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CONTENTS

Rural broadband presents new opportunities and unique challenges for the telecoms industry

Patrick Kidney, Partner and Larry Goldman, Chief Analyst

Governments worldwide are seeking to provide rural broadband in order to deliver connectivity to underserved and hard-to-reach citizens. This will bring significant opportunities to citizens, governments, operators and suppliers.

Rural broadband is often provided via government intervention; governments support investment when the normal commercial processes have not addressed citizens' needs. As such, these interventions deliver critical services that are needed but are not fully justified by the normal commercial investment criteria. That is, it is difficult or impossible for commercial operators to fully recover their investment from the revenue paid by the residents and/or businesses in rural areas.

Governments must set policies that are unique to the needs of these under-served citizens. These policies nearly always involve significant subsidies that are not otherwise available to operators. These subsidies come with rules that are not present in the normal commercial world to protect the public purse. For example, requirements in terms of coverage, pricing mechanisms and network access may be stipulated. Subsidies can also create new opportunities and competition for operators, vendors and investors.

Broadband has become just as fundamental as services such as electricity and transportation to enable societies to run smoothly. The pandemic reinforced and amplified the importance of broadband for the whole of society, not just those who can be easily reached and can comfortably afford it. Indeed, the increased levels of home schooling and remote working meant that broadband shifted from being very nice to have to being essential. Those without it were not only cut off from Game of Thrones, but also from essential economic and/or government services.

Rural broadband implementations take many years and go through several distinct phases

Serious rural broadband deployments are major public infrastructure efforts that take years to plan and implement and need to serve for decades. The main phases of a rural broadband effort are:

- strategy
- policies and regulations
- procurement
- implementation (including governance).

> “Providing rural broadband opens up significant opportunities for citizens, governments, operators and suppliers

Strategy

The first step is to set a strategy for what is to be achieved. This is a political process that involves consultations with stakeholders including government departments, telecoms operators, industry groups, rural advocacy groups and the general public. Problems must be understood. Strategy efforts generally cover the following six areas.

- Where do we need to intervene? Where does the problem lie?
- Will we mandate a technology or be technology-neutral? How will the technology evolve in the future as requirements change?
- Is it important to use existing infrastructure or should we emphasise acquiring new infrastructure?
- What products will the effort produce? Will it enable wholesale services that are used by established operators to reach consumers or will it provide retail commercial services to the consumer?
- What will it cost?
- How is the public purse protected when balancing efficiencies in spending with above-average profits?

Policies and regulations

Work must be done to set out the means to implement the goals once they have been agreed and the funds have been allocated. Governments generally lay out a set of rules for commercial companies in the areas listed below.

- Where will coverage be required?
- What are the technology specifications and user requirements both now and in the future?
- What products must be available to consumers and at what price?
- What are the operational KPIs that must be delivered and maintained?
- How will the interests of companies that are already serving the market be protected?
- How will spending efficiencies be incentivised while protecting against above-average profits for network operators?

Procurement

Then follows a process of allowing and incentivising companies to bid to receive the government subsidies. Policy setters need to listen to the concerns and suggestions of those interested in bidding and will typically address any legitimate concerns, including the following.

- How will the formal bidding process work?
- Will bidders be restricted in how much of the intervention area they can bid for?
- What are the financial requirements for bidding and what are the penalties for non-compliance?
- How are the bidders to be evaluated? Are they in compliance with the criteria, is their technology plan feasible, are they financially viable and able to carry out the work?

Governance

Building networks may still take years once the successful bidders have been announced. Subsidies are paid to the successful bidders when they reach milestones in terms of building infrastructure and connecting customers. In some cases, there the policy setters may mandate that the operational costs of networks are subsidised, particularly in the early years of the deployment. Some of the winning bidders may fail to deliver, and therefore significant governance effort is required by the subsidising public body to keep all the suppliers on track to deliver the finished benefits.

Conclusions

Rural broadband deployments give governments the opportunity to modernise and improve the way of life for under-served portions of their population. Full broadband connectivity is a key enabler for the provision of government initiatives, such as smart health and remote education. It also provides opportunities for the telecoms industry to add millions of new customers for well-established broadband services. However, telecoms industry players will have to adjust to a different commercial model and must approach the process in partnership with the government.

Successful rural broadband projects require significant government funding and many years of planning and implementation. Governments work through the many phases to ensure a good result. Service providers, vendors and investors need patience and a willingness to adapt to a government contract business model.

Analysys Mason has provided extensive support for National Broadband Ireland.

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The synergies between content and networks upon which the internet is based should be nurtured

David Abecassis, Partner

An old idea has had a resurgence in recent months: internet content and application providers (CAPs) should pay for the privilege of delivering traffic on internet service providers' (ISPs') networks to meet their end users' requests. This is the set-up in South Korea,[1] but interconnection and traffic delivery are left to commercial negotiations between ISPs and CAPs nearly everywhere else in the world. Sometimes these players agree to exchange money as well as traffic, but in most cases, everyone pays their own costs based on their individual incentives.

This has led CAPs to construct their own networks from a combination of owned and rented infrastructure in order to be able to deliver traffic in major cities around the world, in places where ISPs can easily interconnect and expand capacity (such as internet exchange points) and in data centres where ISPs and CAPs can peer privately with one another. Large CAPs also make caches available to enable ISPs around the world to store CAPs' content directly in their networks. Via these mechanisms, ISPs can avoid having to buy IP transit or international connectivity to another country (particularly the USA), and CAPs can control the cost and quality of their services up to the boundary of the ISP's network, which benefits their common users. Smaller CAPs (and some large ones) use commercial content delivery networks (CDNs) to facilitate this activity, and now often use public cloud services, who themselves make data centre and networking infrastructure available to their customers worldwide.

We estimate that CAPs worldwide invested a total of USD883 billion in infrastructure (including hosting, data transport and content delivery) between 2011 and 2021 (Figure 1). About half of this investment occurred between 2018 and 2021; investments averaged USD120 billion each year during this period. We also estimate that these investments have enabled ISPs to save over USD5 billion per year, based on analysis that Analysys Mason conducted with Netflix in early 2022.

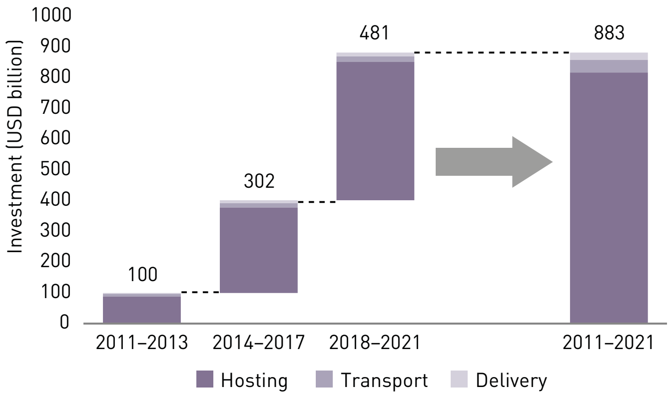


Figure 1: CAPs' investments by infrastructure cluster, worldwide, 2011–2021 [Source: Analysys Mason, 2022]

This organisation of traffic delivery on the internet has worked very well and has supported growth in the scale and scope of online services that many of us use daily. The COVID-19 pandemic illustrated the importance of the internet for working, studying and staying connected, as well as the need for internet infrastructure that is resilient and scalable in order to cope with spikes in demand. Overall, everything worked better than expected, and there is some evidence that access to meaningful broadband connectivity actually saved lives during the pandemic.[2]

This illustrates powerfully that there are clear synergies at play between connectivity and content. Access to business support systems, productivity software and online communications apps, all of which are increasingly hosted on public cloud platforms, is what allows people to work remotely. The same sort of applications, when used by schools and universities, enable students to continue learning at home. Online streaming and gaming keep many of us entertained and sustain growth in the audio-visual and gaming industries.

These synergies drive the demand for better connectivity. The results of Analysys Mason's consumer survey show that users of more-advanced online services, including streaming and gaming, already subscribe to faster broadband packages than those that do not use such services and, crucially, are more likely to upgrade their connections to faster speeds when available (Figure 2).

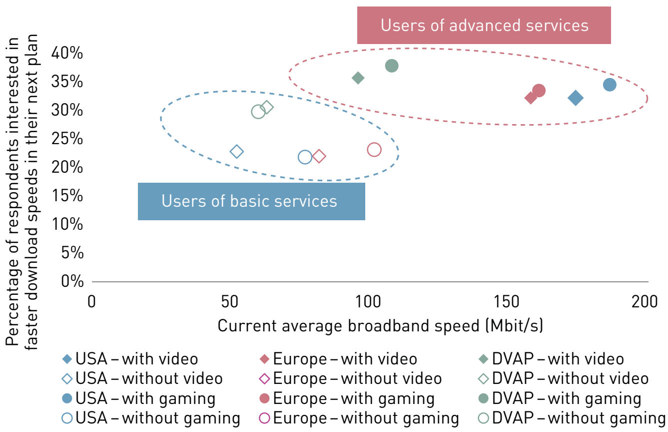


Figure 2: Correlation between the use of advanced services and broadband speeds, developed Asia–Pacific (DVAP), Europe and the USA, 2021 [Source: Analysys Mason, 2022]

These trends are crucial for the success of gigabit-capable networks worldwide; people will upgrade to fibre and 5G either because it is cheaper than what they currently have or because it will improve the service quality in ways that are meaningful to them (by providing them with access to new services, for example). ISPs are understandably keen to maintain their revenue, particularly in the current macroeconomic climate where their costs are likely to go up. They should therefore focus on making networks work for the next wave of services, be they metaverse, cloud gaming or industrial services.

Some ISPs have been sketching out a vision in which they are both connectivity providers and service providers as part of their efforts to get regulators and policy makers to mandate CAPs to pay them to deliver traffic. This model was very successful for ISPs with telephony and cable TV, but it is far removed from what consumers and businesses expect from the internet today.

> “We estimate that CAPs worldwide invested a total of USD883 billion in infrastructure (including hosting, data transport and content delivery) between 2011 and 2021

Regulators and policy makers should carefully consider the potential impact of imposing fees on the wider internet ecosystem (which includes consumers, businesses and public sector organisations that rely on an open internet without bottlenecks or 'toll roads' to work, play, study and stay connected) when assessing and responding to calls for fundamental changes to how the internet works. Indeed, in our recent work, we found that network usage fees risked creating barriers to entry and growth for smaller and new CAPs, thereby reducing efficiency and competition and lowering the quality of experience for end users.

Perhaps more importantly, the ISPs and telecoms operators who are currently clamouring to be paid by CAPs should recognise what they do best: operating network infrastructure that is secure and resilient and offering great reliability and customer service to end users. The recent boom in investments by digital infrastructure funds, which shows little sign of abating, is a sure sign that this is where the value lies, not in making the internet smaller, more complex and potentially more expensive.

Questions? Please feel free to contact David Abecassis, Partner, at david.abecassis@analysysmason.com

[1] Internet Society (May 2022), *Internet Impact Brief: South Korea's Interconnection Rules.*
[2] World Bank Blogs (August 2022), *Did internet speed impact exposure to COVID-19?*; Digital Planet (June 2022), *The Impact of Internet Access on Covid-19 Mortality in the United States.*

Spending on private networks will reach USD7.7 billion in 2027, but challenges to adoption persist

Ibraheem Kasujee, Analyst

The number of private LTE/5G network deployments worldwide is growing rapidly. Indeed, Analysys Mason forecasts that the number of networks will grow at a CAGR of 65% between 2021 and 2027 to reach 39 000. Spending on these networks will rise to USD7.7 billion during the same period; this is a large figure in isolation, but appears small when compared to the spending on public network infrastructure. However, private networks could act as an important new revenue stream for the mobile industry in the longer term, and will also be an important bellwether of the success of 5G in the industrial sector.

This article is based on Analysys Mason's report, *Private LTE/5G networks: worldwide trends and forecasts 2022–2027.*

Enterprises' spending on private networks could become significant if suppliers address the challenges to adoption

Enterprises' spending (capex and opex) on private LTE/5G networks will reach USD7.7 billion worldwide in 2027 and will grow at a CAGR of 48% between 2021 and 2027 (Figure 1). Most private network suppliers will not generate significant new revenue initially, but they should nonetheless address the private networks market as an important long-term opportunity. However, suppliers will need to develop strategies now to address the challenges to private network adoption in order to build the market. These include the following.

- Private network solutions are currently highly bespoke and complex; these are characteristics that limit the ability to scale. Early private network adopters are typically large corporations that have the resources to buy and operate complex solutions; smaller firms do not have these capabilities and will need networks that are simpler to buy and manage.
- The cost of private networks is currently prohibitively high (compared to Wi-Fi, for example) for the broader enterprise market.
- The awareness and understanding of private cellular networks is still low among enterprises, especially small and medium-sized enterprises (SMEs), and will take time to grow.

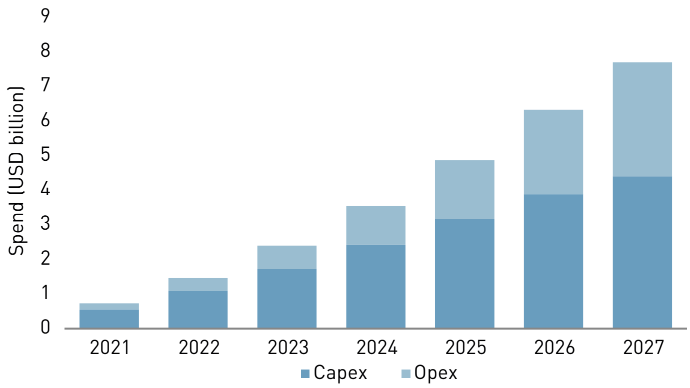


Figure 1: Private network capex and opex, worldwide, 2021–2027
(Source: Analysys Mason, 2022)

> Private networks will be an important bellwether for the success of 5G in the industrial sector

The current complex and expensive private network propositions are out of reach of most enterprises. Enterprises require simpler, affordable solutions with a service wrap that includes support for the network and the applications that will run on it. We believe that spending on private networks has the potential to grow even more quickly after the forecast period, but only if suppliers address these challenges to make their solutions accessible to a broader enterprise market.

The number of private networks that use 5G is growing, but from a very small base

Analysys Mason estimates that 26% of the 1900 live private networks in 2021 used 5G, but that almost half of all deployments will use 5G by 2024. We forecast that this figure will grow to two thirds of all private networks (of which there will be 39 000) by 2027 (Figure 2). For more discussion about the current private network deployments, see Analysys Mason's Private LTE/5G networks tracker.

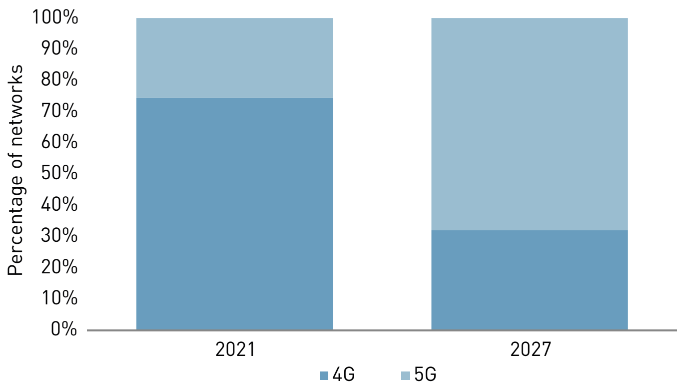


Figure 2: Split of private network deployments, by technology, worldwide, 2021 and 2027 [Source: Analysys Mason, 2022]

The manufacturing sector has been the leading early adopter of private 5G networks; we estimate that more than 50% of private networks in the sector used 5G in 2021 and that this figure will rise to almost 90% by 2027. Analysys Mason's research suggests that enterprises, especially those in the manufacturing sector, are deploying 5G because it can achieve unique results in terms of automation. Manufacturing firms are investing to support new applications in the long term and believe that 5G will be the most suitable technology in the future to address requirements such as low latency.

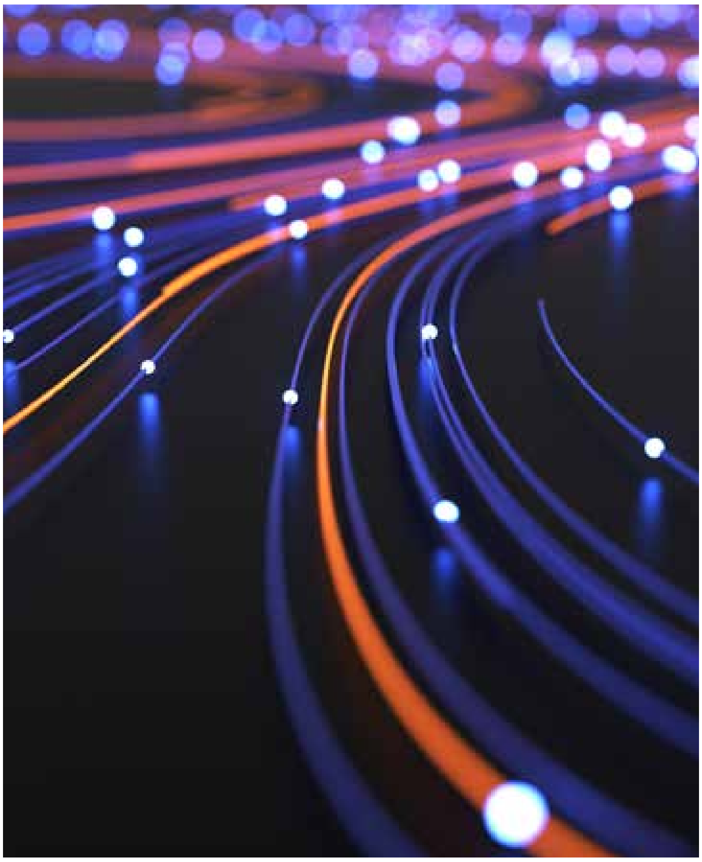
Nevertheless, the adoption of 5G for private networks is not homogenous worldwide. The majority (73%) of publicly announced private network deployments in North America are based on LTE.1 Indeed, AWS's recent private networks offer is based on LTE, despite the 'Private 5G' product name. Many of the early use cases deployed using CBRS shared spectrum, in public sector education for example, do not require 5G capabilities. We estimate that the adoption of 5G in private networks is higher in Western Europe and emerging Asia–Pacific (mainly China) than in North America, and that 5G is used in 41% and 46% of private network deployments in these regions, respectively.[1]

The private networks market is an important bellwether of the success of 5G in industry

Telecoms vendors and operators alike are placing a significant emphasis on the new opportunities that 5G enables in the industrial sector, and private network solutions will be key to demonstrating the value of 5G for industry. However, there is still insufficient activity to address some of the barriers to adoption such as the higher cost of 5G relative to other network technologies and the complexity in deploying such networks, despite significant and growing interest in private 5G. Analysys Mason believes that there is scope for the private networks market to grow significantly more quickly beyond 2027, but such growth will depend on suppliers doing more to address the barriers to adoption.

Questions? Please feel free to contact Ibraheem Kasujee, Analyst, at ibraheem.kasujee@analysysmason.com

[1] The forecast split is slightly different and reflects data sources that are not in the public domain. For information on publicly announced deployments, see Analysys Mason's Private LTE/5G networks tracker.



Hollow-core fibre for low latency and increased bandwidth: the next game-changer in optical cables

Franck Chevalier, Co-Head of Technology

The amount of data carried through telecoms networks is increasing at a rate of between 20% and 30% every year. This is partly driven by the move to next-generation access (NGA) and higher-speed mobile access networks. Hyperscalers and cloud players are also creating new demands for high-capacity core networks between data centres.

In addition to the apparent need for higher capacity over time, specific applications such as high-frequency trading, gaming or augmented/virtual reality (including the metaverse) have very low latency requirements.

Network operators have been addressing the trend of increasing demand by increasing the optical transmission capacity of their fibre networks. Each wavelength is carrying more data, and some networks are using dense wavelength division (DWDM) (that is, more wavelengths per fibre). However, some operators and hyperscalers are reaching the limits of silica-based fibre technology and to meet higher demand will eventually have to light or deploy additional fibres to cope with the demand. An alternative is to shift to radically different optical transmission medium technology called hollow-core fibre.

Silica-based fibres impose latency limits and restrict the use of spectrum to C and L bands for long-haul applications

Optical transmission has revolutionised telecoms by enabling the transmission of terabit per second bandwidth over a single fibre pair over long distances (for example, thousands of kilometres in submarine applications). However, the fibre medium has traditionally been based on fused silica (glass), which has two limitations.

- **Latency.** Silica has a refractive index of (roughly) 1.5 and optical electromagnetic waves can only be transmitted in a silica medium at two thirds of the speed of light in a vacuum. This is in marked contrast with systems that use air as a transmission medium (for example, microwave links) where the signal can be transmitted at close to the speed of light in a vacuum ('c').
- **The attenuation profile limits specific spectrum transmission windows.** Traditional silica-based fibres can only use a small spectrum window to transmit signals over long-haul applications, due to the need for low attenuation. If the attenuation was lower over a wider spectrum window, additional spectrum could be used in the fibre, and significantly higher bandwidths could potentially be carried on each fibre (provided that suitable electro-optic devices are developed to match these as-yet untapped spectrum bands).[1]

The latency of optical fibre is adequate for most current applications, but some applications are highly sensitive to latency. For example, in high-frequency trading applications, if the signal must travel between Frankfurt and London (700km), and all else is equal, a trader using a fibre-optic system between these two locations will receive the latest stock quotes around 1 millisecond after a trader who uses a microwave transmission system giving the latter an advantage (and indeed microwave systems joining London to Frankfurt in a straight line have been built for this very reason). Systems that cross major oceans or continents face even larger impacts.

The transmission of optical signals over long distances is designed to use the C band and L bands (Figure 1) – the so-called 'third transmission window'. This is because signal attenuation is wavelength-dependent and the third transmission window wavelength range exhibits the lowest attenuation.[2] Up to the L band, the floor in attenuation is dictated by Rayleigh scattering (as light travels in the core, it interacts with the silica molecules and these collisions between the light wave and the silica molecules result in attenuation or loss of signal), which is an inherent property of silica-based fibres. For wavelength in the U Band and above, the attenuation becomes dominated by absorption.

> Continuing growth in the volume of data traffic and the need for low latency will lead operators to deploy hollow-core fibre networks

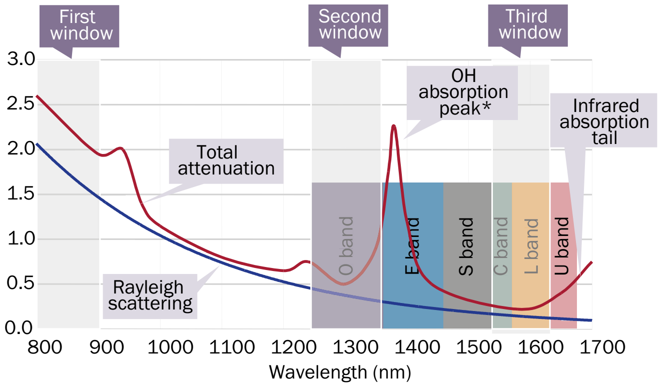


Figure 1: Silica-based fibre attenuation profile as a function of wavelength [Source: Analysys Mason, 2022]

Hollow-core fibre can transmit signals at a higher speed than silica-based fibre and could release additional bandwidth

To avoid these limitations, significant focus has been recently put on researching hollow-core fibre, which transmits the signal in a very small tube filled with air (instead of silica/glass). Although the significant improvement in latency of hollow-core fibre over silica-based is well-established (that is, transmission at the full speed of light), hollow-core fibres have traditionally suffered from higher attenuation than silica-based fibre.

One of the reasons for the higher attenuation is due to manufacturing process challenges to produce these hollow-core fibres, which are still at a nascent stage of their lifecycle. However, if the manufacturing processes keep on improving, hollow-core fibre could be produced with significantly lower attenuation than silica-based fibre, overcoming the fundamental Rayleigh limit in the silica-based medium. In turn, lower attenuation would enable:

- transmission over longer distances, reducing the requirement for optical amplifiers and repeaters or allowing the use of lower-powered transmitters, with resulting power savings
- additional spectrum bands to be used for transmission in long-haul applications, which would allow significantly more capacity per fibre.

Commercial deployments of hollow-core fibre are starting for low-latency applications but are still at a nascent stage

euNetworks, a Western European bandwidth infrastructure company, announced in April 2021 that it had deployed the first hollow-core fibres from provider Lumenisity.[3] The link is between Interxion, a data-centre provider and the London Stock Exchange. This was the first commercial deployment of this technology in the world and was part of an agreement covering additional deployments over the coming years between trading venues and other locations.

Comcast announced in April 2022 that it had deployed a 40km hollow-core fibre link in its home market of Philadelphia.[4] The fibre provider was also Lumenisity. Comcast tested bidirectional transmission on the same fibre strand at speeds of 10Gbit/s to 400Gbit/s. Comcast says 40km is significantly longer than previously demonstrated hollow-core fibre deployments. Comcast's core business is residential rather than commercial services, so the most likely benefit of ultra-low latency is supporting gaming or other immersive consumer applications (such as VR/AR) that the metaverse might bring.

Hollow-core fibre roll-out will address low-latency needs at first and may occur at scale in the late 2020s if attenuation can be reduced

Use of hollow-core fibre will require operators to install new fibre cables that can reside in the same ducts as existing silica-based fibre. We expect more operators in developed markets to test hollow-core fibre in 2023 and limited commercial deployment in 2024 and beyond to complement existing fibre/microwave links in handling low-latency requirements. As the technology evolves and, if we are correct, that attenuation in hollow-core fibre becomes lower than that of silica-based fibre, additional currently unused spectrum will become available, allowing greater capacity per hollow-core fibre. Therefore, we do expect larger-scale deployment of hollow-core fibre in core networks in the late 2020s/early 2030s.

Questions? Please feel free to contact Franck Chevalier, Co-Head of Technology, at franck.chevalier@analysysmason.com

[1] Some of these spectrum bands are used by coarse wavelength division multiplexing (CWDM) applications but cannot transmit over large distances.
[2] Erbium-doped fibre amplifiers (EDFA) have also been developed to specifically operate in the C and L bands to extend transmission reach.
[3] https://eunetworks.com/news/eunetworks-deploys-lumenisity-limited-coresmart-hollowcore-fibre-cable-in-london.
[4] https://corporate.comcast.com/press/releases/comcast-first-isp-hollow-core-fiber-faster-speed-lower-latency.

Enabling data centre sustainability continues to be key for both governments and operators

Jay Lee, Manager and Dion Teo, Principal

There has continued to be a growing emphasis on ensuring the sustainability of data centres worldwide since our last article on data centre sustainability in November 2021, from both a government perspective and an operator perspective. This is becoming even more critical because consumers, businesses and governments are becoming increasingly aware of the direct negative effects that data centres can have. These include noise emissions, high water usage and, more critically, an indirect increase in carbon emissions due to high electricity consumption.

Technology continues to be the key to unlocking large-scale improvements in data centre sustainability. Bright spots have emerged, including signs of increasing industry collaboration, which may potentially enable a more sustainable data centre industry for all.

Governments continue to implement measures to tackle data centre sustainability

Governments have ramped up their efforts to improve data centre sustainability over the past 9 months. Some examples are given in Figure 1.

Country	Initiative
Germany	The Frankfurt City Council announced, in June 2022, that it will be limiting data centres to specific neighbourhoods. In addition, it intends to impose guidelines to ensure that new facilities are energy-efficient and it will design a heating plan for the city that uses heat generated by data centres.[1]
Singapore	The IMDA launched a pilot in July 2022 that invited applicants for new data centres after lifting a moratorium on new data centres that was first imposed in 2019. Applicants will be evaluated based on key criteria including sustainability, with the aim to have "best-in-class resource efficiency and decarbonisation".[2]
Netherlands	The Dutch government announced, in February 2022, that it would be reimposing a 9-month moratorium on new hyperscale data centres while it develops new rules to manage new builds. This is due to concerns that include the very high consumption of renewable energy by such facilities, which could have been used for other purposes.[3]

Figure 1: Recent government initiatives to manage data centre sustainability [Source: Analysys Mason, 2022]

Similar measures to manage data centre sustainability are likely to be considered and introduced by more countries, particularly as the general populace becomes increasingly aware of its impact, as illustrated by the examples in Figure 2.

Country	Description
Netherlands	Meta's planned development of the largest data centre in the Netherlands saw backlash from residents who argued that "it asks too much of our electricity, it asks too much of our water".[4] Meta initially obtained local council approval for the facility, but it was forced to put a hold on its plans in March 2022 after facing political opposition in the Dutch Senate.
UK	The Greater London Authority issued a letter to developers in July 2022 warning them that new developments in three boroughs may be rejected due to insufficient electrical capacity. It further cited that a key reason for this is the recent rise in the number of data centres that "use large quantities of electricity, the equivalent of towns or small cities, to power servers and ensure resilience in service".[5]
USA	Residents in Prince William County, a part of Northern Virginia that has the largest data centre market in the world, raised complaints about "catastrophic noise" emerging from data centres and sought a pause on approvals for new data centre builds until the issue was addressed.[6]

Figure 2: Examples of the direct disruption and impact caused by data centres [Source: Analysys Mason, 2022]

Data centre operators need to improve their sustainability to improve access to financing

Improving the sustainability of data centres is not only in the interest of governments. Data centre operators should also take note due to:

- increasingly stringent requirements for new data centre builds imposed by regulators and governments
- environmental, social and governance (ESG) initiatives becoming an important evaluation criterion used by enterprises when selecting suppliers that offer data centres
- the growing emphasis on ESG factors by financiers, which can affect a data centre operator's ability to attract funding and/or investment.

Traditional credit rating agencies now also offer ESG ratings due to demand from investors to assess the sustainability of corporate entities. This provides evidence of the growing importance of ESG factors in supporting funding or investment.

Data centre operators are thus increasingly using sustainable financing to raise funds to support their operations and expansion plans. This can be through the issuance of green bonds, which are bonds that are raised for climate or environmental sustainability projects. Leading data centre operators have used such bonds extensively in recent years. For example:

- **Equinix** issued USD1.2 billion of green bonds in April 2022 to reach a total of approximately USD4.9 billion of green bonds issued[7]
- **Digital Realty** issued two additional green bonds in 2021, bringing it to over USD6 billion raised via green bonds since 2015.[8]

The importance of sustainability for data centre operators when trying to attract financing is expected to increase further. Indeed, 83% of respondents to a worldwide survey of senior executives in 2022 expect that scrutiny and due diligence surrounding ESG issues when making data centre investment/development decisions will increase greatly over the next 24 months. In addition, the survey results further revealed that 75% of both debt providers and equity investors are willing to pay a premium to invest in a data centre facility with very good or excellent ESG credentials.[9]

Innovation will continue to be at the forefront of improving data centre sustainability

Innovations in data centre cooling and clean energy will continue to be critical to improving the energy efficiency of data centres and reducing their carbon footprints. New advances continue to be made; hyperscalers are particularly committed to research and development to improve data centre sustainability.

- Microsoft announced, in July 2022, that it had made a breakthrough in successfully testing a first-of-its-kind hydrogen generator running at 3MW. This provides evidence that a zero-carbon-emissions alternative to traditional diesel-powered back-up generators is feasible.[10]
- Google has implemented a carbon-intelligent platform that is able to "shift moveable compute tasks between different data centres, based on regional hourly carbon-free energy availability" to support its goal of operating fully on carbon-free energy by 2030.[11]
- Meta has been using advanced data centre cooling approaches, such as direct evaporative cooling, to reduce water usage when cooling its data centres. It has stated that its facilities are thus "over 80% more water efficient that the average data centre".[12]

Co-location providers are similarly exploring innovations that can improve sustainability. For example, Equinix opened its first co-innovation facility (CIF) to work with partners and test sustainable innovations such as fuel cell technology and liquid cooling.[13]

The implementation of such innovations across the industry will be facilitated by the increasingly collaborative environment regarding sustainability measures. An example of this collaboration is the launch of the Low Carbon Patent Pledge (LCPP) in 2021 by key industry players including HPE, Meta and Microsoft. Members of the LCPP agree to share patents for low-carbon technology applications. Alibaba Cloud joined the LCPP in April 2022 and made nine of its patents related to green data centre technology available to external parties.[14] This highlights the common goal of the cloud and data centre industries of ensuring a sustainable future.

Conclusion

The impact that data centres have on sustainability is becoming increasingly apparent, not only to governments, but also to the general populace due to noise emissions, excessive water usage and, most critically, carbon emissions. The measures to manage sustainability that are starting to be introduced by governments in mature data centre markets thus need to be expanded to other markets to ensure an increase in data centre sustainability. In addition, data centre operators also have a need to manage sustainability concerns to ensure compliance with new regulation, to secure customers and to obtain access to financing and/or to maximise valuations. Investments in innovation will continue to be critical because they will play a key role in enabling large improvements in data centre sustainability. Additional measures such as sourcing renewable energy and improving energy efficiency will continue to be important approaches for all data centre operators to consider.

Analysys Mason has conducted multiple projects in the data centre space worldwide, including market studies, due diligence exercises and helping regulators to develop their data centre policies.

Questions? Please feel free to contact Jay Lee, Manager, at jay.lee@analysysmason.com or Dion Teo, Principal, at dion.teo@analysysmason.com

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Backhaul networks: comparing the economics of using satellite mega-constellations rather than fibre optics

Carlos Placido, Consultant

The recent deployment of high-capacity, low-latency LEO satellite mega-constellations brings challenges for telecoms operators in the retail broadband market but also provides new options for the economic expansion of terrestrial backhaul networks.

Satellites are becoming mainstream, which is altering the dynamics of the telecoms market

Telecoms carriers have long partnered with satellite operators to enable communication services in remote communities, but this been a niche market.

Over the last few years, technology advances have made satellites more cost-efficient for broadband and mobile backhaul, but – compared to terrestrial options – link latency and bandwidth costs have been high, which has tended to limit satellites to being the 'technology of the last resort'. However, players in the LEO satellite mega constellation market, including Amazon (Kuiper), OneWeb and SpaceX (Starlink), are bringing satellites into mainstream use, thereby altering the dynamics of the telecoms market.

SpaceX disrupted the satellite business by taking a vertically integrated approach to satellite manufacture, launch and network operation. The company has launched more than 3000 satellites and announced services in around 40 countries, and its their mission to "rebuild the Internet in space" is underway. Other players, such as Amazon, OneWeb and Telesat, have established partnerships with network providers and telecoms operators. Amazon and Verizon are collaborating in the USA on the yet-to-launch Kuiper constellation, and several other partnerships involving AT&T, Vodafone and others have been announced.

Constellations are an alternative to fibre-optic backhaul

Hundreds of terabits deployed in space can serve multiple applications including MNO backhaul. If we compare the relative costs of fibre and satellite backhaul, it turns out that satellites can be a cost-effective alternative to fibre for some combinations of the distances that need to be bridged and communities' aggregate demand.

Deploying multi-billion dollar mega-constellations is capex-intense; Elon Musk said, "every new satellite constellation in history has gone bankrupt. We hope to be the first that does not." However, a proper benchmark for deciding on the preferred approach to telecoms operator backhaul depends on fairly comparing the net present value (NPV) of a potential investment in (say) a fibre-optic network (regional/long-haul/festoon) compared with leasing aggregate capacity from a managed-services satellite operator. Given the unknowns that surround mega-constellations, a sensitivity analysis may be a good way to conduct such an assessment.

Sample sensitivity analysis: fibre versus satellite

Northern Sky Research (NSR) has a toolkit that can be used to perform such an analysis; the Non-GEO Constellations Analysis Toolkit 3.0 (NCAT3) can help to evaluate the pros and cons of connecting previously unserved communities with fibre and satellite (Figure 1).

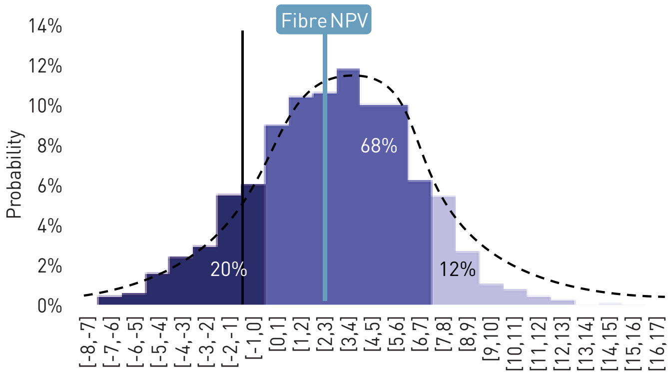


Figure 1: A net present value (NPV) sensitivity analysis of satellite and fibre optics [Source: Analysys Mason, 2022]

> New and high-capacity satellites are altering the optimal choice of technology for backhaul networks

The sample case assumes that an operator plans to serve 10 very remote communities with projected aggregate bandwidth demand of 7Gbit/s, requiring a fibre-network deployment of 3000km. Fibre projects vary in cost widely but, for this assessment, we made the following assumptions.

- **Cost.** The cost per kilometre includes the fibre itself, splices, amplifiers and civil work related to buried-cable installation. We have assumed USD8000 per kilometre, which is low and may be misleading because terrain challenges and other local/regional conditions can increase such costs substantially.

- **Unprotected network.** Our analysis assumes an unprotected, single-path fibre network; a protected ring would be more expensive.

One thousand possible results were recorded via a Monte Carlo simulation driven by randomly generated input ranges. Sample-case results show that if the telecoms operator leases 7Gbit/s of high-throughput satellite (HTS) capacity to reach 10 remote communities (instead of building a 3000km fibre-optic backbone network), there is a high chance (72%) that NPV will be positive, in the range of USD266 000 to USD7.1 million. There is a low probability that NPV will turn negative for the satellite option. On the other hand, if the telecoms operator builds a fibre-optic backbone network, NPV will be USD2.5 million.

Bandwidth costs are a key element of this comparison

Naturally, the satellite business case is sensitive to capacity costs. In Figure 1, NPV becomes negative for the sample case if bandwidth cost is higher than USD65 per Mbit/s per month. Also key to this analysis, is having realistic multi-year projections of aggregate traffic demand, because the point at which satellite is preferable to fibre is traffic-dependent. The marginal cost for fibre to serve virtually unlimited levels of bandwidth demand is low, diminishing the opportunity for satellites to compete for such links. However, the example shows that LEO constellations can potentially become a cost-effective alternative, if priced properly, for addressing a particular range of demand levels and the required distances to bridge. At other ranges of demand and distance, other solutions may be more appropriate including microwave point-to-point links or hybrid solutions that combine fibre links, microwave point to point and satellite solutions.

Because constellation players are doing the capex 'heavy-lifting', satellite backhaul is a relatively low-capex solution for telecoms operators (requiring only suitable satellite terminals), which could enhance specific metrics such as return on investment. Lastly, when aggregate traffic-demand projections are uncertain, an opex-based satellite solution can reduce risks by allowing the carrier to postpone the fibre investment decision.

Conclusions

Fixed and mobile network operators that want to connect the unconnected by expanding core and backhaul networks may find attractive satellite solutions from newly deployed LEO mega-constellations, at least for some ranges of demand and distance to bridge.

Recent trends indicate that backhaul via satellite may become attractive under a wider range of conditions if competition intensifies and oversupply drives down the cost of satellite bandwidth, particularly for high-volume telco leases.

NSR's *Non-GEO Constellations Analysis Toolkit 3.0 (NCAT3)* is an assembly of flexible, easy-to-use analytical models that benchmark LEO and MEO satellite constellations at architectural and business layers.

Questions? Please feel free to contact Carlos Placido, Consultant, at carlos.placido@analysysmason.com

Mandated network usage fees could degrade network quality, decrease competition, and harm consumers

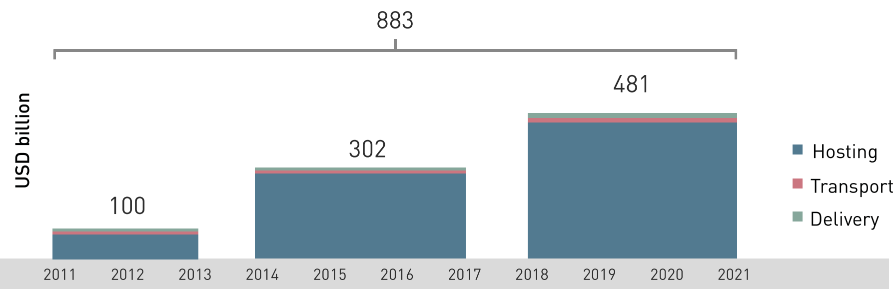
Content and application providers (CAPs) invest extensively in global internet network infrastructure

Infrastructure investments in hosting, transport, and delivery are made in addition to other CAP investments in content, applications, and services for end users; the availability of these online services also drives demand for broadband access services from internet service providers (ISPs).

Total spend by CAPs on internet infrastructure over various periods since 2011

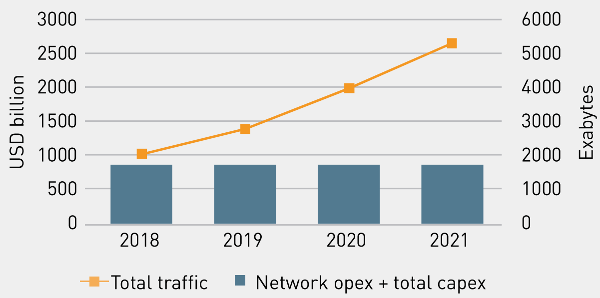
CAP investment in 2011–21 was USD883 billion. In the past four years (2018–21), CAPs invested USD120 billion per annum.

These investments help to reduce ISPs' costs, while optimizing performance for end users.



The current voluntary interconnection regime incentivizes CAPs and ISPs to invest in efficient, cost-effective traffic delivery to provide quality experiences for end users

Growth in traffic delivered over fixed and mobile access networks, and evolution of network-related telecom operator costs from 2018 to 2021



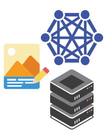
In 2018–21, network-related ISP costs increased by 3% in total over three years, whilst network traffic increased by over 160% in that same period, showing that ISP networks can handle significant traffic growth at modest incremental cost.

CAP network investments that bring content closer to end users also help ISPs to manage costs, saving ISPs USD5.0–6.4 billion per annum.

Network usage fees would impose high interconnection costs for a non-existent problem, and they would disrupt incentives, investment, and competition

If introduced, network usage fees could have detrimental effects on multiple stakeholder types

Impacts on CAPs include:



- Fewer resources to invest in content and infrastructure
- Higher barrier to entry for smaller/local CAPs

Impacts on ISPs include:

- Reduced ability to offer high-quality online experiences
- Reduced long-term ISP competition and investment

Impacts on end users (consumers and businesses) include:

- Higher ISP prices, less ISP choice, and reduced quality of broadband services (e.g. latency)
- Reduced quality of service from CAPs and fewer new CAPs to choose from in the future

For more details please see:

https://www.analysysmason.com/internet-content-application-providers-infrastructure-investment-2022

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  We cover all aspects of strategy development and review based on a highly analytical and data-driven approach. Our propositions include corporate growth strategy (organic and inorganic), business unit strategy (including consumer and enterprise products), and infrastructure strategy (including capex optimisation through data analytics).

- **Transaction support**

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- **Transformation**

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