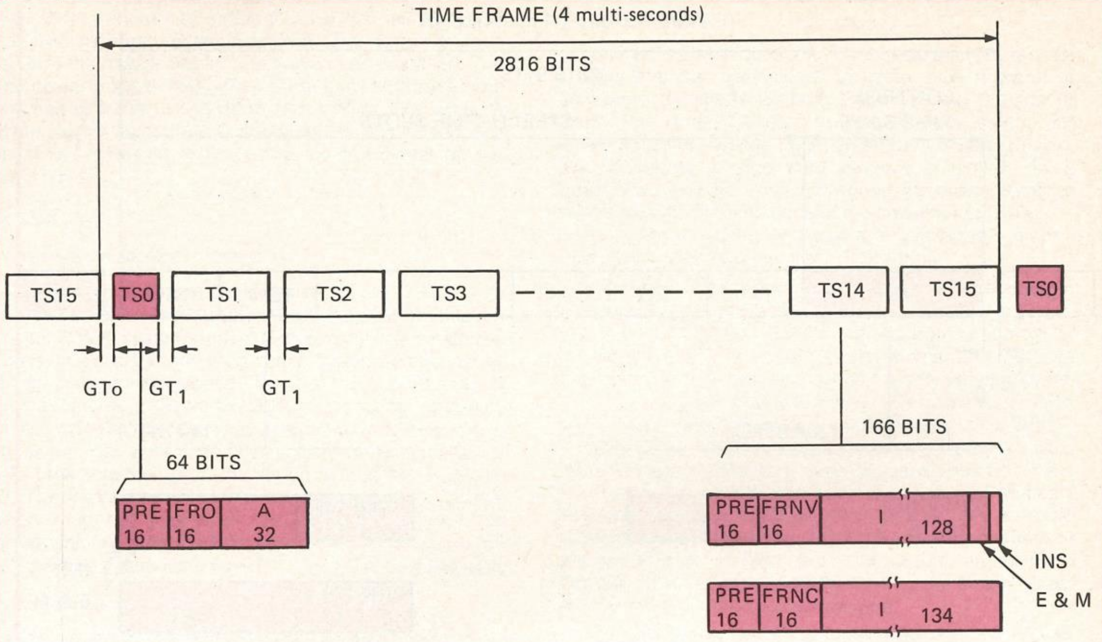
As signals travel down the Repeater chain the phase relationship between the upward and downward frames change. As each additional hop is added the downward frames arrive later by the transmission delay of that hop and the upward frames must be transmitted earlier by an equivalent amount to stay in phase at the TDM Controller. Because downward TS0 is used as the timing reference, this means that the upward frame must be transmitted two hop delays earlier for every hop away from the TDM Controller. Each Subscriber and Repeater unit thus needs to know how many hops away from the exchange it is. This is done using a zone switch, which is set at installation. Zone 1 corresponds to 1 radio hop, Zone 2 to 2 hops etc.

Telex

Up to 28 telex services can be provided by dedicating one timeslot (timeslot 1) to telex transmission. A multiframe is established in which each telex service has access to timeslot 1 in every 28th frame. This gives a data

Journal of Telecommunications and the Digital Economy, ISSN 2203-1693, Volume 7 Number 4 December 2019

http://doi.org/10.18080/jtde.v7n4.242



GT_0: GUARD TIME (22 BITS)
GT_1: GUARD TIME (16 BITS)
PRE: PREAMBLE (16 BITS)
FRO: TIME SLOT SYNCHRONIZATION (16 BITS) TSO START CODEWORD (SAME FORM AS FRAME SYNCHRONIZATION OF DOWNWARD)
FRNV: TIME SLOT SYNCHRONIZATION (16 BITS) VOICE START CODEWORD
FRNC: TIME SLOT SYNCHRONIZATION (16 BITS) DATA START CODEWORD
A: ALARM INFORMATION (32 BITS)
I: SPEECH OR DATA INFORMATION (128 OR 134 BITS)
E&M: E&M SIGNALING INFORMATION (4 BITS)
INS: INSERVICE (NOT USED FOR UPWARD)

Fig. 7b: Upward Frame Structure

rate of 1 Kbit/s which allows telex transmission of up to 300 baud. The telex multiframe structure is shown in **Fig. 10.**

Battery Saving

As with analogue radio Subscriber systems, DRCS Subscriber units which are not in use cycle between a low power consumption OFF state and a higher power consumption READY state. This is known as battery saving operation. If an incoming call is signalled or the customer lifts his/her handset the unit goes into the fully active state. The ready period lasts 144 ms and the off period 720 ms. Repeater units also battery save. To ensure that terminating call signals actually manage to

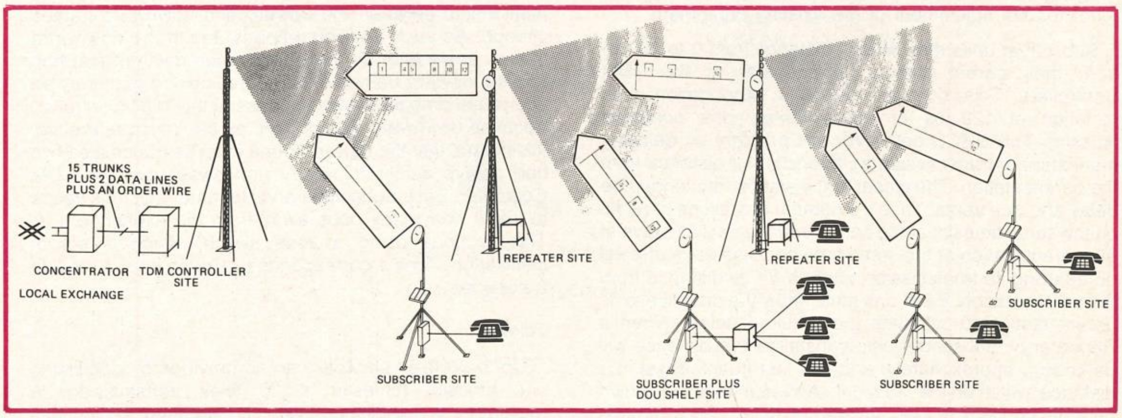


Fig. 8a: Downward Timeslot Transmission

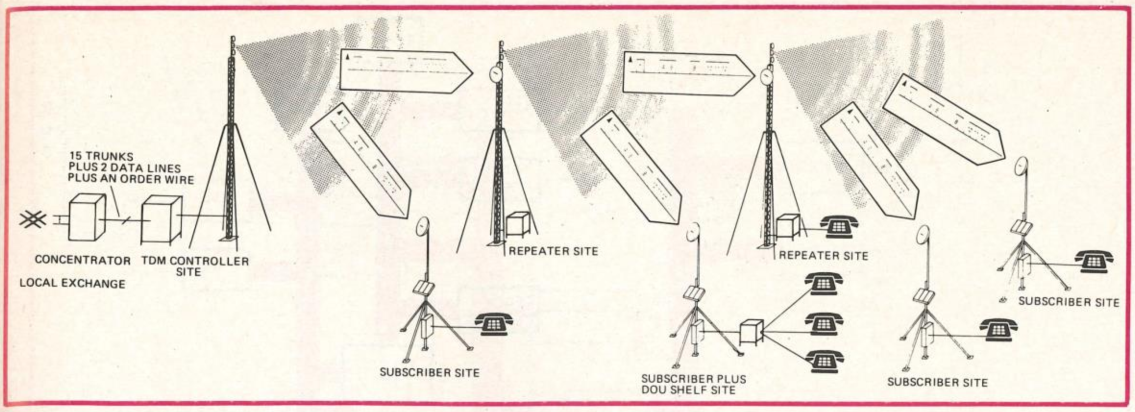


Fig. 8b: Upward Timeslot Transmission

pass through a chain of battery saving Repeaters the TDM Controller sends out a battery saving synchronising signal which causes the entire system to battery save at the same time. The battery saving system is so designed that only those units which are actually in use are not battery saving. As shown in **Fig. 11,** Repeaters which do not have calls passing through them remain in battery saving.

SWITCHING AND CONTROL

Switch Blocks

The switch block used by the DRCS is a two stage remnant reed relay switch using the NEC FRC21 unit. This has been used extensively in the ND20 and MOPAX (Mobile Telephone System) switching systems. The switch is arranged in two modules with each module serving 64 exchange Line Connect Units (LCU), giving full availability access to all 15 Trunk Connect Units (TCU). While the switch provides full availability, it is theoretically possible that congestion can occur as the arrangement of the switches within each module only allows 8 internal lines for 32 LCUs.

Control

The major components of the exchange and equipment, the Central Processor Unit (CC), the Concentrator regional processors, the Visual Display Controller (VDC) and the Data Transmission Controller (DTC), can be seen in **Fig. 9b.** The VDC is the supervisory processor for the man-machine interface and is able to support two VDUs. The DTC is the means by which the CC communicates with the TDM Controller and, via the TDM Controller, the rest of the system. Because of its importance to the systems integrity, the DTC, together with the data transmission path between DTC and the Data Controller (DC) in the TDM Controller, is fully duplicated. When the Concentrator and TDM Controller are co-sited, the links between the two are physical connections of a maximum of 15m in length. Greater distances are accommodated with RS232, 1200 bit/s modems connected over physical pairs or derived circuits.

The system software for the DRCS is based on the 780D (Z80/8080 Compatible) microprocessor for the CC, VDC and DTC. For the TDM Controller, Repeater and Subscriber units, the 80C39 is mainly used because of its lower power consumption. In a few instances the 8748 or 8085 is used. The CC and DTC are fully duplicated. All program software is contained on Ultraviolet Erasable PROM (EPROM) except for the office data which is stored in Electrically Erasable PROM (EEPROM). In this way, the system software can be easily updated by the supply of new EPROM's. In the case of the office data the advantages of EEPROM are:

- Non volatile.
- Easily updated/copies (by keyboard command).
- Minimised reload time in the event of a system failure that requires a restart.

In addition to all program being EPROM resident, extensive use is made of EPROM storage for transmitter and receiver sequencing data and preamble/identity code generation. Some use is made of ROM in programmable logic array situations.

Call Sequence

Line Supervision

As is general practise in telephony the DRCS monitors the loop status of each customer's telephone and monitors the line status of the exchange interface. Under normal circumstances while the customer's telephone is in the off-hook condition, the timeslot will remain assigned and active for that call but if the DRCS detects Line Lock Out condition (exchange Busy Tone), then after 10 seconds the timeslot is dropped, allowing it to be used for another call. In this way timeslots are not held indefinitely by a customer leaving his telephone off the hook. Prior to the timeslot being dropped, the DRCS tests the customer's telephone hook status. If the off-hook condition still exists, the loop condition is repeated to the exchange from the respective LCU and local Busy Tone is generated at the DOU. If the customer's telephone is placed on-hook then local Busy Tone is stopped. The condition is repeated to the exchange end via a free timeslot and the loop is removed from the LCU. The exchange then detects on-hook and Line Lock Out is released.

Timeslot Assignment

The usage of the timeslots for originating/terminating calls and delay adjustment is controlled by the CC. Under normal circumstances when there are four or more timeslots idle, the CC assigns two for originating calls, one for delay adjustment and the rest for terminating calls. The CC then uses TSO to inform all Repeater and Subscriber units of the originating and delay assignments. As timeslots are used, the system maintains two originating and one delay until there are only three timeslots free, at which stage it assigns one for originating and one for terminating calls. If there are only two free timeslots, it

Journal of Telecommunications and the Digital Economy, ISSN 2203-1693, Volume 7 Number 4 December 2019

http://doi.org/10.18080/jtde.v7n4.242

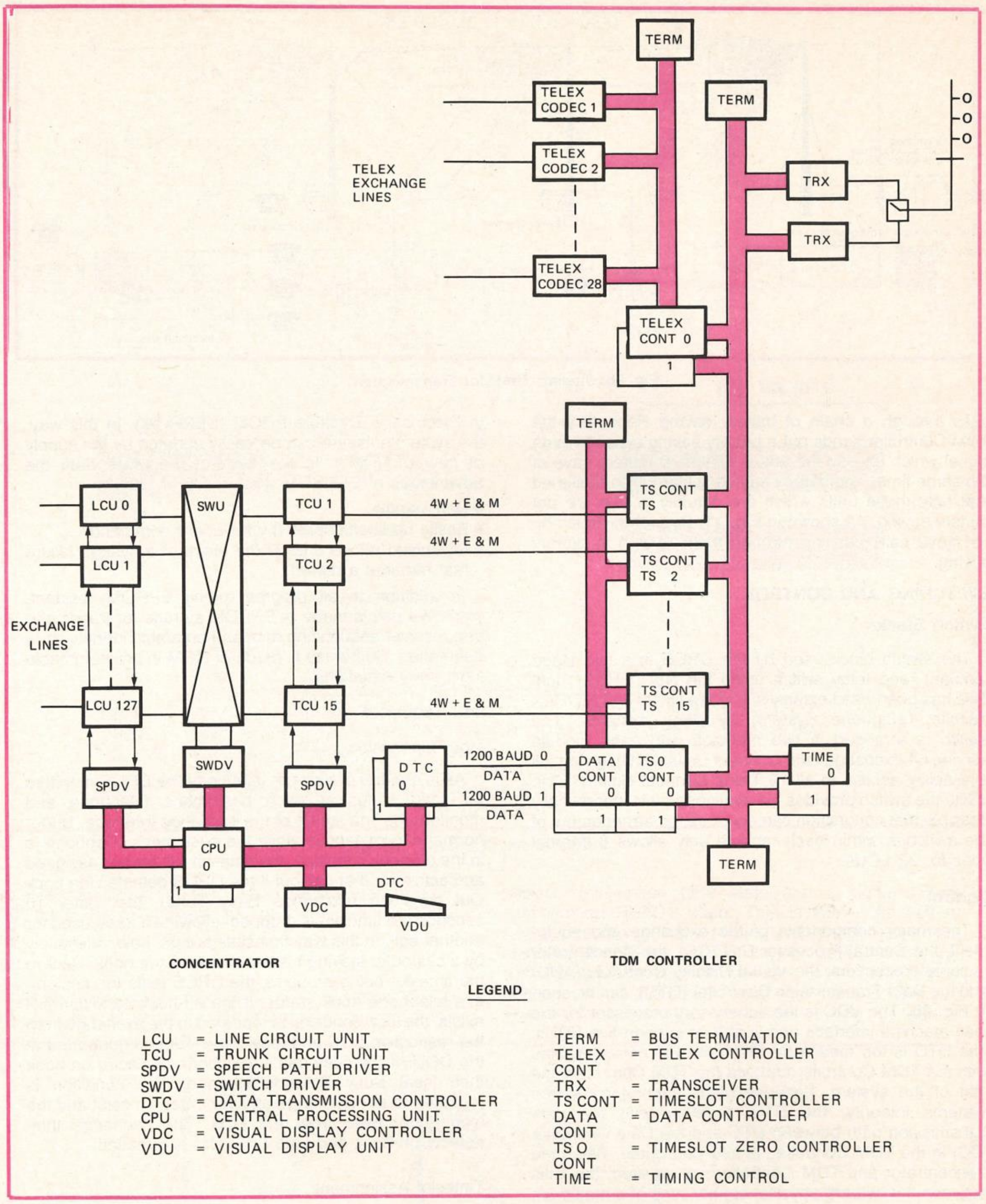


Fig. 9a: Exchange Unit Bus Structure

assigns one originating and one terminating. Finally if there is only one free timeslot it assigns it for originating calls and if there is a terminating call the system will wait 600ms to check for any originating requests (which take precedence) before assigning the timeslot to the terminating call. In the case of all timeslots being busy, any originating requests are given local busy tone while terminating calls are detected at the LCU and are queued by the CC while awaiting a free timeslot.

Customer Terminated Call Sequence

- The LCU detects ring current from the exchange. The CC passes this information plus the timeslot assignment information through the DTC serial common control line to the DC within the TDM Controller. The TDM Controller then sends a Page code, DOU Identity code and Timeslot Assignment code through control TSO.
- When the Page code is detected and the Identity code matches that of a DOU at a Subscriber or Repeater unit,

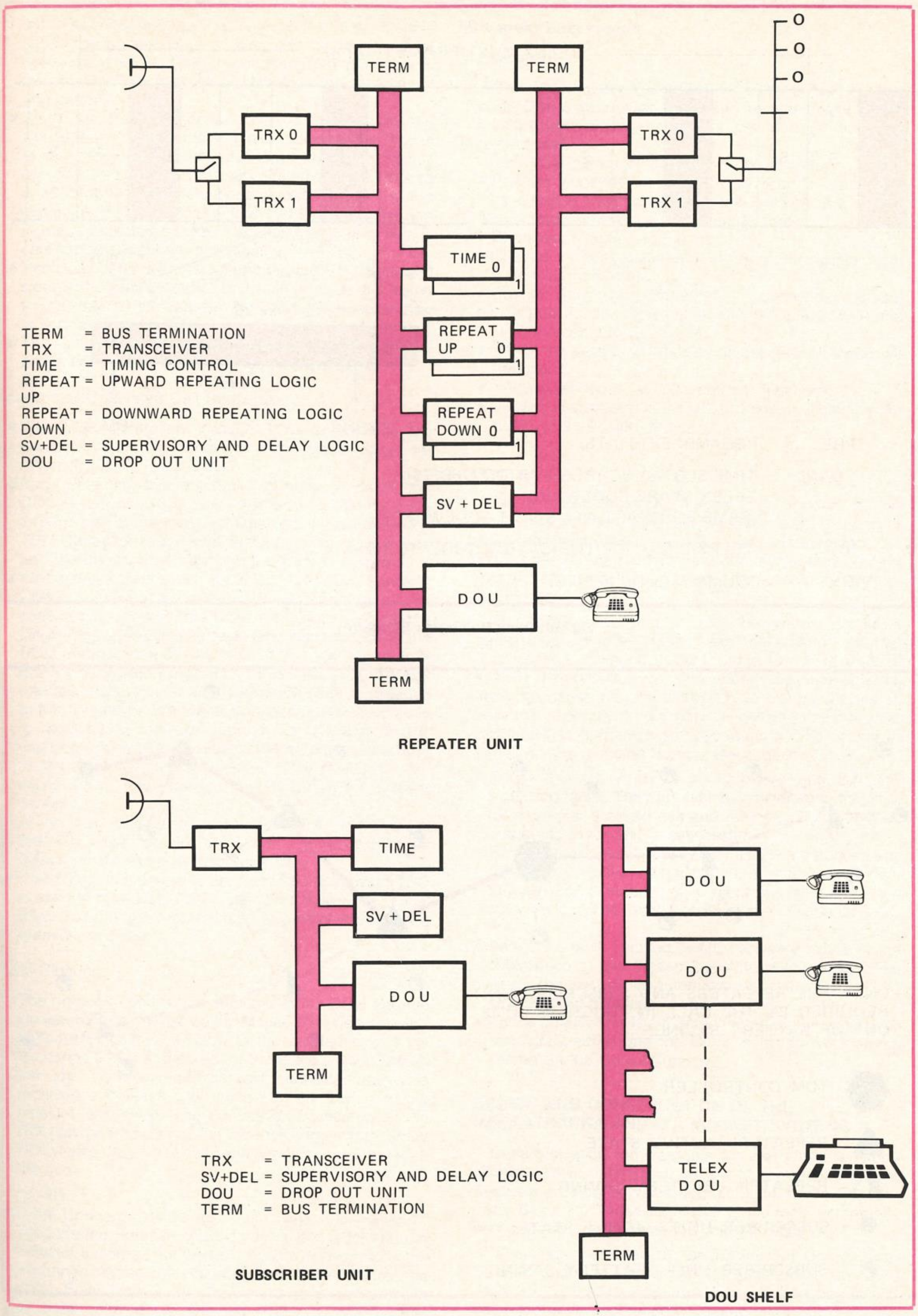


Fig. 9b: Repeater, Subscriber and DOU Bus Structure

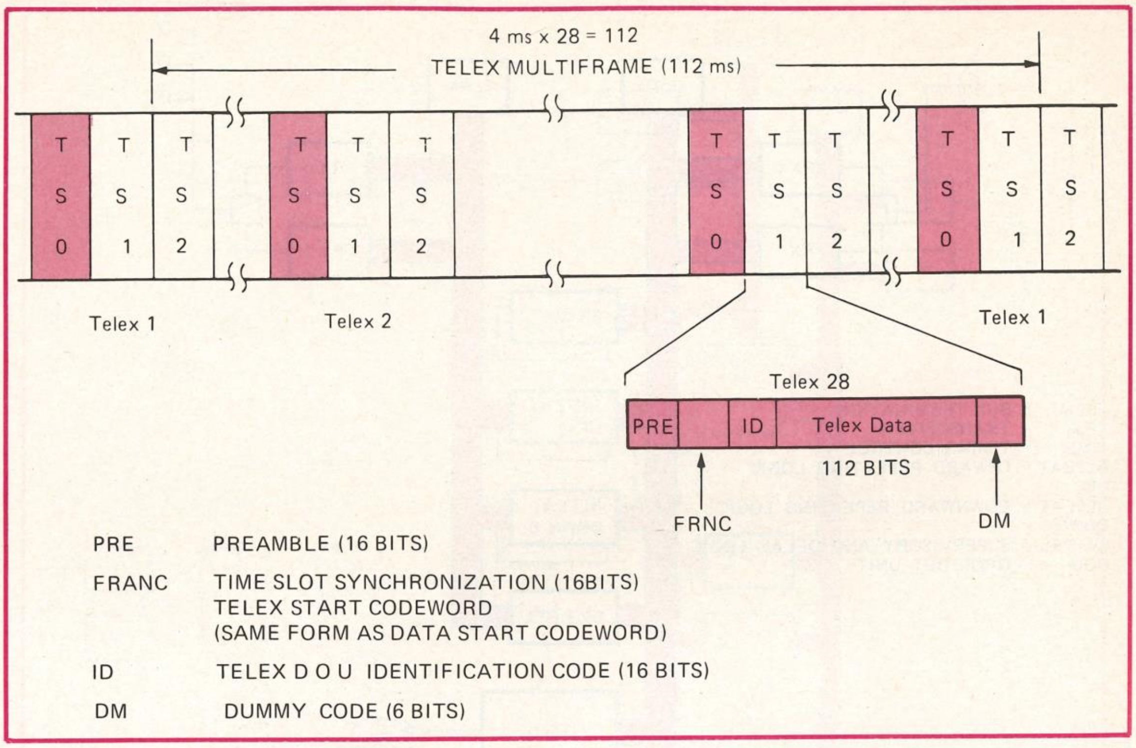


Fig. 10: Telex Multiframe Structure

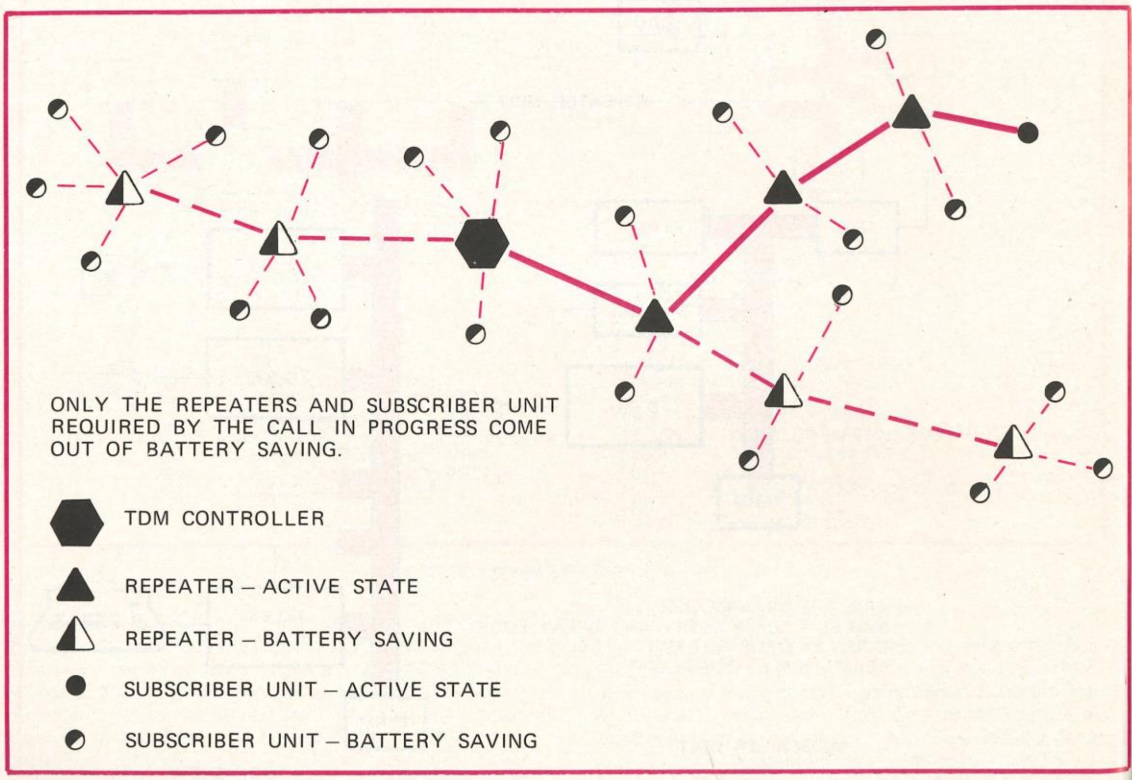


Fig. 11: DRCS Battery Saving

the DOU sends a Page Response code and the Identity code through the timeslot assigned by the Timeslot Assignment code. Then the chosen TCU (timeslot) is switched to the respective LCU to allow the detection of ring cadence.

- When the Page Response code is detected by the Concentrator, it forwards ring information via the M lead of the assigned timeslot (the cadence of the ring is synchronised with the M lead signal). This continues until either, the DOU telephone is taken off-hook or the exchange returns to idle polarity. At the DOU, the ring signal is detected on the E lead and ringing current is sent to the telephone in sympathy.
- The DOU detects the telephone off hook condition and signals the concentrator via the M lead. At the same time a speech path between the DOU and the telephone is set up.
- The Concentrator detects the E lead signal in the TCU and a DC loop to the Exchange is established.

Customer Originated Call Sequence

- The TDM Controller, through TSO, broadcasts the numbers of the two timeslots which are assigned for originating calls to all DOUs.
- Upon detecting the telephone off hook condition, the DOU sends an Originating code and an Identity code through one of the assigned timeslots. In response, the TDM Controller sends back an Originating Accept code and the Identity code through the chosen timeslot.
- When these codes are received, the DOU sends a Connection Required code. If the Originating Accept code is not received, the DOU continuously sends the Originating code up to a preset time limit after which the DOU attempts the originating call through the other of the two assigned timeslots. If this also fails, the call attempt is abandoned and local Busy Tone is switched to the telephone. When the Connection Required code is received at the Concentrator, a DC loop to the exchange is made at the respective LCU corresponding to the DOU originating the call. Dial tone from the exchange is then sent to the DOU via the speech timeslot.
- At the DOU, dial pulses are sent through the M lead to the TCU which converts the E lead signals back to dial pulses on the two wire exchange loop.
- If all 15 speech timeslots are busy, the downward TSO is used to broadcast an All Timeslots Busy code. Local Busy Tone is then switched to the telephone whilst it remains off hook.

Call Clearing

- The on hook condition is detected at the DOU and the Concentrator signalled via the M lead. The Concentrator then removes the DC loop to the exchange and the exchange line is monitored for the idle condition. When the idle condition (unbalanced line impedance) is received a Release code is sent to the DOU and the timeslot is cleared. The connection is cleared at the DOU on the reception of the Release code and for some DOU types the unbalanced idle condition is repeated to the line.

— OR —

- If the Concentrator detects Busy Tone (LLO) after 10 seconds the Release code is sent to the DOU and the timeslot is cleared but the LCU maintains the loop to the exchange. When the Release code is detected at the DOU, Busy Tone is switched to the telephone until the on hook condition is detected. The LCU loop is then cleared.

System Supervision

Operation

The system can be controlled via either of the two VDU ports. One is designated "local" and the other "remote". An in-built 1200 bit/sec modem is provided to drive the remote port.

The VDU operator can perform the following:

- Perform supervisory tests on all remote equipment including a "capacitive kick" and leakage test on the customer's line and terminal equipment.
- Changeover duplicated items.
- Change switching parameters (e.g. timing for time supervision signals).
- Change Office Data (Repeater unit, Subscriber unit and individual service registration) and if required "write" the ammendments to EEPROM.
- Check the system TDM delay adjustments at individual stations.
- Initialise testing of all Concentrator functions.
- Display system status for all subsystems including the status of duplicated items.

Alarms

All remote subsystem alarms are reported to the Concentrator where they are categorised as "Urgent" or "Non-urgent" and the respective system alarm raised. The VDU operator can interrogate the system for further information using the VDU and if necessary carry out further tests.

In addition to raising alarms, the system classifies certain Concentrator faults and depending on that classification chooses an appropriate signalling retry or system restart sequence. The underlying philosophy is, firstly, to cause as little disruption to customer calls as possible, secondly, to establish all calls if at all possible, and finally, to keep the system operational. The classifications and the resulting actions are as follows:

- Phase 1 fault: Includes all hardware and DTC-DC signalling faults. They are typically minor only affecting, for example, a single call and they usually involve an automatic re-try that is successful.
- Phase 2 fault: Usually caused by a software abnormality or where a Phase 1 fault counter's limit is exceeded. The system is automatically reset and all established calls are lost. The reset is on the same CC and DTC-DC link.
- Phase 2.5 fault: Caused by CC hardware failure or the occurrence of four Phase 2 restarts within a specified time. The system is automatically reset and the CC changed. All established calls are lost.
- Phase 3 fault: This is a manual restart of the system. All calls are cleared and the CC is selected by a switch setting on the Concentrator.

DESIGN AND CONSTRUCTION OF THE MEEKATHARRA AND MT. MAGNET SYSTEMS

Communication requirements for the remote pastoral districts of the upper Gascoyne and Murchison in Western Australia are now serviced by two Digital Radio Concentrator Systems. These terminate at the local community service towns of Meekatharra and Mt. Magnet.

When commissioned by the Minister of Communications, Mr Duffy, at a commemorative ceremony on 19-20 June 1985, the Meekatharra and Mt. Magnet DRCS became the first operational, volume production systems in Australia. These initial systems operate at 500 MHz.

Journal of Telecommunications and the Digital Economy, ISSN 2203-1693, Volume 7 Number 4 December 2019

http://doi.org/10.18080/jtde.v7n4.242

System Overview

Both systems were been programmed for construction in two stages. The Meekatharra DRCS initially provided 57 individual services via 8 Repeaters and 43 Subscriber radio units. During 1985/86 it was expanded to 13 Repeaters providing 67 services. Mt. Magnet DRCS initially provided 58 individual services via 10 Repeaters and 38 Subscriber units. During 1985/86 it was expanded to 13 Repeaters providing 71 services. The initial installations operate at 500 MHz and the expansions operate at 1500 MHz.

Together the systems encompass an area of some 200,000 square kilometres **(Fig. 12)**

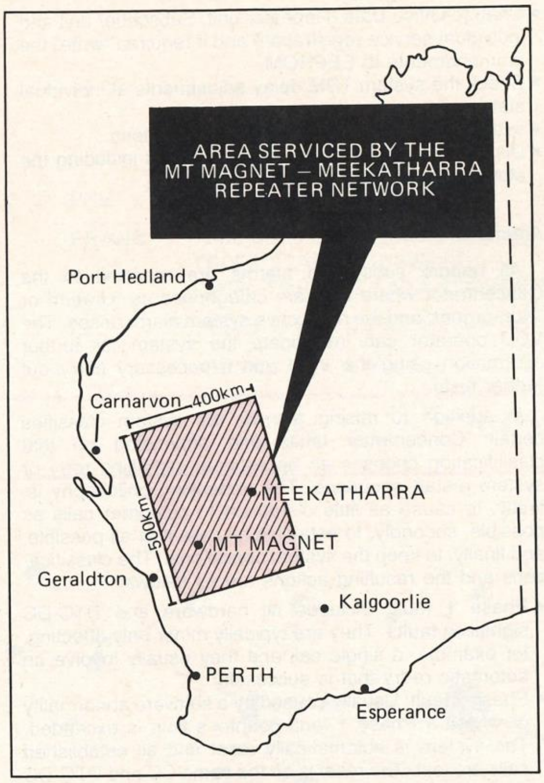


Fig. 12: Meekatharra and Mt. Magnet System Area

Predominant activities in the area include the pastoral industry based on wool production, mining, specifically for gold, and tourism. The total population is less than 3000 people, accommodated largely in the towns of Meekatharra, Cue, Mt. Magnet, Sandstone, Yalgoo and the hamlet of the Murchison shire.

Apart from the bitumised great Northern Highway, all roads in the vast area are gravel of varying quality. This, together with limited telecommunications infrastructure at even major towns, presented some special challenges in the design and installation of appropriate communications facilities.

Meekatharra

Situated 764 km from Perth on the Great Northern Highway, the town is a regional centre, serviced by road and air. The airport can handle large aircraft in emergencies, as an alternative to Perth.

The Royal Flying Doctor Service (RFDS) has a base station in Meekatharra which originally provided the only facility available for communications to pastoral station homesteads and mining camps. Since the introduction of DRCS, the RFDS radio station primarily conducts School of the Air broadcasts.

Mt. Magnet

196 km to the south of Meekatharra and also on the highway, Mt. Magnet is situated 569 km from Perth and is serviced by road transport.

Although older than Meekatharra, Mt. Magnet (named in 1854) is the smaller of the two towns. Both towns flourished in the 1890's with the discovery of gold, then declined in the late 1940's. With the escalation of gold prices in the late 1970's and the end of a seven year drought in 1984, a revival in the mining and pastoral industries is current.

Telecommunications Infrastructure

The upper Gascoyne/Murchison is one of the last areas in Western Australia to be wholly serviced by open wire transmission systems. A fully utilised route extends 523 km easterly from Geraldton to provide trunk circuits to the 400 line ARK521 type exchanges in Mt. Magnet and Meekatharra (and smaller exchanges at Yalgoo, Cue and Wiluna). See **Fig. 13.**

Introduction of DRCS severely taxed these existing transmission and switching systems, requiring the following supplementary actions:

- Doubling of the power supply at each telephone exchange, including complete replacement of the rectifier and battery banks.
- Installation of trunk line doubling equipment employing time assignment speech interpolation techniques, to achieve increased circuits to the parent exchange in Geraldton.
- Expansion of the telephone switch numbers from 300 to 400 at Meekatharra and Mt. Magnet, plus rearrangements in the Geraldton minor exchange.

Future developments include the proposed installation of an optical fibre route to provide trunk circuit relief from Mullewa to Mt. Magnet in 1987 and subsequent extension to Meekatharra and Newman in later years. The fibre will be supplemented by a 34 Mbit/s radio bearer from Geraldton to Mullewa and an AXE type exchange to be installed at Geraldton during 1986/87.

Design

General

Planning the introduction of the DRCS in Western Australia commenced in 1982/83 and from June 1983 the Western Australian Radiocommunications Design Group of Telecom began the radio network design specifically to suit Meekatharra and Mt. Magnet pastoral districts.

Also about this time Telecom announced the Rural and Remote Area Programme and later introduced Country Wide calling. Initial customer locations were identified by Customer Services Section of the Local Operations District (the task is now undertaken by Marketing Branch).

Radio network design followed the familiar steps of field visit, map, study, site selection, propagation test, detailed design, field site survey, Aboriginal heritage impact study, commencement of site acquisition and minor adjustments to site relocations and design assessment.

Helicopter Surveys

Due to the vast distances to be travelled and the lack of

http://doi.org/10.18080/jtde.v7n4.242

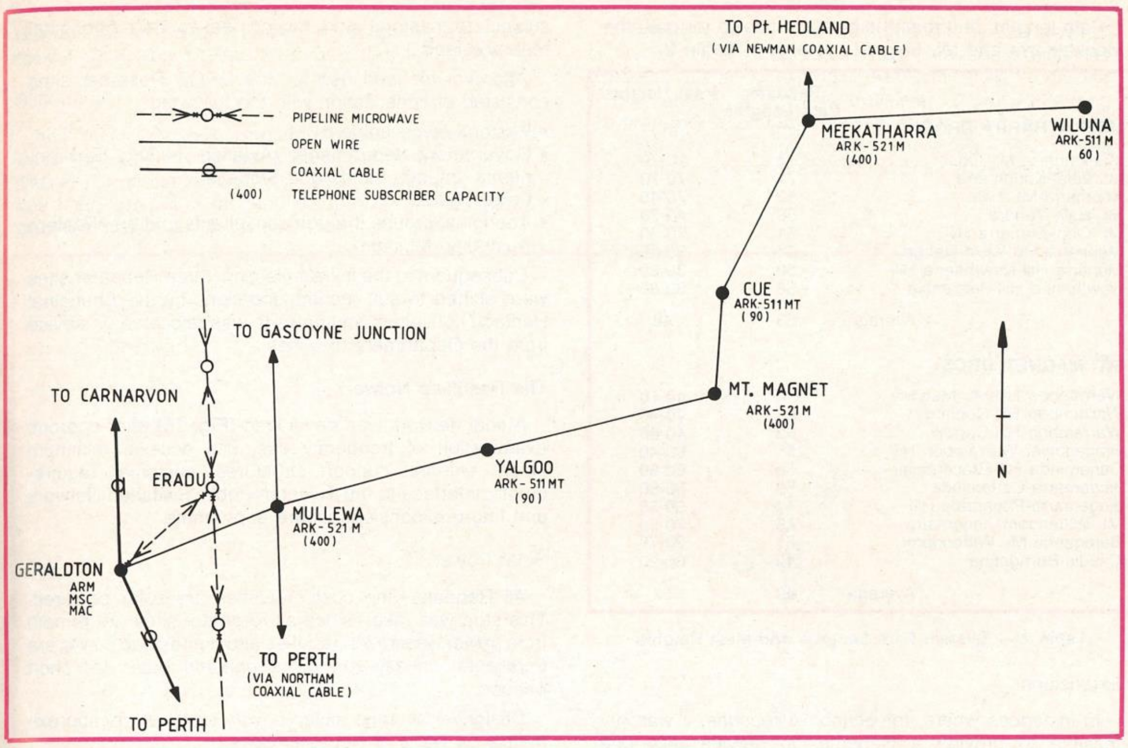


Fig. 13: Murchison District Communications Network

detailed maps, helicopters were employed extensively during the field visits and the propagation testing phase.

A new technique involving the use of two helicopters, was successfully applied to check possible radio paths by propagation testing. The simple but effective concept is illustrated in **Fig. 14.**

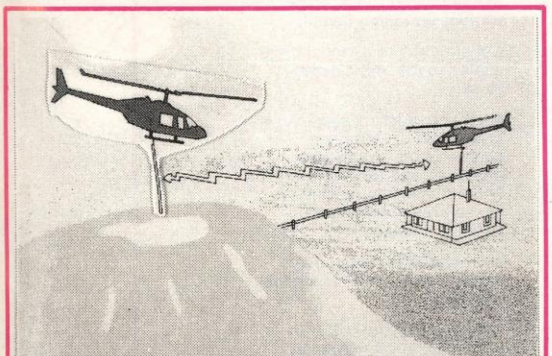


Fig. 14: Helicopter Radio Path Survey

Radio equipment mounted in each helicopter, and omni directional antennas, (lowered in the helicopter hover position) were selected to test marginal paths. Attachments to each aircraft were approved with the Department of Aviation.

Tests at 150,500 and 1500 MHz have been successfully conducted by this technique. For example, a maximum path loss of 130 dB at 520 MHz was sought on Repeater to Subscriber Unit paths and free space loss on Repeater to Repeater paths by increasing hover height until the target loss was bettered.

The main benefits of helicopter testing are:

- A large range of height/gain tests can be conducted in a short time scale.
- Significant cost savings in the order of 50 per cent can be realised in comparison with ground based techniques involving pump-up masts.
- Reduced wear and tear on vehicles, test equipment and personnel.

Repeater Site Selection

Two main factors contributed to the selection of Repeater sites.

- Terrain Type
  The Murchison area consists of mainly flat, open ground with occasional hills rising up to 50 metres or more above the surrounding plains. The area is characterised by sparse vegetation and reasonably accessible (by four wheel drive vehicle) flat topped hills and granite outcrops. Such hills provided excellent elevation for Repeater sites and contributed to a reduction in mast heights.
- Overshoots
  The limited number of channels in the 500 MHz band and the terrain type required that particular attention be paid to cochannel overshoot. Frequency reuse was based on a cellular plan and kept to an absolute minimum. Where appropriate, the omnidirectional patterns were offset to a near cardioid shape to further reduce the possibility of interference.

Repeater sites were initially selected on 1:1,000,000 maps as a best fit to customer distribution (very sparse) and terrain advantage. These sites were optimised during field visits, further design and site survey. Several radio paths approach the equipment's specified maximum of 70 km in length (one path is 71.2 km).

Path lengths and mast heights are shown for both the Meekatharra and Mt. Magnet systems in **Table 2.**

	Repeater Path Lengths (km)	Mast Heights (m)
MEEKATHARRA DRCS		
Meekatharra-Mt. Obal	17	20-70
Mt. Obal-Koonmarra	71	70-70
Koomarra-Mt. Hale	52	70-40
Mt. Hale-Yundra	58	40-70
Mt. Obal-Munarra Hill	51	70-30
Munnarra Hill-Weld Range	54	30-20
Munarra Hill-Nowthanna Hill	50	30-30
Nowthanna Hill-Barrambie	68	30-80
Average	53	48
MT. MAGNET DRCS		
Warramboo Hill-Mt. Magnet	4	40-10
Warramboo Hill-Coolarda	62	40-70
Warramboo Hill-Carron	62	40-80
Bracegonier-Warramboo Hill	55	60-40
Carlaminda Hill-Bracegonier	55	50-60
Jingemarra-Carlaminda	50	50-50
Jingemarra-Poondarie Hill	44	50-50
Mt. Wittenoom-Jingemarra	45	70-50
Burriganna-Mt. Wittenoom	61	90-70
Caudle-Burriganna	49	60-90
Average	49	57

Table 2 — System Path Lengths and Mast Heights

Extensions

In instances where, for economic reasons, it was not feasible to provide a Repeater to service only one customer, extension by Single Channel Analogue Radio Systems operating at 150 MHz was implemented.

Approval for Land Use

The Murchison area is wholly owned Crown land subject to pastoral and mining leases and Aboriginal reserved land.

Approval for land use for the DRCS Repeater sites consisted of consultation with the following:

- Pastoral lease holders
- Government departments (Aviation, Mining, Environmental Impact, Lands and Surveys)
- Local Shires
- Aboriginal groups through consultants and the Western Australian Museum.

Subsequent to the initial selection, three Repeater sites were shifted to suit recommendations by the Aboriginal Heritage consultant and one site was relocated on advice from the Department of Mines.

The Resulting Network

A final network was developed **(Fig. 15)** after rigorous examination of frequency use, site access, minimum height antenna support structures, customer requirements, interface to the Telecom Public Switched Network and future expansions where appropriate.

Solar Power

All Repeater and customer sites are solar powered. This step was taken since all Repeater sites are remote from power generation facilities and homestead plants are unreliable, usually run on a demand basis for short periods.

Designed average solar power loads were approximately 54 watts at Repeater sites.

Installation

General

The first DRCS in Western Australia were implemented on a special projects basis with a Project Engineer

Function	Group	Responsibility
• Survey	Telecom Drafting Group	Site survey including block contour and plant layout.
• Access and Site Clearing	Department of Construction	Construction of 4 wheel drive quality roads and cleared block.
• External Plant at Repeaters	Telecom Radio-lines and Electric Power Transmission Ltd. (EPT)	Mast construction and installation of Repeater shelter, solar array frame, antennas and feeders, earthing and site security fencing. Radio-lines-Meekatharra. EPT-Mt. Magnet.
• External Plant at Customer End	Telecom Great Northern District Operations	10 metre pole, equipment shelter, solar array and house cabling.
	Telecom Radio-lines	Antenna support structure greater than 10 metres in height plus shelter and array frame.
• Solar power equipment and power upgrade at Exchanges	Telecom Telepower Group	Solar panel mounting, interwiring, battery installation and voltage regulator commissioning at repeaters plus rectifier and battery bank. Installation at Exchanges.
	Telecom Country Installation	Solar power at Customer premises.
• Internal Plant (Radio Equipment)	Telecom Country Installation	Installation and commissioning of all radio equipment and exchange Concentrator.

Table 3 — Project Functional Groups

responsible for several functional groups — each with special expertise. These groups are shown in **Table 3.**

Schedule

Installation began in September 1984 extending outward from the exchange toward Subscriber stations. Despite some material delivery delay in the early stages and later, a number of "teething" problems, the system was commissioned on schedule in June 1985.

Installation activity was not hampered by bad weather to any significant degree, however, travelling distances were enormous. For example, the technical staff (only one of several groups) recorded travelling 120,000 km during a seven month period. This represents more than 2400 manhours spent simply driving. There were no lost time accidents, however, due to driving or for any other reason.

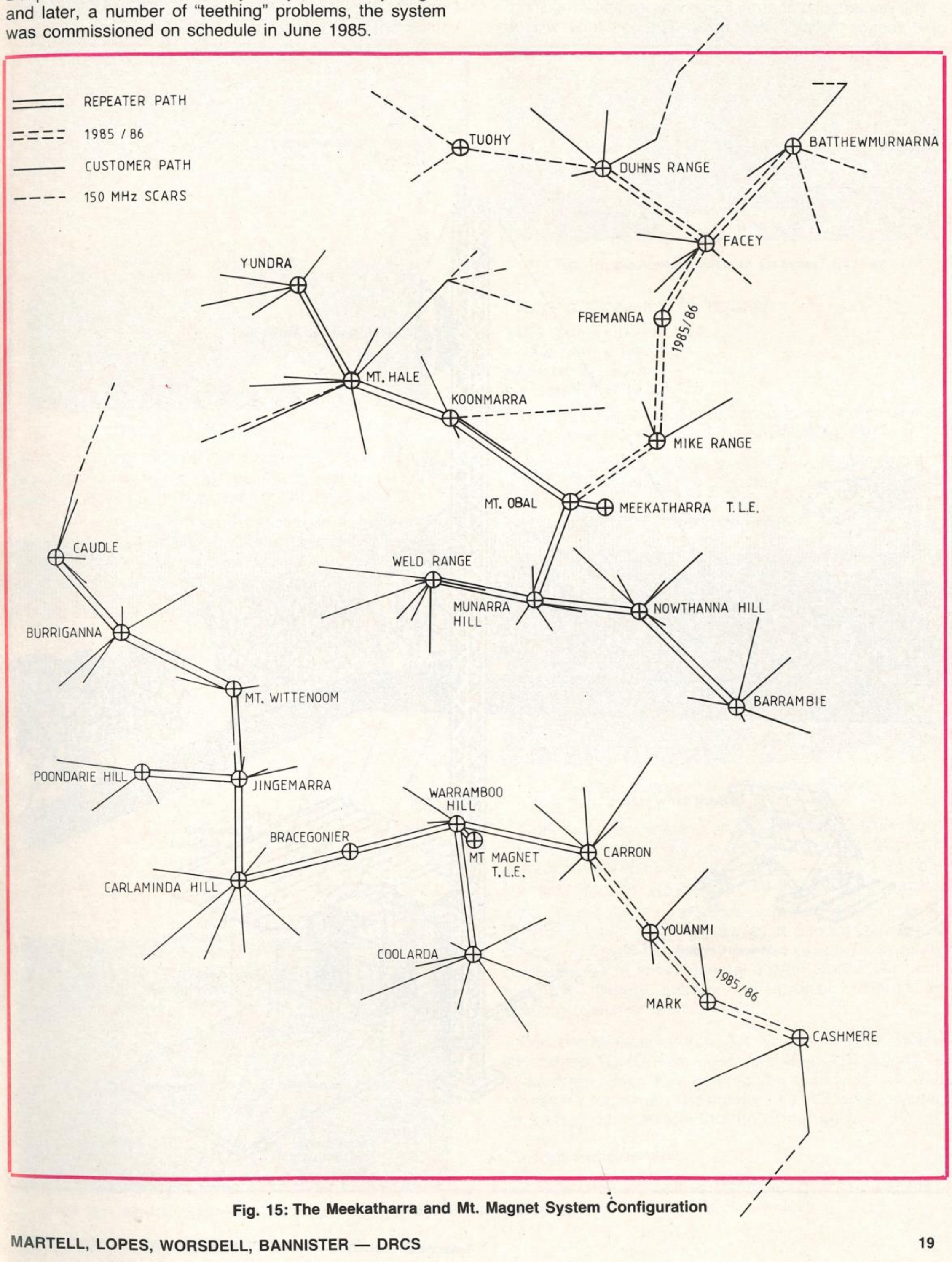


Fig. 15: The Meekatharra and Mt. Magnet System Configuration

Journal of Telecommunications and the Digital Economy, ISSN 2203-1693, Volume 7 Number 4 December 2019
http://doi.org/10.18080/jtde.v7n4.242 84

External Plant

The Repeater layout used at Meekatharra and Mt. Magnet is shown in **Fig. 16** and will form the basis for future installations. A typical site is shown in **Fig. 17.** On average, external plant at a Repeater site can be completed in three weeks.

The Repeater solar array frame was located a minimum of 6 metres north of the mast. This distance will be increased for WA installations north of the Tropic of Capricorn to avoid midday shading during the summer solstice. The mast and solar array frame are sufficiently robust for installation in cyclonic areas.

The Repeater shelter comprised a thermally transparent, free standing, cabinet fabricated by Siemens Ltd. Manproof security fences were erected around all Repeater sites on the Mt. Magnet DRCS and low cost cattle proof fences were erected around all Repeater sites

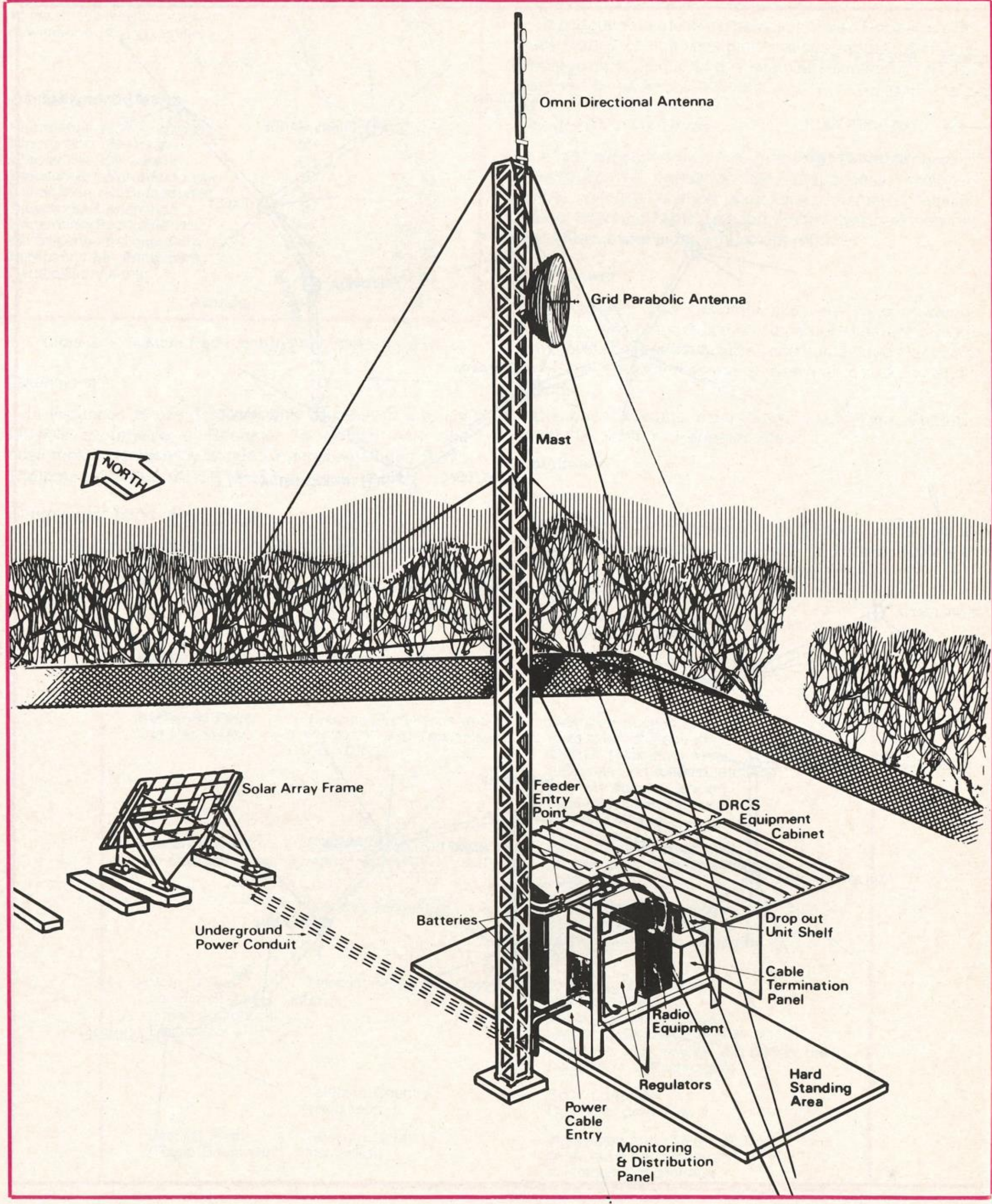


Fig. 16: Repeater Site Layout

http://doi.org/10.18080/jtde.v7n4.242

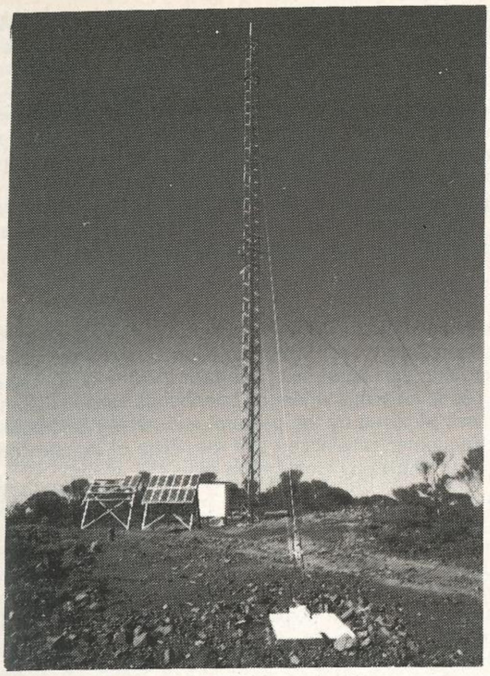


Fig. 17: Typical Repeater Site

on the Meekatharra DRCS. In this way a comparison between the systems can be made and a judgement made on the extent of security for future systems.

Typical external plant at customer sites is shown in **Fig. 18.** A sectionalised tubular steel pole, antenna, environmental shelter, and solar panel array were located as near as practicable to the station homestead.

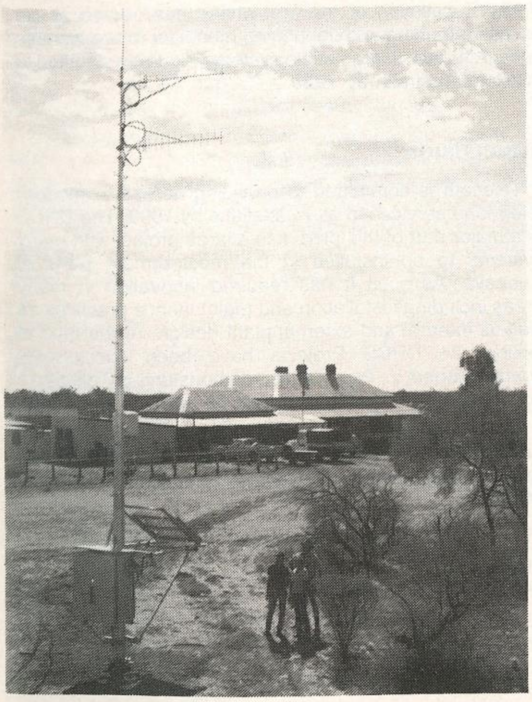


Fig. 18: Customer Equipment at Milly Milly Station

Internal Plant

Electronic equipment was installed on the South facing side of the Repeater shelters **Fig. 19).**

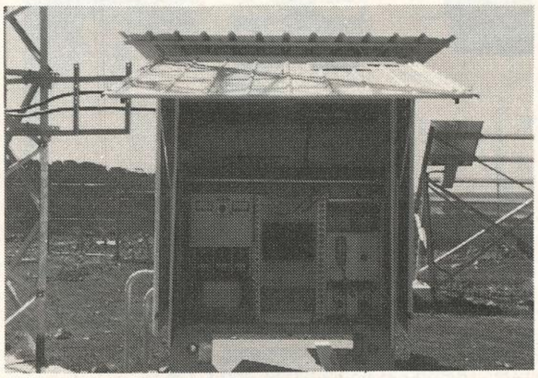


Fig. 19: Equipment Side of Repeater Shelter

A typical Repeater site included:

- The radio Repeater unit
- Solar power regulators
- A shelf for DOUs
- A technicians telephone

12 Volt, 1000 Ampere hour battery banks were installed on the north facing side of the shelter **(Fig. 20).**

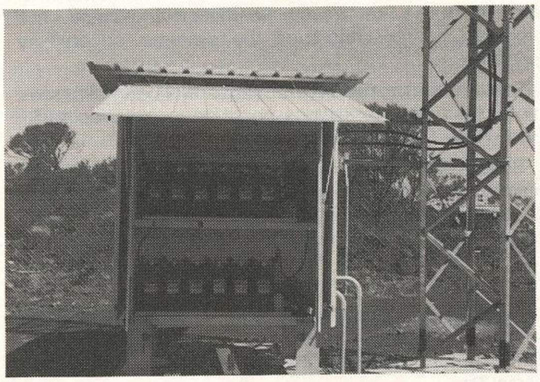


Fig. 20: Battery side of Repeater Shelter

Generally, the equipment at customer sites consisted of a Subscriber radio unit fitted with one DOU, a solar power regulator and lightning arrestor. Two, 6 Volt, 90 Ampere hour batteries are charged by two 30 watt solar panels.

For customers requiring two or more services a DOU shelf was installed. Additional solar panels and battery storage was often necessary in these cases. Six separate combinations of environmental shelter type, solar array type and battery storage dimensioning catered for differing customer requirements.

For both Meekatharra and Mt. Magnet, the Concentrator and the TDMC were co-located **(Fig. 21).** A width of about 4 rack units was required in a suite which allowed access front and rear. The supervisory VDU was mounted on a small table adjacent to the Exchange unit.

Current Performance

A wide range of customer terminal equipment has been tested successfully on DRCS including:

Journal of Telecommunications and the Digital Economy, ISSN 2203-1693, Volume 7 Number 4 December 2019

http://doi.org/10.18080/jtde.v7n4.242

Fig. 21: Installation of the Mt. Magnet Exchange Units

- Standard Telephone Instruments
- Coin Telephone (Goldphone and CT3)
- Computer Phone
- Telex
- Parallel Services (up to three instruments)
- Extension Bells
- A Weather Observation Terminal (WOT) supplied by the Bureau of Meteorology
- Small Business Systems including solar powered commander T105s at several locations.

NEC Engineers visited the system to assist with the resolution of problems associated with the introduction to the field of the first volume production equipment. The problems mainly concerned the system's supervisory functions.

System transmission performance has been assessed by 36 hour data recordings on sample paths, using Bit Error Rate Testers (BERTS).

Both systems meet overall service objectives although a small number of stations have experienced unavailability outside specification due to individual unit malfunction. Background Bit Error Rate (BER) is well within specification. Short and long term BER due to propagation performance is also within specification.

The data recordings have shown a slight susceptibility to lightning discharge in the form of small bursts of errors. These bursts, however, are not noticeable during conversation.

A traffic measurement unit has been designed by the Western Australian Telecom Electronic Design Group and installed on both systems. The device records data on All Time Slots Busy (ATB) and Time All Time Slots Busy (TATB) by incrementing in 6 second intervals. Due to the high ratio of Time Slots to Services for the initial phase of the system, no registrations of congestion have been noted.

Solar power equipment on both Meekatharra and Mt. Magnet DRCS is performing reliably and has a safe margin for increased telephone traffic.

Early results from data logged at 4 sample sites, indicate the Repeater shelters are easily dissipating the excess heat generated by current traffic levels. The inside temperature rise near the roof of the shelter is of the order of 1 degree C relative to the outside shade temperature. This performance is to be expected since the shelters and radio equipment are designed to operate with a 5 degree C rise for the dissipation associated with the maximum traffic possible i.e. 15 time slots continuously active. These shelters have been well accepted by installation and maintenance staff as the lift-up door provides protection from the sun whilst allowing the free flow of air.

Customer Reaction

As might be expected, the provision of an automatic telephone facility, with trunk and international Subscriber dialling and the capability of interfacing with modern data services to locations where no telephones existed before was well received by the pastural and mining communities. Customer satisfaction and the value of the service has been shown by high calling rates.

During installation, customers were progressively cut into service on the understanding that some interruption to service may occur prior to formal commissioning. No charges were levied although outgoing calls were restricted to local access (STD barred). Many calls were initiated in this phase helping with the early detection of equipment design faults. Telecom installation staff were treated with great hospitality while in the field.

On Commissioning day, the commemorative functions were attended by capacity crowds at the Murchison, Meekatharra and Mt. Magnet Shire Halls and a special function at the Mileura station homestead.

Expansion

Work has already been completed on extensions to both the Meekatharra and Mt. Magnet systems, and other projects have commenced.

The installation of the first phase has served as an excellent training and debugging model for future installations. A further 9 large scale systems are to be installed in Western Australia by 1989.

CONCLUSION

Telecom is committed to providing access to modern telephone services to all Australians by 1990. The DRCS is a major part of this plan. It is a large project with many systems to be installed in the most remote parts of Australia. As such it has required innovation in many areas including installation and maintenance practices as well as internal and external plant design. At the time of writing, 25 DRCS Projects have been successfully commissioned in four States, demonstrating Telecom's committment and ability to reach its goal.

As recognition of its achievements in the DRCS, Telecom was awarded the 1986 Engineering Excellence Award by the Institute of Engineers Australia, Queensland Division.

The Australian Telephone Network in 1992

This map, reprinted from Brass (1993), highlights the extensive geographical reach of the Digital Radio Concentrator System (shown in yellow).