Towards a National Broadband Strategy for Australia, 2020-2030

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Abstract: This Report has been developed by the TelSoc National Broadband Network (NBN) Futures Group, drawing on substantial work since early 2019 to examine the current state and desirable future of broadband services in Australia. The purpose of the Group and this Report is to ensure Australia's broadband infrastructure and services continues to develop in a financially responsible and timely manner, delivering value, economic benefit and new services to all Australian residents in all locations and in all economic circumstances. Broadband infrastructure, including the NBN in particular, represents National Critical Infrastructure providing essential services important for the development of a digital economy and online society. All Australians should benefit to the maximum extent in realising the social and economic potential of broadband. Large, long-term investments and programs that address the demand side, as well as the supply side, of broadband require a clear long-term vision and plan (the National Broadband Strategy), supported by a robust bipartisan commitment that endures beyond electoral cycles. The Report is not such a Strategy but is a major contribution towards it. It is addressed to all stakeholders, especially to the Commonwealth Government which has leadership responsibility, and to industry organisations whose involvement is important for success.

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Australia's National Broadband Strategy: An Overview

1. Executive Summary

This Report has been developed by the NBN Futures Group, with support from TelSoc, and draws on the substantial work that the Group has undertaken over the past two years to examine the current state and desirable future of broadband services in Australia. Our work includes conducting four public forums on various aspects of broadband policy and on the future of the National Broadband Network (NBN), which is central to broadband infrastructure and services both now and into the immediate future. The purpose of the extensive work program of the NBN Futures Group and this Report is to ensure Australia's broadband infrastructure and services continues to develop in a financially responsible and timely manner delivering value, economic benefit and new service experience opportunities to all Australian residents in all locations and in all economic circumstances across Australia.

Our proposals in this Report have been developed in a rapidly changing environment. This period has seen significant shifts in the policy context for broadband networks — with the remarkable dependence on them during COVID-19, the completion of the NBN build and projections of upgrade, the rollout of 5G and other initiatives. It is timely to form a common understanding of future directions.

We recognise that broadband, and the NBN in particular, represents National Critical Infrastructure ("Critical Infrastructure", n.d.) providing essential services that are

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fundamentally important for the development of a digital economy and online society in Australia. Broadband services provided over mobile networks are also increasingly important for Australian users, and this is being reinforced with the introduction of 5G technology. It is important that all Australians benefit to the maximum extent in realising the social and economic potential of broadband. The investments that have been made to date and which still need to be made are very large and are for the long term.

Large, long-term investments and programs that address the demand side, as well as the supply side, of broadband require a clear long-term vision and a long-term plan (which we have called the National Broadband Strategy), and need to be supported by a robust bipartisan commitment from all leaders that endures beyond commercial and electoral cycles.

In this Report we have outlined the requirements and essential content of a National Broadband Strategy together with conclusions relating to specific issues that need to be addressed. Our main conclusions are set out in Section 10 of this Overview and are supported by the various Annexes that make up the Report. In summary, they are:

- That there needs to be a National Broadband Strategy with a clear vision for Australia's broadband future.
- The NBN needs to be recognised as National Critical Infrastructure.
- The Strategy needs to have bipartisan support.
- The Strategy needs to be long-term covering a rolling 10-year horizon.
- The Strategy needs to address supply-side and demand-side goals, with a view to maximising social and economic benefits through digital inclusion and by scaling up applications development and use.
- The Commonwealth Government must take the key leadership role in developing the Strategy, but must engage widely in the process, given the broad social and economic consequences of broadband.

This report is addressed to all stakeholders in Australia's broadband future, but especially to the Commonwealth Government which has leadership responsibility, and to the industry organisations whose engagement and involvement is so important to success.

2. Introduction

Australian Governments and industry have long recognised that, for Australia to develop as a modern digital economy and society that is inclusive nationally and competitive globally, it will need to have modern broadband infrastructure and appropriate settings in its national policies, including direct intervention when required. Broadband planning needs to be guided by a robust national broadband strategy that has a longer-term horizon than current

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commercial planning perspectives or election cycles, and which has broad and consistent bipartisan support.

The NBN Futures Group, with support from TelSoc (the Telecommunications Association) (both of which are described in the Annexes to this Overview), are of the view that it is now timely for renewed national discussion and action to develop a comprehensive National Broadband Strategy for Australia to cover at least the next 10 years, and to plan the future for the National Broadband Network, which will have a central role in the National Broadband Strategy during that time.

3. This Report

This Report documents the work of the NBN Futures Group (supported by TelSoc) since the beginning of 2019 on national broadband issues. The work commenced with consideration of the ownership options for NBN Co, but quickly developed to address a range of issues associated with broader broadband strategy and policy.

This Report is intended to be a thoughtful and deep analysis of issues that need to be reflected in Australia's National Broadband Strategy for the longer term. It does not purport to be that Strategy. The Report is addressed to policy makers and those with the power and duty to act as leaders in this field. Our key audience is therefore the Commonwealth Government and the Commonwealth Parliament, where responsibility resides for communications services, national social welfare and the national economy.

However, there are stakeholders who have important leadership roles in this field – including NBN Co itself, other telecommunications service providers, users of telecommunications services, the media and the general public – and all of these are important audiences addressed through the document.

This Report consists of a short overview, with annexes dealing with each of the main themes numbered 4–8 below.

The conclusions have been made as concrete as the information available allows.

4. Vision and Objectives for the Strategy

TelSoc's values

The primary focus of TelSoc is on the development of telecommunications and with realising the potential of telecommunications for social and economic development. Insofar as it has any advocacy role, TelSoc is limited to that. Through the *Journal for Telecommunications and the Digital Economy*, TelSoc aims to promote reasoned discussion on technology, social and

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economic issues and on themes associated with the sector and with its wider impacts. This Report is a further initiative in that tradition.

Vision for the National Broadband Strategy

The National Broadband Strategy should encompass all public access networks, both fixed and mobile. The National Broadband Network operated and managed by NBN Co is very central to the strategy, especially in the near term, but is not the entirety of the issues that need to be considered.

The National Broadband Network and other broadband infrastructure is fundamental infrastructure secured though substantial investments in long-term assets in a time of rapid technology change and of uncertainty in demand preferences and patterns. This is potentially therefore an area of substantial commercial risk.

The vision for the national broadband strategy recognises that long-term national investment must be supported by an equally long-term national broadband strategy based on robust, inclusive planning work and sustained by bipartisan support. In substantive terms, the vision is for the reliable delivery of accessible, affordable and appropriate broadband services nationally to support Australia's development as a competitive and leading digital economy and as an inclusive digital society. The vision further recognises the potential of high-performance broadband capability to support innovative new services and employment opportunities associated with growing social and economic structural change. It is both long-term and continuing, but needs to be translated into instalments capable of short-term realisation.

Principles for the National Broadband Strategy

Bearing in mind that the National Broadband Strategy will be critical for the development of the national economy and for national economic and social inclusion:

- the strategy needs to recognise the role of broadband and of the NBN in particular in supporting Australia's evolution to a digital society and digital economy;
- the strategy needs to incorporate technical performance and service quality goals over at least the next 10 years and be subject to periodic review and refreshment;
- the strategy can only deliver over multiple electoral and economic cycles if it has widely-based, bipartisan support;
- the strategy must reflect a whole-of-Government, whole-of-economy and whole-of-society approach, with net benefits of specific initiatives considered on that basis, rather than purely in commercial terms; and

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- the strategy needs to be underpinned by the values that Australia espouses as an inclusive liberal democracy and must not only seek to extract full value from the national investment in the NBN, but must ensure that the benefits are fairly, widely and reasonably shared.

5. Social and Economic Benefits of National Broadband Networks

Broadband capability has become critical for the evolution of the online society and the digital economy in Australia and globally. This process has been ongoing for some time, but has now been given further impetus and attention because of the imperatives of online interactions in response to the COVID-19 pandemic. The pandemic has dramatically highlighted the importance of national telecommunications networks, and of the NBN in particular, in delivery of services ranging from telehealth and tele-education, through to supply chain management and fulfilment, working from home, maintaining community cohesion and personal relationships. There is a substantial body of opinion that many of the social and economic adaptations made in response to the pandemic will remain as a 'new normal' in a post-crisis world. It is not the purpose of this Report to speculate on what that new normal might be in any detail, other than to note that ubiquitous broadband access will be a central requirement.

Obtaining value

A major component of the next phase of broadband network development in Australia, post the completion of the initial build of the NBN, will be an emphasis on realising the full social and economic benefits of such networks, both fixed and mobile.

This is a view given strong support in statements of the Minister, Paul Fletcher, and Shadow Minister, Michelle Rowland. At the NBN Futures Forum in July 2019, Minister Fletcher emphasised the need to "get the maximum social and economic impact from the $51B taxpayers' money" and to understand "how best to leverage this extraordinary national investment". Shadow Minister Rowland identified "the task of public policy will be to maximise the benefit of that investment [in the NBN] now and into the future" (Campbell & Milner, 2019).

Essential Service and Universal Access

Broadband access has become an essential service, similar to other utilities. Life is certainly possible without such services, but full inclusion and interworking makes access necessary for all intents and purposes. As society and the economy are transformed by greater and greater

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online presence, the essential nature of broadband services will become more and more manifest. The important point is not to be concerned about how true this might be at any time and for any set of activities, but to plan on the basis that it is so in the national broadband strategy.

The consequences of essential service status include setting and planning for a ubiquitous, minimum level of universal broadband service, noting that the minimum will increase over time. It is a tenet of the social benefits of broadband that a minimal offer should be available to every premises. The strategy should be based, in part, on a minimal broadband service available to everyone and incremental improvements in that minimum standard over time. Flexibility to respond to future needs will be an essential aspect of any universal access policy.

Future demand

Devising a long-term strategy in an era of rapid technological development and innovation is difficult, with penalties for providing inadequate capacity and for building infrastructure that may be stranded. We note that, to this point, the construction of much of the broadband infrastructure through NBN Co has responded to bottom-up demand estimates based on the requirements of "applications stacks" relating to multiple simultaneous usage in households and small businesses. We consider that this approach is dependent on having reasonable knowledge of the applications that might arise in the longer term and of their data rate requirements. However, the approach is useful in setting a minimum requirement and will also be useful in determining minimum capacity requirements for universal service. However, on its own it will not lead to a responsive approach to meeting future demand, which is highly uncertain due to the impact of unpredictable innovation in the ways that communication technology and applications will evolve.

The approach that we believe ought to be adopted in the national broadband strategy is to favour technologies that are capable of rapid upscaling to provide substantial additional capacity for relatively little incremental cost. Clearly FTTP (fibre to the premises) delivers on this, but will not be feasible in all customer settings. As discussed in section 6 below, progressive implementation pathways are available for upgrading existing technologies in ways that enable increased capacity to be delivered progressively to almost all Australian customers.

Inclusion and Access

There are substantial social and economic costs that are incurred through non-inclusion and these need to be studied and measured more comprehensively than they are at present. They form part of the broader picture of costs that are not taken into account when the focus is the

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commercial feasibility of broadband delivery at the level of the enterprise – including at the NBN Co level.

For Government, community and commercial organisations, the costs incurred are in terms of multiple service delivery modes, in the absence of ubiquitous broadband access. At the level of the individual and of commercial enterprises, the losses from non-inclusion are in terms of lost amenity, lost potential and, ultimately, the possible costs of expensive workarounds. The social and economic costs where inclusion is inadequate or non-existent is not only a cost on those directly affected, but on all who seek to transact or engage with them.

For these reasons, regional equity in access to affordable high-speed broadband services is recommended as a good national investment, supported by an upgraded Universal Services Obligation for communications services.

We agree with the Australian Digital Inclusion Alliance (ADIA) that a National Digital Inclusion Roadmap should be developed by Government providing for a coordinated approach to access and affordability of broadband services, development of digital capabilities and for accessibility by all sectors and community groups (ADIA, 2020).

Applications development and scaling

In the course of its work the NBN Futures Group has identified substantial numbers of online developments and initiatives, often commenced as pilots, trials or small-scale projects. To be viable many of these developments need to gain scale and thereby gain traction. To date this has been a commercial process, with hit-and-miss outcomes dependent on many factors, including chance. While that will continue to be a mainstream process for applications development, particularly outside those required by large corporations and Government, the scaling up of the use of online applications in key sectors – telehealth, online learning, access to government services, etc. – is a major challenge requiring substantial demand-side, user focused policies and programs to tackle the underlying issues of digital capability, culture and economics. This will need cross-portfolio leadership within Government.

Research and databases

Systematic research, regularly updated, into the broader social and economic impacts is needed to provide a wider base of knowledge for all in the sector, and also to enable evidence-based policy settings to be established and reviewed as part of the National Broadband Strategy. The research that we envisage is needed to provide an ongoing demand-side focus, to offset the substantial attention given to supply-side issues associated with NBN rollout and technical characteristics of the broadband capacity and services.

Demand-side areas of focus will include:

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- the contribution to the macro economy;
- expansion of Internet use in a broad range of information, communication, transaction and entertainment applications;
- specific socially valued application areas, such as government services, education, health, banking and public broadcasting;
- specific economic development areas, such as business (corporate and SMEs), agriculture, tourism;
- broader social impacts, such as decentralisation; and
- possible benefits of future application areas, such as the Internet of Things, driverless vehicles and augmented reality.

Our work, and that of other groups such as the Australian Digital Inclusion Alliance, strongly suggests that in every sector and applications field there are many initiatives, trials and localised projects. Broadband usage and applications reflect a patchwork. This is not surprising and is expected to continue. The social and economic value of the investment of resources would be substantially improved if the Commonwealth Government were to take a lead in developing either directly or through a university or other institutional form, a database of such initiatives and improved connectivity between the participants.

6. Technologies and Technical Pathways

In 2014 NBN Co adopted a MTM (Multi-Technology Mix) approach to the rollout of broadband access, in lieu of the previous approach that concentrated on FTTP (fibre to the premises) for all wired connections. The MTM approach was designed to deliver broadband faster and at lower overall cost. NBN Co uses a variety of access technologies to reach customers' (end-users') premises, namely:

- FTTP, Fibre to the Premises (NBN Co distinguishes between FTTP installation in 'brownfields' areas – that is, areas where a telecommunications access network already exists – and 'greenfields' areas, usually newly built housing estates or industrial parks);
- HFC, Hybrid Fibre-Coax, based on the Telstra HFC network for Foxtel and Internet access;
- FTTN, Fibre to the Node, where an active node, fed by fibre, replaces a pillar or other junction point in the existing copper-line access network;
- FTTB, Fibre to the Building, for multi-tenant buildings, in which fibre is run to the building's communications point and the existing inside wiring is used for access to each individual premises;
- FTTC, Fibre to the Curb, for which fibre cables run to just outside property boundaries and a small active node is used to terminate the fibre and provide a connection to the existing copper lead-ins to the premises;

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- Fixed Wireless, where a microwave radio link is established between an NBN Co site and an antenna installed on the outside of a premises; and
- Satellite, NBN Co's SkyMuster service, where access communication is between NBN Co's geostationary satellites and an antenna mounted on the outside of the premises.

NBN Co has recognized that future technology upgrades will be necessary to provide higher speed services. In its *Corporate Plan 2020-23*, NBN Co provides a "Future technology roadmap" (pp. 29-32) for uprating each of these technologies (except for Fixed Wireless[1] and Satellite).

Our conclusion has been that the NBN fixed line services should be uprated to at least 100/50 Mbps service capability[2] as soon as possible in the first five years of the initial National Broadband Strategy and to 1000/500 Mbps service capability[3] everywhere by the end of the 10-year period, prioritised as appropriate in terms of commercial benefit. We therefore welcome the recent announcements by NBN Co that 72 per cent of its fixed line network is currently capable of delivering speeds of 100/40 Mbps and the company's estimates that its highest peak wholesale speed tiers of 500 Mbps to close to 1 Gbps downstream will be available on demand to an estimated 75 per cent of homes and businesses on the fixed line network by 2023 (NBN Co, 2020). Target dates should be established for the remainder of the fixed line network, thereby minimising lost opportunities for society and the economy.

Fixed wireless and satellite services pose a greater challenge because of user contention for system-limited capacity. Nevertheless, even fixed wireless systems can provide improved capacity in many circumstances if they are supported by aerial fibre links to the wireless nodes in rural communities.

5G technology

Much discussion of 5G technology is about its application as a wireless service, and specifically about the rollout of 5G cellular mobile services. All mobile network operators in Australia are now rolling out 5G services.

The international Broadband Forum (n.d.) is currently developing standards for the delivery and management of 5G services over fixed networks, mainly in the context of combined fixed and mobile operators. With appropriate system and software developments, these standards would enable the provision of 5G services over the NBN, both by Retail Service Providers and, potentially, by NBN Co itself.

The National Broadband Strategy needs to take account of 5G mobile services as an alternative, and therefore as competitors, to fixed broadband access provided by the NBN. In addition, it needs to endorse NBN Co using 5G technology to provide a range of wholesale

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services, including to support 5G mobile and radio networks. Our work recognises that 5G is an opportunity for NBN Co to develop a more sustainable business in the future. Leveraging 5G technology in a fixed wireless configuration will enable services at rates of 100/50 Mbps to be provided more cost effectively in the near future.

7. Financial Considerations

At the end of the initial rollout in June 2020, NBN Co was funded from the Commonwealth via $29.5B in equity and a $19.5B debt facility. NBN Co is not paying a dividend on the equity and is being charged 3.96% per annum interest on the debt facility funds drawn down. In 2019-20 NBN Co generated total revenue of $3.8B and earnings before interest, tax, depreciation and amortisation of $1.8B before subscriber costs, and -$0.6B (negative) after including those costs. NBN Co is required to substitute private borrowings for its Commonwealth debt facility by June 2024, and in 2020 was able to establish an initial facility of this kind for $6.1B. NBN Co has not released details of the interest rates that it has negotiated for its private debt facility. Debt capital is readily available below the Commonwealth's 3.96% rate, however.

The financial information available from NBN Co, especially the forecasts in its Corporate Plan 2021-24, is high level and averaged to a level that precludes detailed analysis.

For the purposes of future financial expectations of NBN Co and for the National Broadband Strategy, the following key points need to be taken into account:

- With the initial rollout completed in 2020, NBN Co will be transformed from an organisation with a largely construction focus into an ongoing operational enterprise, but with some specific construction tasks to complete and future upgrades to support. This will require NBN Co to adjust its resource levels accordingly.
- With the ready availability of low-interest, long-term debt funding, NBN Co should be able to profitably retire its current Commonwealth debt facility by 2024, but also to consider debt funding for new infrastructure investment and upgrades. This is supported by NBN Co's announcement on 23 September 2020 that its $4.5B fibre extension program will be debt funded, with debt expected to rise to $27.4B by June 2024.
- The Commonwealth Government has stated on many occasions its reluctance to make further equity contributions to meet NBN Co new investment requirements. However, it should be prepared to consider specific cases for funding where the national interest requires it. This means a perspective that is beyond the commercial boundaries of enterprise-level economics. A clear example is with satellite-based services, but all NBN services have substantial externalities in terms of economic benefits and should be viewed in a wider context.

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- The individual MTM technology uprating paths set out in the NBN Co Corporate Plan need to be pursued with a view to implementation in the first five years of the National Broadband Strategy. The capital cost of doing this for all FTTP, FTTN (and Curb) and HFC connections is estimated by the authors at approximately $7B (see Annex D, section 3), some of which will have been covered in the fibre extension program announced by NBN Co on 23 September 2020. NBN Co has not provided enough information to estimate uprating costs for Fixed Wireless and Satellite connections.
- In the case of Fixed Wireless services, NBN Co should be prepared to improve fibre support to Fixed Wireless nodes using aerial cable and other delivery modes.
- Revenue estimates will be affected by the extent of connection of the 4.4 million premises that are passed by the NBN and are ready to connect as at June 2020, but are not yet connected. Essentially, the potential benefit is a low incremental cost for a full per-premises revenue gain, assisted by third-party investments in some cases.[4] Some of these unconnected premises will be connected during the 18-month transition period that NBN Co provides, some may remain or become all-mobile data services, others will be affected by affordability and other digital inclusion issues, and there may be some residual who do not take up any broadband service option. NBN Co estimates take-up of around 73% by 2024. We consider that NBN Co should establish the programs it will undertake in conjunction with retail service providers to achieve and potentially exceed this take-up, provide estimates of revenue impacts for different levels of take-up, and regularly report results achieved.

8. NBN Ownership Options

We have examined the cases for and against various ownership options in this Report, ranging from various sale options to various options for retention in public ownership. In conducting this examination, we have recognised that the NBN is a crucial component of National Critical Infrastructure.

NBN Co should not be protected as a legislated monopoly. It needs to be competitive and to remain open to all modes of broadband competition with the exception of the time-bound fixed network service prohibitions which currently apply to Telstra. In addition, the arrangements currently in place to constrain arbitrage that is not in the overall public interest should be maintained, and be subject to regular review to ensure that they are as "light touch" as possible while remaining effective.

The key principle in this Report about NBN Co ownership is that it should not be a matter of ideological preference, but should reflect the role of providing fixed wholesale broadband as an essential service and how that might be best guaranteed under the circumstances that apply

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from time to time. Important considerations will be the policy and regulatory settings and the level of effective competition from services provided using alternative technologies and infrastructure.

We have concluded that sale of NBN Co is not a realistic option for at least the next five years and possibly for the whole 10-year period of the initial National Broadband Strategy. However, the issue of whether and, if so, how NBN Co might implement a greater charter opportunity by becoming a 5G wholesaler and having appropriate opportunities to engage in greater wholesale transmission opportunities (not only access services) needs to be addressed.

9. Developing a Bipartisan National Broadband Strategy – Next Steps

We have argued the case that Australia needs a National Broadband Strategy, which addresses in a bipartisan manner the longer-term considerations for ubiquitous availability and use of broadband services needed for Australia to become a successful digital economy and society. We have outlined some of the key issues that need to be included in the Strategy. But developing the actual Strategy and achieving a broad-based consensus that will guarantee robustness and effectiveness is a matter for national leadership, and particularly for leadership by the Commonwealth Government.

The breadth of considerations and issues means that many, possibly most, Government portfolio areas will be involved. A coordinated approach will clearly be necessary. A Sub-Committee of Cabinet may well be an appropriate way to lead and manage this development process.

We also note the recommendation by the Australian Digital Inclusion Alliance in September 2020 that "a single department could be appointed to lead [on developing] a National Digital Inclusion Roadmap" (ADIA, 2020). The proposed Roadmap needs to be part of the larger National Broadband Strategy now being proposed, and the approach of a single lead department may have merit as an alternative.

Before finalising a firm policy, the Government needs to consult widely in the case of the National Broadband Strategy to ensure that it reflects appropriately the diverse range of interests at stake and issues in play, and has legitimacy, robustness and relevance as a result.

10. Conclusions and Recommendations

From our work since the beginning of 2019 we have arrived at the following conclusions, which we encourage the Commonwealth Government, and all who seek to shape Australia's broadband future, to adopt:

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1. Australia needs to have a National Broadband Strategy reflecting national broadband policy settings and providing long-term guidance for the development of infrastructure and services and for ensuring that all Australians enjoy the full potential social and economic value of broadband, both fixed and mobile.
2. The National Broadband Strategy must:
    a) articulate that Australia is committed to continuously developing and maintaining world-class broadband infrastructure and services that will be provided to maximise social and economic inclusion, and to express in detail what this means at nominated points in the timescale covered by the Strategy;
    b) be longer-term in its perspectives, and initially provide a clear roadmap for the next 10 years;
    c) be broadly based and broadly supported, seeking the bipartisan support necessary for certainty, continuity and consistency across the life of multiple parliaments;
    d) be concerned to ensure that the network benefits from broadband investment – that is, benefits to society at large, not realisable at the enterprise level – are identified, assessed and realised;
    e) emphasise the demand-side aspects of broadband service, and the need to maximise economic and social inclusion through policies that deliver high quality affordable broadband services to all areas, sectors and customer segments;
    f) recognise that broadband infrastructure and services will be provided by many vendors on many platforms, but also that the NBN will have a central part to play for at least the next 5-10 years in Australia; and
    g) establish a Universal Broadband Service roadmap with clear download and upload targets and intermediate milestones, while recognising that flexibility to address future unknown application innovation will be a critical success factor.
3. The National Broadband Strategy needs to outline the policy and regulatory settings that will operate for the next 10 years, subject to regular monitoring and refinement. NBN Co should not enjoy any form of statutory monopoly in broadband access service provision, subject to the existing time-bound prohibitions on Telstra running their course.
4. The National Broadband Strategy should make provision for regular assessment of broadband needs and demand and for the broader economic assessments needed to guide national policy. In particular, the Strategy must favour broader assessment of capacity needs that allow for unanticipated step-function changes in the requirements

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of applications. It is the role of the Strategy to ensure that social and economic development will not be unduly constrained in future by a lack of capacity. We recommend that the NBN access service for all premises connected via fixed network technologies should be uprated to 100/50 Mbps service capability as soon as possible in the first five years of the initial National Broadband Strategy and to 1000/500 Mbps service capability everywhere by the end of the 10-year period.

5. The Commonwealth should be prepared to make further investments in NBN Co, especially in relation to specific-purpose infrastructure development programs that are needed for high quality broadband to be affordable in high-cost areas and for currently underserved communities and population segments, e.g., to encourage greater decentralisation of population.
6. The Commonwealth must be prepared to promote and sponsor applications development and research to ensure the best possible working arrangements are in place in the residential, small business, enterprise and government spaces to bring about maximum benefit.
7. The charter for NBN Co needs to be clarified as part of the National Broadband Strategy and revised to reflect current industry needs and developments. In particular, its charter needs to explicitly reinforce its essentially wholesale role, but also be reviewed in the light of current circumstances and likely future developments. As part of that review the following extensions of the charter should be considered:
    a) enable NBN Co to provide wholesale services to industry verticals and full participation in the Internet of Things;
    b) enable the adoption of new technologies, such as 5G, and to become a 5G network wholesaler; and
    c) allow for the provision of wholesale transmission generally, not necessarily limited to fixed access services.
8. In pursuing the major objective of extending the social and economic benefits of broadband services, the Commonwealth should support programs to overcome digital exclusion and establish effective levels of digital capability, and to scale up the usage in a range of activities that has been demonstrated during COVID-19. These programs will require substantial research and project support.
9. The Government should set goals in a new Statement of Expectations for NBN Co covering the next 5-year period, and this statement should be reviewed at regular intervals to guide NBN Co's rolling investment and operating plans.
10. NBN Co must take action to deliver the efficiency gains associated with its transition from a mostly construction organisation to an ongoing operational entity following the completion of the initial NBN rollout. In particular, it should:

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a) Address the 100,000 premises identified as difficult to serve and which are outstanding as at June 2020;
b) Implement over the next 5 years the capacity uprating plans outlined in its Corporate Plan 2020-23 for each of the technologies in the Multi Technology Mix; and
c) Develop cost-effective capacity uprating plans for Fixed Wireless and Satellite access, including, for Fixed Wireless Access, the use of aerial fibre and other means to support more effective wireless nodes.

11. NBN Co should publish much more detailed dissections and analysis of its existing and forecast costs, consistent with its role as an accountable public enterprise in a quasi-monopoly position, to facilitate a broader discussion on its performance, plans and options.
12. NBN Co should undertake a number of initiatives to improve its medium-term financial position and its ability to fund capacity improvements and technology upgrades, including:
    a) securing new revenues through effective programs to connect a substantial portion of the 4 million premises that are ready to connect but remain unconnected as at June 2020;
    b) plan and implement over the next 5 years (2021-2025) uprating the capacity of the technologies in the MTM to meet the service capacity targets referred to earlier; and
    c) establishing private loan facilities at lower cost and extinguishing its Commonwealth loan facilities before June 2024, and expanding debt financing as a source of capital, as appropriate.
13. There is a strong case for NBN Co remaining in public ownership for as long as it retains a central role in the provision of Critical National Critical Infrastructure based services. NBN Co should remain in public ownership for at least 5 years to enable it to develop into a sustainable enterprise. Thereafter, ownership might be reviewed in the light of changing circumstances as required.

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Endnotes

[1] In the plan it is stated that the Fixed Wireless will be upgraded to support 50 Mbps downstream services where possible. NBN Co has implemented a Fixed Wireless Plus service which aims to deliver the maximum potential wholesale speeds that the network is capable of delivering to that premises at the time of use. It is understood that this addresses the fact that spectrum over which wireless services operate is shared and finite, so the aim is to optimise the experience around the available radio capacity. NBN Co currently provides the following Fixed Wireless services: 12/1, 25/5 and Fixed Wireless Plus. Fixed Wireless Plus replaced the previous ranged tier 25-50/5-20**.** Wireless services are considered in speed ranges by NBN Co due to the shared spectrum resource.

[2] 100 Mbits per second downstream capacity and 50 Mbits per second upstream capacity. The choice of 100/50 is proposed as the reference service, as it is the default service delivered by GPON technology when configured for use with 24:1 passive splitters, which is the predominant technology used for the delivery of FTTP.

[3] 1 Gbit per second downstream capacity and 500 Mbits per second upstream capacity

[4] Such as, for example, from State and Local Government, retail service providers and other co-investors

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Annex A: TelSoc and the NBN Futures Project

TelSoc

TelSoc is the operating name of the Telecommunications Association Inc., a voluntary membership-based association of interested individuals, who seek to discuss, research and advance issues associated with telecommunications and the digital economy. TelSoc and its predecessor organisations have served as the learned society of the Australian telecommunications industry continuously since 1874 (initially as the Telegraph Electrical Society), convening regular talks by experts and publishing papers and monographs on Australian telecommunications for more than a century. Most of our individual members are professionals who have worked in the sector, including those with academic, research, regulatory and operational interests in the industry.

TelSoc seeks engagement with policy makers and other stakeholders on telecommunications issues via its quarterly publication, the *Journal of Telecommunications and the Digital Economy* ("the *Journal*"), and through the policy forums and other events that it organises. The *Journal* and its predecessor, the *Telecommunications Journal of Australia*, have been published continuously since 1935, initially in print and since 2007 online.

NBN Futures Project

The NBN Futures Project began as an idea put forward at the TelSoc Journal's Editorial Advisory Board in February 2019: that the options for the future ownership and enhancement of the National Broadband Network should be researched and debated in a systematic way, through public lectures and policy articles published in the *Journal*.

This proposal was enthusiastically supported by all present, who held a series of subsequent meetings to work out project objectives and plan actions. In the course of these, additional TelSoc members and others with useful skills and knowledge were invited to join the project.

On time frame, it was decided to develop, by early 2021, some well supported policy options that might influence both of the major political parties in the lead-up to the forthcoming federal election. Best endeavours are being made to seek bipartisan support for the project's recommendations.

To help develop these ideas it was decided to hold a series of public policy forums, under the TelSoc banner, and to transform as many of the presentations as possible into papers of record, published in the TelSoc Journal (the *Journal of Telecommunications and the Digital Economy*). The Project Team also made a submission in January to the federal Parliamentary

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Joint Standing Committee on the NBN, to alert relevant political advisors to the existence and potential of this project.

The first NBN Futures public forum, held at RMIT University (courtesy of Mark Gregory) on 31 July 2019, concentrated on examining the options for eventual ownership of the completed NBN. Chaired by John Burke, it included presentations by Peter Gerrand, Jim Holmes, Graeme Samuel AC and Michael Cosgrave (ACCC). A report on the forum appears in Campbell & Milner (2019).

The second NBN Futures public forum, held at RMIT on 22 October 2019, focussed on realising the user potential of the NBN. It featured presentations by Teresa Corbin (CEO, ACCAN), Chris Wilson (on the Australian Digital Inclusion Index) and Murray Milner (on the New Zealand broadband market experience). A report on the forum appears in Campbell (2019).

Details on the broad scope of the project as at December 2019 can be found in Holmes & Campbell (2019).

The third NBN Futures public forum, *Learning from International Experience*, was held on 25 February 2020, again at RMIT, featuring Richard Ferrers (on OECD comparisons) and Murray Milner (on lessons from the successful New Zealand Ultra-Fast Broadband program), with discussion from Jim Holmes (Incyte Consulting). A report on the forum appears in Campbell (2020).

The fourth NBN Futures public forum, *Social and Economic Considerations: Digital Inclusion and Telehealth*, was held on 18 August 2020 via videoconference. It was chaired by Jim Holmes and included sessions on Digital Inclusion by Ishtar Vij, coordinator of the Australian Digital Inclusion Alliance, and on telehealth by Professor Anthony Smith of the University of Queensland Telehealth Centre and Professor Peter Brooks of Northern Health, Victoria. A report has been published in the *Journal* in Campbell, Smith & Brooks (2020).

Project Membership: Active members of the NBN Futures Project, in alphabetical order, have been: Trevor Barr, John Burke (convenor), Leith Campbell, John Costa, Richard Ferrers, Peter Gerrand, Andrew Hamilton, Peter Hitchiner, Tim Herring, Jim Holmes, Allan Horsley, Murray Milner and Craig Watkins.

Articles in the *Journal of Telecommunications and the Digital Economy***:**
Covering content presented in the first forum:

Leith Campbell and Murray Milner, "The NBN Futures Forum" (Campbell & Milner, 2019).

Peter Gerrand, "NBN Futures: The Option of Merging NBN Co with InfraCo, as a Benefit to the Digital Economy" (Gerrand, 2019).

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Jim Holmes, "Getting the NBN Infrastructure We Need" (Holmes, 2019).

Project overview:

Jim Holmes and Leith Campbell, "The NBN Futures Project" (Holmes & Campbell, 2019).

Covering content presented in the second forum:

Leith Campbell, "The NBN Futures Forum: Realising the User Potential of the NBN" (Campbell, 2019).

Teresa Corbin, "Promoting Digital Inclusion Through the NBN" (Corbin, 2019).

Covering content presented in the third forum:

Leith Campbell, "The NBN Futures Forum: Learning from International Experience" (Campbell, 2020).

Richard Ferrers, "Enhancing NBN's Value: Comparing NBN with Australia's Top 10 Trading Partners and OECD" (Ferrers, 2020).

Murray Milner, "Ultra-fast Broadband" (Milner, 2020).

Covering content presented in the fourth forum:

Leith Campbell, Anthony Smith and Peter Brooks: "The NBN Futures Forum: Social and Economic Benefits of Broadband for Digital Inclusion and Telehealth" (Campbell, Smith & Brooks, 2020).

Submission to the Joint Standing Committee on the National Broadband Network:
https://www.aph.gov.au/Parliamentary_Business/Committees/Joint/National_Broadband_Network/smallbusinessandcase/Submissions (Submission 20)

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Annex B: Vision and Objectives

1. Vision

The vision that has been the focus of the work over the last two years and the preparation of this Report is of ubiquitous, high quality, high speed broadband that is affordable to all in Australia and which will provide an essential service needed for Australia to develop and remain an inclusive online society and a competitive online economy into the future.

This vision is continuing – and needs to be agreed and given substance in terms of national broadband infrastructure and services with regard to evolving technologies, market circumstances and national needs.

2. Objectives

The vision needs to be given substance and be realised through:

1. Longer term substantive objectives;
2. Medium-term substantive objectives for the national broadband infrastructure, and for the NBN in particular; and
3. Process objectives in relation to how Australia should seek to achieve its substantive objectives.

Longer term substantive objectives

These objectives are:

- **Digital Society**: to provide all residents and visitors with affordable, reliable network access to all essential services, high and low speed, across Australia.
- **Digital Economy**: to provide all Australian businesses with internationally competitive network access to their customers, suppliers, staff and collaborators across the world.
- **National Infrastructure**: to provide reliable and economical broadband access to fixed and mobile networks, transport infrastructure, emergency services, education, health and public broadcasting networks.

It should be clear that these objectives cover more than the role of NBN Co. All broadband providers in Australia contribute to the national broadband infrastructure.

These objectives need to be given specific meaning for each planning period, to reflect changing expectations and requirements. However, they are likely to be enduring at the higher level expressed above in the long term.

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Medium term substantive objectives

These are objectives for the national broadband infrastructure, and for the NBN in particular.

These objectives are best expressed in a National Broadband Strategy that provides direction and some certainty about the priorities that need to be met over the next 10 years. The Strategy will need to be reviewed and, as needed, revised to remain current.

The National Broadband Strategy, to do the work required of it, will need to:

- Be authoritative, reflecting the commitment of the Commonwealth Government as the institution with the key leadership role in relation to broadband infrastructure and services;
- Be comprehensive, covering both supply-side and demand-side targets for broadband;
- Recognise that broadband access services at both wholesale and retail levels in the market will be provided by many providers on a multi-modal platform and network basis, but that the role of the NBN and of NBN Co will be central for fixed access, at least for the 10 years covered in the initial Strategy;
- Identify the performance levels that are planned to be available to residential and enterprise customers served by each of the mix of technologies at the end of each period within the Strategy (at least by the end of the first five-year period, from 2021 to 2025); and
- Incorporate a Statement of Expectations for NBN Co.

Process objectives

These are objectives in relation to how Australia should seek to achieve its substantive objectives.

Australia's national broadband infrastructure and the NBN in particular are long-term, high-cost assets that reflect a very large national investment of public and private resources. As recent developments, and particularly the impacts of the COVID-19 pandemic, show, reliance on ubiquitous broadband services is effectively entrenched. Broadband access needs to be viewed and planned as an essential service, broadly similar to any other utility that is regarded as essential for modern living.

This means that there needs to be a robust level of bipartisan support for national broadband policy and for the key settings in the National Broadband Strategy. The Strategy needs to provide for a consistent approach over long-term investment cycles to provide some certainty for all investment in this field. These cycles and the perspective they require are well in excess of political or electoral cycles and short-term business cycles.

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Other process objectives are driven by the enduring values that Australia espouses as an egalitarian, inclusive liberal democracy – including an agreed minimum level of service coverage to all communities and areas of the country, and affordable access by all.

The process objectives that result from the above considerations are:

- Transparency in developing and approving the National Broadband Strategy and in monitoring and assessing implementation;
- Processes that maximise bipartisan support;
- Establishing affordable access options for all Australians in all geographic locations; and
- Regular reviews of the national Broadband Strategy and of Statements of Expectations for the NBN to ensure they remain current and reflective of dynamically changing circumstances.

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Annex C: Extending the Social and Economic Benefits of Broadband

1. Summary

The major goal of the next phase of broadband development in Australia, following the completion of the initial build of the NBN, should be achieving the full social and economic benefits of broadband networks and delivering value to end users.

The present COVID-19 crisis has demonstrated the benefits of broadband networks in supporting many vital online activities. It has also highlighted the negative impact of digital exclusion on the ability of some citizens to participate in those activities.

Australia needs a substantial and focused approach to pursuing these benefits. Developing this approach will require a contemporary policy focus to embrace a demand-side, user- focused perspective. Significant initiatives have recently been undertaken.

This paper identifies a number of important components for the next phase of broadband development.

2. Situation

A major component of the next phase of broadband network development in Australia will be an emphasis on realising the full social and economic benefits of such networks, both fixed and mobile. This is a view given strong support in statements from both the Minister Paul Fletcher and Shadow Minister Michelle Rowland. At the NBN Futures Forum in July 2019, Minister Fletcher emphasised the need to "get the maximum social and economic impact from the $51B taxpayer's money" and to understand "how best to leverage this extraordinary national investment". Shadow Minister Rowland identified "the task of public policy will be to maximise the benefit of that investment [in the NBN] now and into the future" (Campbell & Milner, 2019).

The current experience of COVID-19 has significantly changed perceptions of these benefits. For many, broadband networks have enabled working at home, studying and communicating in various forms. Many innovative instances of "living online" are revealed each day, at the same time as there are major social innovations such as broad-based telehealth, to which there have been long-standing barriers.

During the course of this project, the NBN Futures Group has given continuing attention to the ways to fully recognise and achieve these social and economic benefits, through two forums

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– *Realising the User Potential of the NBN* (Campbell, 2019) and *Social and Economic Benefits of Broadband Networks: Telehealth and Digital Inclusion* (Campbell, Smith & Brooks, 2020) which attracted over 100 participants in total – as well as a Discussion Paper (NBN Futures Group, 2020), which went through several phases of review by experts external to our group.

Our early considerations occurred in a context in which there had been limited attention to these issues for many years and our Discussion Paper consequently sought to generate active discourse and specific proposals for action. The Paper recognised two major themes in achieving these benefits — given an extraordinarily heightened awareness due to the COVID-9 situation — namely:

- a focus on better understanding and scaling up beneficial online activities, including:
    - online learning;
    - personal communications;
    - working from home;
    - small business processes;
    - creative and cultural activities;
    - online interaction with government;
    - telehealth, which we have chosen to take as a particular case study of activity;
- digital inclusion programs to ensure citizens have the capability to engage with these and other online activities through increasing access, affordability and personal abilities, as examined in detail by organisations such as the Australian Digital Inclusion Alliance, the Australian Communications Consumer Action Network and the Australian Digital Inclusion Index.

The Discussion Paper emphasised the need for long-term, coordinated action focused on these linked themes, possibly through the establishment of new entities.

3. Recent Initiatives

During the last year, practical initiatives have been undertaken by the Commonwealth Government and NBN Co. These include:

- The establishment of the Digital Technology Taskforce, as a cross departmental body coordinated by the Department of Prime Minister and Cabinet with an external Experts Advisory Committee and including a specific area of focus on digital skills and inclusion ("Digital Technology Taskforce", n.d.).
- The establishment of the Australian Broadband Advisory Council to provide advice and recommendations to the Minister, Paul Fletcher, on matters including:

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- ways in which the NBN and 5G can be used to lift Australia's economic output and the welfare of Australians more generally;
- opportunities to increase the use of the NBN, 5G and other broadband networks, including by small and family businesses;
- barriers to using the NBN and 5G, including financial and cultural/behavioural issues and cost-effective strategies to reduce such barriers;
- potential implementation, communication and outreach strategies.

Over an initial 2-year period, the Council will develop digital connectivity strategies for the agriculture, education, tourism, media and digital content, and health sectors ("Broadband advisory council established", 2020).

- Increasing emphasis by NBN Co. on pursuing social and economic benefits through its corporate plans and actions in relation to affordability and inclusion, including:
  - A $150m COVID-19 response package to help Internet providers "to connect low-income families with home schooling needs and assisting small and medium businesses and households facing financial hardship" ("COVID-19 relief", 2020);
  - a process of codesign with Internet service providers and community groups on approaches to increasing connection of older Australians ("Media Statement", 2020).

We welcome these initiatives and recognise the importance of seeing how they develop over time. At the same time, we identify some of the matters that we consider need to be taken into account in considering how a long-term emphasis evolves from these initiatives.

4. Components of an ongoing process

The following components of the ongoing broadband development process arise from our understanding of the social and economic benefits achieved (or not) by broadband networks over the last several decades. Key sources are our Discussion Paper, our NBN Futures Forums and our interactions with experts in relevant fields.

4.1 A continuing "demand side" policy focus

We need to recognise enhancement is required to the National Policy focus. For a considerable period, debate about national broadband network development in Australia has focused on the technical and ownership aspects of the relevant infrastructure. The social and economic benefits of this infrastructure are, however, derived from the ways in which it is put to use by a wide variety of users — residential, small business, corporates, government agencies and other service providers. This user focus, or demand-side perspective, requires a quite different orientation than that of the supply-side perspective on technology and services. Globally,

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research is identifying that, once the infrastructure is substantially in place, nations are increasingly starting to take a demand-side focus on policy development:

> "Theoretical research and international experiences have demonstrated that, while both supply-side and demand-side policies have a positive effect on broadband diffusion at the initial stage of broadband adoption, only demand-side policies appear to generate a positive and increasing effect after one has reached a certain degree of broadband penetration" (Liu, 2016, pp. 177-178, 183).

This user-focused perspective brings in elements of social, economic and policy research and development on which we have had relatively little emphasis in our national policy debate.

Taking Telehealth as an example, we have been advised that major factors in scaling up applications so apparently beneficial during COVID-19 include the comfort of patients with the approach and their easy access to and capability with technology, cultural acceptance within the health profession, and economic aspects such as the provision of Medicare items. While massive increases in Telehealth consultations have occurred, the fact that about 90% of these have been by telephone indicates the need for a focus on factors limiting the use of video consultation ("Telehealth and coronavirus", 2020).

Clearly, the influencing of all factors such as these which are across many sectors is within the remit of a number of Ministers — Communications, Health, Education, Government Services, Agriculture and others — making appropriate policy development a cross-portfolio matter.

4.2 A broad consideration of social and economic benefits

While it makes a great deal of sense to focus in the short term on sustaining and scaling up the clearly observable benefits of online activities since the advent of COVID-19, over time a broader approach will be desirable, including:

- Identifying areas of focus such as:
  - Assessment of macro-economic benefits;
  - Expansion of Internet use in a broad range of information, communication, transaction and entertainment applications;
  - Specific socially valued application areas, such as government services, education, health, banking;
  - Specific economic development areas, such as business (corporate and SMEs), agriculture, tourism;
  - Broader social impacts, such as decentralisation;
  - Possible benefits of future application areas, such as Internet of Things and augmented reality;
- Developing a framework for the recognition of benefits as they apply to users, service providers, and society broadly;

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- Recognising the critical underlying requirement of digital inclusion and broader activity-oriented capabilities.

4.3 Generating discourse

There have been claims about the social and economic benefits of broadband networks over the years, but little apparent sustained, interrogating discourse or research in Australia:

- There have been limited generators of wide-ranging discourse since such activities as the University of Canberra hosting a symposium, *Converging on an NBN Future: Content, Connectivity, and Control* in 2012 ("NBN future", 2012), and the Institute for a Broadband-Enabled Society and its now-defunct successor, the Networked Society Institute, conducting a range of public seminars and forums from 2009 to 2019.
- There are more niche, sector-based approaches such as the University of Queensland's Centre for Online Health's public seminars, and the Australasian Telehealth Society's annual conferences on *Successes and Failures in Telehealth* ("SFT-19", 2019).

Our experience of conducting the NBN Futures Forums has shown the merit of cross-disciplinary public discourse, which could be greatly expanded to an extensive inclusion of policymakers, practitioners and researchers.

4.4 Long-term coordinated activity

In contrast to some other countries with advanced broadband infrastructure, which have long-established plans and central agencies to guide demand-side development, Australia has a patchwork history of policy and research activities. Research and policy development bodies with a demand-side emphasis must have longevity to ensure the building of intellectual capital.

These latest initiatives provide an opportunity to adopt a long-term strategic understanding and consequential plans.

4.5 Scale requirements of programs

In relation to Digital Inclusion/Capability

A common estimate of the number of people in Australia who are not accessing the Internet on any regular basis is 2.5m, with 2m being over 55 (ABS, 2018, Table 1). In contrast, the Commonwealth-funded *Be Connected* program, specifically directed at older persons, aims to reach up to 100,000 people annually (eSafety Commissioner, 2018, p. 2). A more robust approach to digital inclusion and enhanced digital capability will be required to ensure significant scaling up of current activities.

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The Australian Digital Inclusion Alliance identifies more than 50 current projects operating in an uncoordinated fashion and not embracing all the groups with most exclusion – such as those on low income, people with disabilities, and also Indigenous people. They propose the development of a Digital Capabilities Framework and a National Digital Inclusion Roadmap to be driven by a single government department (ADIA, 2020).

Table C-1. National Digital Inclusion Roadmap (Source: ADIA)

Affordability	**Ability**	**Accessibility**
Addressing availability and affordability of Internet services	*Ensuring everyone has the capabilities and confidence to benefit from and complete activities on the Internet*	*Allowing everyone to use the Internet including those living with disability, from culturally or linguistically diverse backgrounds, or with other needs*
Access to devices and the Internet	Analysis of digital capability programs being provided to understand gaps and overlaps Creating a Digital Capabilities Framework to provide a common understanding of what it means to be a digitally capable individual	Ensuring websites are compliant with the latest accessibility standards
Removing cost as a prohibitive barrier	Implementing a consistent way for individuals and community organisations to find out what is available locally by way of programs and resources to encourage digital inclusion	Ensuring whole of government adherence to accessibility requirements suitable for public procurement of ICT products and services

In activity areas

Similarly, the scale of actions required in particular activity or sectoral areas will be significant, including greater skilling in using online capabilities and techniques in professional training programs and with current practitioners and the introduction of new supportive roles such as the Digital Health Navigators suggested in the Telehealth area (Brooks, Duckett & Oldenburg, 2020).

Required action includes fully encouraging the engagement of small businesses which may require expanded training programs to expand capabilities and incentive structures, such as grants for equipment, specific training and business restructure. The recently announced Jobmaker Digital Business Plan (n.d.) recognises the need for encouragement of this nature, although full details are not readily available at the time of publication of this document.

4.6 Opportunities from higher speed infrastructure

We have focused initially on the significant benefits that can clearly be obtained by scaling up current applications in a wide range of activity areas – through focusing on the issues of digital inclusion, culture and economics of particular sectors, and ensuring existing technologies

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meet reliability and common speed requirements, as far as possible. The capacity for visual communications provided by the broadband infrastructure underlies many of these applications. Other applications are likely to emerge with higher speed infrastructure, particularly through the increasing capacity for transfer of large data files. Ongoing development processes should include the capacity to nurture these initiatives.

4.7 Universal Service

Australia has a long tradition of recognising the social benefits of a standard telecommunications service, available universally at reasonable cost throughout the country. Currently, the concept of universal service, originated in 1996 in its present form, applies to fixed telephony and payphones. But in the 2020s the mobile phone has become the near-universal telecommunication device on which virtually all consumers depend, and is the device most used by Australian adults to access the Internet (ACMA, 2020a) particularly by people of low income. In a country with a significant number of homeless people (most of whom do use and depend upon mobile phones), an updated definition of universal service – necessarily a broadband service – must include serving those without fixed addresses.

The 2014 Statement of Expectations for NBN Co contains a policy objective of at least 25 Mbps downstream to all premises, but the service to many regional and rural premises falls well below this speed, particularly in peak periods. The Regional Broadband Scheme, which is due to commence on 1 January 2021, provides for a shared funding scheme between fixed-line broadband carriers to support NBN's fixed wireless and satellite service provision.

A fundamental question to consider further is whether the universal service should be that which is desirable to have in all premises for full social and economic participation – considered to be 100 Mbps by 2025 – but which may not be fully technically feasible, or whether it constitutes a more basic standard service that should be available to all areas. Closely associated with this question is that of how the service level is to be funded – on a commercial, cross-industry or government-supported basis.

A standard broadband service would reasonably need to be at the level of NBN Co's 2014 objective and be at least 25 Mbps download speed and 5 Mbps upload speed, and should include access by mobile devices through radio access links. Consideration of universal provision will therefore need to take into account:

- the significant access to broadband service through mobile phones and hence the provision of the universal service by fixed or mobile means;
- provision of free Wi-Fi at various locations;
- provision of the service by carriers other than NBN Co;
- the timeframe of progressive implementation;

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- cross-industry funding support including mobile as well as fixed-line carriers; and
- the need for continual review and likely extensions to 50 Mbps download and 20 Mbps upload speed and beyond over time.

4.8 Organisational supports

Policy and project development to achieve social and economic benefits is likely to require particular supports, including:

- Social and economic research, preferably through structures that enable the continual building of understandings;
- Easily accessible national data: This will require, firstly, the identification of necessary measures and procedures to capture a broad cross section of data; and, secondly, a more consolidated database than currently exists through the Australian Digital Inclusion Index and the private survey work by the Australian Communications and Media Authority (ACMA, 2020b) and for other purposes. ACMA might be this ongoing repository of information. South Korea's National Information Society Agency, created over 30 years ago, collects and publishes extensive annual statistics (Park & Kim, 2012).
- Possibly a purpose-built organisation to drive the understanding and development of social and economic benefits of broadband networks, and provide ongoing policy and project support and research, such as a Broadband Institute proposed in the earlier Discussion Paper (NBN Futures Group, 2020).

5. Conclusion

Dramatic change has occurred in the use of broadband-based online services as a consequence of the COVID-19 pandemic, now supported by the completion of the NBN rollout. These circumstances must be seized upon and further developed to maximise the benefits to end users and the national economy.

The current initiatives by government and NBN Co are important but not necessarily sufficient. They should be placed within a vision of possible benefits, with a clear understanding of the long-term requirements for policy development, social and economic research and project support.

Scaling up the many applications flourishing during COVID-19, actively pursuing other opportunities that the technology provides, and thoroughly focusing on the requirements of digital inclusion and capability building is a major task requiring significant investment. A particular focus needs to be given to the development of the personal skills of all end users to maximise effective participation. These investments will be justified by the benefits to the whole of society beyond the specific commercial interests of NBN Co.

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This necessary, but so far not fully explored, demand-side perspective on policy needs an informed discourse of all relevant parties. The establishment of a national cross-portfolio activity to ensure the efficient and effective development of online services is urgently needed.

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Annex D: Technology Pathways and Development

1. Overview

This Annex provides an overview of the access technologies used in the NBN and the proposals for how they may be enhanced to provide greater communications capability in response to user demand. The first part summarizes some of the evidence that indicates user demands for increased access speeds over time and makes a comparison with planned 5G performance. The second part considers each access technology in turn and describes the pathway to "uprating" that technology. Where possible, the description supports NBN Co's own plans for increasing the technology capability.

2. Demand for High-Speed Services

In designing a multi-technology mix for the NBN, the government depended on a bottom-up estimate of the 'need' for broadband speeds (Vertigan, 2014). This suggested that 25 Mbps would be an adequate downstream speed for most households for some years into the future. While there may or may not be little 'need' for higher speed services, there is clear evidence that a significant number of users desire speeds at or above 100 Mbps downstream, and even at 1 Gbps or higher, and are willing to pay for them.

This Annex considers the actual market demands and demand estimates that indicate a desire for higher downstream speeds to demonstrate that there will be demand to upgrade the services of the NBN beyond the capabilities of the initial deployment. It does not examine how such upgrading could be paid for: this is recognised in Annex C, Section 4.7 as a core question in considering future universal service requirements and in Annex F in seeking to understand how NBN Co will be able to fund infrastructure investments.

It is important to note that, apart from perceived market demand outlined here, there may be other drivers for upgrades. In the policy sphere, for example, consideration of social equity may lead to a general upgrade to a common performance standard across all accesses. Treating the NBN as a household utility (like water or electricity) may lead to a common and improving performance level. There may also be commercial drivers. Improved performance could lead to NBN Co selling more services at higher prices, thereby improving its average revenue per user. A wider deployment of fibre to the premises or to the kerb would lead to lower operational costs per line, improving NBN Co's earnings. Some of these matters are taken up elsewhere in this report.

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NBN Co (2019) has recognized that future technology upgrades will be necessary to provide higher speed services. In its latest *Corporate Plan 2020-23*, it provides a section on "Lifting Australia's digital capability" (pp. 22-32). NBN Co says (p. 30): "This approach includes a commitment to continually evolve the product portfolio to meet changing customer demands."

The New Zealand experience

The New Zealand experience is enlightening. Milner (2020) has reported that in mid-2019 services at 100 Mbps downstream (and 20 or 50 Mbps upstream) make up 69% of subscribed accesses to the Ultra-Fast Broadband (UFB), with only 16% at 50 Mbps or lower. Access at 200 Mbps symmetrical makes up 6% of accesses, while 9% of accesses are at 1 Gbps (1,000 Mbps).

International comparisons

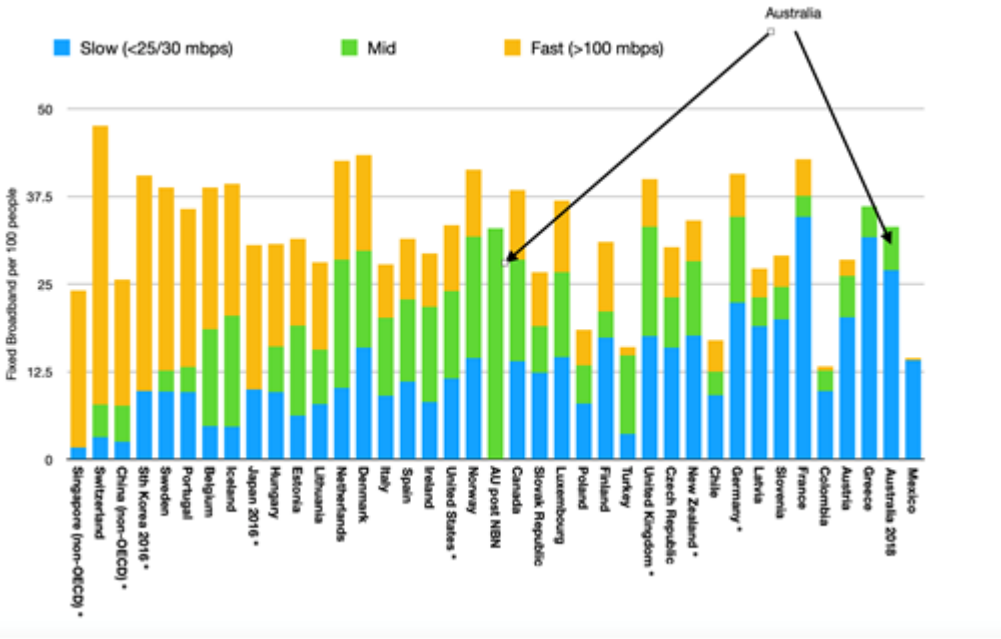

Figure D-1. Australia broadband download speeds compared with OECD and other countries in 2018
Source: Ferrers (2020), Figure 2.

Ferrers (2020) has identified that in comparable countries there are a significant number of services at 100 Mbps or greater. Figure D-1 reproduces a graph from Ferrers (2020) indicating the proportion of accesses subscribed to per 100 people at several speed bands. The countries have been sorted into decreasing order of average access speed. The graph shows, for example, that the top ten countries have significant numbers of subscribed accesses at 100 Mbps or higher. If the NBN *only* delivered 50 Mbps services, Australia would still only be in the middle of the pack. In addition, Ferrers (2020) provided data to show that average broadband speeds in other countries increased by 20-30% from 2018 to 2019.

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Ferrers (2020) also noted that there is demand for services at 1 Gbps. He highlighted an offering in Thailand (a country many Australians would not consider technologically advanced), where True Corp. has offered 1 Gbps service at less than $140 per month.

It is important to note that the figures quoted above are *subscribed* speeds: that is, customers are willing to pay for them and are doing so. The evidence is clear: there is significant demand for services at 100 Mbps and above at affordable prices. Both Ferrers (2020) and Milner (2020) suggest that access at 1 Gbps or higher will be taken up if offered at reasonable prices.

Comparison with mobile broadband

For IMT-2020 (the 5G standard), the ITU-R has set *minimum* performance standards for enhanced mobile broadband service (Mohyeldin, 2016). Peak data rates are downstream 20 Gbps and upstream 10 Gbps. In a dense urban environment, users 95% of the time should be able to access 100 Mbps downstream and 50 Mbps upstream. These are "user experienced" data rates, that is, user data exclusive of transmission and control overheads.

The 3rd Generation Partnership Project (3GPP), the main standardisation body for 5G, has defined the performance requirements for 5G mobile services (3GPP, 2019) in a number of scenarios, some of which are shown in Table D-1. As a result of these requirements, it is likely that users will come to expect 50 Mbps downstream and 25 Mbps upstream as a *minimum* in almost all circumstances.

Table D-1. 5G Performance Requirements

	Scenario	Experienced data rate (DL)	Experienced data rate (UL)	Area traffic capacity (DL)	Area traffic capacity (UL)	Overall user density
1	Urban macro	50 Mbit/s	25 Mbit/s	100 Gbit/s/km²	50 Gbit/s/km²	10 000/km²
2	Rural macro	50 Mbit/s	25 Mbit/s	1 Gbit/s/km²	500 Mbit/s/km²	100/km²
3	Indoor hotspot	1 Gbit/s	500 Mbit/s	15 Tbit/s/km²	2 Tbit/s/km²	250 000/km²
4	Broadband access in a crowd	25 Mbit/s	50 Mbit/s	[3.75] Tbit/s/km²	[7.5] Tbit/s/km²	[500 000]/km²
5	Dense urban	300 Mbit/s	50 Mbit/s	750 Gbit/s/km²	125 Gbit/s/km²	25 000/km²

Source: Table 7.1-1 (part only) in 3GPP TS 22.261 V17.1.0, p. 48 (3GPP, 2019)

While 5G deployments in Australia may not deliver these data rates on a wide scale, they set an expectation among users. If fixed access cannot match or exceed the performance of enhanced mobile broadband, users will prefer the mobile solution, if the price is satisfactory.

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Bottom-up service estimates

There have been many bottom-up estimates of the 'need' for broadband, where the estimated requirements of individual services are aggregated to calculate the required downstream and upstream access speeds. These estimates vary greatly, as the following examples show.

A relatively recent one from WIK Consult is quoted by Telstra (2020) in its submission to the Parliamentary Joint Standing Committee on the National Broadband Network. Telstra provides the following commentary (Telstra, 2020, p. 5):

> In 2018, WIK forecast the expected demand for bandwidth in the UK by 2025 on behalf of Ofcom (the UK's communications regulator). As illustrated in the table below, WIK expects that consumer demand will be driven by the parallel usage of several applications with higher requirements for download, upload and quality parameters compared to today. Telstra's experience suggests these to be equally applicable in Australia.

Telstra (2020, p. 6) then includes the following table of requirements.

Table D-2. [Telstra] Estimation of bandwidth requirements by application (Mbps)

Application category	Downstream bandwidth in 2015	Assumed CAGR (%)	Downstream bandwidth in 2020*	Downstream bandwidth in 2025
Basic Internet	2	25	~6	~20
Home Office/VPN	16	30	~60	~250
Cloud computing	16	30	~60	~250
State-of-the-art media and entertainment (4k, 3D, UHD)	14	20	~40	~90
Progressive media (8k, VR)	25	30	~100	~300
Communication	1.5	20	~5	~8
Video communication (HD)	8	15	~10	~25
Gaming	25	30	~100	~300
E-Health	2.5	30	~10	~50
E-Home/E-Facility	2.5	30	~10	~50
Mobile Offloading	2	30	~10	~15

Source: WIK. *Calculated by Telstra from WIK data

In its report, WIK forecasts demand of households in 2025 under a range of scenarios as:

- 'Top Level' demand (1 Gbps+ downstream, 600 Mbps+ upstream): 8%–40% of households;
- 'High Level' demand (300 Mbps–1 Gbps downstream, 300 Mbps–600 Mbps upstream): 49%–42% of households;
- 'Low to High Level' demand (up to 300 Mbps downstream, up to 300 Mbps upstream): 35%–10%;
- No broadband/refusal: 8%.

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From this material, we could estimate that downstream speeds of 300 Mbps or more would be required by more than 50% of households in 2025. While we may question whether this represents an estimate at the high end of useful forecasts, we can take it as evidence that there will be significant demand beyond 100 Mbps downstream in the next 5 years. NBN Co itself has recognized this with a wholesale service at 250 Mbps downstream ('Home Superfast', NBN Co, 2020b, p. 18).

The Bureau of Communications and Arts Research (BCAR) in the Australian Department of Communication and the Arts has forecast household consumption of fixed broadband services first (BCAR, 2018) up to 2026 and recently (BCAR, 2020) up to 2028. BCAR has considered the demographics and usage patterns of Australian households and small businesses and has classified Internet applications into groups based on common drivers (such as streaming for video, gaming and virtual reality). From this analysis and various assumptions about simultaneous use of applications, BCAR produced estimates of the cumulative density function of the maximum household requirement for download speed. The traffic is dominated by streaming video but, importantly, BCAR took account of emerging household applications such as virtual reality and the proliferation of Internet-of-Things devices.

The BCAR estimates have become somewhat more optimistic in the latest report. In its 2018 forecast, average monthly data usage increased from 95 GB in 2016 to 420 GB in 2026. In its current forecast (BCAR, 2020, p. 43, Figure 22), average monthly data usage in 2026 is about 600 GB, climbing to near 800 GB by 2028.

In BCAR's base case, 95% of households will require 56 Mbps or less at peak times in 2028, and only 0.1% will require download speeds above 78 Mbps (BCAR, 2020, p. 77). This should be well within the deployed capability of the NBN by that year.

The BCAR base case appears to be a conservative view for two main reasons. The first is that the growth in downloaded data is low – only 14% per annum to 2028, while the observed growth was about 42% per annum in the period 2010–2018 (BCAR, 2020, p. 38). BCAR notes that growth rates are declining over the long term, but the estimated decline seems excessive, especially given the step change in demand observed by NBN Co during the Covid crisis (NBN Co, 2020b, p. 30): this may represent a 'new normal' for working from home. The second reason is that demand may be affected by characteristics of Internet use other than download speed: BCAR notes this on p. 76. Higher download and upload speeds may well produce a more positive perception of Internet performance and hence lead to greater 'demand' for broadband. Indeed, the current market demand for accesses at 1 Gbps may well be partly driven by a perceived overall benefit to Internet usage from this high speed.

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3. Uprating the NBN

In this chapter, we consider the issue of how to make the NBN responsive to customer demand for higher speed services. We call this 'uprating' the NBN, to distinguish it from 'upgrading' the NBN, which probably involves a wholesale replacement of technology, such as 'upgrading' to Fibre to the Premises. We outline the methods by which NBN Co can deliver higher speed services from the current multi-technology mix.

Our aim is to demonstrate that the NBN in its current configuration can be responsive and agile in service delivery in many areas without necessarily a wide-area upgrade of technology. An important consideration is to avoid the need, where possible, of a new installation in a customer's premises. Such installations are time-consuming and costly. We do assume, however, that it would be possible for a customer to make a simple change like swapping out an old modem for a new one.

NBN Co (2020b) has recognized that further technology upgrades are necessary to provide higher speed services. In its latest *Corporate Plan 2021*, it provides a section on "NBN Co's high-speed future" (p. 18), describing residential accesses up to 1,000 Mbps, and a "$4.5 billion network investment plan" (pp. 40-44) including an investment of $3.5B for direct network upgrades. NBN Co says (p. 40): "The plan will deliver targeted and demand-driven investments to ensure the network keeps pace with increasing demand for higher broadband speeds and greater capacity."

The initial technology mix

NBN Co uses a variety of access technologies to reach customers' (end-users') premises:

- FTTP, Fibre to the Premises, also known, in the domestic sphere, as FTTH, Fibre to the Home. NBN Co distinguishes between FTTP installation in 'brownfields' areas – that is, areas where a telecommunications access network already exists – and 'greenfields' areas, often newly built housing estates or industrial parks.
- HFC, Hybrid Fibre-Coax, based on the Telstra HFC network for Foxtel and internet access, suitably upgraded.
- FTTN, Fibre to the Node, where an active node, fed by fibre, replaces a pillar or other junction point in the existing copper-line access network.
- FTTB, Fibre to the Building, for multi-tenant buildings, in which fibre is run to the building's communications point and the existing inside wiring is used for access to each individual premises. For NBN Co, FTTB is similar to FTTN with the node placed in the building.
- FTTK, Fibre to the Kerb. (NBN Co uses "FTTC", Fibre to the Curb, but we prefer the Australian spelling to avoid confusion with FTTC meaning Fibre to the Cabinet or other uses. In the UK, BT uses "FTTC" to describe what we mean by FTTN.) In FTTK, fibre cables run to just outside property boundaries and a small active node is used to

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terminate the fibre and provide a connection to the existing copper lead-ins to the premises.
- Fixed Wireless, where a microwave radio link is established between an NBN Co site and an antenna installed on the outside of a premises.
- Satellite, NBN Co's SkyMuster service, where access communication is between NBN Co's geostationary satellites and an antenna mounted on the outside of the premises.

For all technologies except FTTN and FTTB, an NBN NTD (Network Termination Device, an NBN-supplied modem) is installed in the premises to terminate the NBN connection. This, in turn, is connected via Ethernet cable to a service modem provided by a Retail Service Provider, and thence to whatever customer equipment – computers, television sets, telephones, alarms – is required.

NBN Co, in its latest plan (NBN Co, 2020b), has provided the numbers of premises passed by each access technology at 30 June 2020, at the end of the initial rollout. After this time, according to the previous plan (NBN Co, 2019), once some hard-to-reach premises have been passed, all future growth in premises passed will be handled with FTTP.

Table D-3 shows the technology mix at the end of the initial rollout. Also shown, because this is important for uprating the NBN, is the proportion of accesses based on each technology that are capable of providing 100 Mbps or higher downstream. These numbers are taken from NBN Co (2020b), p. 41, "Current network enabled speed", except for the separation of FTTP into 'brownfields' and 'greenfields', which is taken from NBN Co (2019).

Table D-3. NBN technology mix at end of initial rollout

Access Technology	Premises Passed ("RTS — Ready for Service")		Capable at 100 Mbps or above
	Number (million)	Proportion of total premises (%)	Proportion (%)
FTTP (brownfields)	1.1	9.5%	100%
FTTP (greenfields)	0.9	7.5%	100%
HFC	2.5	21%	100%
FTTB	0.6	5%	100%
FTTN 100	1.2	10%	100%
FTTN 50	1.9	17%	0%
FTTN 25	1.0	9%	0%
FTTK	1.5	13%	100%
Fixed Wireless	0.6	5%	0%
Satellite	0.4	3%	0%
Total	11.7	100%	

Sources: Premises Passed – numbers from NBN Co (2020b), p. 41, "Current network enabled speed".

In this table, 'FTTN 100' refers to accesses that are capable of delivering 100 Mbps or more downstream; 'FTTN 50' refers to accesses that are capable of delivering 50 Mbps downstream but not 100 Mbps; and 'FTTN 25' refers to access that are capable of delivering 25 Mbps downstream but not 50 Mbps. This is the first corporate plan in which NBN Co has separated FTTB from FTTN and provided details of the range of download speeds available on FTTN.

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Within the FTTN footprint, 29% (1.2M premises) of accesses are capable of 100 Mbps or higher downstream. (This is higher than the 24% estimated in Gregory (2018).)

Outside the fixed-line footprint, NBN Co claims that all Fixed Wireless accesses are capable of delivering 50 Mbps downstream, but not 100 Mbps. Similarly, Satellite can deliver only 25 Mbps.

NBN Co's stated aims are to provide at least 50 Mbps downstream to 90% of premises in the fixed-line footprint of the NBN (i.e., excluding Fixed Wireless and Satellite areas) and at least 25 Mbps downstream to all premises. NBN Co is careful to note that its quoted speeds are *wholesale* speeds; the actual speed delivered to a customer will also depend on other factors, including the equipment of the Retail Service Provider.

Table D-3 shows that NBN Co has achieved its aims. In the fixed-line footprint, almost 91% of premises passed, excluding only the 1.0M passed by 'FTTN 25', can be provided with at least 50 Mbps downstream. All premises passed can have at least 25 Mbps downstream.

Attributes of the technology mix

Apart from maximum download speeds, which we focus on in this chapter, there are many other attributes for each technology, including minimum latency, availability, and reliability. We can make general statements about each technology – for example, FTTP is probably the most reliable access technology; satellite suffers from a minimum latency of 400 ms, because of transmission to and from geostationary orbit – and NBN Co publishes a "dashboard" of general performance measures. However, aside from Fixed Wireless and Satellite accesses, we have no technology-specific information on performance.

NBN Co reported in February 2020 (NBN Co, 2020a) that the access network was available 99.92% of the time. This is in line with operations for a well-managed copper access network.

Availability of broadband services also depends on the availability of mains power, for both customer premises equipment and active equipment in the access network. Some residential and business customers will invest in battery backup to provide short-term continuity of service after a power failure. Within the network, NBN Co provides battery backup for active equipment, except for HFC and FTTK accesses. HFC and FTTK access may therefore be seen as less reliable, especially for business services.

Bandwidth on the NBN

The actual speeds available on the NBN are shaped by NBN Co according to its pricing model. This means that, on average, users do not experience the maximum speed available on their access technology.

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There are two components of bandwidth purchase:

- AVC (Access Virtual Circuit), which sets the maximum download and upload speeds available to the end user (at the wholesale level – information rates will be lower). AVCs come in discrete value pairs, from 12/1 (12 Mbps downstream; 1 Mbps upstream) through 50/20 and 100/40 to 1000/400. NBN Co provides download speeds 10-15% higher than the nominal maximum speed, to bring actually measured downstream speeds closer to the nominal maximum.
- CVC (Connectivity Virtual Circuit), which sets the maximum downstream rate for all the subscribers of a Retail Service Provider (RSP) at an NBN Point of Interconnection. The CVC can be any integer value of Mbps. Presumably, each RSP purchases an amount of CVC capacity that matches its backhaul capacity at the Point of Interconnection. Total CVC capacity purchased by an RSP can be shared across the Points of Interconnection.

An RSP will usually purchase less CVC capacity than the sum total of the AVCs for all its subscribers at the Point of Interconnection. This is because not all the access network capacity is used all the time, even in the busy hour. Contention ratios of 10:1 (that is, the CVC and backhaul capacity is only one-tenth of the total AVC line rates) or higher have been common and, averaged over a sufficiently large and diverse user base, have no noticeable effect on service quality. However, this is almost certainly not appropriate when the user base is small or becomes less diverse (for example, with everyone streaming videos during the busy hour in the evening).

Uprating the NBN technologies

In this section, we consider for each of the NBN access technologies in turn the capabilities to deliver downstream access speeds of 100 Mbps or greater and up to 1 Gbps (1000 Mbps).

FTTP

FTTP is used to pass about 17% of premises. It is often seen as broadly capable of any access speed. While this is generally true of direct fibre to the premises, most of the NBN's FTTP is delivered through GPON (Gigabit Passive Optical Network). That is, one fibre from an NBN site is 'split' by a passive optical splitter nearer to the end-customers' premises into at most 32 accesses to individual premises. A total of 2,488 Mbps is shared among these accesses downstream and half that upstream. The maximum split ratio of 32:1 is probably rarely used in the NBN and lower split ratios (24:1 or lower) are likely for the relatively spread-out households of the Australian suburbs.

In a standard GPON configuration, 24 premises could have a 100/50 service (100 Mbps downstream, 50 Mbps upstream) without contention. In operation, some contention is probably not noticeable, so 28 or even 32 premises could perhaps subscribe to 100/50 service.

Delivering 1 Gbps service in a standard configuration is also possible, but only for one or two accesses without contention on each PON. NBN Co has reportedly installed additional fibres

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to each splitter site, so a reconfiguration at the splitter site to provide a direct fibre connection for a 1 Gbps service (or higher) is possible. Importantly, this involves no change at the customer's premises and only a brief interruption to the service.

Enhancements to the GPON standards will also deliver standard configurations with higher speed accesses. The ITU-T has standardised a PON, XG-PON (ITU-T, 2012), that is capable of delivering 10 Gbps downstream. A symmetrical configuration, with 10 Gbps in both directions, is included in the standard, but it may require a significant upgrade to the customer premises termination.

HFC

HFC is used for about 21% of premises passed. NBN Co says (NBN Co, 2020b, p. 41) it can deliver up to 100 Mbps downstream everywhere in its footprint; 70% of accesses are capable of 250 Mbps; and 7% can achieve 500 Mbps to 1000 Mbps. NBN Co does not appear to publish information on how many premises are passed by a typical coaxial cable run, so the maximum number of high-speed services that can be delivered in each area is not publicly available. However, it is clear that NBN Co has been introducing fibre further into the network and reducing the length of the coaxial cable runs than was typical for delivery of cable TV.

HFC is used by the large cable-TV companies in the US and is thus on an upgrade path to higher speed services. Cable Labs (2019) has announced a '10G' project to specify the technologies for an upgrade path for HFC to deliver 10 Gbps downstream services. These technologies will be progressively available to NBN Co. It is likely that a concentrated adoption of 10G services in an area would require some further network reconfiguration – more fibre and shorter cable runs. NBN Co has already announced plans (NBN Co, 2019) to move progressively to DOCSIS 3.1 and DOCSIS 4.0, both Cable Labs standards, to provide the capability for higher speed services.

NBN Co has announced (NBN Co, 2020b) a $3.5B upgrade plan that includes $0.4B "for new capacity investments in the HFC network to enable access [to the] highest wholesale speed plans" (p. 41). This would appear to be a DOCSIS 4.0 upgrade for the network to provide downstream speeds up to 1000 Mbps.

FTTB

FTTB passes about 5% of premises. The delivery of access to individual premises depends on the building's inside wiring. For many older buildings, this will just be telephony twisted pair, in which case access using VDSL could deliver a few hundred Megabits per second downstream and somewhat less upstream. For more modern buildings with cat6 cables or even fibre in their risers, download speeds up to 1 Gbps should be easily achievable. Table D-3

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shows that all FTTB accesses are capable of 100 Mbps downstream. For NBN Co, upgrading the connection to the building by direct fibre is essentially the same as for FTTP.

FTTN

FTTN passes about 36% of premises, that is, more than one-third of the total. This is a large proportion of suburban homes. The key issue for FTTN is that it is strongly distance-dependent, which is why only 29% of FTTN accesses (see Table D-3) can deliver 100 Mbps downstream. The maximum download (and upload) speed falls away rapidly along the length of the copper cables from the node to each premises.

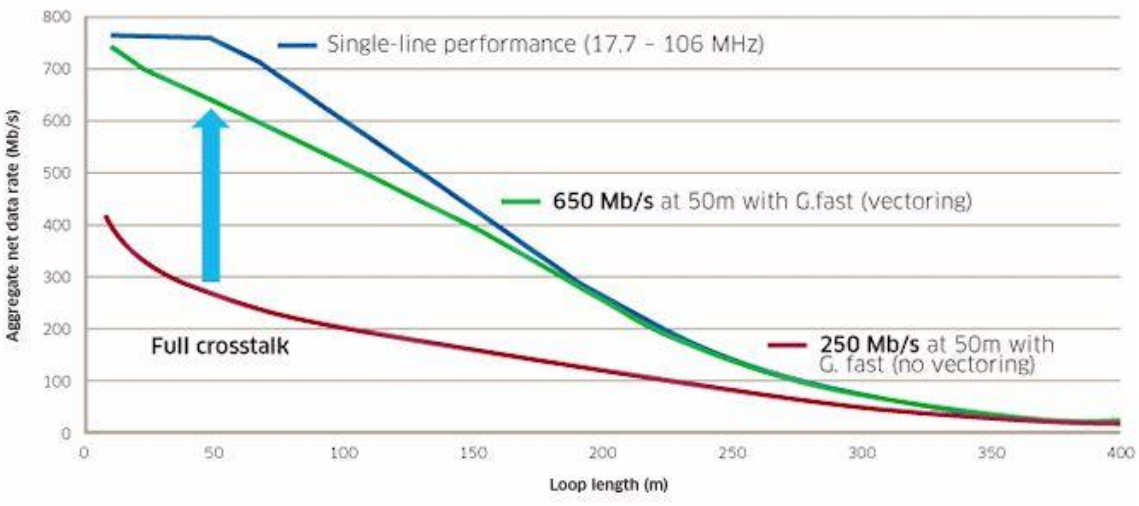

Figure D-2. Data rate as a function of cable length
Source: Jackson (2013), Figure 3.

Figure D-2 is an old chart reporting G.fast line results from Austria on "good quality cable" (Jackson, 2013). G.fast is a high-speed DSL standard. It can be used with vectoring, essentially the coordination of signals within copper cable bundles to increase data rates. Currently, NBN Co is deploying VDSL, a slower DSL standard, on the copper cables of the NBN. The speeds shown in Figure D-2 would only be available after an upgrade to G.fast. NBN Co will be making G.fast available in its FTTK deployments (NBN Co, 2020b, p. 41).

If only 29% of premises supplied by FTTN could get 100 Mbps or more downstream, it suggests that no more than 29% of premises are within about 200 m of a node and 71% of premises are at longer distances. For those within 200 m, the deployment of G.fast and other technical possibilities can deliver speeds up to 250 Mbps or more; for those beyond 200 m, the possibilities are severely limited without a change of access technology.

In some cases, the legacy DA design does not lend itself to high-speed DSL services, usually because the distribution cables are too long. For these cases, NBN Co can use micronodes that can terminate up to 48 cable pairs: see Figure D-3.

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Figure D-3. An NBN micronode during installation (Credit: Tim Herring)

NBN Co has announced (NBN Co, 2020b) a $3.5B upgrade plan that includes $2.9B "to take fibre deeper into the FTTN footprint, enabling premises to move to an FTTP service when they order a higher speed plan" (p. 41). If NBN Co is to achieve its aim of making "its highest wholesale speed plans available to up to 75 per cent of households and businesses in the fixed-line network", then about 1.5M accesses on FTTN will be affected by this upgrade investment. About half the investment will probably be for new FTTP lead-ins (that is, fibre connections into premises); the remainder will add more fibre in the access network through local fibre networks (p. 44).

After this upgrade, there will still be about 2.6M premises passed (about 21%, or one in five, of all premises) in the FTTN footprint that cannot get at least 100 Mbps downstream.

It appears that NBN Co is not considering an upgrade to FTTK within the FTTN footprint as an interim step towards eventual FTTP.

FTTK

FTTK is used to pass about 13% of premises in the initial rollout. FTTK (called 'deep-fibre FTTdp') and surrounding issues are well described in two papers by Watkins & Lillingstone-Hall (2014a, 2014b). FTTK can provide 100 Mbps or more and, with an upgrade to G.fast (see Figure D-2), can provide 1 Gbps downstream over the tens of metres of cabling from the street to a customer's premises. NBN Co has been deploying G.fast-capable units in the FTTK footprint since the end of 2018 (NBN Co, 2019, p. 31) and has now announced (NBN Co, 2020b) a $0.1B "uplift program to provide 100Mbps line speeds for premises on the [FTTK] network and enable access to [the] highest wholesale speed plans" (p. 41). This involves the "on-demand … deployment of G.fast capability or the provision of fibre lead-ins" (p. 41). Given the size of the investment, this is expected to be mostly G.fast deployment.

FTTK can be upgraded relatively easily to FTTP but, importantly, this involves a new fibre installation at customers' premises and hence is relatively expensive. FTTK is, on a world scale, a niche technology and so is unlikely to benefit over time from greater volume production or global technology advances.

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Fixed Wireless

Fixed Wireless, installed for about 5% of premises, is used when it is not economical to lay cables from an NBN Co site to a customer's premises. This is predominantly in low-density regional areas (with property frontages of 50-60 m and more). Fixed Wireless, like all radio technologies, can suffer from fading by obstacles or atmospheric conditions. Because the endpoints are not moving, fading in Fixed Wireless can be significant and long-lasting. Some degree of individual design, in, for example, antenna placement or alignment, is required for each Fixed Wireless installation.

Upgrades to Fixed Wireless were described by NBN Co as "[f]uture capability being explored" (NBN Co, 2019, p. 29) but are described only as "[c]ontinued investment to help manage capacity and performance" in the latest corporate plan (NBN Co, 2020b, p. 16). Fixed Wireless benefits from the same technology advances as cellular mobile but, as it is a niche technology compared to mobile, it lags somewhat.

Upgrading Fixed Wireless to FTTP may be economically feasible in some circumstances. The New Zealand experience suggests that, if directional drilling can be used where there are no hard-surface paths, FTTP installations in areas with street frontages up to 100 m may be cost-effective. This could substantially expand the FTTP footprint in regional areas.

FTTP expansion is also possible if the initial installation costs can be spread over a sufficient user community or there is co-investment by other parties. For example, SmartFarmNet is planning to provide symmetrical, high-speed broadband services via FTTP to 650-1000 premises in the Wamboin, NSW, area (SmartFarmNet, n.d.). This would replace Fixed Wireless and Satellite services provided by NBN Co. NBN Co itself has announced (NBN Co, 2020b, p. 40) a $0.3B fund for co-investment with governments or local councils.

In any case, NBN Co's installations are rather under-dimensioned. NBN Co says its sites have a "design threshold of a 30-day average of 6 Mbps download throughput in the busiest hour of the day … (averaged across all active services connected …)" (NBN Co, 2019, p. 32). High throughput services cannot be maintained.

It is unclear what factors, other than cost, drive the low performance level of the Fixed Wireless installations. NBN's Fixed Wireless may be limited by the spectrum available to NBN Co, which was given access to spectrum used for Time-Division Duplex (TDD) services. This would limit the maximum transmission capability of the radio link. It stands in contrast to the Turkcell experience (Ericsson, 2019) using the same vendor (Ericsson) but with several frequency bands with Frequency-Division Duplex (FDD). The *minimum* download speed to be deployed in the Turkcell case is 100 Mbps. It is likely that NBN Co's Fixed Wireless

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installations will in time be upgraded to 5G multi-input, multi-output (MIMO) transmission, which may provide some higher transmission speeds downstream and upstream.

Bob James – quoted in Campbell (2019) – has suggested that Fixed Wireless will never be competitive with cellular mobile and that a combined mobile and fixed wireless network in regional areas would make better economic sense. This would appear to be a good technological option but how it could be achieved in the Australian context requires further consideration. It seems likely in any case that customers will prefer high-throughput mobile services, when they are available, over a limited fixed wireless service without mobility.

Satellite

Satellite, used for 3% of premises, is the least capable of the NBN access technologies. It does not provide downstream speeds above 25 Mbps and, although it can provide telephony, it does so with noticeable transmission delay. Subscriber charges are also higher than for other access technologies. There is evidence – cited in Corbin (2019) – that some customers would prefer to keep their DSL services rather than move to the NBN satellite access. (Most potential satellite customers, however, are beyond the reach of terrestrial broadband. Telstra, for example, advertises that it covers 99.5% of the population with its mobile services, suggesting that there are between 300,000 and 400,000 premises that are not covered).

The future of satellite service was marked by NBN Co as "[f]uture capability being explored" (NBN Co, 2019, p. 29). Satellite technology continues to evolve, with higher power geostationary satellites and new spectrum options. All such advances exclude acceptable telephony because of the transmission delay. There is also the promise of future low-Earth-orbit satellites (LEOs) providing high-speed internet access, including telephony. It is unlikely that NBN Co would launch its own LEOs for service in Australia, since the satellites would, of necessity, spend most of their orbits outside Australian range.

As with Fixed Wireless, the best technological option would seem to be some combination of NBN services with cellular mobile or other offerings but, again, how this could be achieved in the Australian context is open to question. There may always remain some very hard-to-reach premises for which satellite service is the only or best option, but many fewer than the current 400,000 planned to be served by satellite.

Cost of Uprating

The announced spend of $2.9B for fibre upgrades to the FTTN footprint, which we estimate will affect 1.5M premises, gives some insight into the cost of uprating the FTTN to FTTP.

The average cost per premises in this upgrade is about $1,900. This is made up of the cost of new fibre installations in the access network and, importantly, the cost of new fibre lead-ins

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at premises that request the highest speed services. The New Zealand experience, together with a high-level analysis of NBN Co's reported access costs, suggests that the installation of fibre lead-ins costs about $1,000-1,500 per premises, which leaves about $500-900 per premises passed for upgrades in the local fibre network. This is consistent with the costs per premises reported by NBN Co (2020b, p. 55).

The announced network upgrade costing $3.5B includes not only $2.9B spent on fibre upgrades, but also $0.4B for HFC upgrades and $0.1B for G.fast installations in FTTK. The total upgrade brings all of FTTP, HFC, FTTK, FTTB accesses, and 1.5M FTTN accesses up to the capability for more than 100 Mbps downstream. This still leaves 2.6M premises passed by FTTN, plus the 1M premises served by Fixed Wireless and Satellite, with lesser capability.

Using the average costs for the fibre upgrades, we can estimate that bringing the remaining 2.6M premises in the FTTN footprint up to the standard of FTTK with G.fast would cost about $900+$100 per premises passed, or approximately $2.6B. Adding an allowance to uprate the Fixed Wireless network (whose total cost to date is less than $2B – 600,000 premises passed at $4,315 cost per premises) of another $1B (and likely to be less) leads to a total cost of uprating the whole network to 100 Mbps or higher (excluding the Satellite component) of about $7.1B. Of this, $3.5B has already been budgeted.

In all these uprating calculations, the Satellite component (400,000 premises passed or 3% of the total) remains with the minimal capability of 25 Mbps downstream. NBN Co is expecting that the take-up of the Satellite service will remain steady at 100,000 premises connected up to 30 June 2024 (NBN Co, 2020b, p. 53, Table 2: Premises Activated).

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Annex E: The NBN in the 5G Era

1. Introduction

The abbreviation '5G' refers to the 5th generation of mobile (cellular) communications, offering many enhancements over the current 4th generation. 5G is an important contribution to a National Broadband Strategy. It can enhance the capabilities of the NBN as well as providing infrastructure competition in broadband access.

The performance standards for 5G have been set by the ITU's IMT-2020 project and technical standards are being developed by the 3rd Generation Partnership Project (3GPP). Equipment based on 5G radio standards is now being deployed. Related standards are still in development.

On 13 August 2020, the Chief Executive of Telstra Corporation Ltd, Andrew Penn, released Telstra's results for the 2020 financial year (Telstra Corporation Ltd., 2020). He sees a future that belongs to 5G:

> "Earlier this year we decided to bring forward $500 million of capital expenditure planned for the second-half of FY21 into calendar year 2020. This is enabling us to accelerate our 5G rollout further while injecting much needed investment into the economy. As a result, late last month I announced that we have increased our ambition and plan to cover 75 per cent of the population with our 5G network by June next year."

What is so significant about 5G that Telstra (and also Optus and Vodafone TPG) are investing so much in it? There are user benefits (higher data speeds, low latency and a much greater range of applications), cost benefits to the carrier (greater spectrum efficiency in transmitting large quantities of data) and simply "being on the right side of history" with all the marketing benefits of being supported by the 5G mobile phone manufacturers. However, the much broader potential of 5G can be explained in terms of its architecture and functionality.

There are four significant ways in which 5G differs from 4G:

1. the specification of distinct usage scenarios
2. network virtualisation
3. new radio (NR)
4. wireless-wireline convergence (WWC).

Usage Scenarios

IMT-2020, the International Telecommunication Union's "overall roadmap for the development of 5G mobile" (International Telecommunication Union, 2015) defines three

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distinct usage scenarios for 5G networks (International Telecommunication Union, 2017, p. 1):

1. eMBB—enhanced Mobile Broadband
2. URLLC—Ultra-Reliable and Low-Latency Communications
3. mMTC—massive Machine-Type Communications

These scenarios place differing demands on a 5G network: eMBB requires greater data rates, URLLC lower latency, and mMTC, which is designed for the Internet of Things, much greater numbers of connected devices than 4G.

To satisfy these demands, 5G has a flexible network architecture that allocates to each service the resources appropriate to its requirements. For example, URLLC services might need their data to follow the shortest path through the network to minimise latency; eMBB services might require a path with greater capacity.

Network Virtualisation

The most important aspect of the 5G architecture is network virtualisation.

The core of a 5G network (5GC) consists of network functions, such as the user plane function (UPF), which directs the flow of user data through a 5G network, and the access and mobility management function (AMF), which controls user access, connected together by a network that supports the 5G usage scenarios. The 5G standards define a protocol that the network functions use to communicate with each other.

The network functions are designed to be virtual: software that runs on virtual machines in the cloud. Because there can be multiple virtual machines on the same hardware, multiple network functions can share the same server in a data centre. Unlike physical hardware, they can be easily relocated if necessary.

The network can also be virtual and share a common physical network with other virtual networks, 5G or otherwise. The underlying physical network must, of course, support the 5G usage scenarios. The overlay virtual networks then inherit this capability.

Consequently, the whole 5GC, both network and functions, can be virtual: it is not tied to dedicated hardware.

New Radio

5G new radio (5G NR) is the air interface for 5G networks. An air interface specifies the format (modulation) of a wireless signal. The big difference from 4G is that, in addition to frequencies below 6 GHz, 5G NR will use spectrum with wavelengths of about a millimetre, in particular

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at 26 GHz and at 28 GHz. The benefit of using this spectrum is that it can support very high data rates. The trade-off is that its range is very limited.

The new frequency bands are well suited to indoor use. The Australian Communications and Media Authority is planning to auction spectrum in the 26 GHz band commencing in late March 2021 (Australian Communications and Media Authority, n.d.).

Wireless-Wireline Convergence

While we naturally think of 5G in a wireless context, the Broadband Forum is currently finalising standards that specify how a router can connect to a 5G network over a wired connection. It is defining interfaces for both 5G-capable routers and legacy routers (such as those in service today). These standards will enable the provision of 5G services over the NBN. Telstra is heavily involved in their development.

2. What Can NBN Co Do?

Can NBN Co play a role in the roll-out of 5G networks?
Broadly, it has five options:

1. Do nothing.
2. Uprate the NBN so that it can support the full range of 5G services.
3. Allow 5G carriers to use its dark fibre as backhaul from base stations.
4. Upgrade the NBN so that it supports Network as a Service (NaaS).
5. Provide a wholesale 5G service.

Do Nothing

It is possible for a 5G carrier to use an existing NBN fibre-to-the-premises (FTTP) service to connect to a (wireline) router or a (wireless) femtocell located at a subscriber's home or business.

5G Wireline

Why would a 5G carrier prefer providing a wireline 5G service instead of just a standard Internet access service? There are three reasons: (1) so that it can use its 5G wireless network for backup, (2) so that it can transfer fixed-wireless subscribers to wireline, and (3) so that it does not have to operate separate networks for wireless and wireline subscribers.

The first reason is obvious: if an NBN service were to go down, a subscriber's router could maintain connectivity by swapping over to a 5G wireless network. The second would give the 5G carrier a tactical advantage in acquiring subscribers in an area where the NBN was about to roll out, e.g., in a new housing estate. It could provide fixed-wireless service before its competitors and then cut over to the NBN when it became available.

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The third reason might be the most significant in that it affords a 5G carrier the opportunity to reduce its costs by eliminating the system that delivers fixed services and using the 5G system for both wireless and wireline services.

5G Wireless

A femtocell is the cellular analogue of a Wi-Fi access point. It would use spectrum in the 26- and 28-MHz bands to provide a 5G service over a limited range, for example, indoors or around a homestead. Femtocells can act as (limited) wireless extensions of NBN wired connections.

The advantage over a Wi-Fi access point is that it would allow smartphones to connect to it in preference to a base station, providing better service over a shorter radio link. However, the quality of a femtocell service would depend on that of the underlying NBN service.

Uprate the NBN

It would be perverse if the NBN, a wireline network, could not meet the IMT-2020 targets for bandwidth and latency. Does it? The IMT-2020 targets for minimum *peak* data rates are:

- downlink—20 Gbit/s
- uplink—10 Gbit/s

The NBN uses many technologies to provide service: fibre to the premises (FTTP), hybrid fibre (coaxial and fibre to the building, kerb, and node), fixed wireless (4G), and satellite (Sky Muster).

Passive Optical Networks (PONs)

The equipment that NBN Co currently uses for its FTTP service complies with the G-PON standard (International Telecommunication Union, 2008) and allocates a nominal peak data rate of 2.4 Gbit/s across up to 32 premises. *Prima facie*, it falls far short of meeting the 5G targets. The other NBN technologies are worse.

However, data rate requirements differ depending on the usage scenario. The maximum data rates above are most relevant to an eMBB service, and, even then, "the more relevant data rate will be the target average rate of 100 Mb/s per user in densely populated areas". For URLLC and mMTC services the "bandwidth requirements are in the kilobits-per-second to low megabits-per-second range per user equipment (UE), in many cases even only burst-wise" (Wey, Luo & Pfeiffer, 2020, p. 51).

However, it is possible to upgrade the NBN FTTP equipment to comply with a more recent standard that provides much better performance. The NG-PON2 standard (International Telecommunication Union, 2013) provides for an aggregate of 40 Gbit/s downstream and of

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10 Gbit/s upstream, which would be sufficient to meet the IMT-2020 bandwidth targets. The 50G-EPON standard (The Institute of Electrical and Electronics Engineers, Inc., 2020), which has just been approved, would also suffice. OptiComm Ltd, an NBN Co competitor, has just announced (Dinham, 2020) that it will soon deploy equipment that complies with the XGS-PON standard (International Telecommunication Union, 2016), which provides for 10 Gbit/s symmetric (i.e., both upstream and downstream) service.

Latency is different from bandwidth in that it is cumulative. Therefore, it is necessary to examine the contribution of each link in a network. One of the fundamental innovations of 5G is the separation of a mobile base station, also referred to as a gNB, into three parts: a centralised unit (CU), a distributed unit (DU), and a radio unit (RU). The purpose is to minimise the amount of equipment at the top (radio unit) and at the base (distributed unit) of a mobile tower. However, it also applies to femtocells. The 5G core (5GC) network connects to the centralised unit and the radio unit connects wirelessly to users.

The links between the 5GC and these units are referred to as backhaul (5GC–CU), midhaul (CU–DU), and fronthaul (DU–RU), or generically as x-haul.

As with data rates, latency requirements differ depending on the type of service: "the latency requirements for eMBB are in the range of multiple tens of milliseconds end-to-end (e2e), which leaves time of the same order for transport on the backhaul or on the F1 [midhaul] interface" (Wey, Luo & Pfeiffer, 2020, p. 51) and "With latency-critical services such as URLLC, the F1 [midhaul] and Fx [fronthaul] latency may both be in the <100 μs [0.1 ms] range" (Wey, Luo & Pfeiffer, 2020, p. 54).

A PON has a typical latency of the order of 10 ms and a best case of about 3 ms (M. Ruffini, personal communication, July 28, 2020), so, while there is no problem supporting eMBB and mMTC services, URLLC would appear to be out of the question (by an order of magnitude).

The most significant source of latency in a PON arises from the way in which it assigns the aggregate bandwidth across the premises connected to it. It uses a mechanism called dynamic bandwidth assignment (DBA) to implement this process, the aim being to maximise the utilisation of the shared network. A method of reducing this latency is cooperative (CO) DBA, which synchronises DBA with the scheduling process of the baseband unit of a 5G network. This would be implemented in the form of a cooperative transport interface (CTI), which is currently in the process of being specified (Wey, Luo & Pfeiffer, 2020, p. 55).

Digital Subscriber Lines (DSL)

The focus in this discussion so far has been on FTTP because it is the technology with the best performance and, hence, the one most likely to meet the IMT-2020 targets. However, recent

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work by Cioffi *et al.* (2020) suggests that DSL could also support 5G service. They call this cellular subscriber line (CSL).

This is possible because both 5G and DSL use the same type of modulation: orthogonal frequency division multiplexing (OFDM). Consequently, both use similar mechanisms to correct for interference. The difference is that 5G shifts the frequency of the signal to, for example, 26 or 28 GHz before transmitting it.

Cioffi's idea is to split that frequency shift in two: the first so that the signal best matches the frequency characteristics of a copper cable, the second to change it to the frequency of the transmitted signal. The 5G system can then correct for errors induced in the copper cable using the same mechanism that it does for interference in the wireless signal. It is not aware that there is a copper cable present.

The catch is that the range of 5G signals over copper cables is quite limited, and hence CSL cannot meet the IMT-2020 targets other than over very short distances. However, CSL makes up for this by providing an economical means of implementing a much greater density of base stations, which share the demand for bandwidth. This makes it well suited to the 5G mMTC usage scenario.

CSL is still being developed, and there is not any CSL equipment yet. However, it needs to be considered in planning for the future of the NBN.

Use Dark Fibre for Backhaul

An obvious way in which NBN Co could support the roll-out of 5G services is by allowing 5G carriers to use its dark fibres for backhaul. Dark fibres are optical fibres that NBN Co has installed along streets but has not yet lit up: there is no equipment connected to them. Consequently, they are not generating any income.

If a 5G carrier were planning to install a base station at a location close to a cable that contains dark fibre, the carrier could conceivably use that dark fibre for backhaul. However, NBN Co might be reluctant to offer this, as the dark fibre is there to cater for expansion and to replace fibres that are damaged.

Network as a Service (NaaS)

The core of a 5G network can be entirely virtual. This opens the potential for NBN Co to provide the virtual machines and networks necessary to host a virtual 5G core or other virtual network. The hardware for the virtual machines could be established in fibre access nodes (FANs) and points of interconnect (PoIs), which are linked by optical-fibre rings (NBN Co Ltd., 2018). Such a network as a service (NaaS) would be like Amazon Web Services for NBN RSPs.

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There are two components of 5G that support this: multi-access edge computing for virtual machines and slicing for networks.

Multi-access edge computing (MEC) is "cloud computing at the edge of the network" (European Telecommunications Standards Institute, n.d., p. 3). The edge part of MEC refers to locating computing applications, including virtualised network functions, at the edge of the network in order to reduce latency, which is one of the primary objectives of 5G.

This is of particular benefit for the Internet of Things (mMTC) because having access to MEC applications in the network means that "things" do not (necessarily) require access to the Internet, which provides a measure of security.

Although NBN Co could provide MEC service at both FANs and at PoIs, the most benefit comes from doing so at FANs because service providers cannot install their own equipment there.

Slicing

A 5G slice reserves capacity for a specified group of applications or users. The classic example is a slice for emergency services, providing emergency services communication over a public network as if it were a dedicated private network. Everyone agrees that slicing is important (Higginbotham, 2020), but there is some variation in the specifics of definition (Magretta, 2002, p. 71).

It is necessary to distinguish between two types of slice that are closely related: transport slices and 5G slices, which are similar to virtual paths and circuits in Asynchronous Transfer Mode (ATM).

A physical network uses transport slices to implement the different 5G usage scenarios. A transport slice is a reservation of bandwidth along a path across a network that satisfies the latency constraints for a usage scenario. For example, a direct path is best for URLLC slices because it minimises latency (LL = Low Latency). If a physical network has multiple virtual networks, a transport slice would typically be specific to one of them, but multiple virtual networks could share a transport slice.

There is no specific standard for transport slices; however, segment routing is emerging as the preferred method (Filsfils *et al.*, 2019, ch. 5). This uses a colour to identify each transport slice and associates each colour with a sequence of waypoints in the network, thus specifying a path. This is similar to integrated services (Braden, Clark & Shenker, 1994) but does not require the network to keep track of all the paths.

The 5G core uses transport slices to implement 5G slices: one transport slice can support multiple 5G slices, each being associated with a particular application. For example, there

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might be separate 5G slices for Internet access and for Netflix, each using the same eMBB transport slice across the physical network.

Offer a 5G Wholesale Service

The discussion to this point has been on the basis that NBN Co provide facilities that allow service providers to implement 5G services over the NBN. However, NBN Co could, if its remit permitted, offer a wholesale 5G service.

This would not preclude NBN Co's still offering MEC and slice services to RSPs, which they could use to construct 5G and other services. There are no technical barriers to prevent NBN Co offering either or both.

Problems

Allowing NBN to offer a wholesale 5G service would address two issues that arise if only 5G network operators can provide femtocells:

- the potential market failure of slicing;
- subscribers' inability to roam between premises served by different 5G carriers.

Slicing is intended to be an improvement on the one-size-fits-all approach of the Internet. Because the Internet cannot distinguish between applications, it treats them all the same, irrespective of their bandwidth and latency requirements. Of course, some of these applications, such as Netflix, are subscription services and, if you want to use them, you have to pay for them. Consequently, the consumer in this situation will pay for two separate types of service: network access and applications.

For slicing to be of any benefit, the provider of an application has to buy a slice from the operator of a 5G network. In the case of Netflix, the benefit from doing so would be encountering less buffering on that network.

If there were only one 5G network in Australia, an application provider might consider buying a network slice. However, Australia will have multiple 5G networks, and it would not be worthwhile for an application provider to buy slices from the operators of every 5G network in Australia. It would be far easier and cheaper to continue the current arrangement and keep going "over the top."

This is a particular problem for the Internet of Things, which requires femtocells in order to cope with the enormous number of connected IoT devices, which will only have sufficient power to transmit over a limited range. A provider of IoT applications needs to be able to deal with a single RSP to purchase an mMTC slice that covers every femtocell connected to the NBN.

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The second issue is similar but applies to the subscribers of 5G carriers rather than to application providers.

Ideally, a subscriber to a 5G wireline service would like to take his 5G router—and the applications associated with it—from premises to premises. For example, if he rented a beach house for his summer holidays, he may like to take his 5G router with him, plug it in, and have all the 5G applications that he had subscribed to, including Internet access, work seamlessly. Unfortunately, the initial version of the BBF standards for wireline 5G access does not provide for roaming between carriers, so this scenario could only happen if the same 5G carrier connected both premises.

Landlords of short-term rentals would want as many potential tenants be able to use their 5G routers as possible. Consequently, they would tend to purchase 5G connections from the carrier with the most subscribers.

A Potential Solution

There are two possible solutions: mandate roaming between 5G carriers that use the NBN for 5G backhaul or allow NBN Co to provide a 5G access service onto which other 5G carriers could roam.

The problem with mandating roaming is that it will not be viable until the BBF standards allow for it (if ever). This leaves the option of NBN Co providing a 5G access service, which would confer three policy benefits:

1. maintaining the Internet's distinction between access and applications;
2. simple interconnection between 5G carriers and the NBN, thus enabling both synergies and retail competition;
3. defining the universal-service obligation (USO) as a bundle of applications deliverable over either fixed or mobile networks.

If NBN Co were to become a wholesale 5G provider, it would sell three types of 5G service: access, slices, and interconnect.

A 5G access service would be analogous to an AVC. It would provide access to the NBN 5G network from a particular premises. RSPs could buy 5G AVCs from NBN Co and bundle them with Internet access for sale to their subscribers in the same way as today.

A slice would be equivalent to a CVC. It would be accessible from any 5G access service, irrespective of the RSP. However, in addition to RSPs, the customers for this service would include application providers, as each application would have its own slice.

Keeping access separate from applications would make a multitude of applications available independently of the RSP providing the access service. For example, a manufacturer of

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"things" could purchase an mMTC slice from just the one RSP to monitor them remotely anywhere on the NBN. It would not have to enter into an interconnect agreement with every RSP. A landlord could purchase a 5G access service with a certain bandwidth, but not the Internet access that would normally go with it. Instead, the tenant would have to subscribe to his own applications, which would be associated with his 5G router.

5G interconnect service would correspond to a network-network interconnection (NNI). Interconnecting with the NBN 5G network would allow 5G network operators to construct slices that encompassed both the NBN network and their own.

Unlike the Internet, a 5G network can distinguish between different applications if each occupies a separate slice. Consequently, 5G offers the potential to provide a universal-service obligation (USO) service that is defined in terms of a bundle of applications, such as:

- government services (e.g. myGov)
- education
- public broadcasting
- limited Internet access
- telephony.

The advantage of this approach is that it can provide unlimited access to essential services without providing unlimited Internet access. Obviously, the USO would have to include a 5G access service as well. USO services would be available at no charge from any premises connected to the NBN.

3. Recommendations

We recommend that:

1. all relevant equipment in the NBN be upgraded only if it meets the data rate and latency requirements for 5G networks.
2. NBN Co offer multi-access edge computing and transport slice services to retail service providers.
3. NBN Co consider providing wholesale 5G wireless and wireline services over its fixed access network.

Data Rates and Latency

Our first recommendation arises from our view that the performance of the future NBN must be at least as good as that of a 5G network. It applies primarily to PON equipment: OLTs and ONT/ONUs. For example, both NG-PON2 (G.989) and 50G-EPON (802.3ca) are capable of providing the data rates necessary to support 5G services.

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However, meeting the low latency of URLLC services requires that any future PON also implement the cooperative transport interface (CTI).

5G Substrate Network

Our second recommendation arises from our view that the NBN and 5G networks are complementary and that the NBN has a significant role to play in the rollout of 5G services in Australia.

Making the NBN a network platform of MEC virtual machines connected by slices would not only support the rollout of 5G services but enable RSPs to provide non-5G services that had to meet stringent latency requirements.

In addition to broadening the scope of services, it would also broaden the scale of service providers by making it easier for them to offer services.

5G Wholesale

Our final recommendation addresses our concern that there are potential technical and economic issues that can arise from having separate carriers independently providing 5G service over the NBN.

We take the view that allowing NBN Co to offer a wholesale 5G service would neatly overcome these problems but acknowledge that mandating roaming between 5G carriers might also suffice.

26-GHz Spectrum

If NBN Co were to offer a wholesale 5G femtocell service, it would require short-range spectrum in the 26-GHz (n258) and 28-GHz (n257) bands for femtocells. Consequently, consideration would need to be given to allocating spectrum to NBN Co for this purpose.

4. Conclusion

Any plan for the NBN must take account of 5G networks—and vice versa. 5G and the NBN are complementary: NBN Co can make a significant contribution to the roll-out of 5G networks in Australia. As the example of slicing demonstrates, it is even possible that 5G might not fulfil its full potential *without* the NBN.

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Annex F: Financial Considerations

1. Introduction

The purpose of this Annex is to examine, so far as available information will permit, whether NBN Co will be able to fund the infrastructure investments that it must make from mid-2020 onwards, and the sources of funds that realistically are available to NBN Co to do this.

2. Information available

The discussion that appears below is based on financial information that has been made publicly available by NBN Co, particularly in its corporate plans, annual reports and various public statements. This information is at a high level of aggregation and lacks the detail and dissections that would materially assist analysis and review. The latest public statements of financial import by NBN Co – the fibre zones announcement of 22 September 2020, the fibre extension program of 23 September 2020, and the Corporate Plan 2021-24 published on 23 September 2020 – are all of this kind.

As a result, the NBN Futures Group has sought answers from NBN Co to a number of questions, but without success to date. The Group is aware that others have also sought more detailed information on important financial and other aspects of NBN Co's operations, also without success. We consider that, as a public enterprise without any material competition in the fixed wholesale broadband access market, and with limited modal competition in the short to medium term, NBN Co should be accountable to a greater degree than current reporting suggests, and that future Statements of Expectations incorporated in the National Broadband Strategy should make this explicit.

3. Questions for NBN Co

The following questions are some of those that we have sought to put to NBN Co without response to date. They predate 23 September 2020 and therefore might be updated to reflect the same questions that might be asked in the context of the latest Corporate Plan.

(1) Interest rate on private loan facility: What rate of interest applies to the facility?

(2) Retirement of Government loan facility:

a. What was the rate (or average rate) payable on the private loan facilities established by NBN Co in May 2020?

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b. Does any plan to pay back the amount borrowed from the Government depend in any way on the interest on private loan facilities being less than the 3.96% rate applicable to borrowings from the Government?
c. Are there any circumstances in which NBN Co might borrow additional amounts using the Government's facilities or relying on the any implicit or explicit Government guarantee, and, if so, what are they?

(3) Government equity in NBN Co: Does NBN Co have any plans to pay a dividend to the Government in the future in relation to the Government's equity of $29.5 billion in NBN Co?

(4) CAPEX: By way of context, the purpose of specific questions a) and b) below is to better understand how capital costs might be incurred in future, particularly as the NBN is extended to existing greenfield locations and as existing 'ready to connect' premises are connected**.**

a. In the Corporate Plan, 2020-23, at page 52, NBN Co sets out the average cost per premises for each access technology for FY19 and FY20: what are the constituent components in relation to each access technology for making each premises ready to connect, and for actual connection of each premises?
b. The figures referred to above on page 52 are expressed to be "incremental": (i) incremental on what base? And (ii) what categories of cost are not included and what is their value?
c. What is the capital cost of the satellites and what other capex has been allocated to the satellite service?
d. In the Corporate Plan, 2020-23, at page 48, CAPEX is stated to be $1.4 billion for FY21 and $1.4 billion for later years. What planned capital works are included in these estimates? Do they include any network upgrading, and, if so, what?[1]
e. What are the total costs associated with the upgrade pathways for each technology in the MTM that have been previously identified by NBN Co?

(5) OPEX:

a. In an overall sense, the question is what changes will occur, especially to OPEX and to overall financial settings as NBN Co moves from the initial construction phase of its operation prior to July 2020 to being more of an operating and maintenance business thereafter?
b. In the Corporate Plan, 2020-23, at page 51, a category of operating expenditure called "Other OPEX" is identified which, based on the description in the Plan, covers many different cost categories: What is the dissection of the figure for

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each of the years from FY19 to FY23 into the constituent cost categories listed at page 51?

c. At page 51, "Other OPEX" is shown as reducing each year from $2.3 billion in FY20 to $1.7 billion in FY23: Why will the annual total OPEX be reducing year on year in this way, given that the premises connected and new coverage is expected to increase and also given that the fault rate of 0.7 faults per 100 premises, driven largely by the copper cable network, will not change much over time in any of the current plans?
d. What is the direct OPEX incurred each year on a per premises basis in relation to each of the access technologies?
e. What is the expected cost saving that NBN Co will achieve as a result of anticipated workforce changes?

4. NBN Co Corporate Plan 2021-24

At the end of the initial rollout in June 2020, NBN Co was funded from the Commonwealth via $29.5B equity and a $19.5B debt facility. The Corporate Plan 2021-24 anticipates that the Commonwealth equity of $29.5B (which it notes has been capped since 2013) will continue at the same level for the next three years, and that debt funding will be increased by $8B to $27.5B over the period, with the Commonwealth debt facility being withdrawn in favour of private debt facilities by June 2024 (p. 52, 'Funding our Future Strategy').

The Corporate Plan indicates that funding task will be achievable "based on expectations of an investment grade credit rating, strong outcome in the recent bank financing transaction and overall favourable debt capital market conditions for infrastructure borrowers like NBN Co" (p. 52). However, the rates that NBN Co has achieved in its private borrowings to date, expectations about future interest rate prospects and, critically, how these rates compare or are expected to compare with the current Commonwealth rate of 3.96%, are not stated. Clearly, NBN Co may be commercially compromised if it telegraphs detailed rate expectations to the debt markets, but it is important in terms of financial accountability to the public to indicate how its expectations compare to current rates that it incurs.

The additional debt financing is required to complete the initial rollout and to fund the specific fibre business zones, the fibre extensions deeper into the access network, and other initiatives announced on 22 and 23 September 2020. It appears that funding for additional capacity upratings or other new initiatives is not being allowed for in the peak borrowings of $27.5B for the next three years.

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Non-performing equity

NBN Co does not pay any dividend on the Commonwealth's equity of $29.5B and there are no public plans to do so. Such an arrangement would not be viable if NBN Co was in private ownership, and, at a long-term infrastructure investment return on equity of 5% to 8%, the current arrangement reduces overall costs by between $1.48B and $2.36B.

Financial expectations and metrics

The financial expectations outlined in the Corporate Plan 2021-24 suggest that NBN Co's revenues will increase from $3.8B in 2020 to $6.2B in 2024, and its EBITDA inclusive of subscriber payments will increase from negative $0.8B in 2020 to $4.5B in 2024. Net profit after tax will improve from a loss of $5.2B in 2020 to a loss of $0.9B in 2024 (p. 54).

These expectations are modest and make no allowance for capacity upratings and upgrades over and above the programs announced on 22 and 23 September 2020. The overall internal rate of return has been recalculated by NBN Co at 3.7%, up from 3.1% prior to the announcements of these programs. The IRR is modest but in line with a major infrastructure business that provides fundamental services across the whole of society and the economy, and which is essential for social wellbeing and economic welfare. However, these outcomes would be inadequate for private investors.

5. Cost structure

From its inception until the conclusion of the initial rollout in 2020, NBN Co has been in large part a construction company and its overriding concern has been to provide broadband access services as well and as early as possible. With the overwhelming bulk of the initial rollout completed, NBN Co becomes progressively more and more of an ongoing network operation, albeit with continuing targeted programs of infrastructure development. In these circumstances, we would expect to see substantial changes in NBN Co's cost structures and some efficiency gains being achieved.

NBN Co announced in May 2020 that it would be reducing its workforce by 800 by the end of 2020 after completing its initial rollout. The Corporate Plan 2021-24 makes no further mention of this reduction and it may have been impacted by the new fibre programs announced on 22 and 23 September. In any case, getting the workforce size and balance right is a matter for NBN Co management, and NBN Co has appropriately concentrated on the impact of its investments on overall employment (estimated at a peak level of 25,000 additional jobs directly created by the new programs – p. 48, based on AlphaBeta modelling) and on the economy (estimated by NBN Co at a GDP increase of $6.4B per annum by 2024 – p. 46).

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6. New infrastructure investments and revenue sources

Although the matter is far from clear, it appears that the new fibre programs announced on 22 and 23 September 2020 will be a source of improved net revenue within the period covered by the Corporate Plan. NBN Co and the Minister have attributed the increase of the overall IRR from 3.1% to 3.7% largely to these initiatives.

The program associated with extending fibre deeper into the access network and closer to customer premises is essentially aimed at customers currently served by FTTN. With the exception of the brownfields customers yet to have access to the NBN's fixed network, the fibre extension program seems not to be aimed at improving the overall level of NBN take-up. Those who have yet to connect are presumably not, in general, waiting for the higher speeds that will be available under the new program.

As at 2020 the gap between premises ready to connect and those connected to the NBN is planned to have been reduced, as shown below (p. 53):

	2020	**2024**
Premises ready to connect (millions)	11.7	12.5
Premises connected (millions)	7.3	9.0
Gap – unconnected to NBN (millions)	4.4	3.5

Closing the gap further represents a major source of additional revenue at low incremental cost. The announced fibre extension initiatives are directed mainly at existing NBN customers and will not have a major impact on those that are unconnected. The forecasts in the Corporate Plan indicate that NBN Co expects the gap to decrease from 4.4 million premises to 3.5 million premises over the period to 2024. However, all of the gap reduction is expected to occur in the next 18 months or so, suggesting that it will be the result of the existing 18-month transition period expiring for customers to move from legacy network services.

NBN Co should be developing effective programs, with retail service providers, to address the gap of 4 million premises that remain unconnected.

Revenue estimates will be affected by the extent of connection of the 4.4 million premises that are passed by the NBN and are ready to connect as at June 2020, but are not yet connected. Some of these will be connected during the 18-month transition period that NBN Co provides, some may remain or become all-mobile data services, others will be affected by affordability and other digital inclusion issues, and there may be some residual who do not take up any broadband service option. NBN Co estimates take-up of around 73% to 2024. We consider that NBN Co should make clear the programs it will undertake in conjunction with retail service providers to achieve and potentially exceed this take-up, provide estimates of revenue impacts for different levels of take-up, and regularly report results to date.

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The Corporate Plan contains no details of whatever plans NBN Co may have to uprate the capacity of FWA and satellite services.

7. Risk management

The risk management discussion in the Corporate Plan is inadequate, especially in relation to responding to infrastructure competition and wireless substitution (including 5G) with competitive products (p. 57). The risk management challenge for NBN Co is also a potential business opportunity, especially in relation to the provision of 5G wholesale services. To say that "NBN Co must actively manage the impact of infrastructure competition and mass market offerings for business and residential segments through competitive products and pricing constructs that generate positive brand awareness in the market" says nothing about the risk management work in any detail that must be undertaken and the assessment through sensitivity analysis of the potential impact of harms, if realised, to the financial underpinnings of the Corporate Plan.

8. Conclusion

Available information from NBN Co is at a high level of aggregation, including in the Corporate Plan 2021-24. However, we can conclude that NBN Co has the capacity to extend borrowings to allow debt funding at least to the extent of the programs included in the Corporate Plan. It may be able to extend debt funding further to encompass some of the capital programs needed to upgrade the capacity of the various access technologies that are included in the current Multi-Technology Mix. Little is known about how NBN Co intends to upgrade Fixed Wireless Access connection, but there are a number of ways in which these services might be improved. We have no detail on plans for improving satellite service performance.

The Commonwealth is not receiving any financial return on its capital investment of $29.5B in NBN Co and there are no provisions in the Corporate Plan 2021-24 for this to change. This is an important reminder that the financial underpinnings of NBN Co are not commercial, and would need to change if it ceased to be Government-owned.

Endnotes

[1] The Corporate Plan 2021-24 (CP21), at page 54, increases these amounts significantly, to $3.4B in FY21, $3.8B in FY22, $2.4B in F23 and $2.2B in FY24, at least partly to reflect the additional capital program associated with the Fibre Zone and Fibre Extension programs announced in September 2020. However, the question about the make-up of the capital works program and the extent to which other technology uprating is to be pursued, remains. The issue goes also to transparency and accountability.

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Annex G: NBN Co Ownership Considerations

Introduction

Australia's economy is a mixed economy comprising both public and private enterprises. The specific mix that provides the best results in terms of incentives and benefits at any given time is always a matter for policy discourse, and is often influenced by ideological preferences.

In this Annex we aim to stay clear of ideological preferences and to discuss the ownership options for the NBN in terms of the circumstances that might render some outcomes desirable and some undesirable at given stages in its development, for the provision of optimum social as well as economic benefits.

The current policy of the Government is to consider the sale of NBN Co following the completion of the initial broadband access network rollout, subject to a number of legislated pre-conditions being met. These factors and pre-conditions are discussed further below. The Government has reiterated this policy on a number of occasions.

1. Ownership options

The ownership options that we have been concerned with were initially discussed in the first Forum conducted by the NBN Futures Group on 31 July 2019 and reported on in the *Journal* (Campbell & Milner, 2019). The options that we are now considering are:

a) Privatisation through a sale of the business;
b) Retention in public ownership; and
c) Variations on a) and b) based on timing.

At the time of the Forum in July 2019 two further options were being considered. One was the breakup of NBN Co into a number of entities based on the prevailing technologies being deployed, thereby creating a basis for potential modal competition between the entities. This approach would have enabled sale of some of the newly created entities on a progressive basis, and the possible retention of some in public ownership. This option was promoted by the Vertigan Committee Inquiry in 2014 (Vertigan, 2014), and more recently by Gary McLaren (McLaren, 2018). However, there are several practical objections to a structural separation of NBN Co based upon access technologies:

- Its likely accentuation of the digital divide in the lower speed NBN access footprints available to rural and remote areas and certain lower density metro suburbs, versus the higher speed FTTP/FTTB accesses available elsewhere.

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- The economic costs in quintuplicating management teams, staff and support systems for the five new companies based upon different technology platforms (satellite, fixed radio, FTTN, HFC and FTTP/K/B), each suffering a loss of the scope and scale of the original NBN Co. These additional costs would inevitably be passed on to the end users, and/or require additional government subsidies.
- The more recent complication of NBN Co's 2020 policy to provide FTTP accesses to individual businesses or residents based within 130 designated 'fibre upgrade' regional cities or metropolitan suburbs, currently within lower speed FTTN or HFC footprints.
- The further complication of NBN Co's future business incentives to support the Radio Access Networks of 5G companies, which will inevitably motivate the company to provide new fibre links to radio base stations well outside existing FTTP footprints.

In short, what might begin as five 'Baby NBNs' largely differentiated by their technology platforms would soon become network companies largely distinguished by their geographical presence, but with each forced to support the highest speed access technologies in order to meet user demand. This scenario would simply lead to the wealthier companies buying up the smaller ones – as happened with the 'Baby Bells' in the USA – with the financial benefits of the mergers rapidly accruing to the shareholders rather than to the end users.

A second approach which needs to be considered is that NBN Co should be merged with Telstra's fixed wholesale network business unit, InfraCo, after the latter is spun off from Telstra as a standalone entity, and the combined entity (which might be conveniently called "NetCo") would then become a viable wholesale transmission network operator providing internodal, backhaul and access services. For NBN Co and InfraCo to merge, either NBN Co would need to buy InfraCo, thereby potentially retaining NetCo in public ownership, or NBN Co could be sold to InfraCo (once Telstra's shareholding in InfraCo was reduced to a level satisfying competition policy), thereby privatising NBN Co. Therefore, if this merger were to proceed, it would become a variant of either option a) or option b) above. The pros and cons of the merger of NBN Co with a Telstra-liberated InfraCo have been discussed in detail by Peter Gerrand (Gerrand, 2019).

2. Factors affecting ownership

The legislated process and pre-conditions for the sale of NBN Co are set out in the *National Broadband Network Companies Act 2011*, Part 3 (Ownership and Control of NBN Co). Part 3 sets out the matters that must occur before a sale, namely:

- Declaration by the Communications Minister that the national broadband network should be treated as built and fully operational (section 48). The Act requires this declaration to be given by 31 December 2020. As an alternative to such a declaration the Act enables the

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Minister to make a pre-termination period declaration (section 48: The pre-termination period relates to the period before termination of the Commonwealth's ownership in NBN Co.) under the Act, and to define the finishing time of that period. Effectively, this enables the Minister to either make or defer the declaration that the NBN is built and fully operational, if that is needed, and to determine the period for any sale process (or pre-termination period), subject to it being no longer than 12 months (section 48(4)). In any case, these declarations should not be a major hurdle for a sale.

- Once declarations are in place that the NBN has been built and is fully operational, the Productivity Minister may require the Productivity Commission to undertake an inquiry (section 49) to consider and report on a number of issues, including the regulatory framework for the NBN; impact on future Commonwealth budgets of a sale of the Commonwealth's equity; the supply of affordable broadband and other carriage services; equity and social inclusion including in different areas; impact on competition in telecommunications markets and whether NBN Co has a substantial degree of market power in any telecommunications market; market factors including retail broadband prices; technologies used; operational considerations; and other factors set out by the Productivity Minister and considered relevant by the Productivity Commission.
- The Parliamentary Joint Committee on the Ownership of NBN Co then examines the Productivity Commission's Report and reports to both Houses of Parliament (section 49, Note 3).
- The Finance Minister is required to make a declaration on whether conditions are suitable for an NBN Co sale scheme (section 50). In deciding to make such a declaration the Finance Minister must have regard to NBN Co's governance arrangements, NBN Co's business record, market conditions, and other matters he or she considers to be relevant. The Finance Minister's declaration is a disallowable instrument.

If the Finance Minister declares under Section 50(2) of the Act that conditions are suitable for a sale of NBN Co, then, once the declaration takes effect under Section 50(6) of the Act, the Commonwealth ownership provisions cease to have effect and a sale scheme may be implemented according to the rules in Sections 52 and following. A range of sale scheme possibilities are envisaged in the Act. The details of these possibilities are beyond the scope of this Annex. Suffice it to say, sale of NBN Co by sale of shares, issue of hybrid securities and other means are all available to the Commonwealth, as are sales in tranches or of parts of the NBN business.

We consider the legislation to be detailed and comprehensive in setting out the process for termination of Commonwealth ownership. The criteria that should apply, although substantial, do not place appropriate emphasis on the NBN as infrastructure of fundamental

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national importance or on the essential service nature of the services that infrastructure supports – that is, as National Critical Infrastructure. The criteria do not adequately encompass the ongoing and evolving requirements for a national infrastructure to fully deliver possible social and economic benefits. These matters will need to be reviewed and addressed closer to the time if and when privatisation is considered.

3. Analysis of the options – in 2020

As at 2020 there are various arguments that have or might be advanced in favour or against the privatisation of NBN Co – or to terminate Commonwealth ownership, as it is termed in the Act. Some of these have an ideological basis. The arguments (including comments on each) include:

In favour of private ownership:

	Line of argument	Comment
1	Efficiency: NBN Co would be more efficiently run as a private enterprise subject to the disciplines of private ownership.	This is an ideological argument, and many examples of more or less efficient commercial enterprises can be found in both private and public ownership.
2	Competitive market: There is some competition in the provision of broadband infrastructure now and this will grow over time. The Government should exit businesses in competitive markets, because its presence skews industry development.	The market for wholesale broadband services is not effectively competitive at present and is unlikely to become so for at least 5 years and possibly for at least 10 years. Note however that this argument may have greater relevance in future.
3	Financial capacity: NBN Co needs to secure further funding for future stages of infrastructure development, and the Commonwealth Government has indicated its reluctance to provide further funding.	In May 2020 NBN Co demonstrated that it could secure low interest loan funds from private sources when it established a facility for $6.1B. This source is the basis of the $4B plus in funding required for the fibre expansion plan announced by the Minister on 23 September 2020. Clearly NBN Co need not rely on additional Government equity or debt funding even while publicly owned. There is of course an issue about the desired gearing of an enterprise of this kind in both the shorter and longer term.
4	The impact of 5G networks: 5G's ability to provide ultra-fast speeds beyond 100 Mbps makes it a "killer" application in NBN Co's FTTN footprints in particular. NBN Co will need access to much larger sources of funds in order to "fibre up" its weaker access networks to meet 5G competition.	5G represents a substantial business opportunity in the wholesale market to NBN Co a well as a competitive threat. Now that NBN Co has largely met its charter in connecting most premises with broadband accesses, it can extend its fibre connectivity business by supporting 5G radio access networks.

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In favour of public ownership:

	Line of argument	Comment
1	The important pre-conditions required by the National Broadband Companies Act 2011 have not been met and formally certified as required.	These requirements are significant but are only matters of time. The Government's position is that sale will not incur in the current term of Parliament (which could run well into 2022) and the inquiries and other process elements could be met within 1-2 years starting before or after completion of the term.
2	The national benefits resulting from the NBN are not all capable of being realised within the limits of a single enterprise, and therefore the short-term profit perspectives of a private sector owner will necessarily limit investment to lower cost locations with inevitable consequences for equity and service ubiquity.	This is a powerful argument, but may be addressed through public funding of infrastructure or support for service delivery in high-cost rural and regional areas.
3	National Critical Infrastructure that sustains essential services should remain in public ownership.	This is an ideological argument. Other essential services are provided by private firms or a mix of public and private entities. However, the argument strongly indicates that a robust sectoral strategy and regulatory framework (as well as strong regulatory agencies) are needed if the controls associated with public ownership are relinquished. The experience of privatisations in the energy, transport and other sectors is contentious, and certainly has lessons for telecommunications.
4	The NBN needs to be established as a sustainable business capable of delivering on its charter after the initial rollout.	This is an argument for deferring the privatisation issue until some future time, rather than retaining NBN Co in public ownership forever. The criteria for sustainability need to be specified and possibly included in the terms of reference for the Productivity Commission inquiry required by current legislation. There is arguably also a need to update NBN Co's charter once a 2020s update of the 1996 conception of 'universal service' is agreed.
5	The challenge associated with any form of sale based on the Corporate Plan 2021-24 needs to be highlighted. For example, the cost of private equity would hit NBN Co very hard from a cash flow perspective. The ratio of debt to the total of debt plus equity would also be a big hurdle for any sale. It would be hard to see NBN Co being viable for sale even if it addresses its debt issues in the near future without substantial adverse impacts on its operating performance.	Ultimately this may turn out to be a timing argument.

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	Line of argument	Comment
6	Sophisticated broadband networks will evolve over time with new technologies and capabilities, as will user needs and social and economic benefits. This necessary adaptation cannot be adequately built into sale contracts at a point in time.	There are limitations to the ability of sales contracts to include longer term regulatory settings and still attract eligible buyers. In particular, the need for the potential buyer to keep investing and to ensure that the infrastructure meets changing needs cannot be secured by contract.
7	The valuation for sale is likely to be considerably lower than the $29.5B of government equity, resulting in a substantial loss on the Commonwealth's investment.	This is especially likely given the need for future significant investment and uncertain regulatory and policy settings in future. On the other hand, loss of the value of equity may be expected and not be considered as a sale deterrent.

The arguments for and against sale are not determinative and some are not compelling at all. Many of the arguments are highly conditional on circumstances in the broadband market at the time of potential sale, and therefore may be reduced to arguments over timing.

4. Conclusions

Our view is that, for the foreseeable future, the NBN should not be considered as a standard commercial entity which exists to maximise profits in the short to medium term for its owners. The exogenous benefits for society and the economy at large are critical and cannot be captured in terms of firm economics alone, particularly during the next 5-10 years when the NBN will be the major broadband services platform and NBN Co will have substantial market power, especially in the fixed broadband wholesale market. During that period of at least 5 years and possibly 10 years, we see retention of the NBN in public ownership as critical for the realisation of the social and economic benefits of broadband.

The issue should be subject to review as circumstances change. We do not envisage an ongoing discussion that would undermine the efficacy of firm policy settings for investment certainty, but, rather, planning for a further review to start in 2026 or later – that is, after the first 5 years of the coverage of the initial National Broadband Strategy.

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