# 5 Ensuring national availability of high-speed broadband


## SUMMARY

- High-speed broadband services can be provided within Government's initial capital expenditure estimate by deploying a mix of fibre, satellite and wireless technologies.
- Based on the nature of the geographies served and the characteristics of wireless and satellite technologies, Government's coverage objective should be interpreted as ensuring at least 12 Mbps peak data rates are available to all premises beyond the fibre footprint. Under the solution proposed by the Implementation Study, many premises in the final 10 percent would receive substantially higher data rates of up to 100 Mbps.
- Detailed geospatial and cost analysis indicates that the fibre footprint should be extended to 93 percent of premises. This will enable 100 Mbps broadband data rates to be delivered to almost a third of premises in the final 10 percent.
- NBN Co should offer a wholesale Ka-band satellite broadband service targeting the final 3 percent of premises, but available to all premises beyond the fibre footprint to ensure the NBN coverage objective is met. This next-generation technology will deliver a step change in performance, enabling average data rates more than 20 times higher than today. Government should also facilitate a near-term improvement in current Ku-band satellite performance.
- Government should tender for the provision of a fixed-wireless service delivering at least 12 Mbps peak data rates. The successful tenderer(s) should offer both wholesale and retail services to end users. Cost analysis suggests this network should cover premises between the 94$^{th}$ and 97$^{th}$ percentiles, with the specific coverage area to be proposed by the tenderer and approved by Government as part of the tender process. Should no commercial tender prove adequate, NBN Co should be instructed to build the network.
- NBN Co should provide fibre transit backhaul to tower sites priced consistently with the rest of NBN Co's transit backhaul, in areas where the fixed-wireless provider faces backhaul bottlenecks. Transit backhaul to towers should be offered to other market participants on an equivalent, open-access basis.
- Government should add carrier licence conditions to the upcoming 700 MHz spectrum auction to require network operators to implement future technology upgrades in rural/regional areas in parallel with metropolitan areas and should review options to include data rate and coverage requirements. If prices for similar services in metropolitan and rural/regional areas diverge, Government should conduct a review of options to ensure national affordability.

Throughout this chapter we refer to ‘the final 10 percent’ of premises. This refers to those 10 percent of premises which are the most expensive to serve with fibre. Since the cost to deploy fibre correlates strongly with geographic density, the final 10 percent of premises therefore comprise a mix of truly remote areas, small regional towns, outskirts of larger regional towns and urban fringes. As a result, the boundary between the fibre and non-fibre footprints is complex, and should be specified by NBN Co based on detailed geospatial modelling

While there are a number of challenges in serving the final 10 percent, affordable high-speed broadband can be provided to all Australian premises within Government's initial expenditure estimate. In this chapter, we outline the details and implications of the proposed solution, which will deliver a step change in broadband performance and exceed Government’s stated objectives.

This chapter is organised in five sections:

5.1 Making high-speed broadband available nationally

5.2 Extending fibre to 93 percent of premises

5.3 Delivering world-leading satellite broadband services

5.4 Facilitating development of a high-speed wireless broadband market

5.5 Ensuring national availability of voice services.

# 5.1 Making high-speed broadband available nationally

Deploying high-speed broadband in the final 10 percent is difficult. Distances are great, population density low and infrastructure deployment costly. By implementing a range of broadband technologies, a workable solution which delivers on Government's objectives for these areas is possible in spite of these challenges.

This section outlines the challenges of deploying broadband to the final 10 percent of premises, evaluates the technologies that are capable of serving them, and recommends a preferred solution. These findings are laid out in four parts:

5.1.1 Understanding the characteristics of the final 10 percent

5.1.2 Identifying appropriate technologies to serve the final 10 percent

5.1.3 Defining a preferred solution for national availability of broadband

5.1.4 Ensuring availability of next-generation broadband applications.

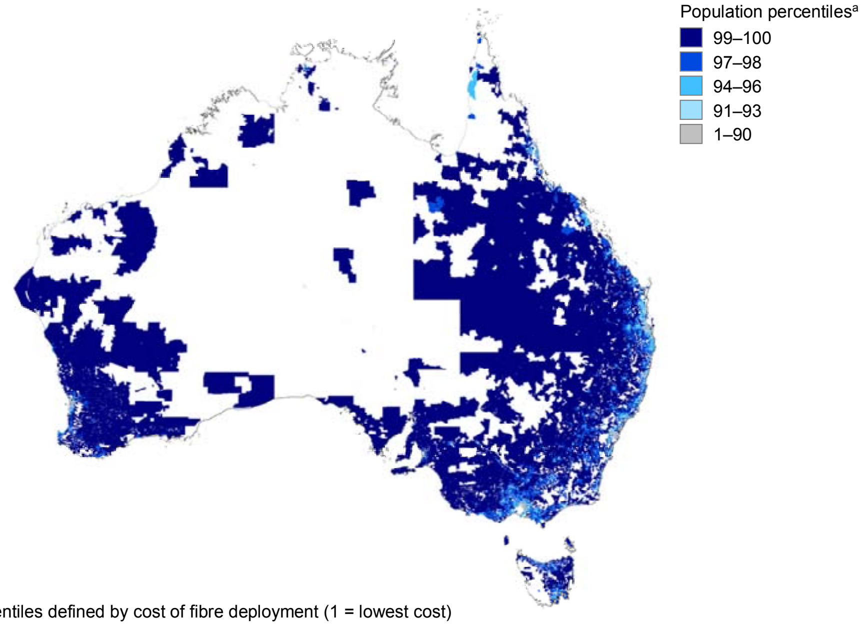
## 5.1.1 UNDERSTANDING THE CHARACTERISTICS OF THE FINAL 10 PERCENT

### Understanding the geography of the final 10 percent

The final 10 percent is characterised by very low average population density. To illustrate—90 percent of the Australian population occupies only 0.2 percent of the landmass. By contrast, the final 10 percent covers a total of 8.8 percent of Australia, with the remaining 91 percent uninhabited. Within the final 10 percent, population density varies significantly. The 91$^{st}$ population percentile on its own occupies less than 0.1 percent of the land area whereas the 100$^{th}$ percentile occupies 5.3 percent. Clearly any solution in the final 10 percent must not only cover wide areas but also be flexible enough to accommodate premises with sharply different density characteristics.

The coverage area is also highly fragmented, incorporating small towns, urban fringes, isolated rural properties and remote communities. Exhibits 5–1 and 5–2 show illustrations of the fragmentation of these areas based on our detailed geospatial modelling (described in Section 4.3.3). This fragmentation produces complicated boundaries between potential fibre and non-fibre areas. While rough demarcation boundaries can be determined up-front (e.g. to allow planning for fixed-wireless and satellite footprints), the total cost of fibre roll-out and precise distribution of fibre and non-fibre areas will not be known before the end of NBN Co's network roll-out.

## Exhibit 5–1. Australia divided into Mesh Blocks ranked by cost of fibre deployment




a. Population percentiles defined by cost of fibre deployment (1 = lowest cost)
SOURCE: Implementation Study

NBN Co may choose to extend fibre to selected areas beyond its initially defined footprint if roll-out costs are lower than projected, or if communities or commercial organisations choose to subsidise fibre roll-outs beyond initial boundaries (Section 5.2).

## Exhibit 5–2. Potential boundary between fibre and non-fibre areas


SOURCE: Implementation Study

Alternatively, if build costs exceed initial projections, Government may revisit the extent to which fibre can be extended beyond the initial 90 percent coverage objective.

## Understanding current broadband service levels in the final 10 percent

Broadband services in the final 10 percent are currently provided by a mix of fixed line, wireless and satellite technologies. DSL broadband extends to about 92 percent of premises. The remaining premises are either too far (usually more than 5 km) from an exchange or located in an area where network operators deem the economics of providing DSL services unattractive.

Wireless broadband is the largest platform outside the DSL footprint, with an estimated 150,000 Telstra subscribers.[138] Coverage statistics suggest wireless broadband extends well into the final 10 percent of premises:

- Telstra's Next G network reaches 99 percent of the population;
- Optus reaches 98 percent with 2G coverage, with 3G coverage below 90 percent;
- VHA's 2G coverage reaches an estimated 94 percent of premises.

Despite this broad coverage, the reality for many users who do not live in close proximity to wireless towers is that service quality can be relatively poor, with experienced data rates often well below advertised peak rates—particularly for indoor use.

Broadband penetration in the final 10 percent is estimated to be below two-thirds of the levels in metropolitan areas, partly reflecting the lower service performance available to end-users. Multiple government programs have helped improve broadband services delivered to underserved regional areas, including the ABG program.

The obvious impediment to the delivery of high-speed broadband services to the final 10 percent is cost. Capital expenditure per premises can be an order of magnitude higher than in metropolitan areas due to low population densities, and the revenue pools are correspondingly lower. Where commercial providers do participate, their motivation can be indirect. For example, the ability to advertise broad mobile coverage areas can be beneficial for attracting customers in metropolitan areas.

138 Industry interviews

### 5.1.2 IDENTIFYING APPROPRIATE TECHNOLOGIES TO SERVE THE FINAL 10 PERCENT

A range of technology platforms can be used to provide high-speed broadband beyond the fibre footprint and deliver Government's objective of providing at least 12 Mbps peak data rates to all premises. We start by providing a perspective on speeds in Exhibit 5–3.

#### Understanding wireless

Third generation (3G) wireless technologies can now deliver peak data rates of 42 Mbps in Australia.[139] Fourth-generation (4G) technologies will increase this performance capability to over 100 Mbps for an uncontended service.

The choice of 4G technology deployed by carriers depends on multiple factors including performance, availability, spectrum compatibility, cost, access to a global ecosystem of providers to ensure supply continuity, innovation and continued cost decreases for equipment. 4G technologies are currently undergoing commercial tests, with a number of commercial launches expected in 2010. Deployment in Australia is expected on 700 MHz spectrum in 2014–15 when the spectrum becomes available due to the 'digital dividend'. The upgrade may occur before that on other frequency bands.

Both the WiMAX and 3GPP technology families offer 4G standards that could be used to achieve Government's objectives, as we discuss below in Exhibit 5–17. Whichever 4G standard is chosen, a number of factors are key to determining the performance of wireless technologies. In particular:

- **Physical barriers and use of external antennas.** The strength of wireless signals decreases significantly when passing around physical barriers such as house walls or when reaching premises out of line-of-sight from the tower. With LTE (part of the 3GPP family), achieving peak data rates of 12 Mbps when indoors requires premises to be within about 1 km of a wireless tower if 2.3 GHz spectrum is used. This distance increases to about 2 km if 700 MHz spectrum is employed. With the use of an external high-gain antenna, these distances increase to about 7 km for 2.3 GHz and about 14 km for 700 MHz. External antennas improve service performance by:
  - Reducing signal loss by about 11 dB by moving the point of signal reception and transmission outdoors and, in the case of elevated antennas, potentially into a line-of-sight path from the tower;
  - Increasing received signal strength by an additional 15 dB, dependent upon antenna type and configuration.

139 *Telstra launches world's first HSPA+ Dual Carrier network*, media release, Sydney, 15 February 2010

Exhibit 5–3. Deciphering the language of speed

**Deciphering the language of speed**

**Understanding peak performance**

Broadband data rates advertised to end-users typically describe the maximum peak data rates achievable on a service under ideal conditions, and often for a limited period of time. The actual experience of the end-user is generally inferior to this headline rate, sometimes substantially so.

Maximum peak data rates decrease with increasing distance from the transmitter. For example, a user close to a copper exchange could experience 20+ Mbps peak data rates over an ADSL link, while users more than five kilometres from an exchange may not be able to receive any broadband service at all.

In wireless networks, with the implementation of 4G technologies such as LTE, more customers will be able to receive peak data rates of 12 Mbps as the coverage range of an existing tower will be extended. If 12 Mbps peak data rates are to be achieved for all customers using a particular wireless network, the network must be dimensioned so that the premises on the outer edge of a cell boundary can receive the 12 Mbps peak data rate. This has the consequence that users closer to the towers can experience peak data rates much greater than 12 Mbps—up to 100 Mbps with 4G wireless technologies.

**Understanding average data rates**

Telecommunications networks are dimensioned with less capacity than the sum of all access connections would require if they were all used concurrently at their maximum potential, with the resulting restriction of performance known as contention. Dimensioning is based on statistical assumptions of subscriber activity during 'busy hours' when the highest number of users are active. The data rate available to each active user during such a busy hour is commonly termed the average data rate.

Contention is common to all broadband technologies at the point where data is aggregated (e.g. on backhaul links), and it is particularly acute with shared access media such as wireless and satellite where the total throughput of the access network is a limiting factor. The higher the number of premises served by an individual wireless tower or satellite beam, the lower the actual data rate experienced by any given user, and the lower the average data rate enabled.

Providing average data rates of 12 Mbps to subscribers with wireless technologies, while theoretically possible, is very expensive. A wireless tower with 50 Mbps capacity operating with 4 distinct sectors could provide an average data rate of 12 Mbps to only 4 premises. This implies a cost of $100,000 per premises for the tower alone. The cost of providing an uncontended 12 Mbps service via satellite can be even higher.

**Specifying the 12 Mbps performance objective**

The Implementation Study believes that Government's objective of delivering at least 12 Mbps should be defined in terms of peak data rates to be enabled in the final 10 percent due to the prohibitively high cost of delivering average data rates of 12 Mbps.

In this chapter, we refer to the 12 Mbps target as a peak data rate target. Where applicable we also refer to appropriate average throughput rates that should be provisioned as we believe this to be the most relevant metric in evaluating the quality of end-user experience. Providing minimum 12 Mbps peak data rates to all premises in the final 10 percent represents a step change from current broadband experience.

Source: Implementation Study

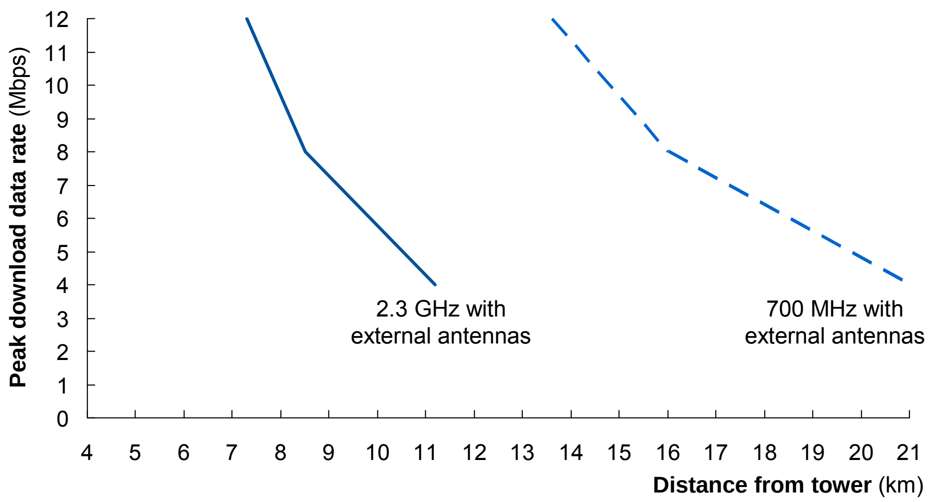
Exhibit 5–4. Defining cell radius

| Defining cell radius |
| --- |
| The cell radius defines the distance between the base station and a point at which a specified performance level, for example the delivery of 12 Mbps peak broadband data rates, can be delivered. Beyond this defined point, the signal strength becomes too weak or attenuated to deliver the required performance.<br><br>To dimension the fixed-wireless network, the cell radius within which 12 Mbps peak broadband data rates can be delivered was calculated based on radio propagation modelling. Key factors considered were<br><br>■ **Frequency band of operation**. Modelling was performed on both 700 MHz and 2.3 GHz spectrum. Lower frequency bands such as 700 MHz have superior propagation characteristics, enabling larger cell sizes.<br>■ **Base station and CPE antenna height**. An LTE 4X2 MIMO antenna system was assumed, with 4 antennas deployed per wireless tower at a tower height of 40m, and 2 antennas deployed at the customer premises at a height of 5 m<br><br>Based on these assumptions, the cell radius to deliver 12 Mbps peak data rates was estimated at roughly 14 km if 700 MHz spectrum is used and roughly 7 km if 2.3 GHz spectrum is used. The return path is dimensioned in accordance with industry benchmarks at a 1-to-4 ratio. |
| SOURCE: Implementation Study |

- **Distance of premises from the tower.** Signal strength decreases as signals propagate further from the tower, reducing the peak data rates available to users, as described in Exhibit 5–4 and 5–5.
- **Sharing of capacity.** Wireless broadband capacity is shared among all users served by a tower as described in Exhibit 5–3.

Exhibit 5–5. Relation of distance from the wireless tower to peak data rates over LTE technology at different spectrum frequencies

**Relation of distance to peak data rates over LTE technology at different spectrums**




SOURCE: Implementation Study

Data rates achieved on wireless broadband networks—even where 4G wireless technologies are deployed and peak data rates of at least 12 Mbps are provided—are not able to support applications that require continuous streaming of high-quality video images such as IPTV.

### Understanding satellite

Broadband satellite services are currently provided in Australia via two main satellite systems: IPSTAR and Optus, both operating geostationary (GEO) satellites over Ku frequency bands.

Next-generation GEO satellites operating over the Ka-band will offer more than 10 times the capacity of today's mid-size Ku satellites, substantially reducing the cost per Mbps of satellite broadband capacity. As a result, Ka-band satellites are the most appropriate choice for Australia's future broadband needs (Section 5.3.2). As an example, two Ka satellites with capacity of 55 Gbps each would be capable of supplying broadband at peak data rates of 12 Mbps and an average data rate more than 20 times higher than today to a coverage area of about 350,000 premises.[140]

Although satellite can provide high-data rates, it suffers from some inherent limitations:

- **Service availability.** Satellite signals degrade in adverse weather conditions, particularly heavy rainfall, and occasionally in solar events. The impact of extreme weather on satellite service performance varies with frequency bands: in the Ka band the effect of rain attenuation is more significant than in lower Ku frequencies.
- **Latency.** High orbit altitudes of around 36,000 km for GEO satellites lead to high latency, reducing the attractiveness of the platform for real-time applications such as voice and online gaming.
- **Need for redundancy.** Given that large numbers of customers can be served by a single Ka-band satellite, providing an acceptable level of service assurance requires launching more than one satellite due to the long lead time of 3–4 years to build and launch a new satellite. This is discussed in Section 5.3.
- **Sharing of capacity.** As with wireless, broadband subscribers share total satellite capacity. This means that the contention ratio must be carefully managed to assure service performance.

Satellite technologies, even when providing high peak data rates, are a less attractive platform for real-time applications such as voice and online gaming. Due to the current high cost of satellite bandwidth, it is not commercially viable to support applications requiring high committed data rates, such as IPTV via satellite. By contrast, the satellite

140 Assumptions: 70 percent subscriber activity rate in busy hours, with upload speeds at 25 percent of peak download speeds

platform is extremely well suited to delivery of broadcast television as is common across Australia today.

### Understanding hybrid broadband

Some communities and commercial organisations worldwide serve remote areas via localised solutions based on hybrid satellite and wireless technologies. The most common of these use a single radio device mounted on a high structure, with satellite backhaul providing the link between the community and core network. Delivered average data rates are typically low, with use of satellite backhaul leading to high latency.

## 5.1.3 DEFINING A PREFERRED SOLUTION FOR NATIONAL AVAILABILITY OF BROADBAND

### Using accurate cost comparisons in evaluating technologies for the final 10 percent

Cost per premises activated is the metric used to compare the financial implications of the choice of technology in the final 10 percent. It is calculated by distributing the fixed costs of each technology over the total number of premises activated and then adding the incremental cost per premises activated of the customer premises equipment (CPE).

An accurate comparison of costs between fibre, wireless and satellite requires inclusion of all initial capital investment costs, ongoing operational expenses, and capital replacement costs, as the life cycles and operating models of each technology differ.

Deploying fibre entails a high upfront capital cost (for trenching, hauling cable, etc). However, the passive infrastructure has a long lifecycle (e.g. the fibre and ducts are expected to last 40 years or more) in contrast to satellites which must be replaced every 15 years.

The annual expense of maintaining and operating a fibre network differs to those of wireless or satellite networks. Wireless and satellite networks both require licensed access to spectrum to operate, and these costs can be incurred on an ongoing basis. In a wireless network, each tower site typically requires ongoing land lease, power and maintenance costs. If a tower is leased rather than built, the operator typically incurs an annual tower leasing cost of over $10,000.

In comparing the three different technologies, the replacement costs (e.g. upgrading wireless active electronics, and launching new satellites every 15 years) and capitalised operational costs have been included in cost per premises activated calculations. Replacement costs have been discounted to their net present value and operating costs have been capitalised at a discount rate of 9 percent.

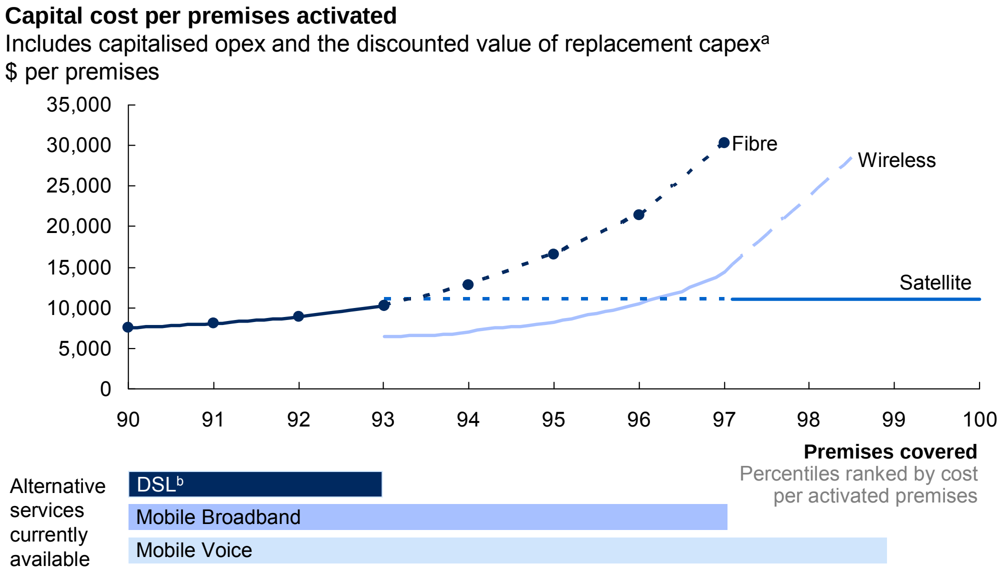
In comparing cost curves, both the financial and service quality implications must be considered before drawing the cut-off points between fibre, wireless and satellite technologies.

As we discuss in Section 5.1.2, from a performance standpoint, fibre is preferred to wireless which, in turn, is preferred to satellite. This is largely due to inherent differences in service quality offered by these respective technologies. Therefore, boundaries between technologies do not simply follow cost curve cut-off points but also account for these quality differences.

Exhibit 5–6 compares the whole-of-life costs of fibre, wireless and satellite for premises in the final 10 percent, accounting for the anticipated take-up rates of each of the technologies. The increase in cost of fibre accelerates sharply after the 93rd percentile, and the additional cost compared to wireless continually widens.[141] The whole-of-life cost of wireless begins to accelerate after the 97th percentile, and by the 98th percentile is markedly greater than the whole-of-life cost of satellite, due to the increasing number of new towers required to serve premises in the final 3 percent.

Unlike fibre and wireless, a satellite solution has a large fixed cost (to launch two satellites and establish gateways) but if spot beams provide national coverage there is no incremental investment to serve additional premises other than in CPE (by contrast, fibre

Exhibit 5–6. Cost comparison of alternative technologies in the final 10 percent




a. Network specific operating expenditure (including maintenance, leases and power) capitalised at 9% discount rate; replacement capital expenditure modelled based on useful life of active and passive infrastructure and discounted at 9%
b. Fixed-line broadband currently covers 92% of premises. Future greenfields adjacent to the fibre access network mean the percentage of premises with access to fixed-line broadband is expected to rise to ~93% in 2018–19

SOURCE: Implementation Study

141 The cost curve does not include the cost of providing transit backhaul due to the complexities in accurately allocating these costs to each percentile.

requires costs associated with the drop, and wireless networks can require additional towers). The satellite line on Exhibit 5–6 shares the fixed costs over the final 3 percent of premises plus an estimated 50,000 premises in wireless blackspots and includes CPE costs.

## Defining the mix of technologies

The principal decisions facing Government in deploying high-speed broadband to the final 10 percent of premises are:

- The specific mix of technologies to use to deliver high-speed broadband services, taking into account technology performance, cost and competition factors;
- The extent to which NBN Co, existing operators or potential new entities should participate in the implementation and delivery of the desired solutions.

The Implementation Study concludes that the final 10 percent of premises could be served via a combination of fibre, wireless and satellite solutions that deliver world-leading broadband data rates relative to the size and population density of the areas covered.

The basis for determining the preferred solution is the clear hierarchy of preferred technologies for delivering broadband services, from fibre and DSL (highest speeds, lowest latency) through wireless (lower speeds, low latency) to satellite (lower speeds, high latency). To the extent possible given expenditure constraints, Government should therefore prefer solutions in this order, and the decision on the extent of a particular technology footprint should not be informed exclusively by cost of deployment. For example, Government may wish to extend wireless service coverage beyond the point at which cost of deployment becomes cheaper on satellite due to the inherent performance advantages of wireless broadband.

The total cost of the fibre, wireless and satellite solution as proposed in this chapter is estimated at $5.3 billion on a whole-of-life basis, assuming costs at the high end of the plausible range of estimates (described further in Chapter 7). No breakdown into the individual fixed, wireless and satellite components has been provided in light of the anticipated commercial tender for the build-out of the fixed-wireless network.

### Extending fibre to 93 percent of premises

The Implementation Study recommends that Government set NBN Co an objective to deploy fibre to 93 percent of premises by the end of the 8 year network roll-out, rather than the 90 percent objective in the original policy statement. This recommendation is based on three reasons:

- First, the cost of deploying fibre to 93 percent is not prohibitive. The Implementation Study’s geospatial modelling shows that the cost to deploy fibre rises as premises density declines. It increases steadily from the 80th percentile and starts to accelerate more sharply as it nears the 90th percentile, at which point it is 1.9 times more expensive per premises than at the 50th percentile. By the 93rd percentile it costs 2.8 times the 50th percentile. Beyond this, the cost of fibre deployment begins to sky-rocket.

- Second, stopping at 90 percent would mean fewer premises would get fibre than those that already get DSL. Most premises out to 93 percent have DSL services available today that are likely to be superior to wireless or satellite services. Practically, it would very difficult to deliver a superior service by shifting an end-user from a DSL-based broadband service to a wireless or satellite service.
- Third, the actual cost per premises activated for an NBN wireless service is likely to be higher than fibre between the 90th and 93rd percentiles. While the cost of covering premises beyond 90 percent is much cheaper with wireless, take-up rates of a wireless service in competition with a DSL service and mobile broadband services from established providers are expected to be materially lower. Applying a realistic take-up rate in the calculation of cost per premises activated across wireless and satellite technologies makes the cost per activated user of implementing a wireless solution higher than fibre, as shown in Exhibit 5–9. Even if take-up was expected to be higher and average cost lower, Government should be willing to pay a premium for fibre, although the quantum itself is a question for Government.

Over time, we expect that Government could aspire to extend fibre even further.

### Providing a fixed-wireless network for the 94th to 97th percentiles

The Implementation Study concludes that the NBN wireless broadband network should extend to the 97th percentile. Beyond the 97th percentile, the whole-of-life cost per premises of providing 12 Mbps peak data rates via a wireless network escalates dramatically, and at the beginning of the 99th percentile the cost (about $24,000) is more than double the estimated cost per premises of providing a Ka satellite service (about $11,000).

In the near term, Government should conduct a commercial tender process for the provision of a fixed-wireless network to ensure 12 Mbps peak data rates are delivered to the 94th to 97th percentiles.

The winning tenderer(s) should be required to operate the network on both a wholesale and a retail basis. Tendering for construction of this network will facilitate use of existing wireless infrastructure (such as towers, backhaul or spectrum) to provide an efficient network build. Using existing commercially available spectrum will also enable a fast roll-out of services. Where required by the winning tenderer(s), NBN Co would provide additional backhaul to tower sites to facilitate the network build. This transit backhaul should be offered to all operators and priced at the same rates as transit backhaul within the fibre footprint.

We expect that in some areas these services can be available within two years from the conclusion of the proposed tender process (Section 5.4). The tender should be designed so that if an acceptable commercial approach is not received, the contract can pass to NBN Co in a subsequent process.

In addition, Government should add carrier licence conditions to the 700 MHz spectrum auction to require network operators to implement future technology upgrades in rural/regional areas in parallel with metropolitan areas and review options to include data rate and coverage requirements. If prices for similar services in metropolitan and rural/regional areas should diverge, Government should conduct a review of options to ensure national affordability.

**Ensuring all premises outside fibre are covered by an NBN Co satellite service**

To ensure ubiquitous access to high-speed broadband, NBN Co should implement a vastly improved satellite service based on next-generation Ka-band technologies. This service would be available to all premises beyond the fibre footprint, as well as customers in wireless blackspot areas. To ensure resiliency of the service, a minimum of two Ka-band satellites should be deployed. Launching two satellites means a substantial amount of capacity will be available and Government should seek to use this efficiently.

The Implementation Study believes satellite should be the primary delivery vehicle for the final 3 percent of premises.

Prior to the launch of Ka-band satellites, Government can facilitate an improvement to the existing Ku-band service in two ways:

- Capture scale purchasing benefits on existing underutilised Ku-band satellites by aggregating demand, for example by requiring NBN Co to bulk-purchase the capacity on behalf of retailers. This can enable greater satellite bandwidth and an improvement in average data throughput rates to be delivered to end users at no extra cost.
- Provide updated modems with higher spectral efficiency than those in use today, enabling higher broadband data rates to be delivered over a given satellite bandwidth.

The combination of these improvements can enable a significant improvement in near-term service performance.

**Preserving the option for improved DSL availability**

The Implementation Study estimates that around 400,000 premises outside the recommended fibre footprint (i.e. in the final 7 percent of premises) have the potential to be served by DSL as they are sufficiently close to current copper exchanges and are not expected to suffer from pair gain/RIM issues.

Most of these premises do not have the option of a DSL service today, either because the volume of addressable customers within the footprint of an exchange is insufficient, or because the price of backhaul is too high to justify the investment. Under the proposed fibre and wireless solutions, NBN Co will be building backhaul into the final 10 percent area to connect fibre exchanges to POIs, and to connect towers in the fixed-wireless network. If NBN Co is required to unbundle this transit backhaul and make competitively priced access available to other market participants, this would likely improve the business case for new entrants providing DSL services and may increase DSL availability.

Since customers outside the fibre footprint will also be offered wireless and/or satellite services under the Implementation Study's proposed solution, offering DSL services in the last 7 percent would also provide competition for these alternative technologies in the near term. The Implementation Study believes this is an appropriate approach while the copper network is functioning, as it is consistent with delivering customers in the final 10 percent the best possible service available.

In practice, many of the premises in the final 7 percent who are eligible for DSL service will be relatively far from the nearest copper exchange, so that experienced data rates will be much lower than headline rates. In this case, the fixed-wireless service, offering at least 12 Mbps peak data rate, would be expected to compete well against DSL.

If the copper network is gradually retired over time, as could be expected given the high costs of copper maintenance in the final 10 percent, customers using a DSL service would need to migrate onto one of the alternative available technologies.

### 5.1.4 ENSURING AVAILABILITY OF NEXT-GENERATION BROADBAND APPLICATIONS

#### Understanding the requirements of Internet applications

Bandwidth demand is growing rapidly. While much usage of the Internet today is still for low-bandwidth applications such as e-mail or web-browsing, higher bandwidth applications such as streaming audio and video, photo-sharing and social networking are becoming increasingly popular. Almost 90 percent of US Internet users use email, with over 60 percent now watching video on video-sharing websites.[142]

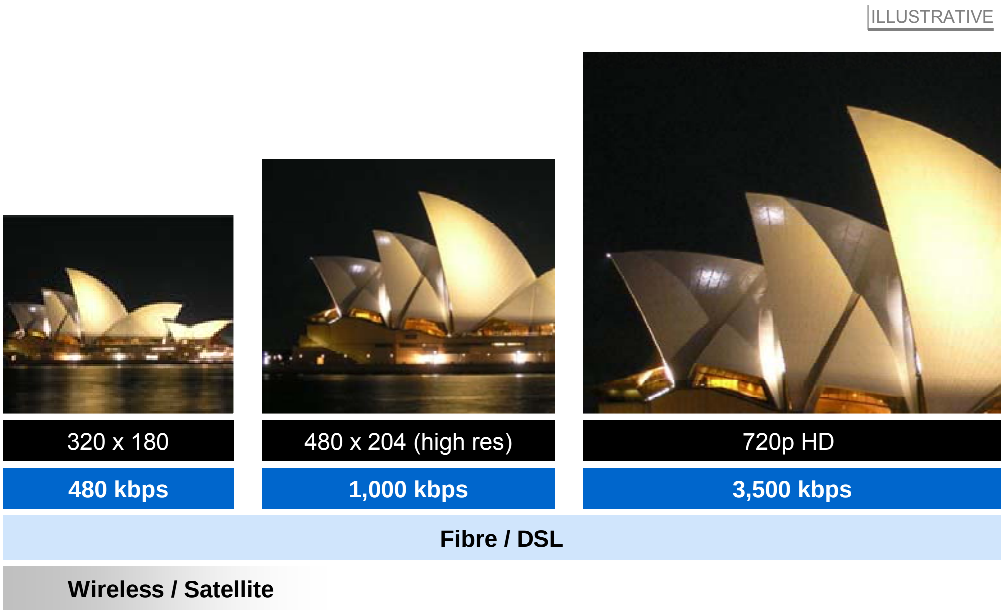
Understanding usage patterns is key for dimensioning wireless and satellite services, since the amount of capital investment required depends not only on the peak data rates that must be delivered, but also the average data rates required. As more bandwidth-heavy commercial and social applications come online, it will be necessary to dimension the network accordingly to meet Government policy objectives and to ensure the full innovation potential from deploying the NBN are realised.

[142] Pew Research Center 2009, Pew *Internet & American Life Projectt*, viewed 26 February 2010, <http://www.pewinternet.org/Data-Tools/Get-The-Latest-Statistics.aspx>

Two parameters define the range and availability of applications broadband solutions can support:

- **Sustained data rates:** Sustained data rates determine whether bandwidth-heavy applications can be supported at all. Interactive video applications can be supported by both wireless and satellite technologies, with applications offered at different quality levels to match the connection characteristics of the user. Exhibit 5–7 shows how the quality of video streaming services can be varied according to the capabilities of the user's broadband service. Provisioning high-bandwidth media services such as IPTV and HD-IPTV that require high sustained data rates is not viable over wireless or satellite broadband due to the costs of provisioning bandwidth for these services.
- **Latency performance**: Latency is a key factor in user experience for real-time applications such as videoconferencing, voice applications and playing online games. Real-time applications can be supported effectively by fixed-line and wireless technologies, and are usable over satellite technologies, albeit at significantly reduced user experience due to the high latency of geostationary satellite broadband platforms.

Exhibit 5–7. Relationship between resolution and video streaming bandwidth requirements




SOURCE: Implementation Study

## Evaluating future requirements for wireless and satellite technologies

Significant increases in Internet data traffic have occurred in recent years, and are projected to continue in the future. Cisco Systems projects that global IP traffic will increase by a factor of 5 between 2008 and 2013, with IP traffic in Asia-Pacific projected to grow at a CAGR of 42 percent.[143] In addition to increasing broadband penetration, increases in consumer traffic are expected to be driven by growth in higher bandwidth applications such as video, which is projected to account for 91 percent of global consumer Internet traffic by 2013.[144]

Current statistics show that the average Australian Internet user typically downloads 2 to 5 GB of data per month, with usage volumes of wireless and satellite users lower than average due to the lower performance capabilities of the technologies.[145] Wireless and satellite solutions need to be dimensioned to accommodate anticipated increases in the usage requirements of individual users, taking account of the range of applications the technologies enable. The Implementation Study believes that to satisfy a realistic estimate of anticipated usage growth, wireless and satellite networks should be designed to accommodate increases of 25 percent CAGR from current usage levels and monthly download volumes more than three times the upper limit of today's Australian average of 2–5 GB per month.

Dimensioning the network to accommodate expected growth in usage will also increase its ability to support social applications such as e-government, e-education and e-health applications. The feasibility of enabling specific applications in these areas must be assessed in more detail when the exact scope and requirements for the services have been formulated. Delivery of some high bandwidth services to institutional premises in remote areas is unlikely to be viable. Alternative technology solutions to provide access to these services are discussed in Exhibit 5–8 below.

143 Cisco 2009, *Cisco Visual Networking Index Usage Study 2009*, viewed 19 February 2010, <http://www.cisco.com/go/vni>

144 Ibid

145 ABS 2009, *Internet Activity, Australia, June 2009*

Exhibit 5–8. Delivery of broadband to public institutions outside the fibre footprint

| Delivery of broadband to public institutions outside the fibre footprint |
|---|
| Consumer-grade wireless and satellite services are likely to be unsuitable for many larger institutions and agencies located outside the fibre footprint, some of which require enterprise-grade services that can:<br>■ Provide sufficient bandwidth to enable a good level of service to be delivered to a number of concurrent users (e.g. multiple classes in a school)<br>■ Enable real-time applications such as high-quality video conferencing for e-education and e-health applications<br>There are a variety of technology solutions available to provide bandwidth-heavy services to remote areas. The choice of the most appropriate technology in any given situation will be dictated by the specific circumstances involved (including location, applications to be enabled and quality of service requirements). As a result, the choice of technology to use should be made on a case-by-case basis. Possible technical solutions include:<br>■ **High-bandwidth satellite.** For very remote locations where only satellite broadband services are available, the provision of high-speed broadband relies on the upgrade of customer premises equipment. Depending on the existing equipment, either the indoor unit, outdoor unit or both need to be changed for the availability of these services. This solution can enable high-bandwidth services, but is suboptimal for real-time applications due to high latency.<br>■ **Point-to-point microwave.** For locations close to fibre or wireless broadband access networks, point-to-point microwave links connecting premises directly to backhaul networks can offer high-bandwidth, low-latency solutions enabling the full suite of Internet applications.<br>■ **Point-to-point fibre.** For areas outside the nominal fibre footprint that are a priority for high-bandwidth connectivity, Government could choose to extend a fibre connection to the institution or agency in question, potentially using amplifiers to extend the range of the fibre where needed. This solution would enable usage of the full range of Internet applications by multiple concurrent users.<br>Independent of the technology chosen, providing these bandwidth-heavy solutions would require significant upfront investments. |
| Source: Implementation Study |

# 5.2 Extending fibre to 93 percent of premises

Fibre technology delivers the highest quality broadband service today and is best equipped to meet growing broadband demand in the future. For this reason, maximising the deployment of fibre should be a priority for Government.

This section explores the possibility of extending the fibre footprint beyond the original 90 percent objective. It concludes that Government should set NBN Co an objective to deploy fibre to 93 percent of premises by the end of the roll-out. Over time, the Implementation Study expects that Government will aspire to extend fibre even further.

The details and rationale for this recommendation are described in the following sections:

5.2.1 Extending the fibre footprint to 93 percent of premises

5.2.2 Facilitating future fibre footprint expansion.

### 5.2.1 EXTENDING THE FIBRE FOOTPRINT TO 93 PERCENT OF PREMISES

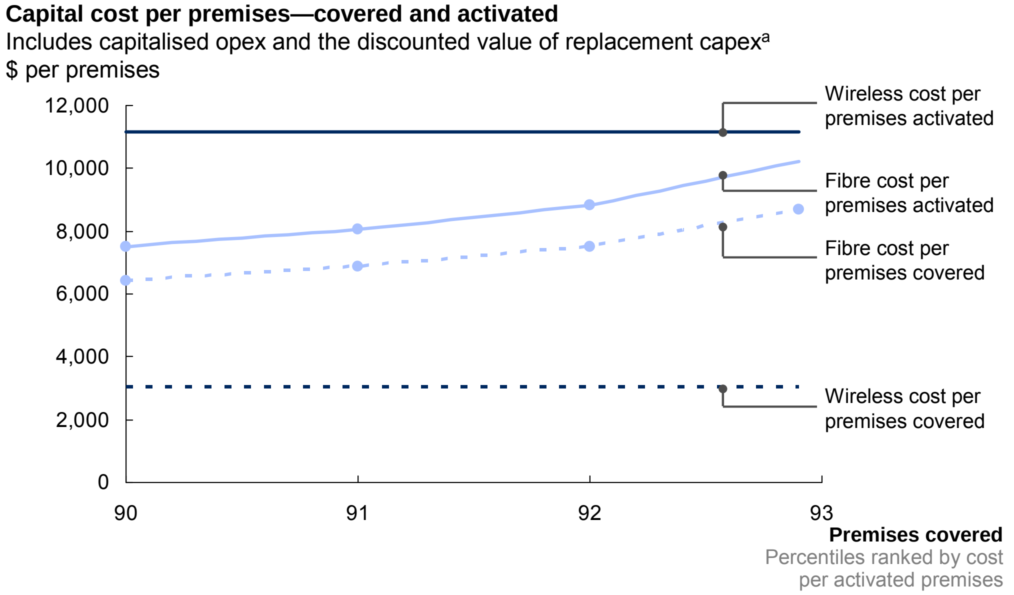
The Implementation Study's modelling indicates that the cost curve for deploying fibre increases gradually to around 80 percent, increases more steeply to around 93 percent, and accelerates very significantly after 93 percent. Fibre can be deployed beyond the original 90 percent target without exceeding Government's initial expenditure estimate, or incurring a prohibitive marginal cost per premises activated.

We recommend that Government set NBN Co an objective to deploy fibre to 93 percent of premises by the end of the 8-year network roll-out, rather than the 90 percent objective in the original policy statement. This would provide almost a third of premises within the final 10 percent access to the optimal broadband technology enabling 100 Mbps broadband data rates. Over time, we expect that Government will aspire to extend fibre even further.

#### Understanding the cost of fibre deployment

Exhibit 5–9 below shows the cost comparison between extending the fibre exchanges and the fixed-wireless network from the 90$^{th}$ to 93$^{rd}$ percentiles. The solid lines represent the cost per premises activated for fibre and wireless, accounting for the differences in expected take-up levels between the two technologies. Fibre has a significantly higher expected take-up rate than wireless due to the superior level of service, and the absence of competitive offerings. Wireless, on the other hand, is expected to have a lower take-up rate as there are competing DSL and mobile offerings available.

Exhibit 5–9. Cost comparison of alternative technologies from 90–93 percent




a. Network specific operating expenditure (including maintenance, leases and power) capitalised at 9% discount rate; replacement capital expenditure modelled based on useful life of active and passive infrastructure and discounted at 9%

SOURCE: Implementation Study

Hence, as noted in Section 5.1.3, while the cost of covering premises beyond 90 percent is much cheaper with wireless than with fibre, applying a realistic take-up rate to a wireless service in competition with mobile and DSL lifts the average cost per actual user substantially.

The cost drivers of fibre deployment are described in Section 4.3, and the cost drivers of a fixed-wireless network are described in Section 5.4.

### 5.2.2 FACILITATING FUTURE FIBRE FOOTPRINT EXPANSION

In the coming years, changes in both demand and supply side economics may make it viable to extend the fibre footprint even further than the proposed 93 percent coverage.

On the demand side, both demographic changes and end-user contributions may make extending the fibre roll-out viable:

- Increases in population density in areas beyond the fibre footprint are likely to result in increased demand and a decrease in deployment cost per premises. This may make fibre deployment economically viable in areas where costs were previously too high. While population increases during the timeframe of the anticipated NBN deployment have been factored in to the current analysis, population growth will continue and may improve the economic viability of further fibre expansion.

- Individual end users or groups of end users may be willing to contribute funding to obtain FTTP connections (Chapter 2).

On the supply side, innovations in fibre deployment technologies (e.g. trenching) and reductions in hardware costs could decrease the cost of fibre deployment significantly, making it economic to deploy to areas below today's feasible population density threshold. While specific developments cannot be predicted today, the scale of the network build and the potential for experience gained from a large-scale roll-out to reduce costs may result in fibre being rolled out to a greater number of premises than currently estimated.

# 5.3 Delivering world-leading satellite broadband services

Satellite has a critical role to play in ensuring nationwide availability of affordable, high-speed broadband beyond the fibre footprint. A much improved satellite service can be deployed to ensure access to wholesale-only 12 Mbps peak data rate broadband to all premises in the final 10 percent.

This section addresses the required technical capabilities for a next-generation satellite service as well as the preferred implementation model:

5.3.1 Confirming the need for a satellite solution

5.3.2 Designing a next-generation satellite platform

5.3.3 Defining the operating model and product offering

5.3.4 Understanding the cost of satellite broadband technology

5.3.5 Ensuring affordability of satellite services

5.3.6 Improving satellite service in the near term.

### 5.3.1 CONFIRMING THE NEED FOR A SATELLITE SOLUTION

Satellite services will continue to be important for providing broadband in the future due to the prohibitive cost of serving lowest-density areas with other technologies. Currently, satellite broadband services are delivered to over 100,000 premises[146] in Australia via GEO satellites operating on the Ku frequency band, most of which already lie in the final 10 percent of the population.

Exhibit 5–6 illustrated that the costs of deploying fibre or wireless networks increases steeply in the final percentiles, due to the high fixed costs associated with providing incremental coverage to low density areas. The fixed costs of satellite differ in that they can be evenly distributed across all premises activated by satellite. Hence if the satellites can be utilised at close to their capacity, the cost per premises activated is significantly lower than for fibre or wireless.

The Implementation Study estimates the cost for NBN Co to build a fixed-wireless service to be around $6,500 per premises on a whole-of-life basis at the beginning of the 94$^{th}$ percentile. This cost increases gradually to $10,500 at the beginning of the 97$^{th}$ percentile, then to $14,400 at the beginning of the 98$^{th}$ percentile, and finally rises substantially to $23,800 at the beginning of the 99$^{th}$ percentile. The assumptions underlying these cost estimates are described in Section 5.4. While it is expected that a

146 Industry interviews

commercial provider could construct the fixed-wireless network at lower cost than NBN Co (for example by re-using existing tower, backhaul or spectrum assets), the cost of serving premises is still expected to quickly become prohibitive beyond the 97th percentile.

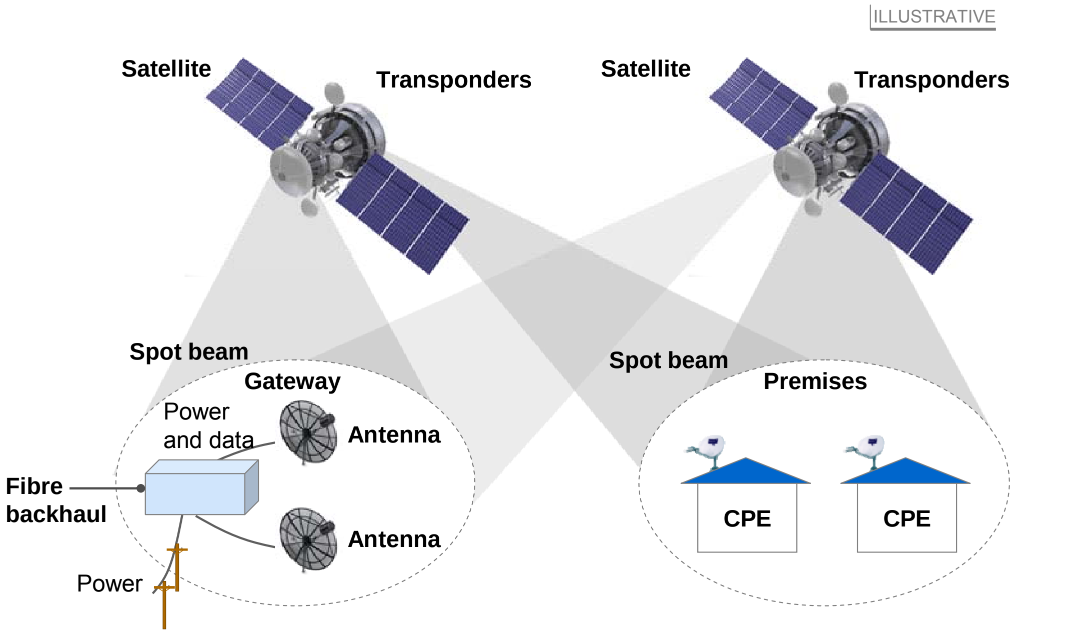
As a result, the Implementation Study believes there will be a need for a satellite solution under any viable scenario. We have modelled a satellite service primarily targeting the final 3 percent of premises, but offering service to all premises in the last 7 percent. This latter requirement ensures all premises in the last 10 percent have access to a wholesale-only offering, and also ensures that no premises are unable to receive at least a 12 Mbps service, for example due to blackspots in the fixed-wireless coverage. In practice, take-up is expected to be low outside the final 3 percent of premises given high-speed wireless alternatives.

The estimated whole-of-life cost of deploying a Ka-band satellite solution is roughly $11,000 per premises (the upfront capital cost is significantly lower). The resulting intersection of the fibre, wireless and satellite cost curves is shown in Exhibit 5–6.

### 5.3.2 DESIGNING A NEXT-GENERATION SATELLITE PLATFORM

When designing the next-generation satellite platform, a number of design considerations should be addressed to ensure resilience and high service quality. Exhibit 5–10 illustrates the schematics for a satellite network.

Exhibit 5–10. High-level satellite network schematic




SOURCE: Implementation Study

Exhibit 5–11. Classification of satellite platforms

| Classification of satellite platforms |
| --- |
| Satellite platforms are classified into 3 groups based on orbit altitude<br>■ **Low Earth Orbit (LEO)** satellites orbit the earth at a height of 200–2,000 km, with typical average orbit durations of about 90 minutes. Multiple satellites are required to achieve continuous coverage. LEO satellites provide lower latency than other orbits; however their currently limited available capacity makes them unsuitable for high-throughput broadband applications.<br>■ **Medium Earth Orbit (MEO)** satellites have larger coverage areas, higher latency and longer orbit cycles than LEO satellites. Nevertheless, reaching consistent coverage for a land mass the size of Australia requires multiple orbiting satellites. Since no commercial broadband deployment is currently available, the feasibility and commerciality of such a solution is untested and therefore it is not proposed here as a suitable solution for the NBN.<br>■ **Geostationary (GEO)** satellites orbit the earth at an altitude of 36,000 km. As their name suggests, geostationary satellites occupy fixed orbital positions relative to the Earth. Use of GEO satellites results in high signal latency due to the long distance between the satellite and earth stations, with signal delays of about 500 milliseconds for a return trip.[147] |
| Source: Implementation Study |

## Selecting the technology platform

GEO satellites offer the most cost-effective broadband solution and are expected to remain the standard satellite broadband platform both worldwide and in Australia. Exhibit 5–11 compares the characteristics of LEO, MEO and GEO satellite platforms.

Next-generation Ka-band satellites are expected to enable substantial increases over the more limited capacities of today's Ku-band satellites. A high-capacity Ka-band satellite is expected to be able to provide a total throughput of over 100 Gbps, compared to typical capacities of around 5 Gbps on a Ku-band satellite today.[148]

This capacity improvement will enable significantly lower costs per bit. Ka-band satellites should therefore be the technology of choice for delivering high-speed satellite broadband. In the unlikely event of Ka-band technology experiencing implementation difficulties, Government should seek to continue provision of high-quality Ku-band service, either leased from commercial providers as is the case today, or by launching additional Ku-band satellites over time.

147 Signal processing and ground-transfer also cause latency, but the effect is small compared to signal transfer to and from GEO satellites

148 Industry interviews. Thaicom 4/IPSTAR is a large Ku satellite with a capacity of 45 Gbps

### Providing for redundancy

To ensure service continuity, the Implementation Study believes the satellite service should be provisioned based on two orbiting satellites. Satellites can be configured such that each serves around half the total number of subscribers. In the case of one satellite failing, the remaining satellite would be capable of serving the entire footprint, albeit at reduced service quality. Given that design-to-launch times are typically 3–4 years, the alternative of using a single satellite risks subscribers losing service for an unacceptably long period, in the unlikely event of a catastrophic failure. Based on the Implementation Study's modelling of demand, two medium-sized satellites would provide adequate capacity over the lifetime of those satellites given expected rates of growth in premises served.

Due to technical constraints, the two satellites would need to be separated in orbit by at least two degrees. In the case of satellite failure, CPE dishes that had been oriented towards the failed satellite would therefore need to be re-oriented toward the remaining operational satellite. While it is possible to procure dual-antenna dishes that are capable of receiving signals from both satellites and avoid this re-pointing, the Implementation Study considers that the low risk of an in-orbit satellite failure does not justify the additional cost of these antennas.

### Planning satellite capacity and spot beams

Long design-to-launch times and the high capital expense required for satellite deployment make careful capacity planning crucial to delivery of high-quality services and efficient operation. The satellite system should be designed to have enough total capacity to provide subscribers with a pre-determined quality of service. In the case of NBN services, the system should be designed to be capable of providing both an affordable entry-level product as well as at least one product with peak data rates of at least 12 Mbps to meet Government objectives.

The service will also need to be dimensioned to cater for the expected growth in usage patterns over time. Although nobody can accurately predict trends in usage demand over the coming years, a reasonable estimate of data usage trends (described in Section 5.1.4) suggests that dimensioning for average data rates in the 300–400 kbps range is appropriate. This represents a very substantial change from the average data rates provisioned today of less than 10 kbps, and reflects an expected change in usage patterns away from simple web browsing to more use of video and interactive services. The final judgement on service provisioning requirements should be made by NBN Co.

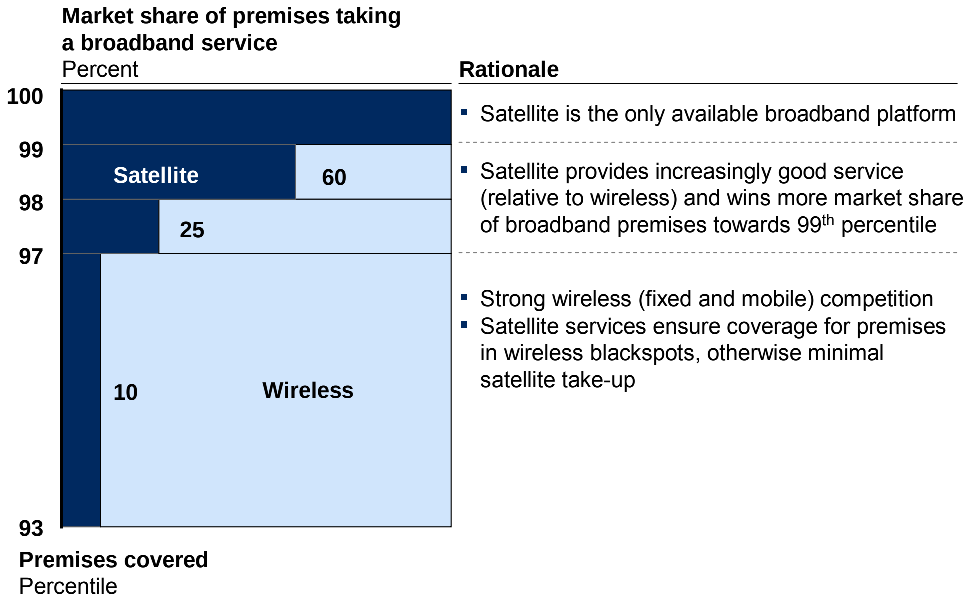
> **Recommendation 43**. That NBN Co be required to provide a next-generation satellite service ensuring access to at least 12 Mbps peak data rates to all premises beyond the fibre footprint. Satellite system capacity should be dimensioned to offer an average data rate per premises that reflects potential growth in usage patterns over the lifetime of the satellite system.

GEO satellite capacity is typically provisioned via a number of spot beams providing concentrated coverage in defined areas. Once the satellite is in orbit, the spot beam locations and beam radii are largely fixed, so the selection of the number and location of the beams is a critical consideration.

One practical approach to facilitate effective demarcation of the fixed-wireless and satellite coverage areas is for NBN Co to define the coverage requirements for the fixed-wireless network based on its geospatial modelling. This will enable NBN Co to design the satellite coverage areas effectively, based on precise knowledge of the planned fibre and fixed-wireless network footprints. Alternatively, it may be desirable to allow a tenderer for the fixed-wireless network to identify those premises beyond the fibre footprint that it would classify as the 94th to 97th percentiles. NBN Co could then configure its satellites accordingly.

Dimensioning the satellite system will also require NBN Co to project take-up of the service. Exhibit 5–12 shows an illustrative example of potential take-up rates in different percentiles within the final 10 percent that was used in the business case modelling. Where strong wireless service competition is present, take-up is expected to be largely limited to customers in blackspot coverage areas who receive either poor or no high-speed wireless broadband services.

Exhibit 5–12. Illustrative model for potential take-up of satellite services




SOURCE: Implementation Study

Provisioning of excess satellite capacity beyond projected demand trends is prudent due to the long potential lead time to acquire additional capacity if planned requirements are exceeded. If the entire satellite capacity is not consumed by domestic broadband customers, it may be possible for the satellite provider to offer capacity to other countries with similar longitude to Australia. However, since spot beams typically cannot be re-allocated dynamically post-launch, this decision would have to be taken before satellite launch, based on the forecast take-up of services.

To enable optimised capacity planning and utilisation, satellite launches can be staggered so that observed take-up rates for services on the first satellite can be used to guide the configuration of spot beams on the second satellite launched. Given the low probability of in-orbit satellite failure it is feasible to delay the second satellite launch for a period of 18–24 months to enable capacity to be monitored.

### Providing gateway redundancy

The location and design of satellite gateways should support service continuity and resilience to weather effects and component failure. In practice, there are two options to improve resilience:

- Each gateway location is designed with a total of four antennas—two primary antennas (one per earth-to-satellite link) and two to provide redundancy to each primary antenna;
- Each gateway location is designed with a total of three antennas—two primary antennas (one per earth-to-satellite link) and one to provide shared redundancy to the two primary antennas.

The redundant antenna should be separated from the primary antenna(s) by at least the distance of an average rain cell size, enabling at least one antenna to communicate with the satellite in most weather conditions.

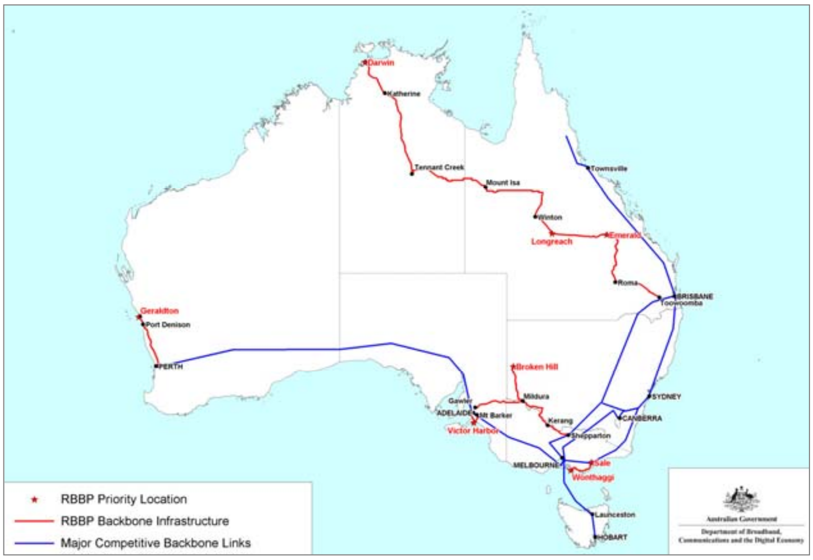
### Enabling frequency reuse

The use of spot beams to transmit the satellite signal allows reuse of satellite frequencies, enabling a greater throughput for a given amount of spectrum. The high frequency of the Ka-band enables smaller spot beams compared to current Ku-band services, enabling a higher frequency reuse factor. As long as no two adjacent spot beams are operating in the same frequency band, each frequency band can be reused multiple times.

To maximise frequency reuse, the gateways that provide satellite up-links need to be placed outside the footprint of the beams. This means it is desirable to place gateways in remote locations away from the premises covered by the beams. While in theory the availability of backhaul to connect gateways can be problematic, in practice locating remote gateways in locations with access to backhaul should be feasible:

Exhibit 5–13. Cross-nation backhaul links pass through remote areas offering good locations for gateways

**Regional Backbone Blackspots Program—All RBBP Routes**




SOURCE: DBCDE

- Existing remote gateway locations for Ku-band and other satellite types can be reused for a Ka-band satellite system;
- Existing cross-country backhaul links passing through remote areas already offer various potential gateway connection points requiring little new backhaul construction (Exhibit 5–13). Transit backhaul built by NBN Co will provide even more optimal locations over time.

## 5.3.3 DEFINING THE OPERATING MODEL AND PRODUCT OFFERING

### Securing Ka-band satellite capacity

NBN Co's options for securing satellite capacity depend upon the likelihood of Ka-band capacity being available in the commercial market at the time of service launch. If capacity is expected to be available, NBN Co can consider a leasing model utilising third-party satellite infrastructure. A leasing model avoids large upfront investments and enables NBN Co to adjust capacity to demand flexibly, within the limits of agreed contract conditions.

Currently there are no plans to launch Ka-band satellites providing broadband coverage in Australia, and it is unclear whether the market by itself will supply the desired capacity. For this reason, the advice of the Implementation Study is that NBN Co should contract with satellite operators to provision a new satellite platform comprising two next-generation Ka-band satellites and the required gateways.

**Advice.** That NBN Co secure capacity for satellite services by contracting an operator to provision a new satellite platform comprising two next-generation Ka-band satellites and the required gateways.

## Defining the satellite product offering

Ka-band satellite services should be offered by NBN Co on a wholesale-only basis, with per customer incentives defined to ensure retailer entry. Services should be offered at Layer 3 due to the need to optimise the satellite link, as described in Exhibit 5–14.

While the requirement for NBN Co to offer Layer 3 satellite services constrains the degree to which retailers are able to differentiate their satellite service offerings, the much higher peak data rates and average data rates enabled by Ka-band technologies will enable a range of services and applications to be delivered.

NBN Co should have some flexibility in defining the range of wholesale services offered, which should include a service offering peak data rates of 12 Mbps, with vastly improved average data throughputs (e.g. in the order of 300 kbps). For example, a 360 kbps average forward data rate could be provided through a total capacity of 110 Gbps provided by two Ka-band satellites to approximately 350,000 premises.[149]

An entry-level service with a lower peak data rate and average data rate should be provided (e.g. 6 Mbps and 200 kbps respectively), priced at a comparable level to entry-level fibre and wireless products. Additional services could also be provided to promote end-user choice and commerciality, for example a premium service with higher peak data rates and average data rates (e.g. 20 Mbps peak and 480 kbps average data rates).

Exhibit 5–14. Choice of layer in the stack

**Choice of layer in the stack**

The GEO earth-to-satellite data link is characterised by high latency, precluding the use of standard transport protocols and requiring stringent network management to ensure good service levels. For this reason the satellite link is always implemented at Layer 3 with both customer premises equipment and retailers connecting at Layer 3.

For a retailer, interconnection at Layer 2 has no added value as the owner of the access data link will be required to shift traffic to Layer 3 to enable effective network management.

Under a Layer 3 capacity leasing model, NBN Co would lease satellite transponder capacity and the supporting earth station network equipment from satellite and earth station operators. Retailers would interconnect to the network through an NBN point of interconnection (POI) at a location with competitive backhaul, with, for example, one POI per state. All network management would be performed by the satellite operator, with retailers operating through a Layer 3 connection.

Source: Implementation Study

149 Assuming a 4-to-1 forward-return ratio and 70 percent activity rate

### 5.3.4 UNDERSTANDING THE COST OF SATELLITE BROADBAND TECHNOLOGY

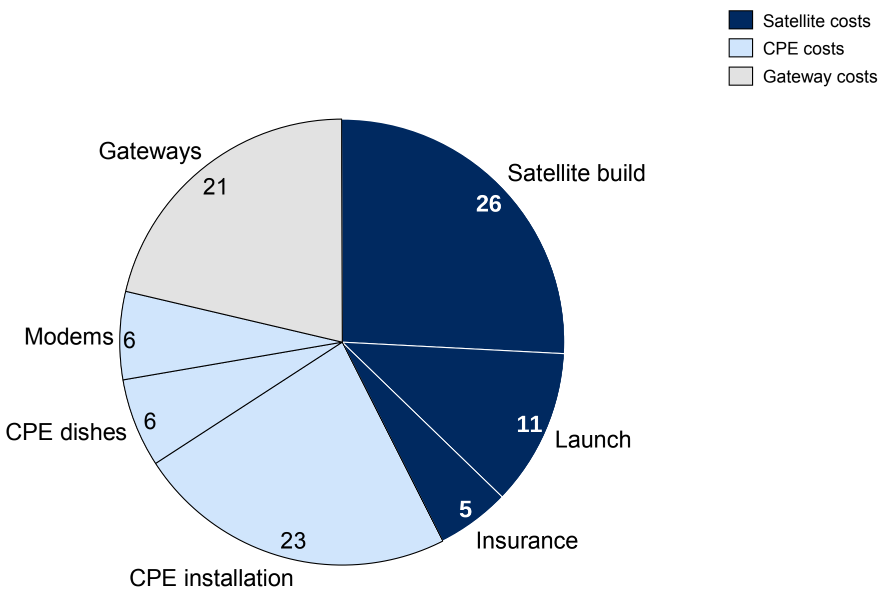
A satellite network has three major cost components: satellite (design and launch), gateways, and customer premises equipment (CPE).[150] A cost breakdown of these three elements is shown in Exhibit 5–15.

#### Estimating satellite and launch costs

The primary cost drivers of a satellite system are the build and launch of two Ka-band satellites, together with the construction of gateways to support the satellites. The cost of two medium-sized Ka-band satellites with 110 Gbps total throughput would have three main components:

- Cost of building two satellites (about 26 percent of the total satellite network cost)
- Cost of launching two satellites (about 11 percent of the total satellite network cost)
- Cost of insuring two satellites for launch and the first year of operations (about 5 percent of the total satellite network cost)

Exhibit 5–15. Satellite network total cost percentage breakdown




SOURCE: Implementation Study

150 Satellite spectrum licences are an annual operating expense. Spectrum licence costs have been included at $2.5m per annum for two satellites.

The rationale for a dual satellite system is to provide redundancy in the case of a satellite failure. Failure could occur during launch (about 5 percent probability), or in rare cases once the satellite is in orbit. Further details on satellite redundancy requirements are explained in Section 5.3.2.

#### Estimating gateway costs

Multiple gateways need to be constructed to host network equipment and enable data connections with the orbiting satellites. Based on industry consultation, it has been estimated that around 11 gateways would be required to support two Ka-band satellites with 110 Gbps total capacity as described in Section 5.3.3.

The required number of gateways is driven by a number of factors, including:

- The total required throughput of the satellite system;
- The number of spot beams and frequency reuse factor;
- Spectrum availability.

The cost of each gateway is driven by a number of factors, for example:

- The level of redundancy built into each gateway;
- The required throughput of each gateway;
- The amount of backhaul and power extensions required to reach the gateway.

#### Estimating customer premises equipment and installation costs

The cost of the Ka-band satellite customer premises equipment and installation is expected to be around $2,000 per premises, approximately $500 lower than typical Ku-band CPE costs. The main components of this are:

- Outdoor dish and antenna (about $350 per premises)
- Indoor modem (about $350 per premises)
- Cabling and installation costs (average of $1300 per premises)

### 5.3.5 ENSURING AFFORDABILITY OF SATELLITE SERVICES

The high cost of providing satellite services means that it is unlikely that a next-generation satellite service could provide affordable prices and achieve a commercial return.

Exhibit 5–16. Overview of the ABG program

| **Overview of the ABG program** |
| --- |
| The Australian Broadband Guarantee (ABG) is a government program with the purpose of helping residential and small business premises located in remote and rural regions of Australia access metro-comparable broadband services, defined as services offering minimum 512 kbps download data rates, and providing 3 GB per month data usage.<br><br>The ABG provides an up-front subsidy to retailers of $2,500 per premises activated, covering the cash cost to provision and install satellite CPE. Additional payments are made to retailers acquiring customers in remote regions where installation costs are significantly higher than average, and for retailers acquiring customers in regions where climatic conditions require more expensive CPE (e.g. tropical north Queensland, where larger dishes are deployed to enable services to operate during the frequent periods of heavy rain). In return, retailers guarantee that the total end-user cost of the service over the first three years does not exceed $2,500, including all installation, equipment and help-desk service costs.<br><br>Currently, over 100,000 premises receive satellite broadband services under the ABG program. Commonly used plans provide peak data rates of 512 kbps, consistent with program requirements, with low average data rates of less than 10 kbps provisioned per subscriber. Currently, these low average data rates do not appear to be a bottleneck for many users, with usage demands low. As usage demands increase, however, customer experience may deteriorate as relatively expensive bandwidth costs are likely to encourage retailers to add subscribers to existing capacity (thus degrading performance), rather than purchase additional capacity. Effectively supporting increased usage will likely require a mechanism to ensure provision of additional capacity at affordable prices. |
| Source: DBCDE 2010, *Australian Broadband Guarantee*, viewed 2 February 2010, <http://www.dbcde.gov.au/broadband/australian_broadband_guarantee> |

There are two drivers of the high cost of satellite broadband services:

- Infrastructure costs: While the ongoing operating expenses of a satellite solution are relatively low, the upfront capital costs of deploying the satellites, earth stations, associated equipment and backhaul links are high. A satellite provider would need to charge high prices for bandwidth to earn a commercial return, with these high wholesale prices likely translating into unaffordable retail prices for end users.
- CPE costs: The high cost of CPE equipment and installation is also a significant barrier to offering an affordable service. Passing on CPE costs to end-users in full, whether as a single up-front payment or spread over the duration of the service contract, would result in a service that is not affordable to end users.

The capital costs of launching two Ka-band satellites should be borne by NBN Co as part of its overall capital expenditure budget, with Government stipulating that NBN Co charge wholesale prices for bandwidth that facilitates affordable retail offers. As described in Section 5.3.3, NBN Co should offer satellite services at Layer 3 on a wholesale-only basis. The exact characteristics of the pricing architecture should be determined by NBN Co, for example by pricing on a retail minus basis, with reference to target retail pricing.

The cost of end-user CPE hardware and installation incurred on customer acquisition or contract renewal can be paid by NBN Co as the satellite operator, as modelled in the Implementation Study's base case. Alternatively, the cost can be covered by a separate subsidy program under which a customer acquisition payment covering CPE costs is made to retailers on customer acquisition, analogous to the current ABG program (Exhibit 5–16). Both models can ensure retailers are incentivised to enter the market and price services affordably to end-users.

Customer acquisition payments to retailers should be designed to ensure retailers actively market affordable, high-quality broadband services throughout the targeted satellite coverage area. This means:

- **Designing to drive take-up.** The payment should cover up-front CPE and installation costs to enable retailers to capture a fair margin on an ongoing basis.
- **Recognising cost to serve differences.** Payments should be tiered to recognise the increased costs of installing CPE in very remote areas and ensure effective marketing of services to those areas.
- **Securing high service quality.** The scheme should include mechanisms to ensure provision of high-quality services to subscribers. For example, retailers receiving the customer acquisition payments can be required to purchase a defined capacity per subscriber that guarantees a minimum quality of service standard is delivered.
- **Providing clarity on rules of engagement.** Clear guidance should be provided on an individual customer's eligibility for NBN-funded CPE, particularly whether customers who have accepted CPE for a fixed-wireless service qualify to receive CPE for a satellite service as well, and vice versa.

**Recommendation 44.** That Government ensure affordability of next-generation satellite broadband services for premises underserved by other technologies through a program that funds satellite CPE costs incurred by retailers and guarantees a high quality of service.

Pricing and service levels will be important competition and demand management levers, and retail service providers should be provided with an appropriate level of service and pricing flexibility to enable effective demand and revenue management of satellite services. Specifically, the service provider should be free to define reasonable product and price differentiation to support commerciality and consumer choice beyond the requirement for an affordable entry-level product and a product compliant with Government's 12 Mbps target.

### 5.3.6 IMPROVING SATELLITE SERVICE IN THE NEAR TERM

There are two primary mechanisms to improve satellite service in the near term, prior to the switch-on for Ka-band services that is at least 3 years away:

- Increasing bandwidth supply at current prices by procuring Ku-band capacity at lower cost
- Improving Customer Premises Equipment (CPE)

This section explores these two mechanisms.

#### Increasing Ku-band bandwidth supply

Current provisioned average data rates under the ABG program are low (less than 10 kbps) compared to about 35 kbps typical of fixed-line DSL customers. As previously discussed, this may simply reflect lower use of high-bandwidth Internet applications by satellite broadband customers currently, however over time the amount of bandwidth purchased by retailers and provided to end users is likely to become a bottleneck given the high cost of this bandwidth.

Increasing bandwidth supply to customers is therefore expected to be a key way to improve broadband performance. Fortunately, existing Ku-band satellites serving Australia have spare capacity available to enable such near-term improvements.

Increasing bandwidth supply can be achieved by:

- Negotiating lower prices from satellite providers to reduce the cost of bandwidth, enabling services to be improved at no additional cost to end-users;
- Increasing the volume of bandwidth purchased per subscriber at current prices, requiring additional expenditure.

If Government does not have appetite to increase the current ABG subsidy levels, the former option is most attractive. This can be achieved by Government centrally procuring satellite capacity on behalf of all retailers, leveraging the ABG program's scale to secure lower prices than currently achieved by retailers negotiating individually. It can then manage bandwidth supply to ensure that promised service quality levels are delivered. Alternatively, Government could have NBN Co do this on its behalf.

## Improving customer premises equipment (CPE)

New satellite modems can enable peak data rates more than 6 times greater than some existing modems in use today.[151] Additionally, new modems can have twice the spectral efficiency of existing modems, enabling twice the data rate to be provided with no increase in satellite bandwidth leased. For users with older, low performance modems, replacement can enable a significant improvement in broadband performance.

Ensuring that investments in CPE for interim Ku-band satellite solutions are usable for future Ka-band satellites is challenging. Ku- and Ka-band services operate at different frequencies, will utilise different satellites, and satellite systems must be designed as end-to-end integrated solutions to function effectively. The outdoor unit (comprising an antenna dish, low noise block down converter and block up converter) that enables signal reception and transmission is specific to a given frequency band, and would need to be replaced on migration from a Ku- to Ka-band. While it is possible to design dual band Ku/Ka antennas, in practice issues such as the uncertainty of the future orbital location of Ka-band satellites make this difficult, meaning that new Ku antennas would also require replacement on migration to Ka services.

Satellite modems are capable of operating on both Ka and Ku frequency bands, meaning that modems upgraded or installed as part of a near-term Ku-based improvement program—if properly designed—would not necessarily need to be replaced when next-generation Ka satellites begin operation.[152] This functionality should be a design objective for interim solution CPE as it has the possibility to reduce costs of migrating customers to next-generation services by about $350 per customer,[153] depending on individual model costs.

151 Industry interviews

152 All elements of a satellite system (gateways, satellite and CPE) must be carefully designed to function as an optimised system, meaning the design for a modem must be carefully selected. Any provider selected for the project would need to design the modem and its outdoor interface together to ensure effective functioning in current Ku- and future Ka–band setups

153 Industry interviews

# 5.4 Facilitating development of a high-speed wireless broadband market

Wireless technologies have a substantial role to play in delivering broadband services to the final 10 percent of premises.

Unlike satellite and fibre, the wireless market has multiple operators with existing infrastructure. Currently however, the business case to provide wireless broadband to much of the final 10 percent at the data rates Government envisages is not viable for these operators. This is due to the high cost of backhaul, the relatively low number of subscribers per wireless tower and the low overall revenue pool available.

Incentives are therefore needed to encourage and accelerate provision of high-speed broadband in these areas. As with the satellite solution, a two-part approach should be pursued to deliver both an immediate improvement and a long-term path for market development.

This section covers four topics:

5.4.1 Implementing a fixed-wireless network to deliver at least 12 Mbps

5.4.2 Understanding cost and affordability of a fixed-wireless network

5.4.3 Enhancing mobile broadband competition

5.4.4 Providing competitively-priced backhaul for wireless.

### 5.4.1 IMPLEMENTING A FIXED-WIRELESS NETWORK TO DELIVER AT LEAST 12 MBPS

To ensure delivery of a wireless network capable of delivering a 12 Mbps peak data rate to a substantial portion of the final 10 percent in the near term, Government should run an open tender process for a provider (or providers) to build and operate a fixed-wireless network that meets specified broadband coverage targets. Detailed geospatial cost modelling conducted by the Implementation Study suggests this network should cover premises in the 94$^{th}$ to 97$^{th}$ percentiles, subject to confirmation based on NBN Co’s own geospatial modelling and network planning.

Participating parties would submit a proposed network design, parameters of proposed service offerings, timing and milestones for the build-out of the network as well as required Government expenditure to deliver the outcomes specified.

## Using a tender process to achieve an efficient outcome

Government has several options to deliver a fixed-wireless network. For example, it could instruct NBN Co to build the network; instruct NBN Co to run a tender process; run a tender process in which NBN Co participates; or run a tender process in which NBN Co does not participate. The Implementation Study believes the last of these options is the preferred approach for several reasons:

- Industry participants are better positioned than NBN Co to construct the network as they would be able to construct and operate the network at a significant discount to NBN Co, by making use of existing assets (e.g. towers, backhaul and spectrum) and expertise (e.g. existing wireless network engineers and technicians). For some operators there would be the added incentive of protecting against loss of revenues.
- If an industry participant constructs the network, they can offer both wholesale and retail services, preventing the potential retail market failure that might result if NBN Co builds a wholesale-only network, given that some communities of users will be small and remote and potentially unattractive to retailers.
- If a commercial tender process is run, Government is better placed to run the tender than NBN Co since it can provide objectivity (preserving the right to ask NBN Co to build the network as a fallback in the event of an unsuccessful tender), and is the logical entity to provide oversight after the tender is executed.

The tender should start with an expression of interest (EoI) process to assess interest from the market and help inform the tender design, particularly in light of previous experience tendering for the provision of a fixed-wireless network under the Broadband Connect program. Government should also consider alternative approaches, such as a competitive grant, that may allow more flexibility in dealing with interested parties. In the design of the tender, Government should be flexible on technology, given both WiMAX and LTE technologies could deliver on Government's objectives (Exhibit 5–17 below)

If a new fixed-wireless network is constructed, it is also likely to be suitable for providing mobile services. While this is not the primary aim of the network, the winning tenderer(s) (or parties) should be allowed to provide roaming or other mobile services if they are consistent with the tender agreement (e.g. do not reduce fixed-wireless service performance). In practice, however, a network covering only 4 percent of the population is likely to have limited utility for mobile services without significant network extension.

NBN Co should not participate in this tender process directly due to concerns over the impartiality of government owned entities competing with private companies in a tender. However, Government should ask NBN Co to provide an initial estimate of the costs it would incur to provide such a network (one such estimate has already been provided to Government as part of the Implementation Study). This will serve as a valuable reference point when evaluating the tenders received. In the unlikely event that no acceptable

Exhibit 5–17. Comparison of LTE and WiMAX

**Comparison of LTE and WiMAX**

4G wireless technologies deliver high-speed broadband performance using advanced techniques including sophisticated antenna arrays (e.g. 4x2 MIMO), large frequency bands up to 20 MHz per sector, all-IP flat networking architecture, and advanced time and frequency division multiplexing (TDD and FDD).

Both 3GPP and WiMAX technology families are developing 4G upgrades:

- 3GPP (GSM), developing the LTE standard;
- IEEE 802.16 (WiMAX), developing mobile WiMAX R2 (802.16m).

Both standards can enable peak broadband data rates of 100 Mbps to be delivered in optimal conditions and enable a significant advance in performance over today's wireless technologies. 4G WiMAX equipment is already available, and the first commercial LTE service was recently launched by TeliaSonera in Sweden.

Existing mobile operators in Australia are expected to make LTE the technology of choice for mobile wireless broadband for a number of reasons:

- LTE is expected to enjoy greater take-up and usage internationally, leading to larger production volumes which will drive innovation and reduce equipment costs;
- The 700 MHz spectrum that is being freed up by the switch from analogue to digital television is expected to be a popular spectrum band for the implementation of LTE internationally, leading to a large equipment ecosystem at this frequency;
- The total throughput of a tower is increased through multiplexing techniques and, hence, there is sufficient capacity to serve a higher number of subscribers with higher speeds.

WiMAX is associated worldwide with higher frequencies (2 GHz and above), with metropolitan WiMAX network roll-outs in a number of markets including Perth and Adelaide.

The appropriate standard for a fixed-wireless network within the final 10 percent will be determined by the spectrum available for operation, the economics of the standard at that spectrum and the expertise of the company tasked with delivering the service.

Both standards can effectively deliver high-speed fixed-wireless broadband.

Source: Implementation Study

commercial bid emerges, Government should reserve the right to instruct NBN Co to build the network, in which case Government may also need to contemplate incentives to encourage retailers to enter some parts of the market.

The Implementation Study believes the tender process is likely to generate viable bids based on both the analysis of the current market and the experience of the Broadband Connect tender. Several participants in the market are likely bidders, having the necessary expertise, and being in a position to benefit from either monetising existing assets or protecting against the loss of existing revenues.

Exhibit 5–18. Implications of spectrum choice for fixed-wireless service design

**Implications of spectrum choice for fixed-wireless service design**

The choice of spectrum for the fixed-wireless service design has important commercial and operational implications. It can be delivered across any range of spectrums, including 1.5 GHz, 2.7 GHz or 850 MHz. For the purposes of cost modelling, the Implementation Study evaluated two specific options of using 2.3 GHz spectrum and 'digital dividend' 700 MHz spectrum (126 MHz of spectrum from 694–820 MHz), the latter of which will likely become available no earlier than 2014. While a range of other frequencies could be used for providing fixed-wireless services, these two spectrum options have been modelled as representative outcomes.

Both frequencies have advantages for use in providing a fixed-wireless service:

- **Fast deployment over 2.3 GHz.** 2.3 GHz—or other spectrum available in the near term—enables fast deployment, allowing customers within the network footprint to experience a significant increase in broadband performance in the near term. 700 MHz spectrum, by contrast, is likely to become available in late 2014 at the earliest, after national restacking of the spectrum following the analogue television switch off. This precludes using 700 MHz spectrum to deliver near-term broadband improvement
- **Low cost of 700 MHz.** 700 MHz spectrum has a lower cost of deployment than 2.3 GHz spectrum due to the larger cell sizes enabled by the lower frequency. With an external antenna, 12 Mbps broadband data rates can be delivered up to 14 km from the cell site using 700 MHz spectrum, but only 7 km using 2.3 GHz spectrum.

However, 700 MHz spectrum incurs a high opportunity cost, unlike 2.3 GHz spectrum. 700 MHz spectrum is desirable for mobile voice and broadband applications, due to its ability to provide good indoor coverage. The preference of operators consulted during the Implementation Study is to reserve 700 MHz spectrum for non-fixed applications. As a result, dedication of part of the 700 MHz spectrum to provide fixed services is likely to impair spectrum auction revenue significantly.

On balance, the Implementation Study believes that the benefits of utilising spectrum in the 2+ GHz range, should it be available in the near term, outweigh those of using 700 MHz spectrum, despite the higher network build costs. While 700 MHz spectrum would enable a more capital-efficient network build than 2+ GHz spectrum, its opportunity cost and lack of availability prior to 2014 makes 2+ GHz a better choice to achieve near-term improvements.

Source: Industry interviews; Implementation Study

In designing the tender process, Government should ensure the availability of commercially-available spectrum for the purposes of building the fixed-wireless network. Exhibit 5–18 discusses some of the tradeoffs around the choice of spectrum to use in network design.

While spectrum in the 2.3 GHz range is likely to be commercially available as one example, Government may need to consider further action to free suitable spectrum if required. Given the risk of limited spectrum availability, Government should also guarantee spectrum renewal rights for the fixed-wireless network operator.

The successful tenderer(s) would be required to offer both a wholesale MVNO service as well as a retail offering. Similar to the satellite wholesale service, the MVNO service would be provided by default at Layer 3. As part of the tender specification, Government should also consider whether to require tenderer(s) to offer support for a Layer 2 tunnelling protocol (L2TP) that would enable Layer 2 data streams to be provided over the network.

The required retail offering is intended to guard against potential failure of the retail market for customers in extremely remote areas. However, in the case of an NBN Co build, NBN Co should not be required to provide retail services due to the substantial additional complexity this would impose. Instead, additional customer acquisition incentives could be provided to encourage entry by other retailers.

The successful tenderer(s) should be required to provide a description of an expected upgrade path for the implemented technology. Additionally, Government should subject data rate conditions imposed on the fixed-wireless operator to regular reviews. These reviews would ensure that fixed-wireless network data rates are consistently upgraded to reflect advancements in wireless technologies.

Previous experience has shown that designing a successful tender process for the provision of fixed-wireless services is not straightforward. To maximise the likelihood of success, the tender should:

- Allow the tenderer(s) to identify the 4 percent of total premises they would cover beyond NBN Co's fibre footprint, using the filtered geospatial data provided by NBN Co and approved by Government. Once the tender is concluded, NBN Co can configure its satellite to serve the remaining 3 percent. This permits maximum re-use of existing infrastructure and alignment with retail interests.
- Require tenderer(s) to define specifications of proposed offers in detail, including minimum average data rates and busy-hour usage assumptions for inclusion in the network design. Both an entry level product (e.g. at least 4 Mbps peak data rate) and a 12 Mbps peak data rate service compliant with Government objectives should be required. To ensure affordability of the entry level product, the price should be broadly consistent with entry-level pricing for fibre and satellite offerings, and set with reference to mobile broadband pricing. A mechanism for adjusting the price over time would also be required, and could vary from a cap on the annual price increase permitted to a regulatory mechanism administered by the ACCC.
- Build in flexibility for inevitable adjustments in coverage boundaries. As NBN Co deploys its fibre network, it may not be exactly as originally planned. The tender needs to contemplate fibre being deployed to some wireless areas, and the provision of wireless to service gaps in the fibre network.
- Have NBN Co deploy additional transit backhaul to wireless tower locations where required. This will reduce the cost of building the wireless network and remove

backhaul bottlenecks. This backhaul should be offered to other operators on an equivalent, open-access basis.

Government should consider a hybrid option for contract delivery, for example milestone payments combined with payments when customers sign on. This can create an ongoing incentive to bring people onto the network while allowing the provider enough cash flow upfront to finance the investment.

**Recommendation 45.** That an Expression of Interest (EoI) and tender process be conducted for a commercial provider to build and operate a fixed-wireless network, specifically:

1. That the network offer services on both a wholesale and retail basis beyond the fibre footprint to cover 4 percent of total premises;
2. That the services include an offer with at least 12 Mbps peak data rates and high average data rates, with service characteristics subject to periodic review; that the services include an entry-level offer providing a high-quality broadband experience at a specified price comparable to entry-level pricing on the fibre and satellite footprints; that Government specify as part of the tender a mechanism for adjusting prices of the entry-level and 12 Mbps offerings over time, for example via a cap on annual price rises or another regulatory mechanism;
3. That the tenderer(s) describe an expected upgrade path for the implemented technology;
4. That spectrum renewal rights for the fixed-wireless network operator be guaranteed;
5. That, in the absence of an acceptable bid, NBN Co be required to build the network and offer services on a wholesale-only basis.

### Upgrading customer premises equipment as part of the network roll-out

As described in Section 5.1.2, use of an external antenna can allow peak data rates of 12 Mbps to be received up to seven times further from the cell site than without an external antenna.

The successful tenderer(s) should therefore be required to provide fixed external antennas to premises where necessary to meet minimum service requirements. This could be based on the distance of a premises from a wireless tower or base station. The type and cost of this CPE should be specified as part of the tender, with CPE costs reimbursed as customers are acquired, similar to the approach currently employed in the ABG program.

Government will also need to decide whether to allow or require the network operator(s) to serve customers outside the 12 Mbps coverage footprint who prefer a wireless service to satellite. For example, a customer who is able to receive a low-latency 10 Mbps peak service over wireless may prefer this to a high-latency 12 Mbps satellite service.

The view of the Implementation Study is that the successful tenderer(s) should not be required to serve such customers—as this would add significant complexity to network dimensioning—but should do so where it is reasonably practical and would not negatively affect network performance. These customers would not receive any minimum service guarantee relating to peak data rates.

To assist with this assessment, NBN Co should be required to report regularly on the performance of the satellite service and the successful tenderer(s) on the performance of the fixed-wireless service as implemented.

### 5.4.2 UNDERSTANDING COST AND AFFORDABILITY OF A FIXED-WIRELESS NETWORK

For the purpose of assessing the business model for NBN Co, we have taken the conservative position of modelling a fixed-wireless network build by NBN Co. As discussed above, we believe that a tender process will succeed and result in lower costs to build than NBN Co could achieve.

The Implementation Study has considered the options of building a fixed-wireless network using either the 2.3 GHz or 700 MHz spectrum. The cost modelling assumes that 2.3 GHz spectrum would be used, which adds a second layer of conservatism as more towers would be required to provide the same level of service compared with a 700 MHz solution.

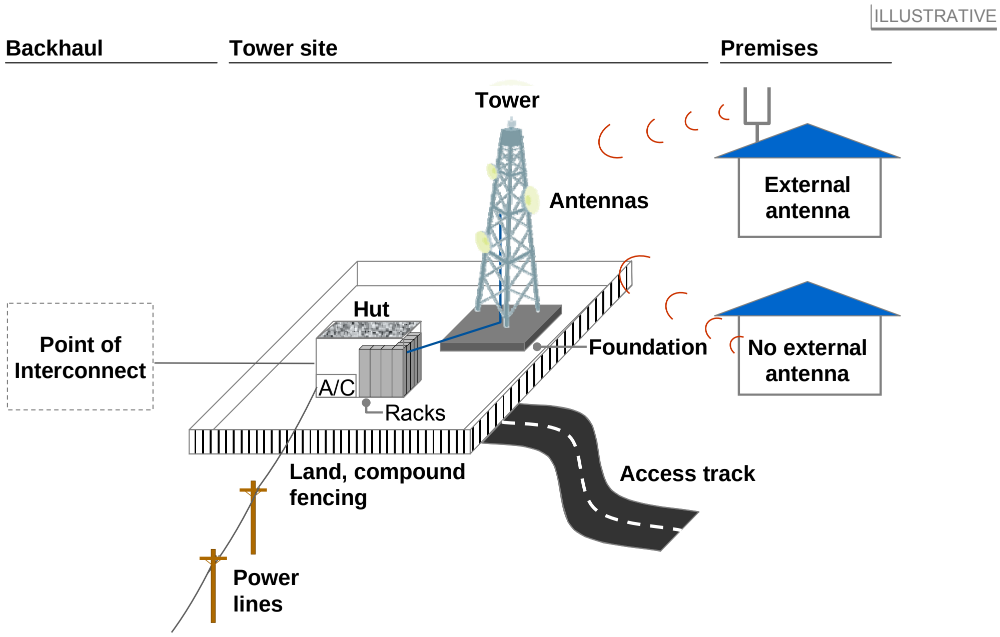
The fixed-wireless network has four major cost components: the towers, the CPE, backhaul and the cost of spectrum licences. Exhibit 5–19 provides a high-level overview of a wireless access network.

#### Estimating wireless tower costs

Cost of a new-build single tower include:

- Preparing and designing the site, including civil works to create road access, build a compound around the site and provide power by connecting to the electricity grid
- Building the tower, including foundations, the steel lattice and the antennas that transmit/receive signals
- Purchasing and installing the active components that transmit and receive wireless data via feeder cables and the antenna
- Building a hut (external building) in which the active electronics are stored

Exhibit 5–19. High-level wireless access network schematic




SOURCE: Implementation Study

Substantial savings are possible if towers are shared between network operators. Today, the major mobile network operators frequently share towers, and a number of towers are owned by independent third parties that specialise in providing tower infrastructure to mobile network operators.

Estimating the costs of providing a fixed-wireless network to meet defined coverage objectives necessitates detailed geospatial modelling. Both the distribution and density of premises affects the number of premises that can be served per tower, which in turn has significant implications for the level of fixed-investment per subscriber. Exhibit 5–20 discusses the detailed approach to geospatial analysis that the Implementation Study has taken in its modelling.

Exhibit 5–20. Geospatial analysis of the number of towers required

**Geospatial analysis of the number of towers required**

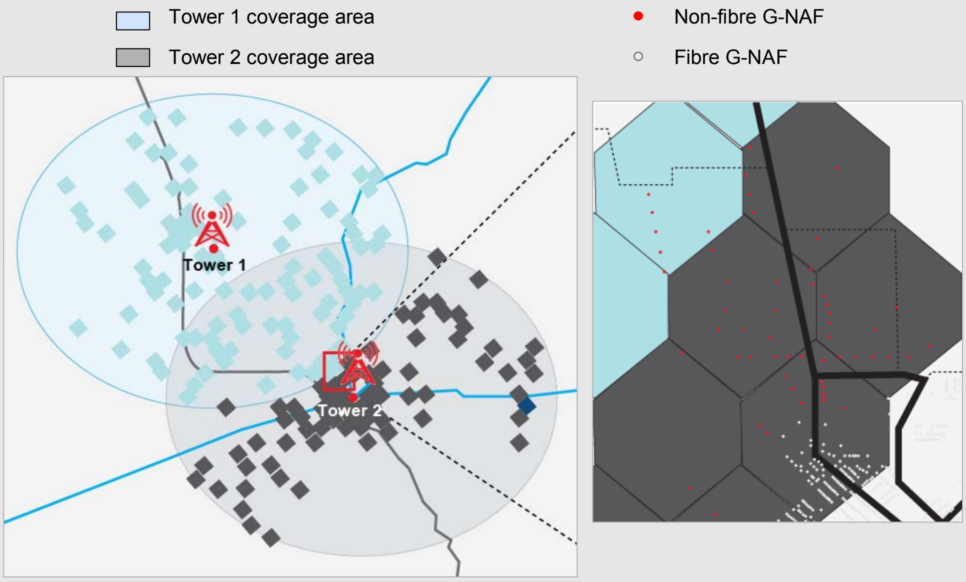
We assessed the number of towers that NBN Co would require to deliver peak speeds of 12 Mbps to the 94$^{th}$ to 97$^{th}$ percentiles on the basis of the LTE wireless network parameters defined in Exhibits 5–4 and 5–5.

Geospatial modelling is required to identify the distribution and density of premises in areas that require wireless coverage and to determine how many towers are required to serve the premises.

First we divided the country into equal sized hexagons (1 km by 1.5 km) to cover land areas outside of fibre coverage. Towers were then placed, starting at the centre of the most dense hexagon as a seed and repositioning the tower to keep adding the next most dense adjacent hexagon. The algorithm ensures that the maximum cell radius is not breached and also generates a second tower when the total number of premises being served by a tower begins to compromise the service levels required.

We illustrate the coverage areas of two towers below, where the hexagons highlight areas with non-fibre premises. In this example, Tower 1 was first placed and filled to its capacity limit of 500–600 premises passed, then Tower 2 was added to give coverage to remaining premises that are either outside the 7 km radius or would breach the capacity limit.

**Illustration of geospatial tower placement**




SOURCE: Implementation Study

A network operator may choose to rebalance the load on each tower or adjust locations of the towers where there are two or more in close proximity, however this was not required for the purposes of cost modelling.

A large number of existing towers in non-fibre areas were identified and these sites were preferred when locating towers. It is likely that the fixed-wireless network operator may not be able to gain access to all existing towers, and we conservatively assume that they would need to build a new tower in an adjacent location to an existing tower around half of the time. We estimate that a total of around 1,100 towers (containing a mix of existing and new towers) will be required to serve the 94$^{th}$ to 97$^{th}$ percentiles by wireless with the 2.3 GHz spectrum.

We used commercially available datasets, including the Geocoded National Address File (G-NAF) for the location of premises, and the ACMA Spectrum Licensing RadDEM database for the location of existing mobile base stations.

Source: Implementation Study

### Estimating customer premises equipment and installation costs

The cost of the customer premises equipment depends whether a high-gain antenna is required to achieve 12 Mbps. Based on geospatial modelling of the cell radius within which 12 Mbps can be delivered indoors using 2.3 GHz spectrum, we estimate that 80% of premises in the fixed-wireless coverage area will require an outdoor high-gain antenna in order to receive a 12 Mbps service. The components of wireless CPE cost are:

- Indoor modem;
- Outdoor high-gain antenna;
- Cabling and installation costs, which are only incurred when a high-gain antenna is required

### Estimating backhaul costs

The Implementation Study recommends in Section 5.4.4 that NBN Co should build fibre backhaul to existing tower sites as well as new proposed locations nominated under the fixed-wireless tender proposal. The cost of building this backhaul network has been estimated on the basis of tower locations that would be required to deliver a 12 Mbps peak service using LTE with 40 MHz of spectrum in the 2.3 GHz range.

The main components of fibre backhaul are:

- Trenching, ducting and laying the fibre
- Purchasing and installing additional active equipment to transmit the total throughput of towers

Exhibit 5–21 discusses in detail the geospatial analysis of backhaul requirements.

Exhibit 5–21. Geospatial analysis of backhaul requirements

| **Geospatial analysis of backhaul requirements** |
|---|
| After the optimal locations for all towers were identified, we used a Dijkstra algorithm to determine how to connect towers at minimum cost.<br>The process was completed in two stages:<br>1) Towers within 5 km of a fibre exchange or a fibre backhaul ring were first connected<br>2) Remaining towers were then connected to the towers that were connected first, rather than to the nearest fibre exchange or fibre backhaul ring.<br>The fibre backhaul network modelled to wireless towers follows a single point link formation, rather than fibre rings that provide redundancy. |
| Source: Implementation Study |

## Estimating spectrum licence costs

Spectrum access costs depend on the frequency band that is selected for the deployment of the fixed-wireless network. AUSTAR proposed to sell its 2.3 GHz spectrum to OPEL in January 2008 for $65 million.[154] This provides a useful reference point for evaluating potential spectrum licence costs for the purposes of our modelling.[155]

## Managing price levels in wireless markets

If NBN Co—or another provider—builds and operates a fixed-wireless network beyond the fibre footprint, its broadband products will compete against mobile broadband products from existing operators as well as potential fixed-wireless products from mobile operators, should they choose to offer them. The fixed-wireless network operator will need to offer prices to compete effectively with existing wireless offers. As with fibre, estimating user willingness to pay a premium price is difficult.

For most end-users, the fixed-wireless network is likely to offer significantly higher average data rates due to denser tower infrastructure and available spectrum that will be used primarily for fixed-wireless broadband services. These advantages will be further augmented by the provision of ubiquitous fibre-backhaul to towers (see 5.4.4). However, the resulting difference in service quality may be difficult to communicate and may not be recognised by some end-users. This will limit the fixed-wireless operator's ability to charge a premium for its services in the near term. In the medium to longer term it is likely that the value of faster speeds to end-users will dramatically increase.

### Managing retail pricing of fixed-wireless products

Participants in the tender process should be required to comply with a condition requiring an entry-level offer delivering a specified minimum performance level (e.g. at least 4 Mbps peak data rate) at a price specified by Government as part of the tender requirements. The price of this offering should be broadly consistent with the entry-level pricing for fibre and satellite offerings, and be set relative to the price of competing mobile broadband products as described above. The minimum performance level required should be reviewed over time as developments in technology occur.

The Implementation Study believes that the fixed-wireless network operator should be free to define reasonable product and price differentiation over and above the entry-level product, with a product compliant with Government's 12 Mbps peak data rate objective required.

154 AUSTAR 2008, Annual Report

155 This cost could potentially be incurred by NBN Co if it builds the network itself, or by another operator, depending on the outcome of the tender process

### Managing wholesale pricing of fixed-wireless products

As we discuss in Section 5.4, as part of the tender conditions to build the fixed-wireless network, the operator should be required to provide Layer 3 MVNO wholesale products to complement the operator's retail offering.

The use of cost-plus pricing mechanisms to set wholesale price levels in this market environment is challenging. For a new operator with a small customer base, the economic price is likely to be above the price imposed by market dynamics. Additionally, true cost levels are distorted by the influence of Government subsidies.

A more feasible price setting mechanism is a retail-minus approach. Under retail-minus pricing, wholesale prices are set to provide retailers with a margin below the expected retail price of the product. Margins should be set to enable the commercial viability of retailers and a viable retail market.

### Ensuring long-term affordability of wireless broadband products

It is important to ensure long-term affordability of wireless broadband products to enable continued take-up and the achievement of high broadband penetration. This will require ongoing review of the pricing of the entry-level fixed-wireless broadband product.

Consistent with the initial pricing, prices should be kept broadly consistent with the entry-level pricing of fibre and satellite offerings. Price-setting mechanisms could vary from an explicit cap set on the annual price increase permitted to a mechanism administered by the ACCC (e.g. maintaining equivalence to fixed broadband pricing in metro regions).

Current Telstra retail pricing caps, for example, are regulated under the *Telstra Carrier Charges - Price Control Arrangements, Notification and Disallowance Determination No. 1 of 2005*, administered by the ACCC. A similar legislative arrangement could apply in relation to the pricing of the entry-level fixed-wireless broadband product.

## 5.4.3 ENHANCING MOBILE BROADBAND COMPETITION

The Implementation Study believes that, over time, Government should facilitate infrastructure-based competition in the wireless broadband market by encouraging expansion of the footprint that is served effectively by commercial mobile wireless operators.

In particular, the upcoming availability of ‘digital dividend’ 700 MHz spectrum provides an opportunity for Government to ensure that mobile broadband coverage in regional and rural areas is improved. The 700 MHz spectrum is a valuable resource for mobile operators, with the large spectrum blocks expected to enable significantly improved mobile broadband services. This spectrum is also being used by a number of international

Exhibit 5–22. Using carrier licences for coverage conditions

| Using carrier licences for coverage conditions |
| --- |
| Under Section 60 of the *Radiocommunications Act 1992*, ACMA has discretion to set procedures for allocation of spectrum, such as the 700 MHz spectrum on which we expect LTE to be implemented.<br><br>It is not established practice to include coverage or quality of service conditions in spectrum licences, and it is more effective to embed conditions in carrier licences:<br>■ The Minister has powers to set carrier licence conditions under Section 63 of the *Telecommunications Act 1997*, granting the Minister direct control over the definition of conditions and their ongoing supervision.<br>■ Carrier licence powers allow the Minister to remove or restrict a right or obligation<br>■ Conditions can distinguish between carriers, including on the basis of the service offered in different geographies. |
| Source: Telecommunications Act 1997; Radiocommunications Act 1992; Implementation Study |

operators for LTE deployment,[156] so is expected to have a healthy and substantial ecosystem going forward.

Deployment of LTE technology in the final 10 percent areas would increase the performance of wireless broadband services significantly. To encourage this deployment, Government should add carrier licence conditions to the 700 MHz spectrum auction to require network operators to implement future technology upgrades in rural/regional areas in parallel with metropolitan areas. Exhibit 5–22 sets out the logic for preferring carrier licences for this purpose as opposed to spectrum licences.

Prior to the auction, the value of requiring one or more successful bidders to expand their coverage footprint should also be reviewed, in conjunction with a consultation process with industry.

Prices for mobile services tend to be uniform nationally and are likely to remain so for the foreseeable future. However, in the event that prices in metropolitan and rural/regional areas diverge too greatly, Government should conduct a review of options to ensure national affordability (e.g. regulatory action or subsidies for high-cost areas).

**Recommendation 46**. That carrier licence conditions associated with the 700 MHz spectrum be added to require network operators to implement future technology upgrades in rural/regional areas in parallel with metropolitan areas; that Government review prior to the 700 MHz auction the value of requiring one or more successful bidders to expand their coverage footprint.

156 For example, Verizon in the USA is currently rolling out LTE over 700 MHz (C-Block) spectrum. Verizon plans to begin the commercial roll-out of LTE in 2010, and to upgrade its existing 3G network to 4G LTE by the end of 2013 (Verizon, *Verizon's $17 Billion Network Investment in 2009 Pays Off,* media release, New York, 29 December 2009)

### 5.4.4 PROVIDING COMPETITIVELY-PRICED BACKHAUL FOR WIRELESS

The lack of access to competitively priced backhaul at adequate capacity is expected to be one of the largest barriers to expanding high-speed fixed-wireless coverage beyond the fibre footprint. Discussions with stakeholders have indicated that provision of backhaul is one of the key considerations in network providers' decisions as to how far they will roll out their networks.

Whereas base stations in metropolitan areas frequently connect via fibre links, most towers in the final 10 percent connect via microwave backhaul, which offers lower capacity and performance characteristics.

Moreover, market prices for backhaul capacity remain very high in regional and remote areas. As discussed in Chapter 6, the economics of providing backhaul across vast distances to service a small number of regional and remote premises has produced natural monopolies on many routes and uncompetitive pricing.

To help alleviate this bottleneck, where requested by the fixed-wireless provider(s), NBN Co should extend fibre transit backhaul links to existing towers and new tower sites needed to provide coverage to the designated footprint. Based on Implementation Study modelling of a fixed-wireless network covering the $94^{th}$ to $97^{th}$ percentiles, this may require providing up to 3,500 km of additional fibre links from existing fibre backhaul networks required to serve 93% of the population with fibre. This transit backhaul should be offered to all operators and priced at the same rates as transit backhaul within the fibre footprint.

> **Recommendation 47**. That Government instruct NBN Co to extend transit fibre backhaul to existing towers and new tower sites needed by the fixed-wireless network operator to provide coverage in the designated areas (e.g. between the 94th and 97th percentiles); this transit backhaul to be offered to all operators and priced at the same rates as transit backhaul within the fibre footprint.

# 5.5 Ensuring national availability of voice services

Copper-based fixed lines are currently the primary delivery method for voice services to customers in the final 10 percent and are expected to remain so in the near term. While a detailed consideration of voice services and treatment of the USO by Government is beyond the Implementation Study's scope, it is important to understand the implications for voice of migrating customers to wireless and satellite broadband solutions.

Within the fibre footprint, as traffic migrates onto the NBN, the copper network is expected to be retired over time. As the amount of copper retained across the country decreases, the cost per premises to maintain it will increase.

Telstra, or whoever bears the voice USO responsibility in the future, will face a choice: continue to maintain a small and expensive copper network to provide voice services (or, potentially, if they are not the copper network owner, pay the owner to maintain the copper network), or utilise alternative technologies to deliver voice services to the majority of customers in the final 10 percent.

These issues are discussed in the following sections:

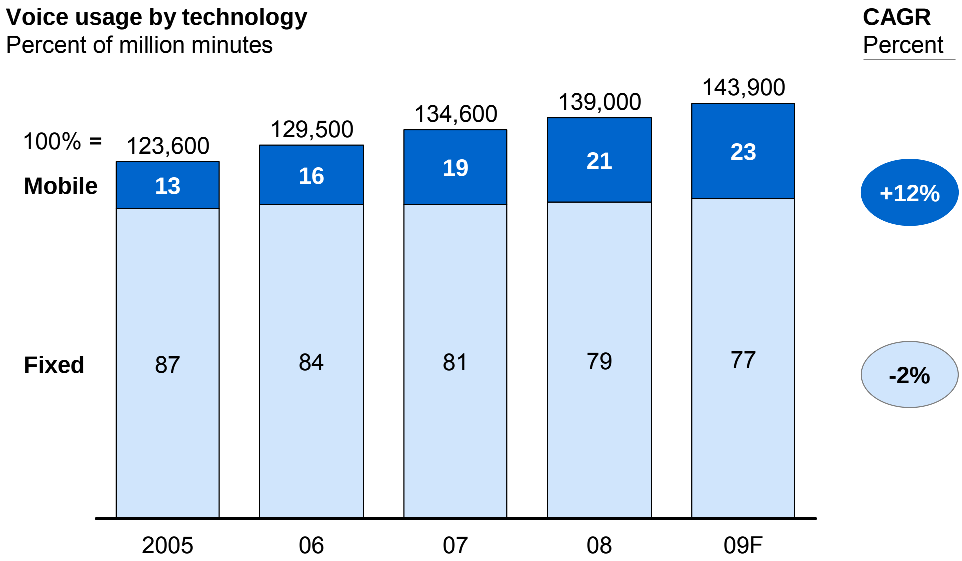
5.5.1 Understanding the voice service landscape

5.5.2 Exploring options for voice service provision.

### 5.5.1 UNDERSTANDING THE VOICE SERVICE LANDSCAPE

Fixed-line technologies are the predominant platform for delivering voice services in Australia. Nearly 90 percent of households currently subscribe to a fixed telephony service, compared to 65 to 70 percent that subscribe to broadband services. Fixed-mobile voice substitution is increasing, as shown in Exhibit 5–23, but fixed-line telephony will remain a core telecommunications service for many Australians in the coming years.

Exhibit 5–23. Fixed-mobile substitution in Australia




SOURCE: Ovum; Quantifica

Today, 99.75 percent of all premises are capable of receiving voice over Telstra's copper access network, with low latency and high availability providing a high quality of service. In addition, Telstra implements a number of copper-based solutions to serve remote premises, including pair-gain systems that enable service for long loops and serve multiple customers over a single copper line.

Radio and—for a small number of premises—satellite technologies provide voice services to the remaining premises.

- Radio concentrators are the most common radio-based solution. Premises in remote communities connect via fixed copper lines to small local exchanges (Remote Line Concentrators or RLCs). RLCs, in turn, are connected to copper exchanges using relatively low frequency wireless peer-to-peer connections.
- Single/Dual Channel Radio connections are used to connect very remote premises far from any communities or clusters of other premises, with 1 to 2 voice channels transmitted over VHF frequencies.
- GEO satellite phones provide voice services to some isolated premises. Latency is high due to the long distance signals travel between the Earth and satellite. Calls between satellite subscribers experience a delay of about 1 second due to the signal travelling twice to and from the satellite and earth between subscribers (the 'double hop').
- LEO satellite services are available and used by some consumers. LEO services are characterised by low latency and relatively high quality of voice service outdoors.

Indoor reception, however, is poor. LEO voice services are currently provided by Iridium satellites, with per-minute prices around $2.[157]

Radio and satellite infrastructures provide significantly lower voice quality than copper-based services, with high latency an additional issue reducing the user experience of GEO-based satellite services.

### 5.5.2 EXPLORING OPTIONS FOR VOICE SERVICE PROVISION

From an economic standpoint, the cost of maintaining copper lines in the final 10 percent is high, due to long runs and frequently harsh environmental conditions. As a result, it is desirable to find more economic (and acceptable quality) alternatives.

With the roll-out of fibre, it is expected that the existing copper infrastructure serving fibre areas will be shut down over time, with customers provided with the option of PSTN emulation on ONTs if they wish to continue to receive a fixed-line telephone service. This provides an acceptable copper-voice service substitute, enabling copper lines to be decommissioned without worsening end-user experience.

Outside the fibre footprint the choice is more complex. While mobile and satellite technologies support voice services, these do not always equal the quality of today's copper voice services:

- **Mobile voice.** The large and increasing share of total voice usage taken by mobile demonstrates that for many users it is already an acceptable substitute for fixed-line services. Fixed-mobile voice substitution is increasing and, additionally, technical developments are improving the call quality of wireless voice services (Exhibit 5–24). Combined with improvements in network quality, these developments are progressively removing the quality advantage historically enjoyed by fixed-line voice services.
- **Satellite voice.** Both GEO and LEO have significant disadvantages as voice platforms. The high latency of GEO services, particularly in 'double hop' situations, makes service quality unacceptable for many users. LEO services enable low latency. They suffer, however, from poor indoor reception if no external antenna is used and are high cost.

157 TR Telecom 2009, *Iridium satellite call plans: Australia*, viewed 12 February 2010, <http://www.trtelecom.com/plans-and-pricing.htm>

Exhibit 5–24. Rise in mobile call quality

**Technological developments are enabling increases in the quality of mobile voice**

Wireless technology innovations such as HD voice are improving the quality of mobile voice transmission and bringing it closer to fixed-line quality.

Mobile HD voice uses improved codecs to sample a much wider frequency range than currently sampled in 3G technologies today, sampling frequencies as low as 50 Hz and as high as 7 kHz. The result is a more realistic reproduction of sounds, providing a more ‘in-person’ feel to voice calls. Due to improvements in processing power and codec software, HD voice requires only slightly more bandwidth than the previous GSM voice codecs (12.65 kbps vs. 12.2 kbps).

HD voice is expected to be implemented by a number of operators in coming years. Industry analysts predict new developments such as HD voice will increase fixed-to-mobile substitution by removing the quality advantage historically enjoyed by fixed-line voice services.

Source: Green 2010, 'High-definition voice won't bring higher revenues for operators', Ovum, viewed 22 February 2010, <http://www.ovum.com/news/euronews.asp?id=8365>

## Options for deactivating copper in the final 10 percent

The acceptability of wireless as a substitute for copper-based voice services makes the decommissioning of many copper lines outside the fibre footprint feasible, both within the coverage area of the proposed NBN fixed-wireless broadband network and in areas covered by existing wireless operators. Most premises in the final 10 percent will be able to receive mobile voice services, with today's mobile voice coverage level of about 99 percent of the population likely to increase with an upgrade to LTE.

A number of premises that today receive copper-based voice services will, however, be unable to receive mobile voice services. Some of these premises will fall outside mobile coverage areas, while others will fall inside coverage areas but be located in coverage blackspots. While small in number, these premises will be scattered throughout the area beyond the fibre footprint. Maintaining copper-voice services to these premises will require the continuing operation of a large number of exchanges. As many exchanges may have few lines active, the cost per premises of continuing copper voice services will be very high, and alternatives should be explored.

## Ensuring fixed-line comparable pricing structures

The experience of fixed-line abandonment in many countries—including Australia—suggests mobile wireless can provide voice service quality acceptable to most users. Ensuring it is regarded as an acceptable substitute will also require matching fixed-line pricing architectures.

One potential approach is to offer home-zone fixed-line equivalent pricing in wireless areas. In this model, if a customer outside the fibre footprint wants a standard telephone service, it would be provided over the mobile telephone network but with untimed local calls offered within a zone corresponding to the user's premises. Over time, price levels would evolve with regulatory reviews of access fees and call charges as is done today.

Such a home-zone voice service would need to be available on a standalone basis to meet the needs of consumers not wishing to take broadband or other products. In addition, providers should be free to market bundled offers such as dual play offerings of fixed-wireless voice and broadband, or, potentially, offers including both fixed and mobile components. Allowing bundling enables retail price competition and innovation, and encourages retailers to pass on some of the economic benefits from serving customers with multiple product bundles.