Final report

Impacts of licensing 5G FWA and private networks in 28GHz

A review of key issues

PUBLIC

Network Strategies Report Number 42010. 5 August 2022

www.strategies.nzl.com

NETWORK STRATEGIES

Executive summary

This study explores the economic impact of deploying localised services, such as 5G Fixed Wireless Access (FWA) and 5G private networks (PN), in key fixed service (FS) / fixed satellite service (FSS) bands – in particular the 28GHz band. In view of the few and limited bands available to satellite, the main focus of the study is on economic issues involved with accommodating localised services at the expense of nationwide and global satellite services. Deployment of 5G FWA and 5G PN in the same bands as fixed and ubiquitous satellite services involves complex technical challenges. These complexities would most likely result in unnecessary higher costs and limitations for the full deployment of nationwide satellite services, as well as complicating deployment of 5G localised uses. The question facing regulators and policy-makers seeking to optimise scarce spectrum usage is whether potential benefits offered by 5G FWA and localised 5G private networks outweigh the socio-economic costs that may be incurred should satellite services be impaired.

Economic evidence from many empirical studies shows that, regardless of the technology, GDP per capita is related to broadband penetration, indicating an increase in economic output as broadband penetration increases. Some studies provide evidence that the positive economic impacts are stronger in emerging economies than in industrialised jurisdictions. Thus, from an economic welfare perspective the relevant issue is not whether mobile broadband is available to communities, but whether any reliable and affordable broadband service is available at all. The underlying technology is irrelevant.

Serious physical and technical limitations hamper the capabilities of 5G FWA / 5G PN in millimetre Wave (mmWave) bands (such as 28GHz) to serve the significant populations across the globe beyond densely populated areas. These physical limitations restrict 5G FWA / 5G private network use to niche market segments, in both rural and urban areas. Beyond urbanised areas, mmWave 5G FWA / 5G PN may only be viable for small towns with access to cost-efficient backhaul and sufficient population density that supports the business case. Independent studies confirm that the business case for 5G FWA / 5G PN is highly dependent on the costs associated with servicing particular locations. In addition to the characteristics of the target coverage area, FWA costs depend on the underlying wireless technology.

Our own case study analysis demonstrates that:

- for a deployment beyond urban areas a connectivity solution based on 5G FWA / 5G private network is around ten times more expensive per end-user than a direct satellite service
- to provide a connectivity solution for an educational facility beyond urban areas the total cost of a 5G FWA / 5G private network solution is at least six times higher than a satellite solution.

Not only can satellite broadband services be offered at substantially lower cost to bridge the urban-rural divide, the pace of deployment is significantly faster than 5G FWA / 5G private network options.

The main cost component in the satellite traffic is the cost of capacity. This is expected to decline substantially with the introduction of Ultra High Throughput Satellites (UHTS). As the cost of capacity declines, satellite services will deliver higher data usage without increasing prices and with even better speeds. Meanwhile the cost for deploying 5G FWA / 5G PN in areas beyond urban centres is dominated by civil works which is unlikely to decrease with time.

The amount of spectrum available to satellite also influences the cost of satellite services. For example, any reduction in the amount of spectrum reserved for satellite in the 28GHz band will result in a higher per-user cost of satellite capacity due to reduced economies of scale, which in turn will reduce the potential economic benefits of using satellite in cases where other technologies are clearly less cost effective. Depending on the extent of the reduction in available spectrum, the number of fixed satellite end-users able to be served may be reduced significantly.

This study has not identified a corresponding economic benefit to be gained from ceding 28GHz spectrum to 5G FWA / 5G PN, since the 28GHz band is already in use for well-established applications including Fixed Satellite Service (FSS) and Earth Station in Motion (ESIM).

The addressable market for 5G FWA is largely as a substitute for other technologies

mmWave 5G FWA technology is characterised by both limited cell coverage area, and a need for high capacity backhaul. The addressable market for 5G FWA appears to overlap existing technologies and services. The economic benefits of FWA in mmWave will only accrue on a very localised basis and should not be expected at all in circumstances where the technology is simply a substitute for another technology of comparable speed, quality and reliability.

5G private networks are essentially private micro-operators

These private networks are tailored to meet specific performance requirements and applications, and do not take a standard configuration. Innovative applications are anticipated but are yet to emerge in the market. As such, the economic value of deploying these services in mmWave is largely uncertain.

Localised 5G private networks co-existing with other services in the same band may be problematic from a spectrum management standpoint. This includes the use of 5G private networks for industrial purposes. If, as some claim, a number of these uses require preferential treatment as critical operations, deployment is better suited in bands where the same type of service is already allocated, in order to prevent interference – for example in the 26GHz band, or in any other mmWave band formally identified for 5G International Mobile Telecommunications (IMT) in the ITU radio regulations.

Another important consideration is that there is ample spectrum currently available in alternative bands to meet the requirements of 5G FWA / 5G private network use cases. Indeed extensive contiguous spectrum, already harmonised worldwide, is available for deployment not only in the mmWave bands, but also in mid band spectrum in the 3.5GHz and 6GHz bands. A total of 17.25GHz was identified for IMT by WRC-19 while the mid band spectrum in the 6GHz band is under study for IMT identification by WRC-23. Meanwhile, it is already clear that the benefits offered by a harmonised spectrum band will not be available for 5G uses in the 28GHz band.

Without the full and unconstrained 28GHz spectrum band (27.5–29.5GHz), the capacity requirements of satellite operators will be unmet causing disruption to existing services and introducing upward pressure on costs. This will negatively affect the utility of current and potential end-users. Given that services such as 5G FWA / 5G PN cannot serve as a substitute for satellite services, the net economic impact of restricting 28GHz spectrum availability for satellite use will likely be an increase in costs for satellite end-users on land and those on the move across oceans (maritime ESIM), and in the air (aeronautical ESIM). This technology plays a key role in enabling ubiquitous broadband connectivity. Moreover for unconnected communities in areas where satellite is the only viable broadband technology such increases in costs may push services further beyond their reach.

Impacts of licensing 5G FWA and private networks in 28GHz

Final report

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1 Introduction

The ITU has identified millimetre wave (mmWave) bands for International Mobile Telecommunications (IMT) services, but these exclude the 27.5-29.5GHz (28GHz) band which is already heavily used by satellite services. Around the world, significant additional investments in High Throughput Satellite (HTS) networks in the 28GHz band are currently being made. Such investments, coupled with full and unconstrained access to this spectrum band, facilitate very rapid deployment of ultra-fast broadband coverage across land, sea, and air on nationwide basis[1].

Nevertheless some 5G equipment vendors are attempting to persuade policy-makers and regulators that the assignment of parcels of the 28GHz band will be necessary to accommodate current and emerging IMT spectrum requirements, particularly in relation to Fixed Wireless Access (FWA) services and 5G private networks (PNs).

The objective of this study is to explore the impact of deploying 5G localised services, such as FWA and PNs, in key satellite bands – in particular the 28GHz band. The main focus is on economic issues involved with accommodating 5G localised services at the expense of nationwide satellite services. A potential conflict is identified between, on the one hand, maximising national economic benefits through nationwide HTS availability, and, on the other hand, setting aside spectrum in this band to accommodate terrestrial wireless broadband systems.

The report is structured as follows:

- an overview of key spectrum issues (Section 2)
- an examination of the potential economic impact (Section 3)
- a utility analysis (Section 4)
- concluding remarks (Section 5).

1 Network Strategies (2021), *Dedicating 28GHz spectrum band to satellite services*, 22 December 2021. Available at: http://strategies.nzl.com/industry-comment/dedicating-28ghz-spectrum-band-to-satellite-services/.

The views expressed in this study are entirely those of Network Strategies.

2 Key spectrum issues

2.1 Private networks: should spectrum be set aside?

This section investigates whether 5G private networks can be supplied by MNOs by customising services via network slicing using already licensed spectrum or whether there is really a need for setting aside spectrum in other bands (Section 2.1.1). We also examine the implications of network synchronisation issues for private network operators (Section 2.1.2) and current regulatory trends regarding mmWave spectrum (Section 2.1.3).

2.1.1 Network slicing

One of the capabilities of 5G is network slicing, which is a form of virtual networking technology enabled by Software Defined Networking (SDN). Network slicing allows the formation of virtual networking paths (network slices) over a shared physical infrastructure (Exhibit 2.1). In other words, each service is allocated a unique set of optimised resources and topology to satisfy its connectivity needs in a dynamic manner. Essentially it is possible for MNOs to carve out separate network slices for use cases or users with specific requirements such as a high quality of service (QoS). Vertical industries, such as health, energy and automotive, can benefit from this feature.

While the network slices rely on the same underlying infrastructure and spectrum, MNOs are able to customise the service proposition to match the needs to individual customers. However PNs, dedicated exclusively to one company or organisation, come with their own requirements for the use of spectrum in private deployments.

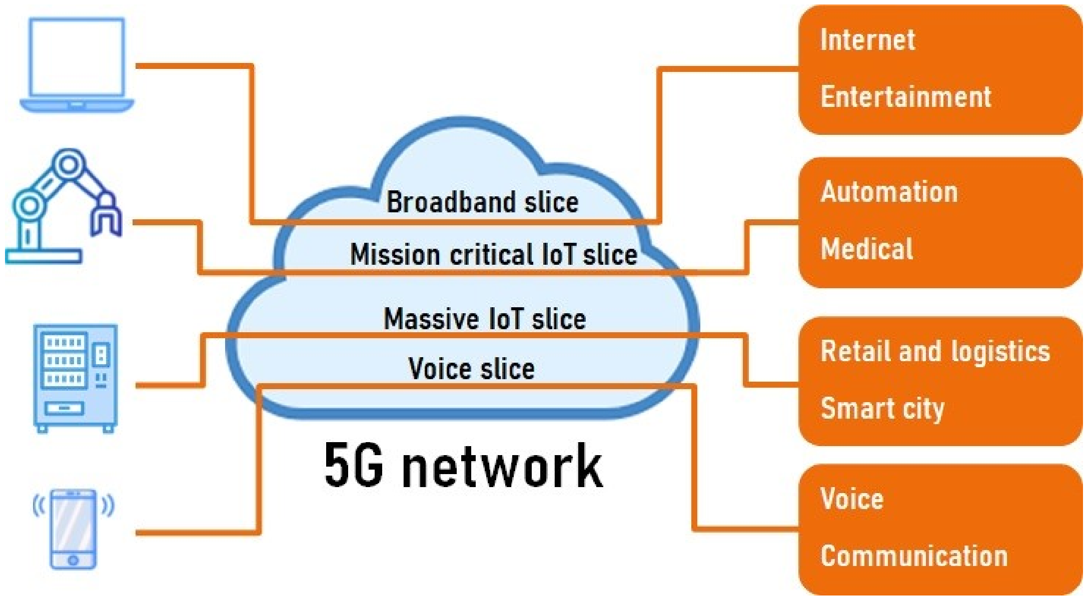

Exhibit 2.1: *Network slicing can span across all network segments allowing the creation customised end-to-end virtual connections [Source: Network Strategies]*

At the micro organisational level, network slicing offers a number of potential cost, efficiency and productivity gains over private networks.

Lower commitment of operational resources

- The customer need not have any involvement in network design and ongoing maintenance under a network slicing model. In contrast, PN require continual maintenance by the owner, as well as responsibilities for hardware and software upgrades. As such organisations accrue savings based on committing less internal IT resources and skills than those necessary to maintain a private network.

- A PN owner is unlikely to experience the economies of scale available to MNOs. On the contrary, additional operational resources may be required for management as the capacity and reach of the PN is extended.

More cost-effective	• PNs typically involve significant upfront investments and require the acquisition of spectrum, whereas the network slicing model offers the opportunity to obtain similar services for a significantly lower total cost of ownership (TCO). • PNs are likely to involve a much longer "time to build" compared to significantly faster deployment with a network slicing option.
More flexibility and agility	• The network slicing model offers a very flexible approach to network deployment and facilitates agile scaling to meet the customers' changing demand or use cases. • Pricing flexibility may also be available with subscription-based services model offerings, for example, pay-as-you-go terms. • PNs may not be sufficiently flexible to meet wide area connectivity requirements in comparison to network slicing models in circumstances for the organisation seeking to implement a 5G solution across a highly dispersed workforce or branches.
MNOs are adept at addressing security and bandwidth requirements	• MNOs are accustomed to meeting user requirements for capacity and for ensuring adequate security protocols are in place. As such the provision of robust data services based on network slicing is fundamentally business as usual. • MNOs are accustomed to providing Service Level Agreements (SLAs) which encompass quality of service and security commitments. • For a PN owner, mission-critical use cases require a grade of equipment that is at least equivalent to that of a telecommunications operator. Replication of such, together with the resources required for operation and maintenance, will involve a significant financial commitment.

The strong case for network slicing over PNs at the organisational level indicates that there are no compelling reasons for setting aside spectrum for PNs. As noted by the 5G PPP Technology Board & 5G IA Verticals Task Force:

> In general, deploying a large number of small specialized verticals-oriented networks can prove to be less efficient than providing different services by a smaller number of large networks, leveraging on 5G flexibility and slicing features.[2]

Furthermore, at the macro level there are a number of clear disadvantages associated with spectrum set-aside, including:

- inefficient use / under-utilisation of scarce spectrum resources for very restricted use cases, particularly where a market-based allocation method has not been applied by the spectrum manager
- development of solutions which are non-standard for niche markets, quickly outdated, and create interoperating difficulties with the 5G environment
- potential fragmentation of spectrum blocks threatening future possibilities for assignment of large contiguous blocks
- the introduction of difficulties in network coexistence.

2.1.2 Network synchronisation amongst operators

Synchronisation is critical to 5G operation especially when it comes to synchronisation in time division duplex (TDD) systems – the preferred mode of deployment among operators and regulators. In TDD systems, radio frames inherently require time and phase alignment between radio base stations operating at the same, or adjacent, frequencies to prevent interference. However, synchronisation among MNOs using the same bands is also necessary to avoid passive inter-modulation issues that can significantly lower receiver sensitivity. While network synchronisation is nothing new, many 5G applications, such as Ultra-Reliable Low-Latency Communications (URLLC), put more stringent requirements on 5G networks. If there is no time synchronisation, guard bands are required between

[2] 5G PPP Technology Board & 5G IA Verticals Task Force (2020), *Empowering Vertical Industries through 5G Networks – Current Status and Future Trends*, 20 August 2020. Page 94.

operators to avoid interference which leads to a less efficient use of the spectrum. Operators may also need to use receiver filters to block interference.

However, these requirements create limitations on the type of applications that can be supported in the same frequency band. For example, a private network requiring running URLLC applications could not co-exist with an MNO providing enhanced mobile broadband (eMBB).

As MNOs typically have considerable spectrum assets, they are unlikely to incur these limitations. However, private network operators with limited set-aside spectrum will face these constraints if they want to deploy demanding applications. Alternatively, these operators would need to cooperate with MNOs to deploy hybrid solutions that meet their requirements. Another aspect is the need to coordinate with neighbouring PNs, which will impose further constraints. A study cited by GSMA shows that unsynchronised 5G networks would require a separation distance of 14km if they are using adjacent spectrum bands and 60km if the networks share the same spectrum.[3] These distances also mean that regulators need to agree on synchronising 5G networks, including PNs, across border areas. Hence, unsynchronised PN use, resulting from operations in spectrum bands not licensed to MNOs, present interference risks at the national level amongst PNs themselves, as well as risks to adjacent band MNO services and cross-border interference risks. This is likely to increase compliance and monitoring costs for the regulator, and generate other costs associated with interference resolution as well as legal disputes amongst interfering and affected parties.

The majority of PNs are either deployed in the C-band (4-8GHz) or in the unlicensed CBRS band. Asynchronous access to unlicensed spectrum in the 2.4GHz, 5GHz and 6GHz bands already provides a space for non-critical 5G applications. However, spectrum sharing schemes such as the License Assisted Access that is already being supported by LTE is now also being supported by 5G NR since 3GPP release 16. This will allow more demanding applications to be deployed by 5G in unlicensed spectrum. Furthermore, there is a growing trend to increase unlicensed spectrum use for private facilities through the expansion of Wi-Fi bandwidth in the mid band (6GHz, currently an agenda item for WRC-23).

3 GSMA (2021), *Mobile Networks for Industry Verticals: Spectrum Best Practice, GSMA public policy position*, July 2021. Page 8.

2.1.3 ITU arrangements

It is important to note that the ITU has rejected several attempts to identify the 28GHz band as a candidate for IMT. A very small number of countries, including the United States (US), Japan, and Korea, made early decisions, prior to WRC-19, to assign the 28GHz band, or parts thereof, for 5G deployment. In 2016, the US Federal Communications Commission (FCC) authorised 5G in the mmWave bands, including the 27.5-28.35GHz segment, along with some other bands outside the 28GHz band.

The FCC has made recent statements acknowledging that it erred in focussing 5G in the mmWave spectrum, and that the 5G spectrum strategy is "pivoting" from mmWave to mid band spectrum[4]. Meanwhile we understand that Japan and Singapore are conducting consultations and studies to accommodate ESIM satellite applications in 28GHz, which may result in suboptimal and complex arrangements preventing full commercial deployment of ESIM. These countries are now facing complex technical challenges in attempting to introduce rapidly growing satellite broadband services to aircraft crew and passengers for gate-to-gate and maritime crew and passengers for pier-to-pier connectivity as a result of earlier 5G decisions.

2.2 Service descriptions

5G Fixed Wireless Access

FWA technologies can assist operators in delivering high-speed broadband with short time to market and lower capital cost than with wireline access networks (Exhibit 2.2).

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4 Axios (2021), *Acting FCC chair says 5G midband spectrum key to closing digital divide*, 17 July 2021. Available at: https://www.axios.com/2021/07/16/fcc-5g-midband-milimeter-spectrum-digital-divide.

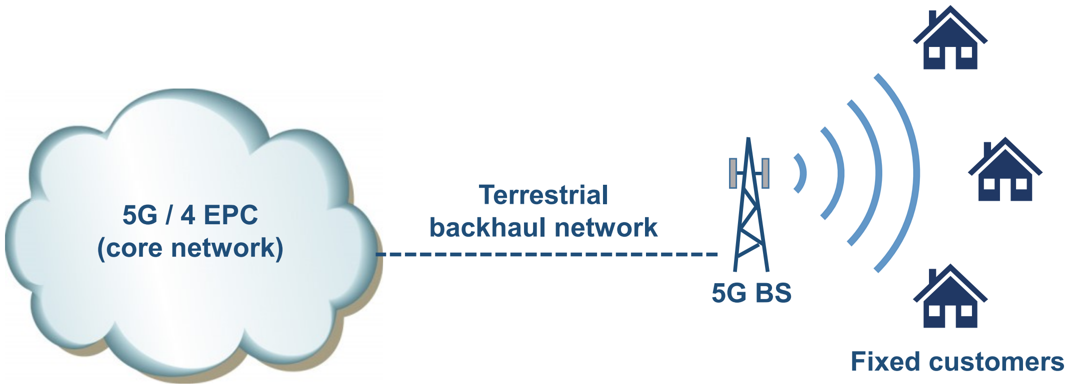

Exhibit 2.2: *5G Fixed wireless access [Source: Network Strategies]*

Previous generations of FWA, such as WiMax and 4G LTE, can only provide limited subscriber speeds due to the spectrum normally available for these services. 5G FWA can provide higher data rates per subscriber, using spectrum in mmWave bands.

The architecture of 5G FWA is similar to previous generations, encompassing a wireless access network comprised of the base station and customer equipment, backhaul network and core network functions. However, from a techno-economic perspective, 5G FWA deployed in mmWave has two distinct drawbacks, namely:

- limited cell coverage area
- need for high capacity backhaul.

mmWave spectrum in the terrestrial broadband context has a very limited reach. At 26/28GHz, the cell coverage radius is typically 100-1,000 metres.[5] Consequently, a large number of small cells is required to provide reasonable coverage which is only economically feasible if the subscriber density is sufficiently large. Millimetre wave signals are also more prone to strong attenuation by walls and foliage. As such, customer equipment is likely to require skilled installation for optimal reception.

5 Sheikh, M. U., Saba, N., Mela, L., Salo, J., Ruttik, K., & Jäntti, R. (2021, October). *Measurement Based Study of Commercial 5G Frequencies in Urban Macro Cellular Environment,* in 2021 17th International Conference on Wireless and Mobile Computing, Networking and Communications, IEEE, pages 175-180.

The large number of 5G small cells with high throughput will require a dense network of fibre or millimetre wave fixed links to backhaul the traffic to the core network. As such, the capital investment for deploying 5G FWA in mmWave bands is very significant and restricts its use to niche areas – for example, where cost of deploying fibre in urban residential settings is higher, such as dwellings located beyond street-level fibre cabinets.

5G private networks

Private 5G networks typically serve a specific community or organisation and do not peer with other mobile networks. 5G private networks can be localised where they serve entities such as factories, stadiums, mining fields or venues for temporary events. They can also be dedicated to serve utility companies. As these networks are tailored to meet specific performance requirements and applications, they do not use a standard configuration. While they typically have their own dedicated access network, they may or may not possess their own core. Depending on the security and latency requirements, core functions may be hosted by cloud managed service providers.

A key issue with 5G private networks is efficient spectrum use. Many of these 5G private networks and their related spectrum uses are essentially for micro-operators that are confined to a specific location or facility. The use of mmWave for these localised private operators is limited by coverage range. However, even in a localised context, coexisting with other services in the same band may be problematic from a spectrum management standpoint. Note that the design of 5G IMT receivers (TDD, transmitting and receiving in the same band) is incompatible for operations with incumbent satellite services that transmit in the same band, for example FSS and ESIM.

Nationwide 5G networks would require national spectrum allocation, in contrast to localised networks used only by specific facilities. Authorities are taking different approaches to address the needs of various market participants. Some authorities are allocating spectrum parcels specifically for industrial 5G networks within existing IMT spectrum allocations, while others are promoting spectrum leasing schemes from public mobile network operators

(MNOs).[6] Depending on the application, 5G PNs are also able to operate within spectrum bands dedicated to unlicensed 5G uses.

6 Vodafone (2019). *An industrial 5G spectrum policy for Europe*. Vodafone public policy paper, November 2019.

3 Economic impact

3.1 Benefits versus costs: satellite use of 28GHz

Fixed satellite services

FSS play a vital role in extending the reach of high-speed broadband services to sizable populations and communities in areas underserved by mobile and beyond. Our earlier research[7] [8] identified large unserved communities:

- approximately 300 million people in the African continent, representing about 22% of the total population
- about 200 million people in the Asia-Pacific region[9].

These numbers increase significantly when taking into account underserved communities – for example, in suburban contexts and beyond, where a mobile signal may be present but broadband capacity is not adequate to provide a full broadband experience. Even in countries with relatively high mobile broadband coverage, there are sizable unserved and underserved populations. For example, the unserved population, with no availability of mobile broadband, in Egypt and Morocco is about 1.5 million and 380,000, respectively.

Satellite technology represents the only possible method of obtaining broadband connectivity in many of these locations. In providing a solution for underserved and unserved communities, villages, schools and medical facilities, the technology serves to lessen the

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7 Network Strategies (2022), *Dedicating 28GHz spectrum band to satellite services: An economic cost-benefit analysis for Africa*, 4 May 2022.

8 Network Strategies (2021), *Dedicating 28GHz spectrum band to satellite services: An economic cost-benefit analysis*, 22 December 2021.

9 GSMA (2020). *The Mobile Economy: Asia Pacific.* June 2020.

digital and educational divide, thereby promoting improvements in socio-economic circumstances.

Key economic benefits include:

- productivity gains through reduced transactions costs
- expanded market opportunities for locally produced goods and services
- timely access to key information to improve agricultural practices / yields
- increased labour participation rates
- reductions in urban drift and supporting re-locations from urban to less urban areas
- improved accessibility of banking / financial facilities.

An ITU study with a sample encompassing 147 developed and developing countries found a higher economic impact of mobile broadband in low income countries compared to higher income countries[10]. Key findings were:

- For countries with lower economic development, mobile broadband yields a 2.04% increase in GDP per capita as a result of 10% increase in broadband penetration, compared to 1.62% in middle-income countries and non-significant results in high-income countries
- An increase of 10% in broadband penetration worldwide leads to an increment in GDP per capita of 0.80% for fixed broadband and 1.60% for mobile broadband.

Results from an empirical study commissioned by the United Nations[11] indicated that both fixed and mobile broadband have a positive economic impact in less developed countries, comprising 47 low-income countries that are suffering from long-term impediments to sustainable development. Such countries typically have significant populations that are underserved or unserved by any broadband technologies. In the sample countries a 2.5% to 2.8% improvement in GDP per capita was achieved as a result of a 10% increase in mobile

10 ITU (2021), *The economic impact of broadband and digitization through the COVID-19 pandemic: econometric modelling*, ITU expert report, June 2021.

11 United Nations (2019), *Economic impact of broadband in LDCs, LLDCs and SIDS, An empirical study*, 2019. Available at: https://www.un.org/ohrlls/news/economic-impact-broadband-ldcs-lldcs-and-sids-2019

broadband penetration. A 10% increase in fixed broadband penetration led to a 2.0% to 2.3% improvement in GDP per capita (Exhibit 3.1).

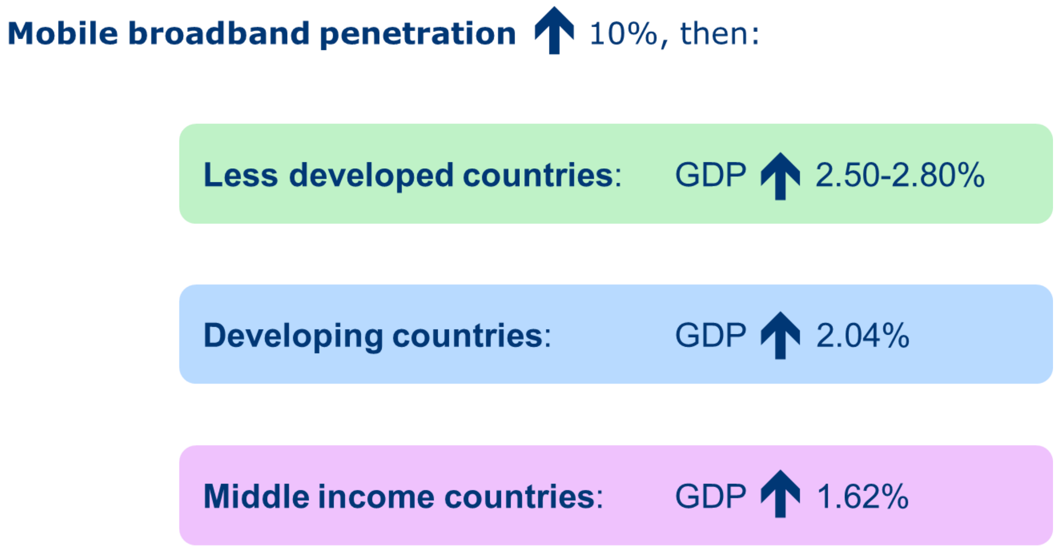

Exhibit 3.1: *Impact on GDP of a 10% increase in mobile broadband penetration [Source: ITU, UN]*

A key finding from the above analysis was that, regardless of the technology, GDP per capita is related to broadband penetration, indicating an increase in economic output as broadband penetration increases. In other words, from an economic welfare perspective the relevant question is not whether mobile broadband is available to communities, but whether any reliable broadband service is available. The underlying technology is irrelevant.

Deploying 5G FWA / 5G PN in the 28GHz band may compromise the economic benefits of UHTS. Some of the critical disadvantages to the FSS operator include disrupting the continuity of the 28GHz band and significant service disruption due to suboptimal technical compromises to accommodate the incompatibly designed IMT receivers.[12] [13] This is

12 S. Kim et al. (2017). *Coexistence of 5G with the Incumbents in the 28 and 70 GHz Bands.* IEEE Journal on selected areas in communications, June 2017.

13 A. A. Abu-Arabia et al. (2020). *Evaluating of 5G NR link efficiency in 28 GHz spectrum sharing*. International Conference on Wireless and Telematics (ICWT). IEEE, 2020.

particularly problematic as the installation of ubiquitous VSAT antennas for FSS does not require licensing in most jurisdictions and ESIM deployments are ubiquitous. In short, ubiquitous broadband satellite connectivity will be negatively affected by mixing dissimilar uses in the 28GHz band.

Earth stations in motion (ESIMs)

Many national economies have recently been adversely affected by the knock-on impacts of international supply chain disruptions. With worsening shortages of key inputs, local production lines falter and suppliers face difficulties meeting demand. Such developments create economic hardship and inflationary pressure, highlighting the vulnerability of local economies to external shocks (such as the COVID-19 pandemic). In this environment mechanisms to enhance and improve efficiencies in logistics and transportation are particularly important.

ESIMs offer continuous broadband connectivity to ships, aircraft and land vehicles which cannot be served by terrestrial networks. By enabling cost-effective high-speed broadband connectivity anytime and anywhere, this application of FSS has the potential to support step changes in productivity and efficiency across multiple key commercial / industrial sectors, including logistics and transportation. The efficient operation of these sectors, in the face of supply chain disruption, is critical for national economic development and prosperity, now more than ever.

Modern ESIM technology performs a key role in enabling ubiquitous broadband connectivity and applications on the move for consumers, businesses and industry. As such, the technology supports numerous economic benefits, as well as offering continuous online connectivity to passengers in the air, at sea and on land.

In the air, for passenger and cargo flights

- Providing in-flight gate-to-gate (G2G) connectivity – meeting passenger demands for seamless in-flight connectivity (IFC), communication, information and personalised entertainment, as well as business applications (such as video conferencing)
- Supporting improvements in operational efficiency – streamlining processes, including better real-time availability and

use of flight deck and other data, improved inflight tracking, early identification of preventative maintenance requirements, electronic flight bag applications, reduced downtime though speedier flight preparations

- Enabling cost savings – lower cost connectivity than legacy air-to-ground systems, replacing costly manual data off-loading processes.

At sea, for merchant shipping, fishing, offshore energy industries, leisure and cruise markets

- Providing pier-to-pier (P2P) connectivity for passengers on cruise ships and leisure vessels
- Facilitating regular crew communications with family and friends during lengthy voyages
- Supporting improvements in efficiency and safety via smart ship applications
- Enabling operational improvements and cost savings, for example via applications to improve fuel efficiency and optimise route planning.

On land, for freight, passenger, emergency response and other vehicles

- Supporting passenger and driver / crew connectivity
- Promoting improved efficiency – for example, via applications for fleet / vehicle tracking
- Enabling cost savings in operations and maintenance
- Facilitating safety and welfare improvements, via faster response times in emergencies.

Achieving G2G and P2P broadband availability would likely be affected by the imposition of restrictions to accommodate 5G systems using the same spectrum band. This means that, for example, in the case of G2G ESIM connectivity may not be available when aircraft are on the ground – at the gate, on the tarmac or on the runway. Effectively, in attempting a sharing regime of 5G FWA / 5G PN and ESIMs in 28GHz, national regulatory authorities may be trading off benefits that can accrue to the local economy via ESIMs with the imposition of unnecessary restrictions devised to accommodate incompatible 5G services. While economic benefits accrue to local economies through 5G FWA and localised private networks in the bands harmonised for IMT (namely, 26GHz, the 17.25GHz of total spectrum identified for IMT in mmWave, the mid bands in 3.5GHz or the 6GHz band), it is not necessary to sacrifice any benefits from ESIMs in 28GHz since current and emerging IMT requirements can be accommodated in any of the bands identified for IMT.

3.2 Benefits versus costs: IMT use of 28GHz

5G FWA in mmWave spectrum

The costs of deploying FWA are often compared with those of wired access networks, as many mobile operators seek to position these services as a quicker and less capital intensive alternative to rolling out fibre networks. In fact FWA costs depend largely on the underlying wireless technology and the characteristics of the target coverage area. In many underserved areas FWA may represent a more feasible option than fibre, however the business case may still be weak.

The physical limitations of mmWave bands restrict 5G FWA use to niche market segments, in both rural and urban areas. In a rural context, mmWave 5G FWA may only be viable for small towns with access to cost-efficient backhaul and sufficient population density that supports the business case. In urban areas, cost-efficient backhaul represents a critical bottleneck. Backhaul requirements for the bandwidth-intensive 5G network will require either high fibre penetration or extensive terrestrial microwave links. As such, the business case for mmWave 5G FWA is valid only in certain instances which depend on the existing infrastructure and cost of alternative technologies such as fibre-to-the-home (FTTH)[14].

Independent studies confirm that the business case for 5G FWA is highly dependent on the costs associated with servicing particular locations.

> mmWave FWA has the potential to allow MNOs to compete effectively against fixed next-generation access (NGA) in some types of location and in some competitive environments. However, the gains are marginal, not radical: cost and cost structure is comparable to fixed NGA and is emphatically dissimilar to mobile. Most of the cost is in backhaul and site access. A further use case will be urban point-to-point connections between multi-dwelling units

14 GSMA (2022), *The 5G FWA opportunity: A TCO model for a 5G mmWave FWA network*, January 2022.

(MDUs), but not inside MDUs. This could incur a lower cost than horizontal dig or duct access for fibre.[15]

A 2021 study[16] of 5G 26GHz in Europe (EU27 plus Norway, Switzerland and the UK) examined the costs and benefits of a various 5G use cases, including FWA. The study estimated the incremental costs for a specified level of FWA deployment, over and above those incurred by an initial commercial roll-out of 5G enhanced mobile broadband (eMBB). With a timeline for deployment of five years the incremental cost was estimated to be EUR4.6 billion. Balanced against these costs were estimated benefits over a 20-year time period of EUR46.5 billion, to derive a cost-benefit ratio of 10.

Key assumptions were:

- beyond areas covered by FTTH, all sites are upgraded with 26GHz for FWA, provided that the population density exceeds 300 people per square kilometre
- a certain portion of mobile macro sites within areas covered by FTTH are upgraded with 26GHz for FWA as an alternative broadband option for consumers within FTTH areas. In total this represented between 5% to 20% of the broadband market in each European country.

The assumptions of this study reflect the major focus of the 5G FWA use case in Europe and other jurisdictions which is to deliver high-speed broadband services to premises in higher density areas. For MNOs the technology represents additional revenue which may be acquired from households and businesses with one or more of the following characteristics:

- not expected to be reached by fibre-to-the-premises (FTTP) networks in the short to medium term
- may be mobile only
- seeking lower price alternatives to existing high-speed fixed services

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15 Analysys Mason (2017), *5G Fixed-Wireless: the investment case for operators*, 2017.

16 Analysys Mason (2021), *Status, costs and benefits of 5G 26GHz deployments in Europe*, final report for Qualcomm and Ericsson, 14 May 2021. Available at ttps://www.analysysmason.com/contentassets/3716b071d2f647c9a9e57e56900b4f66/analysys-mason---status-costs-and-benefits-of-5g-26ghz-deployments-in-europe.pdf.

- may be currently served by lower speed DSL technologies.

In other words, the addressable market for 5G FWA appears to largely overlap existing technologies and services (Exhibit 3.2). As an alternative option, the technology delivers a substitute rather than a complementary service. Given the physical limitations discussed above, the scope for the technology to support new (complementary) high-speed broadband services in low density greenfield areas is extremely limited.

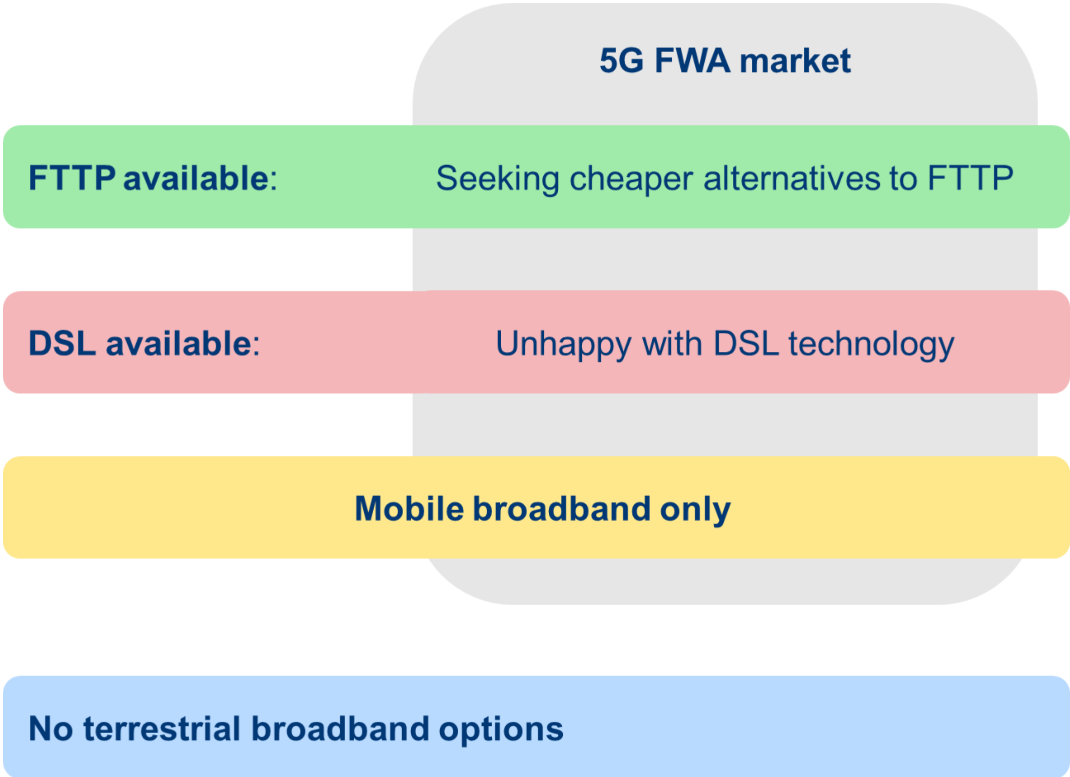

Exhibit 3.2: *5G FWA addressable market [Source: Network Strategies]*

According to the GSMA approximately 68% of 5G FWA launches worldwide were in Europe and the Middle East / North Africa (MENA) (Exhibit 3.3). This is an early indication that this technology offers little prospects for the large underserved and unserved populations of the Asia-Pacific and Sub-Saharan African regions. In the African continent 55% of its total 1.37 billion inhabitants live outside densely populated areas.

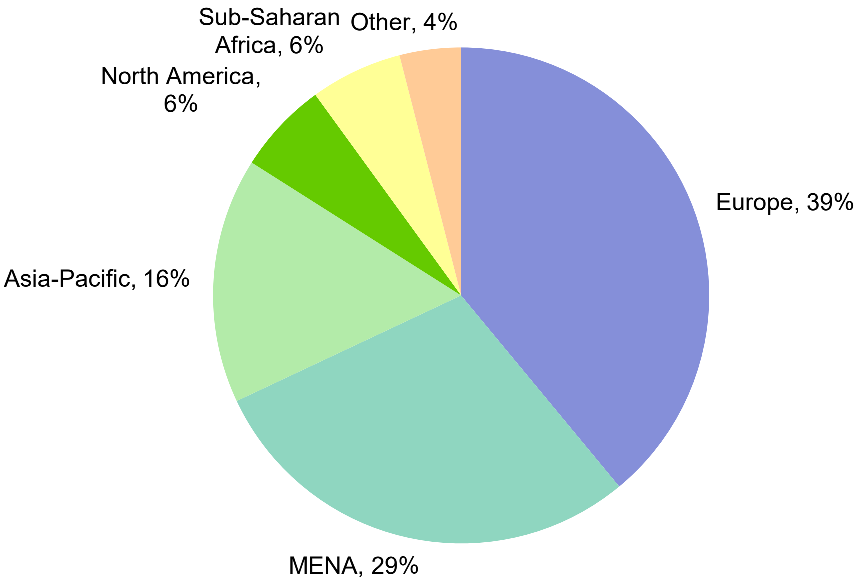

Exhibit 3.3: *5G FWA commercial launches, by region, 2021 [Source: GSMA]*

VANUATU: ACHIEVING UNIVERSAL SERVICE WITH SATELLITE

In Vanuatu over the last decade Government sought to increase broadband availability in unserved and under-served areas through a Universal Access Programme (UAP). In fulfilment of UAP obligations a total of 28 sites were planned to be deployed by two mobile operators (Digicel and TVL) and a satellite service provider (TelSat).[17] Both Digicel and TVL reported that provision of mobile infrastructure to unserved areas was extremely challenging and expensive. On average, the cost of deployment for a single site was between USD350,000 and USD400,000. This cost includes equipment, links, transport by barge, solar panels, helicopter links, and civil works. At the conclusion of the UAP the regulator reported that Vanuatu was fully covered with high speed Internet broadband access through the Telsat service 'at prices that are affordable'[18].

Furthermore, it was clear that satellite played a key complementary role in achieving all of the Government objectives.

> The third major component of the UAP program was to ensure that all government facilities, such as schools, offices, health clinics and other government institutions had available to them broadband internet services. It is not physically possible to cover all government sites via the mobile network, operator provided dedicated data links or via any private government network, so a complementary solution was required to satisfy this UAP obligation[19].

[17] Telecommunications and Radiocommunications Regulator (2015), *Universal Access Policy (UAP) stakeholders update report no. 4*, December 2015.

[18] Telecommunications and Radiocommunications Regulator (2019), *Universal Access Policy (UAP) stakeholders tenth and final report on the status of implementation of the Government's Universal Access Policy*. January 2019. See page 7.

[19] *Ibid*, page 10.

When comparing the relative features and costs of 5G FWA with satellite solutions (Exhibit 3.4) the latest satellite technologies are able to match FWA speeds, while offering more rapid and cost-effective deployment prospects.

	FWA	*Satellite*
Technology	5G	HTS / VHTS / UHTS
Expected speed	250-1,000Mbit/s	100-1,000Mbit/s
Latency	5-15 milliseconds	600-800 milliseconds
Ease of deployment	Depends on location	Rapid
Required infrastructure	Towers/posts	User terminal / rooftop
UE	Router	Terminal
Incremental capex	High	Low
Opex	Moderate	Moderate

***Exhibit 3.4**: FWA and satellite solution features / costs [Source: Network Strategies]*

While 5G FWA in mmWave bands can deliver near fibre-like speeds, balancing the benefits and costs of mmWave 5G FWA is a challenge due to the severe physical limitations of mmWave bands when used for terrestrial 5G IMT applications. Other critical constraints include the need for line-of-sight and high penetration losses through walls and foliage.

5G private networks in mmWave spectrum

5G is expected to provide improved performance and flexibility as it is specified to support a wide range of applications with varying functional and performance requirements. A private 5G network can be deployed using network slicing over an existing public mobile network using the same spectrum licensed to MNOs or as a standalone localised network. In the former case the private network is part of the mobile operator’s network and does not raise any regulatory issues in terms of spectrum. A standalone private 5G network will be a localised network constrained by the physical borders of the network owner.

A private mmWave 5G network can support a range of data intensive applications such as:

- surveillance and video streaming

- industrial automation
- augmented and virtual reality
- autonomous robotics.

Many applications are anticipated but are yet to emerge in the market. As such, the economic value of deploying these services in mmWave is largely uncertain. In terms of spectrum usage, such a network will raise some regulatory challenges. Sharing the spectrum with FSS in the 28GHz band is sub-optimal, given the incompatibly designed receivers of 5G IMT which are intolerant of in-band sharing.

3.3 Addressing the digital divide

As noted above, a recent European study estimated a cost-benefit ratio of 10 for a 5G FWA use case with 26GHz spectrum over a 20-year time horizon. Both the veracity and general applicability of this estimate depends crucially upon the underlying assumptions. The quantification of the benefits appears to be based on an assumption that the use case will generate an uplift to GDP of 1%[20] which in turn was informed by an evaluation of the economic impact of a UK superfast broadband programme[21].

Announced in 2010, this initiative subsidised network providers to extend superfast broadband infrastructure to local areas identified as unlikely to obtain upgraded infrastructure – typically from DSL technology to fibre – as part of regional commercial deployments. 'Superfast' was defined as a minimum download speed of 30Mbit/s. An analysis of the impact of the programme from 2012 to 2018[22] identified a number of economic benefits that had occurred in the subsidised areas by the end of 2018:

- turnover of firms increased by almost 1%
- employment increased by 0.6%

20 The report does not include full details of the assumptions underlying the benefit calculations, but refers to an approach used in earlier studies.

21 Ipsos (2018), *Superfast Broadband Programme Evaluation. Annex B: Economic Impacts*, Ipsos MORI technical paper, 2018.

22 Department for Digital, Culture, Media & Sport (2021), *Superfast Broadband Programme – State aid Evaluation Report 2020*, January 2021.

- the number of businesses increased by around 0.5%
- turnover per worker rose by 0.4%.

We conclude that it is reasonable to assume in a bottom-up calculation that the output of firms in industrialised economies may increase by 1% over a given time-period as the result of a significant increase in available broadband speeds, regardless of technology. However, the general applicability of these results is limited. As already identified, serious physical / technical limitations hamper the capabilities of FWA in mmWave to serve populations beyond densely populated areas. As such economic benefits will only accrue on a very localised basis, and should not be expected in circumstances where the technology is simply a substitute for another technology of comparable speed, quality and reliability.

It is clear that FWA in mmWave is not well suited to addressing the digital divide which exists in significant populations across the world. Moreover, research by the ITU in 2021 demonstrated the geographic progress of 5G population coverage from 2019 to 2020[23] (Exhibit 3.5). There is a clear divide between higher income / industrialised regions and those with many emerging economies.

23 ITU (2021), *The economic impact of broadband and digitization through the COVID-19 pandemic: econometric modelling*, ITU expert report, June 2021.

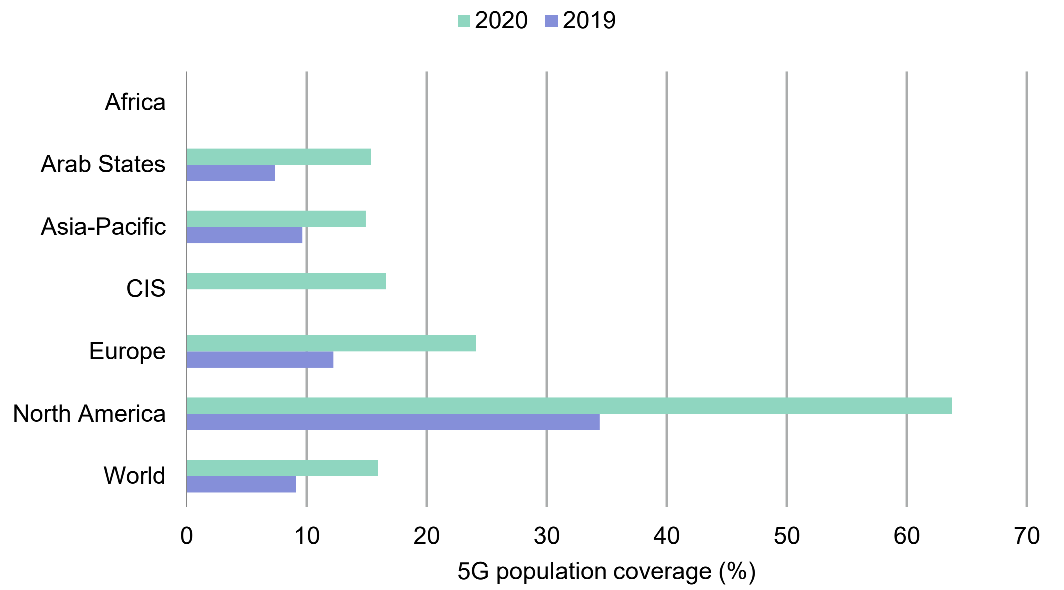

Exhibit 3.5: *Percentage of population with 5G coverage, 2019 and 2020 [Source: ITU]*

Finally, the ITU noted that telecommunication/ICT capital investment per capita in developing regions has declined between 2019 and 2020 (Exhibit 3.6), reflecting a further widening of the digital divide. The most pronounced declines were in Latin America and the Caribbean (-7%) and Africa (-7%), while in North America a per capita increase of almost 5% was observed.

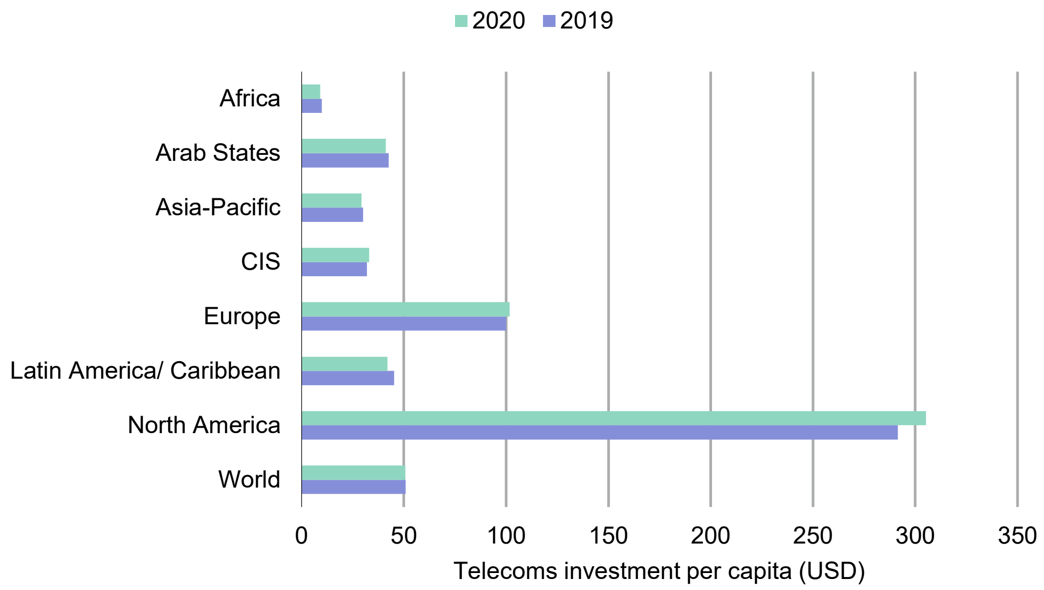

Exhibit 3.6: *Telecommunications / ICT capital investment per capita (USD) [Source: ITU]*

In conclusion there does not appear to be a corresponding economic benefit to be gained from ceding or sharing 28GHz spectrum, already in use for well-established applications including FSS and ESIM, for 5G FWA / 5G PN.

4 Utility analysis

4.1 Overview

We have used two case studies to assess the opportunity cost associated with ceding / sharing 28GHz spectrum to 5G FWA / 5G PN. Both approaches use as the starting point a high-level reference model developed in an earlier study[24] in which we explored the point at which satellite becomes more cost-effective than terrestrial technologies (5G access and microwave backhaul) for a notional service. The reference model calculated the cost incurred by a hypothetical operator in a South East Asian country when providing broadband supply in underserved / unserved areas using satellite in the 28GHz band and 5G technologies.

This earlier modelling work to estimate the cost of connecting users outside densely populated areas demonstrated a clear economic advantage for satellite broadband and satellite-fed Wi-Fi hot spots compared to a mmWave 5G cell site using microwave backhaul links.

Building on the earlier approach we examine the cost of broadband provision to underserved populations. We assume that the satellite operator has full use of the 28GHz band, and compare this with a counterfactual in which the 5G operator invests in 5G RAN for 5G FWA / 5G private network uses operating in mmWave frequency bands, namely 28GHz with 400MHz of available spectrum.

24 Network Strategies (2021), *Dedicating 28GHz spectrum band to satellite services*, 22 December 2021. Available at: http://strategies.nzl.com/industry-comment/dedicating-28ghz-spectrum-band-to-satellite-services/.

4.2 Case studies

Case study 1: Direct comparison of efficient spectrum use

A hypothetical 5G FWA / 5G private network operator is assumed to have available 400MHz of contiguous spectrum block in the 28GHz band. We then compare the respective costs incurred in providing broadband services to an area beyond urban centres using alternative scenarios (Exhibit 4.1):

- **Scenario 1: 5G FWA / 5G private network** – in which the operator deploys a 5G FWA / 5G private network and connects the cell site via terrestrial microwave
- **Scenario 2: Satellite backhaul connectivity with 5G RAN** – same RAN network as in scenario 1 but using satellite connectivity instead of terrestrial microwave
- **Scenario 3**: **Wi-Fi plus satellite broadband connectivity** – deployment of Wi-Fi hotspots to provide broadband access to schools, hospitals and communities outside urban areas via satellite connectivity
- **Scenario 4: Satellite** – in which the operator deploys a standalone satellite network to provide direct satellite broadband connectivity to the subscriber.

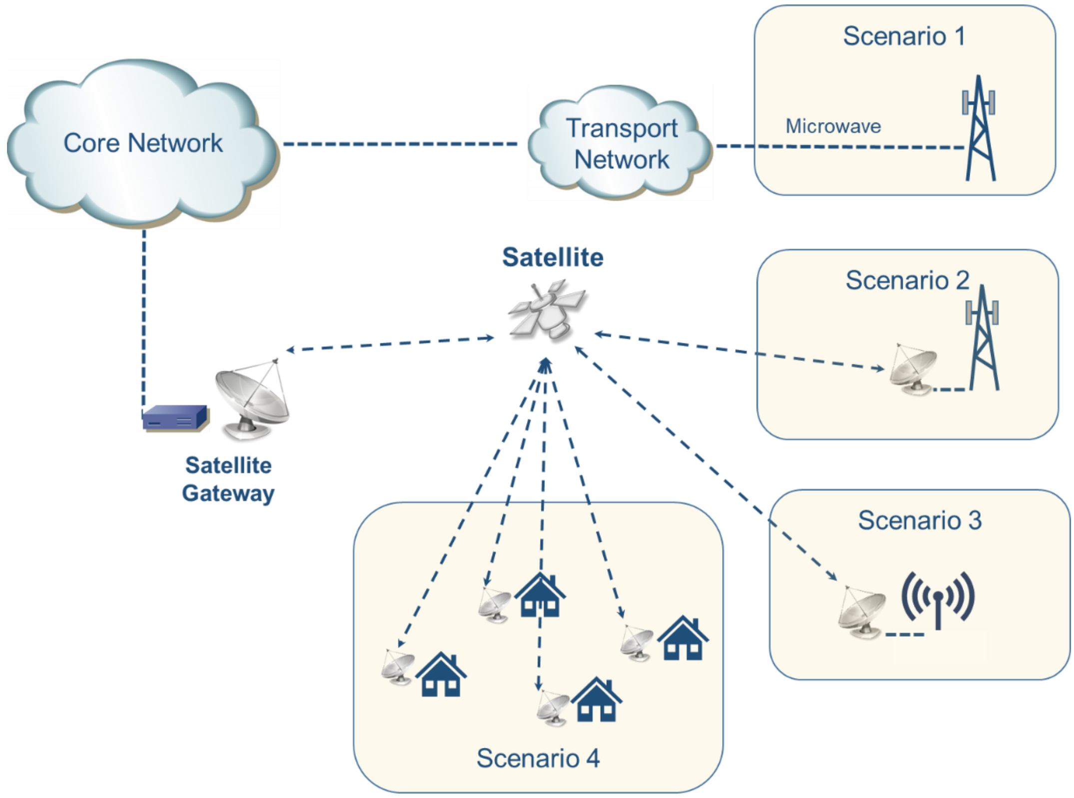

Exhibit 4.1: *Model scenarios [Source: Network Strategies]*

The analysis is based on key characteristics applicable to many underserved and unserved areas and populations. The mobile operator is assumed to use the full 400MHz of contiguous spectrum block in the 28GHz band while no constraints are made on the spectrum use by satellite (Exhibit 4.2).

Key parameter	*Value*
Spectrum band	28GHz
5G spectrum holding in 28GHz band	400MHz
5G cell size	3.15 km^2
Population density	50 persons per km^2
Number of microwave hops required for scenario 1	2
Satellite subscriber monthly data cap	60GB

Exhibit 4.2: *Key modelling parameters for underserved areas [Source: Network Strategies]*

Case study 2: Providing broadband connectivity for education

We explore three scenarios using a hypothetical moderately large school and surrounding community that had not been served by terrestrial broadband. The purpose of the cost comparison is to determine which scenarios offer the greatest benefit or utility to the community. The three applicable scenarios in this case are scenarios 1, 2 and 3 (Exhibit 4.3).

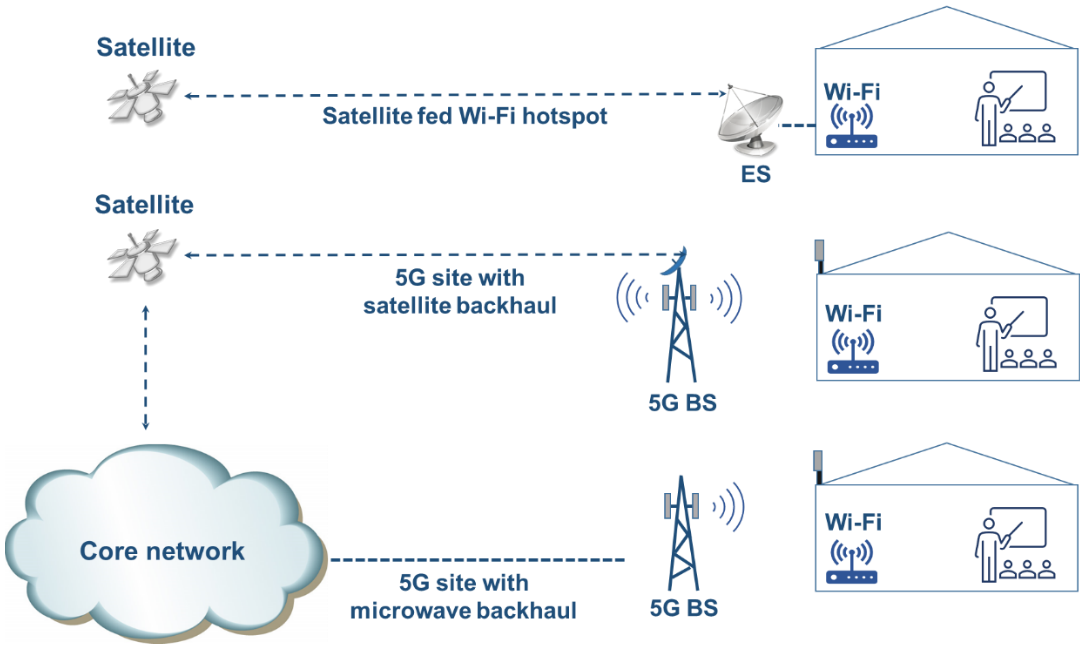

Exhibit 4.3: *Connecting a rural school using satellite fed Wi-Fi hotspot, 5G FWA with satellite backhaul or terrestrial microwave link [Source: Network Strategies]*

In the three scenarios we assume that the Wi-Fi hotspot or 5G site also serves the surrounding community. The key assumptions in the analysis are listed in Exhibit 4.4. All other assumptions remain the same as in Exhibit 4.2.

Assumption	*Value*
School size including staff	210 persons
Number of students in school	200
Number of staff in school	10
Student data consumption	5GB per month
Teacher data consumption	10GB per month
Population of surrounding community	160

Exhibit 4.4: *Key assumptions for providing broadband to a rural school [Source: Network Strategies]*

JAMAICA: SATELLITE BROADBAND SOLUTION PROVIDES CONNECTIVITY FOR UNSERVED SCHOOLS WITHIN WEEKS

In many countries, the COVID-19 pandemic provided further impetus for the timely availability of robust and reliable Internet connectivity for teachers and pupils to facilitate continuity of education and learning. The introduction of satellite broadband Internet services offers a rapid solution for unserved educational facilities beyond urban areas.

The Ministry of Education in Jamaica sought such a solution for schools in areas without any terrestrial networks. Following Government amendments to the VSAT licensing regime, including a reduction in per terminal fees which had threatened the economic viability of the initiative[25], Viasat provided high throughput satellite connectivity to 100 sites in just 48 days.

The service uses Ka Band (17.7-21.2GHz downlink, 27.7-31GHz uplink) UHTS technology, providing each school site with 25Mbit/s download and 5Mbit/s upload speeds. This is sufficient to support simultaneous operation of high-definition video conferencing, multiple video streaming services and connection for on-line education platforms[26].

The program was subsequently extended to connect around 500 schools, encompassing approximately 54,000 students[27].

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25 Fees included both spectrum and regulatory cost components. These fees were reduced from approximately USD4,500 to USD5 per terminal.

26 Viasat (2022), *Promoting Education Through Satellite Connectivity: A Jamaica Case Study*, 27 January 2022.

27 Ministry of Science, Energy and Technology (2021), Statement to Parliament: update on the national broadband plan, 1 October 2021, available at: https://www.mset.gov.jm/2021/10/01/statement-to-parliament-update-on-the-national-broadband-plan/

4.3 Results – Case study 1

The cost for connecting a subscriber for each technology, represented by the total cost of ownership (TCO) per subscriber over a five-year period, is shown in Exhibit 4.3.[28]

The cost of for satellite broadband per subscriber, either via direct connection or Wi-Fi hotspot, is significantly lower than 5G FWA with terrestrial backhaul. Satellite still provides an economic advantage when used as backhaul for a 5G site providing voice and mobile broadband at 28GHz in rural areas. Satellite connected Wi-Fi hotspots, the most cost-effective option, are also the most relevant for underserved and unserved areas as it represents the case for connecting schools, hospitals and public buildings. In terms of comparative affordability satellite connected Wi-Fi hotspots may constitute the only reasonable option for achieving connectivity in this type of location.

28 The 5G deployment cost excludes the cost of spectrum and includes capital and operational costs. The satellite costs include the capital and operational costs of equipment in addition to satellite capacity cost.

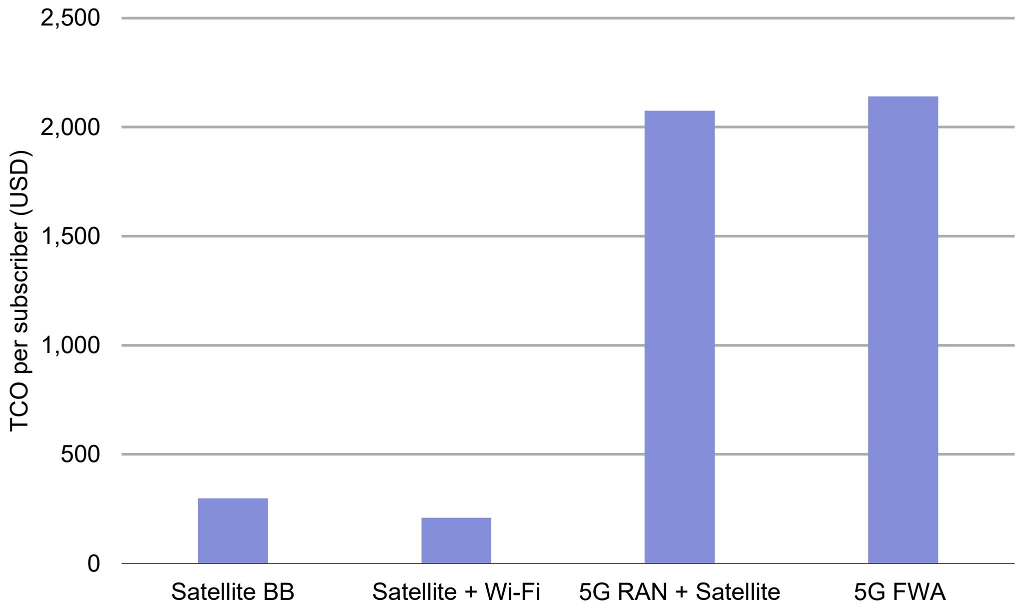

Exhibit 4.5: *Case study 1: Total cost of ownership per subscriber over five years for providing broadband at 28GHz using various technology options [Source: Network Strategies]*

It is important to note the key cost components for each technology option as these give insight into the potential sensitivities in the economic analysis and future cost trends. The cost of satellite capacity is the dominant cost component associated with providing broadband using a satellite-fed Wi-Fi hot spot (Exhibit 4.6). For the terrestrial solution using a 5G FWA / 5G private network site with microwave backhaul, the civil works associated with tower construction and site preparation are the dominant factor. The cost of civil works is unlikely to decline with time while the cost of satellite capacity is likely to decline substantially with the introduction of high throughput satellites and increase in supply. This suggests that satellite broadband solutions are also future proof solutions for many unserved and underserved areas.

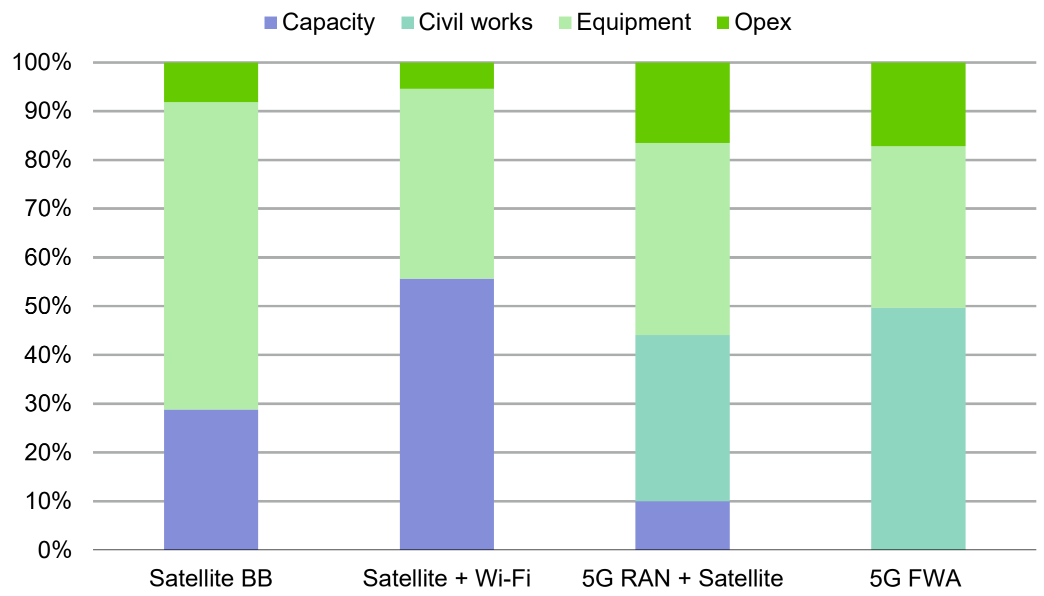

Exhibit 4.6: *Case study 1: cost components for providing broadband services using various technology options [Source: Network Strategies]*

4.4 Results – Case study 2

The total cost of ownership over five years for the three scenarios is shown in Exhibit 4.7. A Wi-Fi hotspot represents the most cost-effective option. Note that this scenario does not include a voice service unlike the 5G scenarios. A localised private 5G site with satellite backhaul remains cost effective for moderate data consumption (Exhibit 4.7). The satellite-fed Wi-Fi hotspot remains the most cost-effective solution even for relatively high student data consumption patterns.[29]

29 The average monthly student data consumption in North America is 1.57GB.

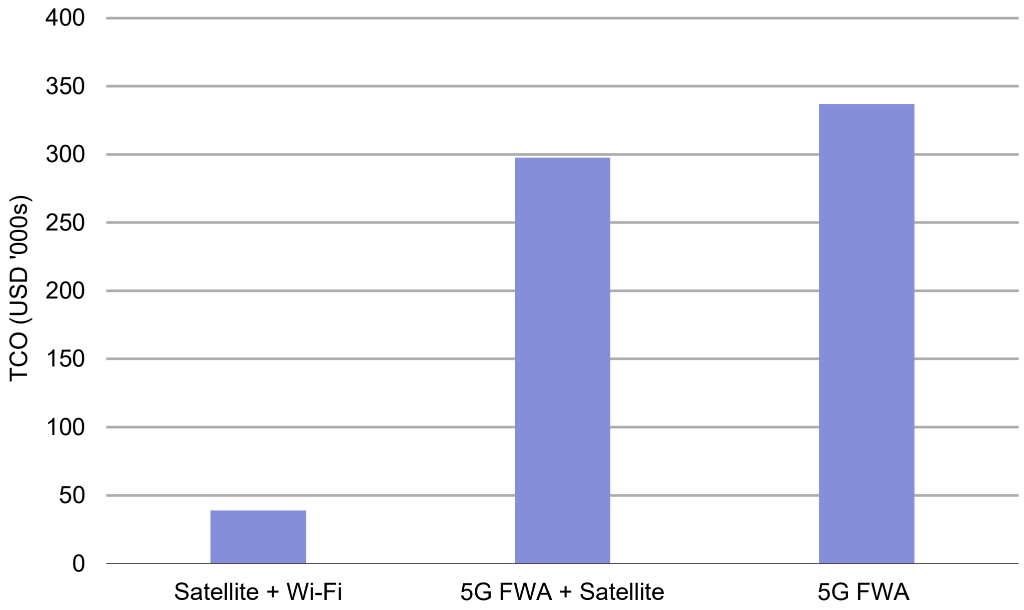

Exhibit 4.7: *Case study 2: Total cost of ownership of connecting a rural school using various technology options [Source: Network Strategies]*

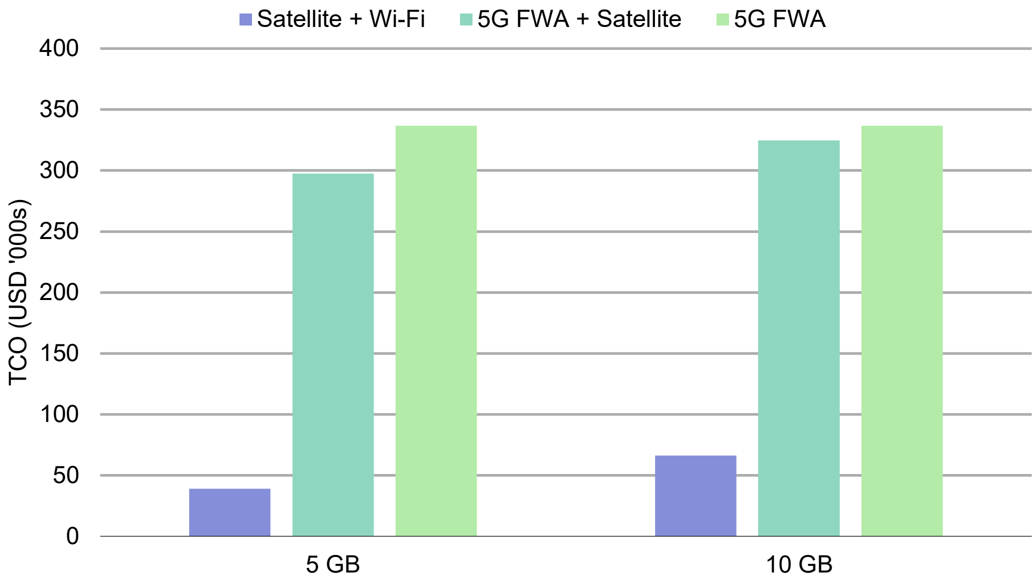

Exhibit 4.8: *Case study 2: Impact of student monthly data cap on the cost effectiveness of school connectivity solutions [Source: Network Strategies]*

4.5 Aggregate potential cost of reduced spectrum

Using the model we have also undertaken some estimates of the aggregate potential cost of reducing 28GHz spectrum available for satellite services by ceding spectrum for or sharing spectrum with the incompatible 5G FWA/ 5G private network uses.

5G FWA in the mmWave typically uses at least 400MHz of spectrum. Current UHTS satellite technology can accommodate hundreds of thousands of broadband users in the same band. Connecting this number of subscribers using 5G FWA in the 28GHz band may cost about 700% more, compared to using satellite. Connecting this number of subscribers using 5G FWA in 28GHz may cost about 1,000% more compared to satellite connected Wi-Fi hotspots. The difference between the cost of providing broadband for this number of subscribers using 5G FWA and satellite-fed Wi-Fi hotspots may be in excess of USD1.1 billion.

4.6 Conclusion

The case study analysis revealed that:

- for deployments in underserved and unserved areas, connectivity solutions based on 5G FWA / 5G private network sites are around ten times more expensive per subscriber than satellite broadband
- to provide a connectivity solution for a moderately large (210 students and staff) educational facility with a 5G private network site in underserved and unserved areas the total cost of a 5G FWA solution is at least six times higher than a satellite solution.

Not only can satellite broadband services be offered at substantially lower cost to bridge the digital divide, the pace of deployment is significantly faster than 5G FWA options.

The main cost component in the satellite traffic scenario is the cost of capacity. This is expected to decline substantially with the introduction of UHTS within this decade. As the cost of capacity declines, satellite services will be able to deliver higher data usage without increasing prices and with even better speeds. Meanwhile the cost for deploying 5G FWA in mmWave is dominated by civil works which is unlikely to decrease with time.

The amount of spectrum available also influences the cost of satellite services. Any reduction of the amount of 28GHz spectrum available for providing satellite services will result in a higher per-user cost of satellite capacity due to reduced economies of scale, which in turn will diminish the economic benefits of using satellite in cases where other technologies are clearly less cost effective, as demonstrated in this study.

To benefit from higher economic gains and lower deployment costs, 5G FWA / 5G private network uses should be accommodated in the bands harmonised for IMT, where there is no need to impose deployment restrictions on either 5G uses or satellite uses (FSS / ESIM). Ample IMT spectrum for 5G FWA / 5G PN is available on an unconstrained basis across all the mmWave bands identified for IMT at WRC-19. We find no economic gain to be obtained from implementing 5G FWA or 5G private networks in the 28GHz band, since this band is globally harmonised for use by UHTS satellite systems including FSS, ubiquitous VSAT and ubiquitous ESIM.

5 Concluding remarks

In a number of jurisdictions MNOs have claimed that assignment of parcels of the 28GHz spectrum band will be necessary to accommodate current and emerging IMT spectrum requirements, particularly in relation to FWA services and private networks.

For MNOs the choice of frequency band for 5G is driven largely by technological constraints and the economics of deployment. Where MNOs seek to deploy mmWave 5G in or close to bands already occupied by other services, regulators and policy-makers must carefully consider the potential socio-economic impact of permitting co-existence and / or mandating co-ordination or interference mitigation measures.

Current and emerging use of 28GHz by satellite

The 28GHz band is already heavily used by HTS, representing significant capital investment by multiple operators. Use cases of FSS, ESIM and other satellite-related applications in the 28GHz band are already substantial. In optimising the allocation of scarce spectrum the utility of existing operations in any spectrum bands is a key consideration for regulators and policy-makers seeking to ensure the long-term benefit of end-users.

5G spectrum requirements may be met without 28GHz

Another important consideration is the availability of alternative spectrum to meet operator requirements. 5G already has very large contiguous spectrum available for deployment in mmWave bands. In the most recent WRC, a total of 17.25GHz of mmWave spectrum has been identified for 5G, including 24.25-27.5, 37-43.5, 45.5-47, 47.2-48.2 and 66-71GHz[30]. It is important to note that the densification of the network, due to the short range of mmWaves, intrinsically allows for a more efficient use of the spectrum.

30 ITU (2020). *WRC-19 identifies additional frequency bands for 5G.* International Telecommunications Union, January 2020. Available at https://www.itu.int/hub/2020/01/wrc-19-identifies-additional-frequency-bands-for-5g/.

The 28GHz band is highly unlikely to be harmonised for 5G

At WRC-19 mmWave bands were identified for IMT services, but these did not include the 27.5-29.5GHz band. Provisions were also adopted governing the use of the frequency bands 17.7-19.7GHz (space-to-Earth) and 27.5-29.5GHz (Earth-to-space) by ESIMs communicating with geostationary space stations in FSS[31].

Full use of the 28GHz band for satellite supports the reduction of the digital divide

Without the full 28GHz spectrum band, the capacity requirements of satellite operators will be unmet causing service disruption. IMT services, including 5G FWA and localised private networks, cannot serve as a replacement for satellite services which are essential to meet the needs of end-users living outside urbanised areas and those on the move across oceans, the land and in the air.

31 International Telecommunication Union (2020), *Implementation of Resolution 169 [COM5/6] (WRC-19) – Use of the frequency bands 17.7-19.7 GHz and 27.5-29.5 GHz by earth stations in motion communicating with geostationary space stations in the fixed-satellite service*, 6 August 2020.