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ANALYSYS MASON

QUARTERLY

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Contents

The terahertz frequencies that are expected in the 6G era offer both opportunities and challenges

Janette Stewart, Partner

Each new generation of mobile technology generally takes up to a decade to define and standardise, so while 5G roll-outs are still ongoing, early-stage research is already underway into what might become the next generation of mobile connectivity, that is, a sixth generation (6G).

There is a vision that 6G connectivity may deliver peak data rates of the order of terabits per second together with sub-millisecond latency. These peak rates are unlikely to be delivered over wide areas, but might be useful for some use cases in localised areas. As such, there is interest in the potential use of frequencies in the sub-terahertz and terahertz ranges to provide the bandwidth to deliver these peak data rates and to enable the intensive use of spectrum within localised areas.[1] However, the characteristics of sub-terahertz/terahertz frequencies are very different to those of the bands used for wide-area, contiguous coverage in mobile networks today. Potential use of sub-terahertz frequencies in 6G therefore raises fundamental questions in terms of usage environments, use cases, network topologies and devices.

Networks must evolve beyond 5G

The vision for 5G is based on three vertices: enhanced mobile broadband, ultra-reliable, low-latency communications and massive machine-type connections. To deliver these, spectrum for use in 5G networks is defined across three frequency ranges: low bands (below 1GHz), mid bands (typically around 3.5GHz) and high bands (currently standardised 5G millimetre-wave spectrum with a frequency of 26GHz).

The ability to map the 5G radio expansion onto existing grids of network sites (which were laid out to efficiently use low frequency bands) has been an important practical aspect of rolling out 5G for mobile operators. The deployment of 5G millimetre-wave bands (such as the 26GHz band) represents a shift in focus away from the traditional lower-frequency bands. The limited propagation of the 26GHz band compared to that of lower-frequency bands means that it is ideally suited to the delivery of very high capacity in localised areas. These characteristics (high capacity and high spatial reuse) will be even more

pronounced if frequencies in the sub-terahertz and terahertz bands are used in the 6G era. However, the characteristics of these frequencies mean that new technologies and materials are needed; extensive research is still required to understand the capabilities and limitations of these frequencies in terms of bandwidth and range.

The commercial viability of using sub-terahertz spectrum remains unclear

The opening up of sub-terahertz and terahertz spectrum is one area of 6G research that is attracting interest due to the potential for these frequencies to provide very wide bandwidths that could support terabits-per-second transmission. The FCC has already opened up terahertz spectrum (above 95GHz) in the USA. It has chosen to offer relatively long-term (10-year) experimental licences (issued on a locally licensed, first come, first served basis), but has designated several portions (116–123GHz, 174.8–182GHz, 185–190GHz and 244–246GHz) specifically for unlicensed use. The regulator in the UK, Ofcom, also consulted on making frequencies above 100GHz available. It decided not to include unlicensed use, but instead introduced a flexible access (shared use) licence in several bands (116–122 GHz, 174.8–182 GHz and 185–190 GHz). We can see, therefore, that the frequency bands released in the USA are similar to those in the UK, but the licensing approach is different.

However, it remains unknown how sub-terahertz frequencies might be deployed together with the spectrum and architecture used in today's mobile networks. This will be the subject of further research, industry debate and standardisation over the coming years. The significant differences between these frequencies and those used by mobile networks today mean that 6G is unlikely to be defined entirely by its ability to use the sub-terahertz/terahertz ranges, so as to ensure an ordered evolution from 4G/5G.

A key consideration for 6G lies in how the network architecture used in mobile networks today might evolve to address future traffic volumes generated by today's mobile consumers, while also catering for the new use cases that might emerge with 6G, which the sub-terahertz frequencies might accommodate. It will be challenging to integrate terahertz frequencies into existing mobile network architecture since terahertz communication only occurs over short ranges (of the order of 100m) and therefore communications will be limited to 'line of sight'. The use of denser infrastructure itself will also bring about several key challenges, largely relating to mobility management, cost and coverage. Such dense infrastructure, or even a move to user-centric, 'no cell' architecture, does not appear to be commercially viable for providing contiguous coverage given the level investment required, and hence would be limited to localised deployments.

As such, networks that incorporate 6G radio will also need access to lower frequencies (such as those used for 4G and 5G today) if they are to provide population and geographic coverage levels that are similar to those of the current generations of mobile networks. The 5G mid bands (around 3.5GHz currently, and potentially expanding into 7GHz, 10GHz or beyond, depending on the outcome of international discussions) will be essential to ensure that the high volumes of mobile data that are expected in the future can be accommodated using evolved 5G architecture. Alternatively, if 5G evolutions do not support traffic growth indefinitely, 6G will need to support the low and mid bands natively.

Analysys Mason has already started to look into 6G, particularly how one might achieve very high data rates and sub-millisecond latency. Details of how to authorise use of new bands, the characteristics of use and the bands to be used are likely to form part of national regulatory authorities' future spectrum roadmaps over the next few years. Analysys Mason's spectrum consulting team is experienced in advising regulators and operators on market and technology trends in the wireless market, spectrum strategy and spectrum roadmap formation.

[1] The sub-terahertz and terahertz ranges encompass spectrum between 90GHz and 300GHz, which is between millimetre-wave and infrared. For more information, see Brave Research Project, Sub-THz frequencies. Available at: http://www.brave-beyond5g.com/index.php/sub-thz/.

Questions?

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Open RAN: on the beach in the UK for the G7 summit, but more work to do to make it widely available

David Abecassis, Partner and Shahan Osman, Consultant

There have been several important announcements about Open RAN over the last few weeks. During the G7 summit in Cornwall (UK) in June 2021, Vodafone proudly showcased connectivity built upon open standards, for surfers and world leaders alike. More seriously, and relevant to the prospect of Open RAN as a new network paradigm, Vodafone also announced that it has procured 2500 Open RAN sites in the UK from Samsung. This builds upon a commitment by major MNOs in Europe to focus their network procurement on Open RAN-compliant hardware and software.

Mobile operators' margins are under pressure but Open RAN could help

This momentum is building in a context of 5G requiring significant investment, although mobile network operators (MNOs) continue to be uncertain about service demand and the business case for 5G. MNOs' margins remain under pressure, due to commoditisation, competition, growth in data demand and an increased focus by governments on resilience and security. Capital efficiency has increased, however, because MNOs have benefited from carving out towers to strategic and financial investors, at high valuations. The trends are similar in emerging markets, but infrastructure carve-outs are limited and many people cannot access, or afford, mobile broadband services.

Open RAN promises to help MNOs to manage some of these challenges, as will independent yet related innovations around software-driven networking and automation, and trends such as network sharing and possibly network-as-a-service delivery models. As a set of standards, however, Open RAN will depend on a developing supply chain to design, productise, manufacture, test and ultimately sell Open RAN-compliant networks, in a context where a small

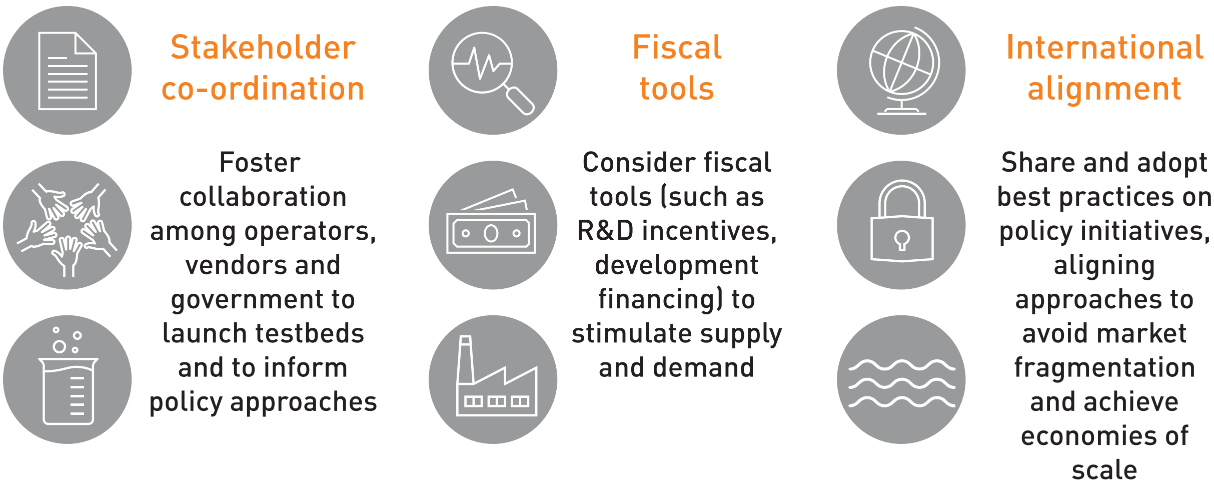


FIGURE 1: WAYS IN WHICH POLICY MAKERS CAN SUPPORT SUPPLY-CHAIN DIVERSIFICATION TO BUILD NETWORK RESILIENCE AND IMPROVE CONNECTIVITY [SOURCE: ANALYSYS MASON, 2021]

number of large, highly efficient vendors are already entrenched and benefiting from significant economies of scale.

MNOs have taken a leading role in convening and organising industry initiatives where they can come together with vendors and other supply chain participants to innovate and bring to market solutions that respond directly to operators' requirements, in a quick and cost-effective manner. This creates opportunities for vendors, and for systems integrators who are essential to bring together interoperable but disparate components into coherent, tested and validated solutions that they can deploy and maintain for MNOs. One such initiative is the Telecom Infra Project (TIP), which has been driven by Facebook and operators such as Telefónica, Vodafone and many others, and which has successfully attracted chipmakers such as Intel, systems integrators such as Dell and Infosys, and infrastructure providers such as edotco.

In a recent report that we prepared in partnership with TIP, we specifically looked at the potential economic benefits of Open RAN solutions, as part of the broader trend towards open and disaggregated network technologies. The impact of these technologies on networks globally could be transformational in several ways, by enabling faster innovation, tailored solutions to specific deployment challenges, including those in remote and rural areas, and improved security and resilience of networks and supply chains.

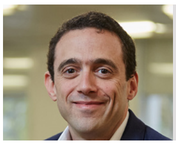
If Open RAN is successful, it could result in a more innovative, diverse supply chain that should bring benefits in terms of supply cost and the total cost of ownership (TCO) of mobile networks. MNOs would then be able deploy more flexible and performant networks, resulting in more people worldwide being connected in a meaningful way, and having greater access to information and services that generate wider socio-economic benefits. We estimated that with modest TCO benefits (10–20%) and fairly broad diffusion of open solutions round the world (progressively reaching 55% of network coverage by 2030), the impact on GDP could reach USD91 billion annually (in real 2020 terms) by 2030, and USD285 billion cumulatively over the next decade.

The success of Open RAN could be accelerated by a combination of industry and policy efforts

Governments and regulators have expressed clearly that they intend to shape policy to improve network economics, resilience and security (see Figure 1). Open and disaggregated network technologies, and Open RAN in particular, are increasingly seen as one part of a broader solution to these challenges. For example, the UK's telecoms supply chain diversification strategy specifically identifies open and disaggregated technologies as one of the tools to achieve a more secure and resilient sector, and agencies such as NTIA in the USA and Ofcom in the UK are testing Open RAN systems.

The industry has challenges to overcome of course, both in terms of the capability of the technology, and the ability of new supply chains to serve a variety of needs for operators globally. All players in the ecosystem need to focus on openness and interoperability to enable products to be developed more quickly. In addition, global systems integrators need to actively participate in the value chain to increase the level of solution testing and integration, which is core to fostering understanding and trust in these solutions, including by MNOs that may not have the resources to drive some of these developments themselves.

We look forward to continuing to support stakeholders across the ecosystem to develop and execute strategies that will achieve the best possible outcome for the telecoms industry in these times of rapid change.



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IoT: successful telecoms operators use large bases of connections to drive investment in the value chain

Michele Mackenzie, Principal Analyst

Analysys Mason has identified four operators as 'Pioneers' in its most recent Operator IoT Scorecard 2021: AT&T, China Mobile, Telefónica and Vodafone. These telecoms operators have been successful in the IoT market because they have mutually supporting aspects to their business – a large base of connections that helps to fund investment into new horizontal and vertical solutions, which in turn help to drive the number of new connections.

This article summarises the strengths of the Pioneers. It is based on research and analysis from Analysys Mason's sixth operator IoT study, Operator IoT Scorecard 2021: operator strategies for IoT, in which we analysed the strategies of 17 of the operators that have been most successful in the IoT market.

Each of the operators included in the Scorecard offers a range of IoT services. The Scorecard identifies the operators' strategic focus and core strengths. Analysys Mason acknowledges that this positioning is often deliberate; operators may opt to specialise in one area of IoT based on factors such as their size, market position, assets and appetite for risk.

The Pioneers have laid the foundations for an IoT business with a clear strategy, robust KPIs and an independent IoT division

Analysys Mason used the following criteria to assess the operators: strategy and vision, scale, connectivity, horizontal capabilities, vertical capabilities, complementary capabilities and, ecosystem and partnerships. The four Pioneers, AT&T, China Mobile, Telefónica and Vodafone all demonstrated:

- a clearly articulated strategy for IoT that is matched with the appropriate levels of resource and investment
- robust KPIs that show that the IoT business executes the strategy effectively
- an IoT division that operates with a high level of independence from the legacy business but can leverage the resources and brand of the core business.

The Pioneers use their size and scale to successfully deliver their IoT propositions

The following factors have enabled the Pioneers to be particularly successful in IoT.

AT&T has been delivering IoT solutions for a long time and has achieved size and scale. It had 81 million connected devices on its network at the end of 2020. It is especially strong in the automotive industry where it provides connectivity for more than 40 million vehicles, 9.9 million of which were added during 2020 despite the COVID-19 pandemic.[1] AT&T leverages its brand and track record in the automotive vertical to support B2B and B2C business models.

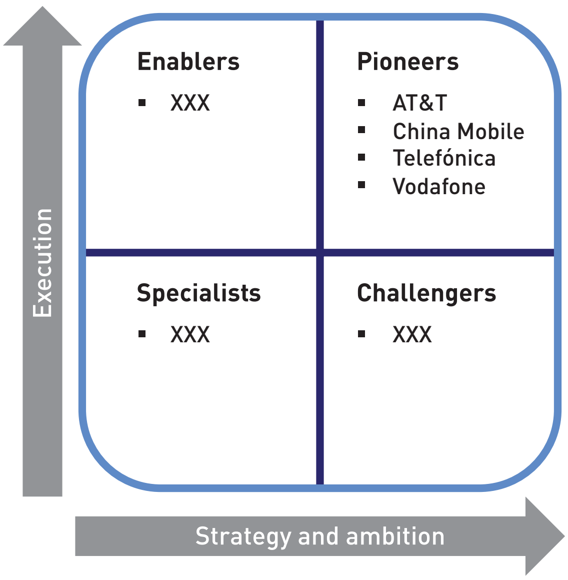

FIGURE 1: RESULTS OF ANALYSYS MASON'S OPERATOR IOT SCORECARD 2021 [SOURCE: ANALYSYS MASON, 2021]

China Mobile is the largest IoT operator in the world in terms of the number of connections and benefits from its huge size and scale. It reported 873 million connections at the end of 2020 and remains well ahead of its main rivals China Telecom and China Unicom. China Mobile has a powerful brand and is a recognised IoT leader in China. It has leveraged its scale to reduce costs and influence market developments, as it has done in NB-IoT. China Mobile IoT has developed hardware and software applications to fill gaps in the market and its integrated solutions facilitate the adoption of IoT. Its parent company, China Mobile, is investing significant resources in 5G-driven industrial transformation and is benefiting from state funding that drives innovation in this area.

Telefónica has benefited from taking a long-term vision for IoT and has developed a strong set of horizontal, vertical and complementary capabilities. The operator had 26.2 million connections at the end of 2020. Telefónica has invested in its KITE, SmartDigits and SmartSteps platforms to build horizontal and vertical capabilities and to generate additional value. It has demonstrated its ability to build vertical solutions with its proposition for the retail sector; it has built a platform to support multiple applications and can demonstrate revenue growth, which it seeks to replicate for other verticals.

Vodafone has achieved size and scale in IoT connectivity and has built on this foundation to develop end-to-end solutions for selected verticals. The operator had 120 million connections on its network at the end of 2020. Vodafone has a bold strategy for IoT and is willing to invest in new solutions. It has proved that it is taking risks and experimenting in order to identify new growth areas and it accepts that not all ventures will be successful. Vodafone differentiated its IoT proposition early on by delivering solutions and services that build on its connectivity offer. Vodafone's acquisitions and investments provide the foundations for its centres of excellence to target key verticals such as automotive, healthcare, industrial IoT and smart buildings.

The Pioneers deliver multi-faceted IoT propositions

The operators featured in the IoT Scorecard, including the Pioneers, have taken distinct approaches to building their IoT strategy because they have embarked on their strategies from different starting points. The addressable market for IoT varies according to each country where the operators have a presence, and each operator has a diverse set of assets that they can use. The Pioneers have built a set of IoT capabilities beyond their initial starting point that have not been constrained by their traditional communications proposition in the consumer and enterprises markets. As such, they have established a solid position on which to win new IoT business in the future. The IoT Pioneers may have taken different approaches, but they have all invested significantly to address the IoT opportunity and build IoT best practice in all of the benchmark criteria.

[1] Estimated number of vehicle connections. AT&T's connected devices total includes "data-centric devices such as wholesale automobile systems, monitoring devices, fleet management and session-based tablets".

Questions?

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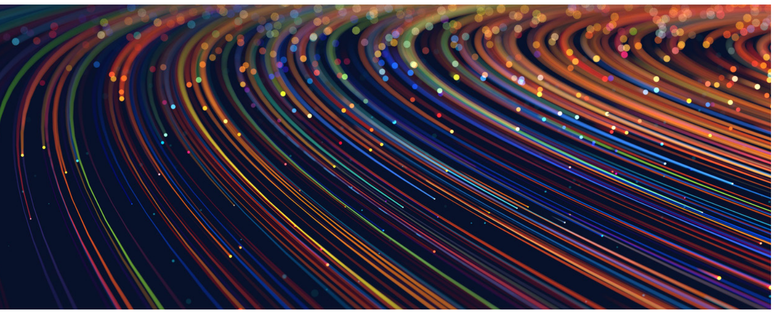
Analysys Mason is well-placed to advise telecoms operators on FTTP deployments

Stéphane Piot, Partner and Philipp Zeidler, Senior Manager



Optical fibre is indisputably accepted as the highest-capacity and most future-proof infrastructure medium for fixed digital communication networks. Fibre has been in use for long-haul high-capacity backbone networks since the 1980s (terrestrial and submarine cables), but the transition of access networks from legacy copper pair cabling to brand new fibre-to-the-premises (FTTP) technology has accelerated worldwide during the last decade. The migration has been slower in some parts of Europe and the Americas (compared to that in some Asian countries or the Nordics, for example), but the COVID-19 pandemic has been driving global demand for high-quality and high-capacity broadband connections.

This migration and modernisation of fixed networks represents the largest (and costliest) telecoms infrastructure undertaking since the initial roll-out of the then telephone-focused copper networks, which began in the early twentieth century. It is therefore only natural that the roll-out of FTTP raises numerous issues: logistical, operational, technical, financial, etc.

In addition, FTTP networks offer opportunities in developing economies, which often lack a legacy fixed (typically copper) infrastructure for mass-market use. In these countries, the market for fixed broadband services is often non-existent and there is strong potential for up/cross-selling mobile-only users.

Analysys Mason has performed over 200 projects related to fibre deployment in the last 3 years. These projects have covered many aspects of fibre including research, strategy, transaction support, network and business transformation, and operational aspects. This article highlights several of the common issues that we have encountered in these projects. Other articles in this series explore how to reduce barriers to FTTP deployments and avoid network overbuild.

Planning the roll-out

The planning for rolling out millions of FTTP lines in a short timeframe is challenging but is a key component for the success of a fibre initiative. Operators must take several aspects into careful consideration to mitigate risks, including:

- securing the supply chain
- preparing high-level designs and geotype sampling to estimate reasonable roll-out costs and avoid overruns
- defining an appropriate roll-out architecture, which has a direct impact on the network cost of roll-out and the balance between fixed (cost per home passed) versus variable cost (cost per connected home), and will also affect the level of competition and the wholesale market structure (typically passive versus active network operators)
- the mix of internal and external resources
- ensuring that IT systems allow rapid commercialisation
- prioritising roll-out zones
- co-ordinating internal departments before, during and after roll-out
- assessing the speed of roll-out that can be supported given the processes in use.

Analysys Mason has extensive experience of helping operators to determine and implement the most appropriate and relevant choices for their specific roll-out footprint and objectives.

Understanding the civil works-related technologies

The roll-out of a new fibre access network requires extensive civil works infrastructure, either underground or overhead, to run the fibre between the various flexibility points (mutualisation points, local exchanges, in-building or on-façade splitter boxes…).

Analysys Mason has an excellent overview of the various types of roll-out techniques that have been used worldwide, and their pros and cons.

Assessing the value chain of the roll-out, operations and maintenance

The number of fibre roll-out initiatives worldwide has led to the creation of a complex value chain, relating to the roll-out, operation, and maintenance of these new networks. This value chain is notably more complex than it used to be for copper roll-out, mainly because of the use of outsourcing, the use of co-deployment to share the massive deployment cost, and the emergence of wholesale networks.

As a result, new players have emerged.

This value chain will evolve as each country moves from a roll-out phase to a more operations- and maintenance-focused phase. Analysys Mason is used to working with all major stakeholders in this complex value chain.

Migrating from legacy copper and cable to all-fibre networks

With the roll-out of new FTTP access networks inevitably comes the question of how to migrate existing copper pair cabling or HFC cable-TV networks to FTTP technology.

In both cases, modernising the networks requires operators to lay fibre closer to the final customer, which eventually raises the question of deciding between a progressive modernising of the current infrastructure (be it copper or cable) or a complete migration to a full-fibre access network. Typical issues at stake include: fixed/variable roll-out costs, maintenance costs, product portfolio, migration approach, customer communication, whether appropriate organisations are in place or can be put in place to support the deployment, coordination and steering, marketing activity required, etc.

Analysys Mason has considerable experience conducting techno-economic studies regarding selecting the highest value solutions. Analysys Mason are also experts in supporting our clients in designing, planning, and delivering operational migration approaches.

Externalising the fibre network into a separate dedicated vehicle (that is, fibre carve-outs)

As mentioned previously, more and more operators have created (or carved out) special purpose vehicles (SPVs) to own and manage their fibre networks. These SPVs are generally (at least temporarily) co-owned by the operators that are rolling out the FTTP network as well as one or several external investors, often infrastructure investment funds. The initial telecoms operator can own part (or not) of the fibre network, and will typically operate and maintain these fibre assets generally as wholesale-only operators, offering various fibre-based infrastructure products to retail service providers, who in turn will address B2B or B2C markets.

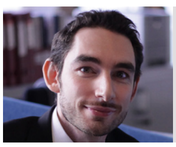
Analysys Mason has led many strategy and transaction support projects related to fibre investment and fibre carve-outs more specifically all around the world and therefore has a thorough understanding of the issues at stake.

Assessing the sustainability of fibre-based networks

Climate change, carbon emissions and energy efficiency have become major concerns for many players in the telecoms industry, and the impact of digital infrastructure in an increasingly digitised society is being more and more scrutinised.

As an integral part of this digital infrastructure, operators must assess the environmental impact of fibre networks, especially FTTP networks, from sourcing of the components and roll-out, to operations, maintenance, and overall longevity of the infrastructure.

Analysys Mason has a deep knowledge of the environmental aspects of FTTP networks, especially when compared to competing access technologies.



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Fibre operators must consider the impact of network overbuild as part of their long-term strategies

Richard Morgan, Principal

Both incumbents and altnets are rapidly deploying FTTP

Fibre-to-the-premises (FTTP) coverage in Western Europe reached 43% of households in 2020, up from just 17% in 2015, and operators across the region are continuing their race to reach the remaining households. Incumbent operators have taken a clear lead in some countries such as France and the Netherlands, while in other markets – including most countries in the Nordic region – alternative network operators (altnets) have been quicker to build networks.

Altnets often aim to maximise FTTP take-up by targeting areas with lower overbuild risk

The number of fibre network roll-outs across Europe is increasing and as each competing roll-out progresses, we are seeing growing levels of network overbuild in many markets. The economic case for deploying multiple parallel networks depends on several factors including network deployment costs, revenue potential per customer, market structure, wholesale arrangements and regulatory factors.

Altnets across Europe have typically aimed to maximise customer take-up on their network through a variety of strategies including targeting areas that they can reach ahead of incumbents and prioritising areas that are considered to be at lower risk of future overbuild. Different geo-demographics and differing regulatory conditions have, however, led to considerable disparities between European countries, as outlined below.

In Spain, regulatory decisions regarding wholesale access to Telefónica's FTTP network, coupled with low capex requirements, has incentivised altnets to overbuild the incumbent. This means that around 65% of the premises passed by FTTP in Spain now have coverage from more than one network.

Regulation in France has forced operators in dense urban areas to share in-building cabling through network mutualisation points in the basement of each building (in less dense areas, the regulation is tuned to have the mutualisation points further from the premises). This has made it economically viable for as many as four parallel fibre networks to be deployed in many of these urban areas, which then connect to these mutualisation points. Similar regulation has been considered in other markets, which could be disruptive to some of the players that are targeting multi-dwelling units (MDUs).

Some altnets are focusing on rolling out fibre in rural areas where high costs reduce the risk of future overbuild, especially in publicly subsidised areas that, by definition, should not be commercially viable for others to follow. However, this approach still poses some risk because European State aid rules mandate that wholesale access is provided via new passive infrastructure such as ducts and poles, which could improve the economics for a future entrant.

Incumbents' appetite for fibre overbuild can vary significantly between countries

Incumbent operators typically have a more-compelling reason to overbuild a first-mover altnet: to protect their

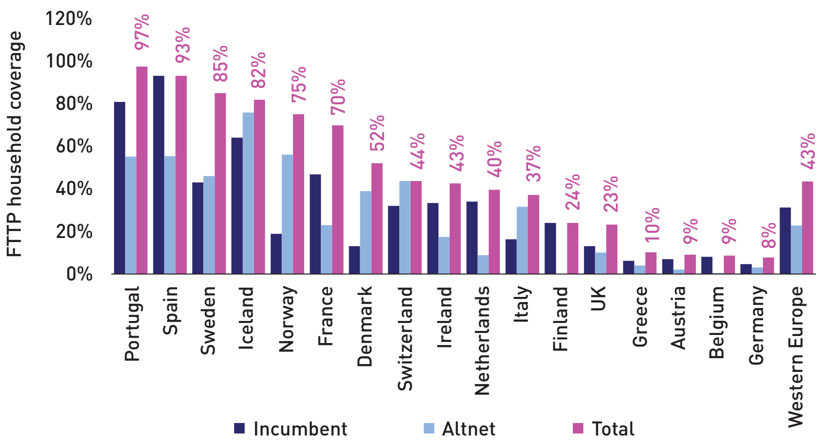

FIGURE 1: FTTP HOUSEHOLD COVERAGE BY INCUMBENTS AND ALTNETS [SOURCE: ANALYSYS MASON, 2021]

significant market share at both the wholesale and retail level. Where altnets are first to reach an area with fibre, incumbents are left with broadly three choices: continue selling over copper-based or wireless networks despite the competition from a superior network technology; overbuild the altnet with their own FTTP network; or take wholesale services from the altnet (if these are available). A variety of approaches is being taken in different countries, as discussed below.

Openreach, the infrastructure division of UK incumbent BT, signalled that it favours the overbuild approach by announcing in May 2021 its intention to increase its FTTP coverage target from 20 million to 25 million premises (over 80% of the UK). This announcement comes at a time when over 100 altnets are competing in a 'land grab' across the UK, and some have argued that Openreach's increasingly ambitious targets could be posturing designed to scare off altnet investment. However, Openreach's plans are supported by a rapid acceleration in the pace of its fibre deployment.

The low level of fibre coverage in Germany is comparable with that of the UK, but Deutsche Telekom (DT) has taken a different approach to that of Openreach and plans to avoid overbuild, instead working with altnets through co-investment and wholesale partnerships. At its recent capital markets day Group CEO Tim Höttges asked, "Why should we overbuild somebody? If they have already built fibre, why can't we embrace them into our infrastructure?". The German incumbent has stated that it plans to build its own FTTP to 60–70% of households but will consider wholesale access elsewhere, supported by existing agreements with Deutsche Glasfaser and NetCologne. The alternative case for overbuild is made challenging in Germany due to current capex requirements outside of dense urban areas of over EUR1000 per home passed, more than double that expected by Openreach in the UK.

Altnets in Sweden and Norway have covered a large share of their respective markets and have achieved strong take-up. Both incumbents are now implementing plans to decommission their copper networks, which no longer enable them to compete effectively. Telia in Sweden has formed wholesale agreements with many altnets and by switching off copper, it will be exiting the infrastructure market in these areas to focus on protecting its retail market share. Telenor in Norway does not have this option because most municipal fibre networks have exclusive partnerships with retail service providers, so in areas where it is not economic to overbuild with FTTP, the company is instead focusing on providing fixed-wireless access (FWA) services using its 4G and 5G networks.

Many incumbents across Europe are overbuilding altnet fibre, especially in commercially attractive urban areas. Altnets with a strong wholesale offering are generally at lower risk of overbuild than retail-only operators, partly because they have signed up major ISPs (which reduces the wholesale revenue opportunity for an incumbent), but also because altnets provide the incumbent with a wholesale alternative to overbuild. The provision of wholesale access at the passive level (for example, dark fibre rather than just bitstream) by altnets can be a more-attractive proposition for incumbents.

The threat of FTTP overbuild from cable operators should not be overlooked

Many altnets are willing to compete in areas where cable networks exist because these are generally managed by retail-only players and although network performance is faster than VDSL, it is inferior to that enabled by FTTP (at least at the very high end above 1Gbits/s). While cable networks have an incremental upgrade path (most operators in Europe are now upgrading to DOCSIS3.1 to enable 1Gbit/s download speeds, with longer-term roadmaps towards DOCSIS4.0 and beyond), fibre players are quick to point out that their technology roadmap should enable them to stay a step ahead of cable network performance (although upgraded cable networks may still be able to keep up with typical end-user needs, cable providers will not want to enter a 'peak speed war' against technology such as XGS-PON).

However, this very fact is driving a growing number of cable operators to overbuild their own coaxial networks with FTTP, as already announced by Euskaltel in Spain and Tele Columbus in Germany, among others. Wherever cable networks exist today, there is good chance of a cable player emerging as another FTTP competitor in the long term. The timing of this trend will vary depending on local market factors and cost drivers: for example, the CEO of Liberty Global claimed on its June 2021 earnings call that due to its duct ownership in the UK, the cost of upgrading to FTTP (using XGS-PON equipment) would not be meaningfully higher than DOCSIS4.0.

Analysys Mason can help operators and investors to navigate issues around overbuild

Analysys Mason's expertise in the fibre sector means that we can help our clients to assess and forecast overbuild, and to develop strategies to mitigate the associated risks. The threat of overbuild means that getting wholesale strategies right is increasingly important for altnets and incumbents, and we have deep understanding of the economics of the different kinds of wholesale services.

Questions?

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Reducing barriers to FTTP deployment can save years of time and cut 30% off the cost of network roll-outs

Andrew Daly, Principal

The COVID-19 pandemic has reinforced our dependence on broadband infrastructure as an essential component of our everyday lives. Millions of people around the world have lived through lockdowns, and broadband connections have been a critical source of work and entertainment. Now, more than ever, there is a need for fast and reliable broadband infrastructure to be available on a widescale basis.

In support of this aim, operators, governments and regulators are pushing ahead with deployments of full fibre networks (also known as fibre-to-the-premises (FTTP)). Some countries are already benefitting from significant FTTP coverage, though many more still have a way to go. However, the economics of FTTP deployment are unavoidable everywhere: as networks get pushed out towards rural areas, network lengths increase, costs are driven up and commercial viability falls.

This increase in network length per premises has two effects: coverage takes longer to achieve and more costs are incurred in doing so. It is therefore important to reduce any unnecessary barriers to FTTP deployment so that coverage can be achieved as quickly and as cheaply as possible. Reducing barriers will also increase the number of premises that can be covered on a commercially viable basis, without the need for government subsidies.

Analysys Mason completed a major piece of analysis to quantify the impact (in terms of time and cost) of reducing each of the barriers to FTTP deployment in the UK. The work was completed in 2020, but the issues considered remain very relevant today. We evaluated barriers in three main categories (planning, deployment and 'other'), as summarised in Figure 1 and below.

- **Planning.** Barriers relating to the planning of FTTP deployments create delays in the deployment workforce being able to start work. These delays can be caused by:

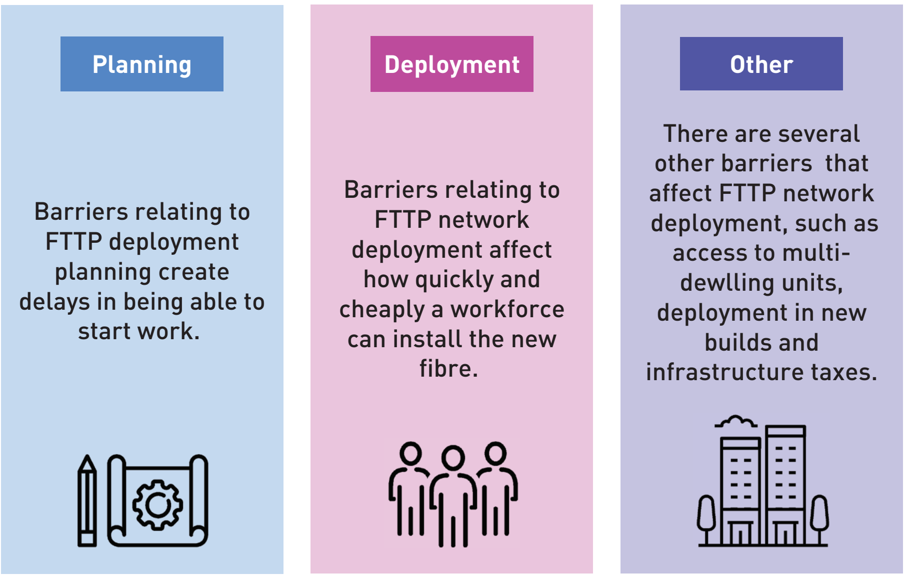

FIGURE 1: SUMMARY OF THE POTENTIAL BARRIERS TO FTTP DEPLOYMENT [SOURCE: ANALYSYS MASON, 2021]

- the need to obtain permissions to begin street works (which must be sought from local authorities)
- the need to obtain permissions to access private land (which must be sought from the landowner)
- the availability of network design personnel (which must be sufficient to plan the network route in advance of the deployment).

- **Deployment.** Barriers relating to the deployment of FTTP networks affect how quickly and cheaply the workforce can install the new fibre. These factors are affected by:
  - the availability of deployment personnel (that is, the total number of deployment personnel available in a country or region)
  - the effectiveness of deployment personnel (that is, whether the personnel can use innovative deployment techniques, which may be restricted by training, availability of equipment and/or local permissions)
  - the reuse of existing infrastructure (that is, the extent to which existing ducts and poles can be reused, rather than new versions of this infrastructure needing to be constructed).
- **Other.** There are several other barriers that are relevant to the deployment of FTTP networks, including:
  - access to multi-dwelling units (which may be blocked by uncontactable landlords, even if residents request connections)
  - fibre deployment in new builds (which should ideally be installed during construction, rather than needing to revisit the development)
  - additional taxes on broadband infrastructure (which can have a significant impact on the commercial viability of deployments, especially in rural areas).

The impact of reducing each of these barriers varies by country, but the overall result is the same: faster coverage, lower costs and a greater proportion of the roll-out covered by the private sector. Indeed, our work shows that reducing all of the barriers listed above would result in a 6-year decrease in the total time taken to achieve 100% population coverage and an almost GBP10 million reduction in the total deployment cost (a reduction of approximately 30%). Please see Analysys Mason's Quantifying the impact of reducing barriers to fibre broadband for more information.

All stakeholders have a role to play in ensuring that these barriers can be reduced.

- Operators (and their network deployment subcontractors) can hire and train sufficient personnel, and can provide training in innovative deployment techniques. They can ensure that they have the personnel required to reach even the most remote areas by making firm commitments to the deployment resource supply chain.
- Governments can legislate to make deployments easier, including reducing the need for permissions, reducing taxes on infrastructure and requiring that developers meet some of the cost for connecting new-build developments. Governments can also refine the design of their subsidy schemes to ensure that subsidies are available at the same time as commercially viable premises are being covered, so that operators do not have to return to an area at a later date. Governments can also explore more-innovative financing solutions, such as state loans (which could be provided with suitable conditions).
- Regulators should promote effective reuse of existing infrastructure (including both telecoms and utility infrastructure), and ensure that wholesale prices allow a fair return to enable fibre operators to compete with each other and take their deployments as far as possible.

The reduction of barriers will help all players in the market, including both established players and new entrants. By working together, operators, governments and regulators can create a deployment environment to push full fibre networks as far as possible and bring benefits to all.

Analysys Mason has wide-ranging experience of supporting stakeholders on all sides of the fibre deployment effort.

Questions?

Please feel free to contact Andrew Daly, Principal at andrew.daly@analysysmason.com

Delivering full 5G coverage and capabilities – with low, mid and mmWave bands

A recent study by Analysys Mason into 5G deployment considered total investments in mobile networks for a 5G eMBB base-case coverage, together with the value created by 5G in terms of the economic benefits produced across different types of use cases. With the same baseline, we investigated the different types of use cases enabled by 5G millimetre-wave (or mmWave) spectrum in the 26GHz band, primarily in conjunction with 3.5GHz and other existing mobile spectrum, but also 26GHz standalone cells, across a wide range of scenarios for outdoor or indoor coverage.

An article in an earlier edition of the UK5G Innovation Briefing described a study conducted by Analysys Mason for Ericsson and Qualcomm into the costs and benefits of deploying 5G networks with full 5G capabilities to address a range of urban, rural, public sector and industrial use cases.

Following on from that work, we were asked to conduct two further studies:

- The first study assessed the cost and extent of 5G coverage provided by commercially led mobile broadband (MBB) deployments, plus the additional investment needed to deliver nearuniversal geographical coverage (using low-frequency spectrum in a single rural network), and additional investment to extend 3.5GHz 5G coverage beyond a commercial (base-case) footprint
- The second study assessed the cost and benefits of 5G mmWave, focusing on use cases gathered from speaking to several operators (both fixed and mobile) in Europe and elsewhere.

5G geographical study

We defined three scenarios to model the cost and extent of 5G coverage across 30 markets in Europe:

- **Base case –** investment to provide population-led coverage of 5G enhanced mobile broadband (eMBB) services by 2023, 2025 and thereafter, assuming 5G radio is rolled out to the existing mobile sites in each market (with population coverage in each market commensurate with existing sites in that market)
- **Low frequency (LF) 5G case –** additional investment to extend low-frequency 5G to full geographical coverage (assuming that a single infrastructure would reach the final percentage of uncovered area in the UK[1])
- **Full 5G case –** incremental costs for full 5G coverage using mid-/highfrequency bands.

mmWave study

The mmWave study involved three components of research and modelling:

- Primary research with fixed and mobile network operators to discuss plans for 5G mmWave deployment
- Secondary research on the latest status of 5G mmWave deployment
- Economic modelling of the costs and benefits associated with the 5G functionality enabled by 26GHz deployment, using a 5G eMBB base case, for selected use cases based on operator feedback.

Key findings

Geographical study

Our modelling suggests that commercially driven mid-band (3.5GHz) spectrum deployment in the UK will reach nearly 70% of the population by 2025, with investment reaching nearly GBP15 billion across the four UK networks by 2025. This equates to only 12% of the geographical area having mid-band coverage, but is more expansive with 700MHz, reaching 95% of the UK in our base case. We also assume that 26GHz mmWave spectrum will have been rolled out across outdoor, and indoor, high-capacity locations.

To bridge the connectivity gap from 95% to closer to 100% geographical 5G coverage in the LF 5G scenario, we estimate that a further GBP85 million of public subsidy will cover estimated capex for a single, multi-use network using

700MHz frequencies. This assumes that the lowest-cost deployment option is a single infrastructure, to avoid additional costs resulting from duplication of infrastructure. This requires co-operation between industry and policy makers to achieve a roll-out structure that will minimise duplication of network build.

We estimate that bridging the midband coverage gap could be achieved with a further GBP0.8 billion of investment, bringing geographical coverage using 3.5GHz spectrum to around 95% of the UK.

The mid-band coverage gap investment assumes the same 5G infrastructure meets the different requirements of multiple 5G use cases via network slicing (e.g. road, rail, agriculture, industry, enterprise). We estimate that the GBP0.8 billion requires a mix of additional commercial investment plus public subsidy. The resulting mid-band coverage under our full 5G capabilities scenario (95% of geography covered using mid-band spectrum).

mmWave study

The mmWave study found that 26GHz spectrum can provide connectivity for mobile broadband users on public mobile networks, 5G fixed-wireless access (FWA) services into homes and offices, as well as a wide range of other consumer, enterprise and industrial uses. Interviews with operators indicated that they intend to use mmWave deployment in multiple localised outdoor and indoor environments (based on network loading and local market demand).

A wide variety of use cases were described (mobile broadband in highcapacity locations, 5G-based FWA, enterprise networks, smart factory and other industrial applications, connected vehicles, events and venue-specific coverage). The present value of UK-wide benefits from 26GHz deployment is estimated to be EUR12.9 billion (GBP11.1 billion), compared to investment in 26GHz infrastructure totalling EUR5.3 billion (GBP4.6 billion) across multiple networks and deployments, as shown below. The analysis is based on a 5G eMBB base case and considers a mix of architectures across the different use cases.[2]

It also assumes that for the eMBB (high-density urban and suburban locations) and FWA use cases, the total number of installations estimated are deployed over a period of five years, beginning in the year that 26GHz spectrum is expected to be assigned. For the remaining use cases, we assume that deployment begins one year after spectrum award.

Interviews highlighted that mmWave can be used to maximise capacity within mobile networks (since frequencies can be reused more intensively without cochannel interference occurring) as well as to allow for more flexibility to adapt time-division duplex (TDD) frame structures to address different uplink and downlink capacity requirements.

While the ecosystem is in its early days for 26GHz, this may change as further European markets proceed with 26GHz licensing during 2021. We note that the upper 1GHz of the 26GHz band (i.e. 26.5–27.5GHz) already has a well developed ecosystem, since this range overlaps with the bottom 1GHz of the 28GHz band. The ecosystem is larger for 28GHz than 26GHz due to the earlier licensing of this band.

In conclusion, the study demonstrates the importance for European regulators to complete 5G licensing in all of the bands identified at an EU level.

[1] That is, filling in coverage gaps not addressed by the other scenarios. In the UK, the Shared Rural Network (SRN) plans to ensure 4G mobile coverage reaches 95% geographical coverage by 2025, and our base-casemodelling assumed that 5G radio would be rolled out onto existing sites, including those sites in the SRN footprint. Hence the 5G low-band scenario considered the costs of covering the final 5% of the UK territory.

[2] A 3.5GHz macro site upgraded with 26GHz, a new 26GHz dedicated site (possibly sharing 3.5GHz from a nearby macro site) and a 26GHz small cell.

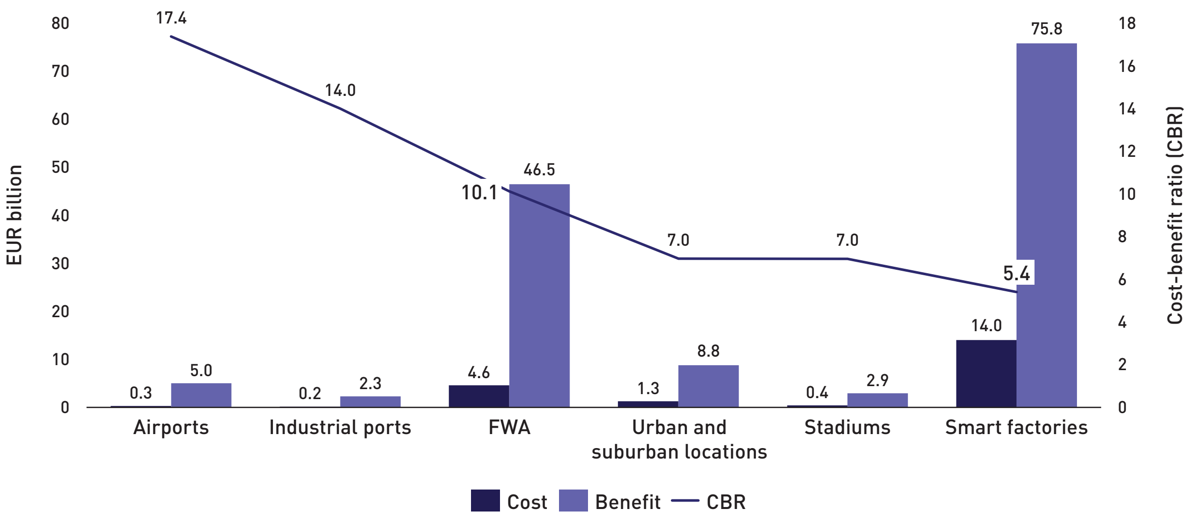

FIGURE 1: PRESENT VALUE OF COSTS AND BENEFITS OF MMWAVE DEPLOYMENT (EUR BILLION) [SOURCE: ANALYSYS MASON, 2021]

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