Primer on telecom infrastructure as an asset class for insurance companies and pension funds

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1. Introduction

This document is a primer on Telecom Infrastructure as a potential asset class for long-term institutional investors. It has been prepared by the Infrastructure Working Party of the IFoA[1] as a starting point for actuaries working in investment to become familiar with the asset class, its key market dynamics, and why it deserves to be considered in infrastructure allocation decisions within insurance company and pension fund portfolios. The search for stable, long-term opportunities that can deliver consistent returns is a constant pursuit in institutional investing. Telecom infrastructure has emerged as a compelling asset class, offering unique characteristics that align with the investment objectives of insurance companies and pension funds.

Telecom infrastructure comprises a diverse range of assets, including physical infrastructure like towers, fibre-optic cables, and data centres, as well as intangible assets such as spectrum licences. These assets form the bedrock of telecommunication services, enabling seamless connectivity and facilitating the transmission of voice, data, and multimedia content for both business and leisure use cases.

The inherent attractiveness of telecom infrastructure as an asset class lies in its essential nature. The growing demand for high-quality, reliable connectivity continues to escalate globally, fueled by increasing internet penetration, the proliferation of smart devices, and the rapid expansion of data-intensive applications. This insatiable demand ensures a resilient revenue stream for infrastructure owners, making it particularly appealing for long-term investors who prioritise stable and predictable cash flows.

Furthermore, the telecom industry is undergoing significant technological advancements, notably the deployment of next-generation networks such as 5G. This presents an opportunity for growth, as the rollout of new infrastructure and the upgrading of existing networks create avenues for capital appreciation and enhanced returns.

2. Key Terms in Telecoms

Mitel describes telecommunications, (also known as telecom), as 'the exchange of information over large distances'. Information herein refers to data that is transmitted as voice, text, video or audio data.

The sector, while very broad, includes a variety of industries, where all points of exchange of information include **both** a transmitter and a receiver. There are usually two points of exchange, but sometimes information transfer can occur between multiple stations at once. The medium of transfer of signal can be by various means including but not limited to fibre optics technology, electromagnetic fields, light or cable technology, etc.

Numerous examples of telecommunications comprise this field, such as, the Internet, telephone and cellular communications, Local-Area-Networks (LANs e.g. ethernet) and Wide-Area-Networks (WANs e.g. a bank, its branch offices and ATMs), radio and television media, as well as other less commonly known means, for instance, telegraphy, among many others.

Figure 1 below depicts the history of telecommunications in helping us gain a greater understanding of the industry and how it has evolved over the years across the examples listed above, to today's familiar everyday technologies.

[1] https://www.actuaries.org.uk/practice-areas/finance-and-investment/finance-and-investment-research-working-parties/infrastructure-working-party

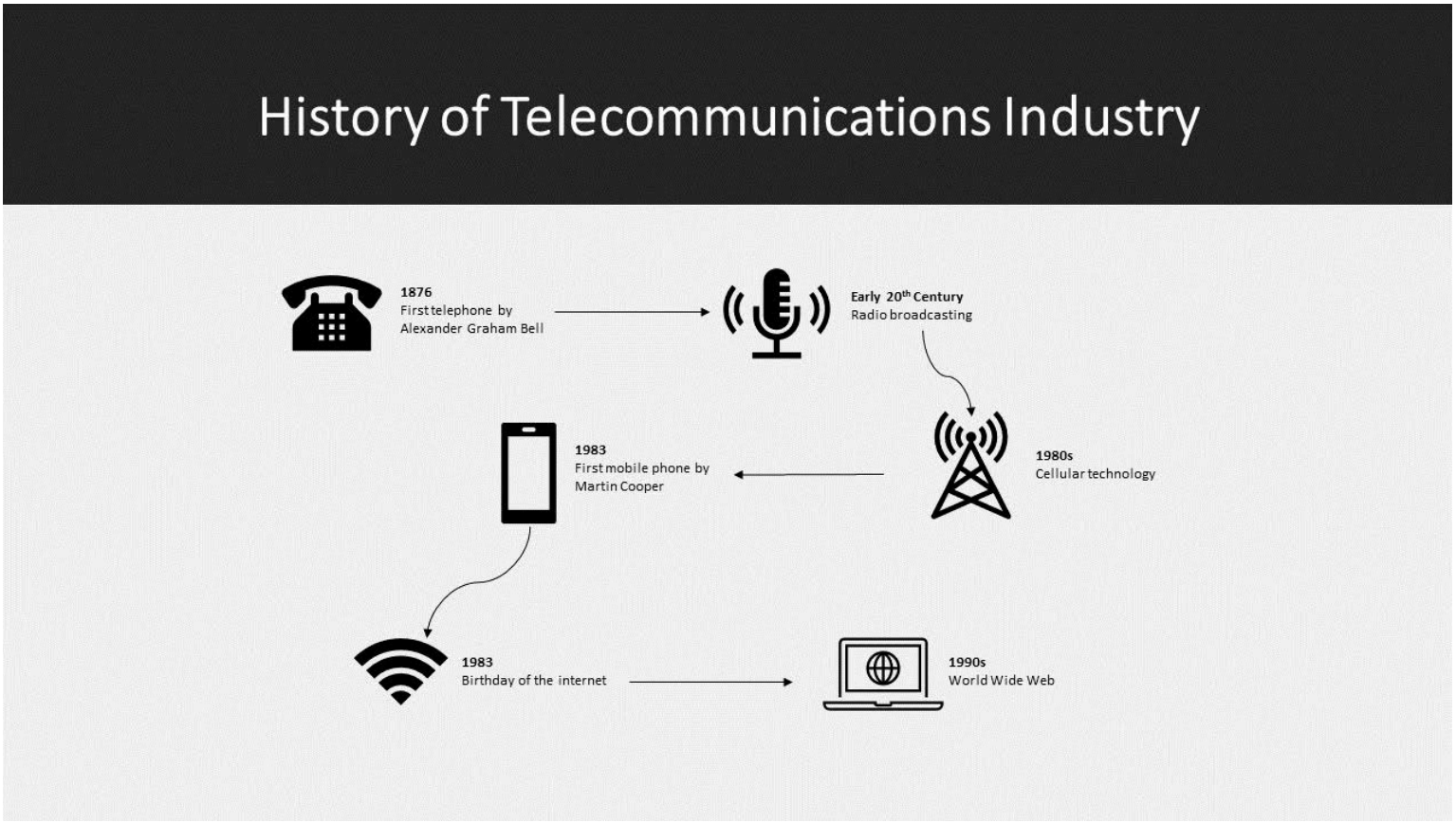


Fig 1: History of Telecommunications industry

Telecommunications service providers allow individuals and businesses alike the means to conduct necessary everyday communication. In today's increasingly globalised economy, this demand for reliable connectivity integrated with the described fueling proliferation of the internet, smartphone devices and data intensive applications point to the essential nature of telecom.

In understanding the sector even further, we first dissect it into the three main sub-sectors encompassing it:

1. **Telecommunications Equipment (largest)**
   This refers to the hardwares used in the telecommunications process. These are split into three main segments as follows:
   i. **Public Switching Equipment** e.g. analog switches and digital switches including Voice over IP switches and Virtual Reality (VR).

   ii. **Transmission Equipment** e.g. base transceiver stations, multiplexers, transmission lines satellites, wireless semiconductors, etc.

   iii. **Customer Premises Equipment** e.g. routers, mobile and landline phones, modem, private switches, fax machines, pagers etc.

2. **Telecommunications Services (next largest)**
   The Federal Communications Commission in the US describes Telecommunications Services as "the offering of telecommunications for a fee directly to the public, or to such classes of users as to be effectively available directly to the public, regardless of the facilities used."

   The Investigatory Powers Act of 2016 under the Parliament of the UK describes Telecommunications Services as:
   "any service that consists in the provision of access to, and of facilities for making use of, any telecommunication system (whether or not one provided by the person providing the service)". The cases in which a service is to be taken to consist in the provision of access to, and of facilities for making use of, a telecommunication system include:

- any case where a service consists in or includes facilitating the creation, management or storage of communications transmitted, or that may be transmitted, by means of such a system.
    - Telecommunication system means a system (including the apparatus composed in it) that exists (whether wholly or partly in the United Kingdom or elsewhere) for the purpose of facilitating the transmission of communications by any means involving the use of electrical or electromagnetic energy."

In simpler terms, they provide the service of accepting, transmitting and delivering information. Telecommunications services are split into five main segments:

i. **Cellular Mobile Services** - these are wireless services that allow consumers to use communication devices such as mobile phones (and other devices) to connect to telephone networks. This allows access to all mobile communication services such as voice and non-voice messaging, data and cloud services etc.

ii. **Radio Paging Services -** these are one-way data communications sent to a mobile device that pings the user on arrival. The communication could consist of a phone number for the user to call, a short message, or an information update, offering a low-cost way to reach people who are on the move e.g. pagers which are commonly used in hospitals.

iii. **Fixed Line Services -** these refer to wired networks that support fixed broadband and telephone services through *a connection to an end customer using a cable*, through which the user can connect to the internet or make a phone call.

This involves the use of a variety of technologies for any high-speed data transmission to a residence or a business. Methods of transmission include physical copper, fibre optic cable, and other fixed broadband technology connections.

An example of this is a landline telephone, or fixed phone line, that transmits signals using metal wire or fibre optic cable, as opposed to wireless transmission as seen in mobile phones.

iv. **Cable Services -** these are cable connections and switched services that operate media services including internet and television using coaxial cables, which are typically one-way entertainment-related services within a licenced operating area e.g. Virgin Media.

v. **VSAT (Very Small Aperture Terminal) Satellite Services -** these are satellite-based communications services based on a small-sized earth station used in the transmission/reception of data, voice and video signals over a satellite communication network, excluding broadcast television e.g. critical military communications and logistics systems.

vi. **DTH Satellite Services -** this is another satellite-based media service provided by cellular providers (Direct to Home). A set-top box and a small dish antenna are installed to receive media services directly from a satellite.

3. Wireless Communication (smallest)

Wireless communication is the transmission and reception of data in free space using electromagnetic fields i.e. devoid of cables or wires. This keeps devices connected to the network without connection by wire, and often involves desktop computers and laptops. There are four main types of wireless connection:

I. **PAN**

A personal-area network consists of a network centralised around the devices of a single person in a single location. It is the smallest network type, covering a maximum distance of approximately 10 metres away from the person/device.

The network could have computers, phones, video game consoles, or other peripheral devices. They can also be wireless, where Bluetooth is the most commonly known wireless PAN. Less commonly known examples of PANs include ZigBee, infrared, wireless printers, game consoles etc.

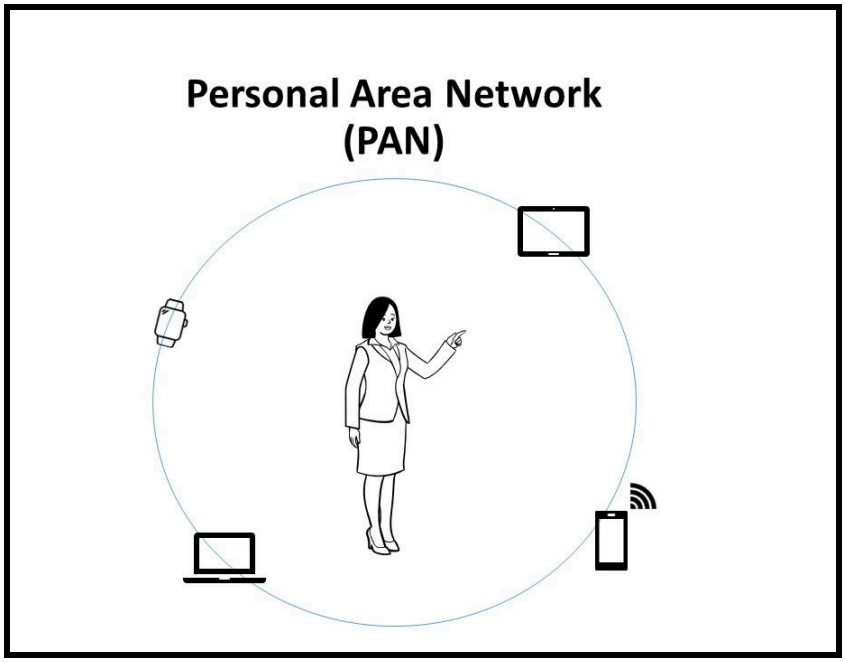


Fig 2: Personal Area Network

II. **LAN**

A local-area-network (LAN) is a type of network that connects devices in a small geographic area, such as a home, office, or school. LANs typically use wired connections, such as Ethernet cables, to connect devices to a central hub or switch. This allows devices to share data, resources, and devices such as printers and storage devices. Examples are joining a home network, work network or a library network etc.

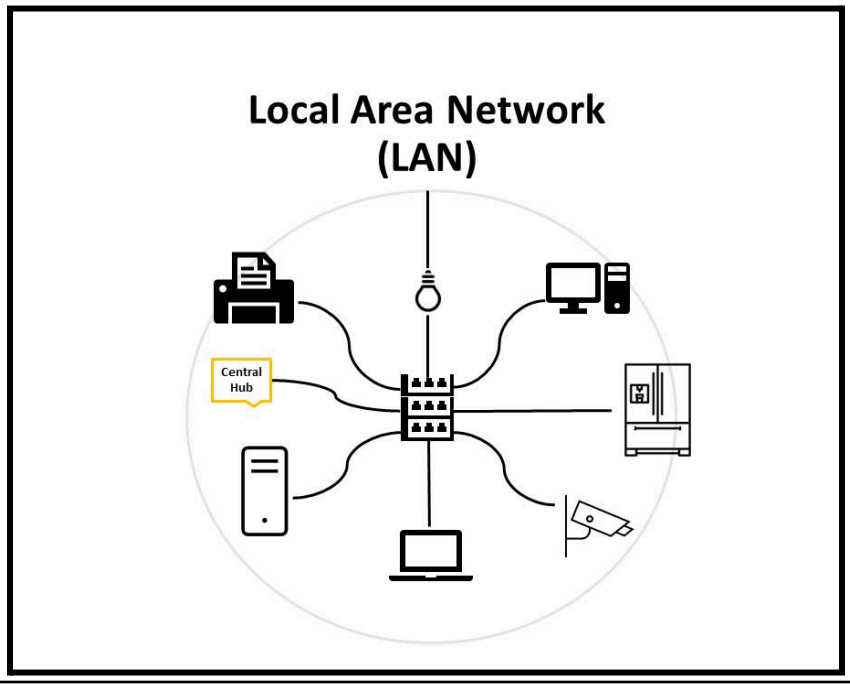


Fig 3: Local Area Network

III. **WLAN**

A wireless-local-area-network works similar to a local area network, however it is completely wireless. Therefore, it connects two or more devices to form a local area network for sharing information in a small geographic area, using entirely wireless communication.

They are common inside homes and small office buildings. Wi-Fi is the most commonly known wireless LAN, followed by mobile phone hotspots.

IV. **MAN**

A metropolitan-area network is a computer network that spans across a city, small geographical area, or business or college campus. One feature that differentiates a MAN from a LAN is its size. A LAN usually consists of a solitary building or area. A MAN can cover several square miles, depending on the needs of the organisation.

Large companies, for example, may use a MAN if they have a spacious campus and need to manage key components, such as HVAC and electrical systems.

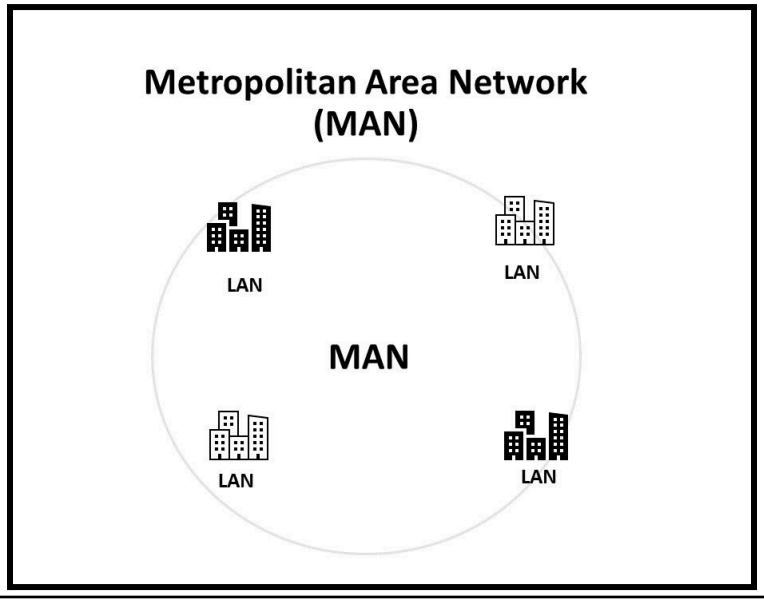


Fig 4: Metropolitan Area Network

V. **WAN**

A wide-area network covers a very large area, like an entire city, state, or country. In fact, the internet is a WAN. Like the internet, a WAN can contain smaller networks, including LANs or MANs. Cellular services are the most commonly known wireless WANs.

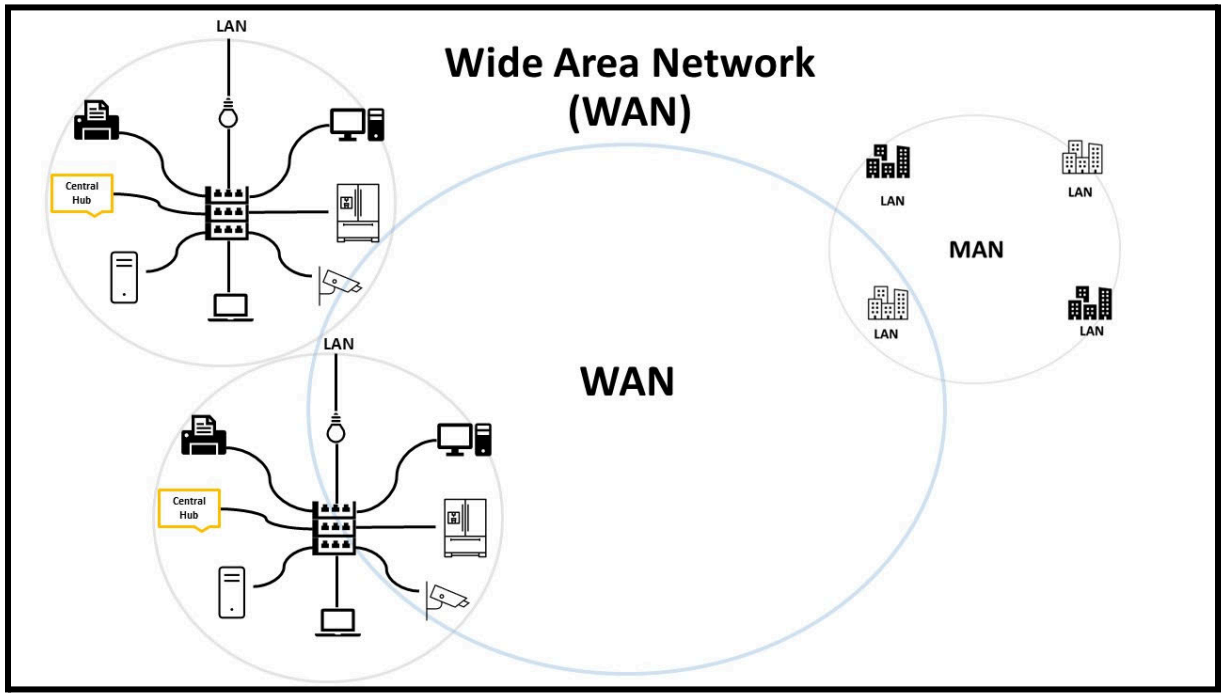


Fig 5: Wide Area Network

The main difference between the different types of networks lies mainly in the distance range offered by each network for a connection to be established. This is illustrated below:

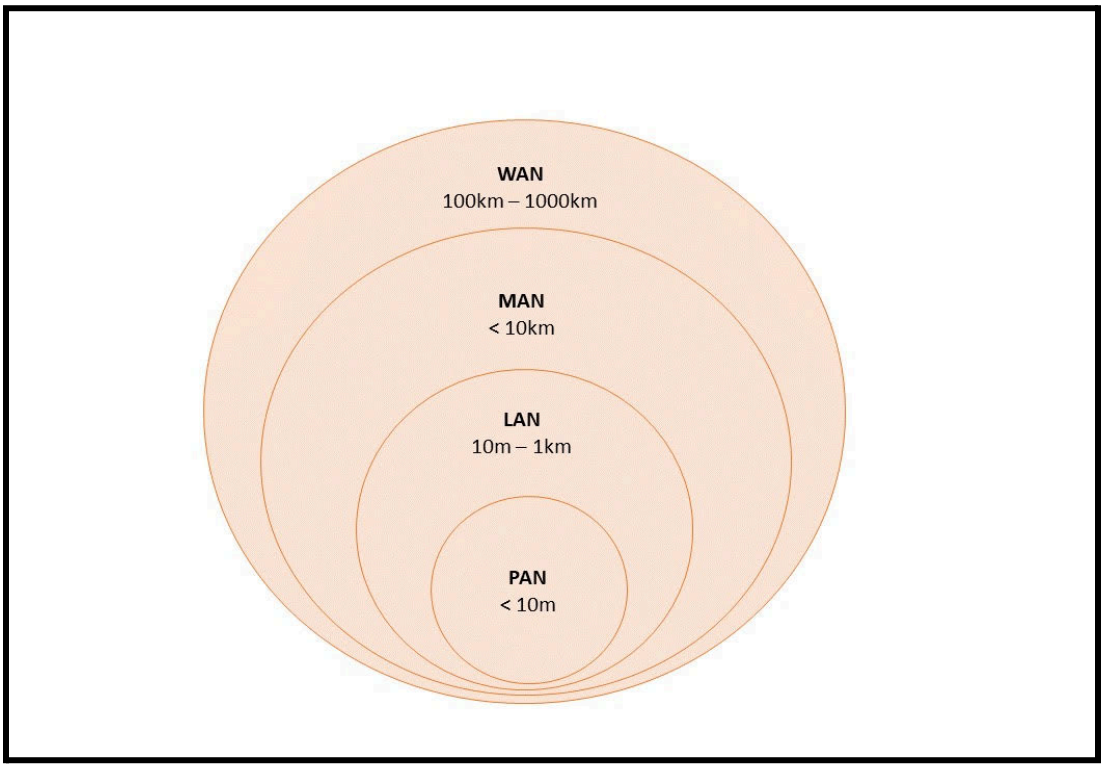


Fig 6: Range of distance offered by each network

A more extensive glossary of key terms in telecoms, both in layman and technical terms, is provided in Appendix I.

3. Overview of the Broader Telecom Sector

The telecom sector is a dynamic and ever-evolving industry that encompasses a wide range of activities, technologies, and services aimed at facilitating global communication and connectivity. In this section we provide an overview of the telecom sector beyond just telecom infrastructure, shedding light on its key components, market dynamics, and trends that impact the industry.

Services

Telecom services form the backbone of the sector, encompassing voice calls, messaging, data services, internet access, and multimedia content delivery. Telecommunication service providers, both mobile and fixed-line operators, play a central role in delivering these services to consumers and businesses. They establish and maintain extensive networks of communication infrastructure, enabling seamless connectivity across vast distances.

Mobile telecommunications, in particular, has witnessed tremendous growth and innovation over the years. The advent of wireless technology and the widespread adoption of smartphones have transformed the way people communicate, access information, and conduct business. Mobile operators deploy and manage networks that allow users to connect on the move, providing voice and data services through cellular towers and base stations.

Fixed-line telecommunications, on the other hand, relies on wired infrastructure to deliver services. This includes copper-based telephone lines, fibre-optic cables, and broadband networks. Fixed-line operators provide voice, internet, and digital TV services to homes, businesses, and institutions. With the increasing demand for high-speed internet and data-intensive applications, the deployment of fibre-optic networks has become crucial in ensuring reliable connectivity.

Infrastructure

In addition to telecommunications services, the telecom sector encompasses several other important components. Equipment manufacturers and technology providers play a pivotal role in developing and deploying the infrastructure and devices that power the industry. They design and manufacture a wide array of telecommunications equipment, including smartphones, network routers, switches, and transmission equipment.

Digital infrastructure is another key aspect of the sector. Data centres, cloud computing services, and content delivery networks (CDNs) form the backbone of digital connectivity and storage. Data centres house servers and storage systems that store and process vast amounts of digital information, while cloud computing enables on-demand access to computing resources. CDNs ensure the efficient delivery of digital content, such as videos, websites, and applications, by distributing it across multiple servers geographically.

Trends and regulations

The telecom sector is heavily influenced by market dynamics and trends. The demand for telecom services continues to grow, driven by factors such as increasing internet penetration, rising smartphone adoption, and the proliferation of data-intensive applications. The industry is witnessing significant technological advancements, including the deployment of next-generation networks like 5G, which promise higher data speeds, lower latency, and enhanced network capacity.

Moreover, the convergence of telecommunications and other sectors is blurring the traditional boundaries. The integration of telecom with media, entertainment, and technology has given rise to innovative services and business models. Companies are increasingly providing bundled offerings that combine telecommunications services with streaming content, digital platforms, and smart home solutions.

In terms of regulation, the telecom sector is subject to government policies and industry-specific regulations that aim to promote competition, protect consumers, and ensure fair market practices. Regulatory frameworks vary across jurisdictions and can impact market dynamics, investment opportunities, and the overall operating environment for industry participants.

The telecom sector encompasses a wide range of activities, technologies, and services that enable global communication and connectivity. From telecommunications services and infrastructure to equipment manufacturing, digital infrastructure, and market dynamics, this sector continues to shape our interconnected world.

4. Global Telecom Market Summary

Telecoms is a global industry. The sector's largest players typically tend to display characteristics of defensive stocks, emphasising it as a good investment choice for investors seeking steady earnings and consistent dividends.The below table, based on a Mobile Magazine online article, gives the top 10 telecommunications companies globally, arranged in order of annual revenue:

Rank	Company	Primary Location	Revenue (USD Billions)	Primary subsector
1	AT&T	USA	168.9	Wireless (MNO)
2	Verizon	USA	133.6	Wireless (MNO)
3	Deutsche Telekom	Germany	122.8	Wireless (MNO)
4	Comcast	USA	116.4	Fixed
5	Nippon	Japan	113.5	Fixed
6	China Mobile	China	109.2	Wireless (MNO)

7	**China Telecom**	**China**	**59.8**	**Fixed**
8	**Vodafone**	**Germany**	**53.2**	**Wireless (MNO)**
9	**Orange**	**France**	**49.9**	**Wireless (MNO)**
10	**Telefonica**	**Spain**	**49.2**	**Wireless (MNO)**

Table 1: Largest telecom companies globally by annual revenue.
Source: https://mobile-magazine.com/articles/top-10-largest-telecommunications-companies-2023

Many of the major players listed above have expanded beyond their home country to host operations in different markets, making a neat breakdown of regional leaders challenging. Below we describe some of the key players in the mature markets of the US, Asia, and Europe.

US

The US is an intensely competitive market, driven by the convergence of the connectivity offerings of the largest players discussed below, along with other companies like Charter and T-Mobile. Pricing strategy is key in what is a largely commoditised market outside of rural areas (which have their own specialist companies like Cable One).

- **AT&T** is the largest telecommunication company in the world and provides a comprehensive service of wireless, broadband, and television. AT&T has become a media giant through aggressive M&A activity, owning brands like HBO, CNN and DC Entertainment.
- **Verizon** has also aggressively expanded into related industries from its traditional strength of offering reliable wireless services. The acquisitions of AOL and Yahoo's core internet service in 2015-16 expanded the company into Media and Internet. Verizon serves corporate and individual customers.
- **Comcast** is a leader in cable with large customer numbers to match. Strategic acquisitions include NBCUniversal. Their approach to bundling its different services has offered customers flexibility to meet their specific connectivity needs.

Asia

Asia is a diverse market, with countries spanning the spectrum of fully connected (South Korea) to earlier stage (India). Infrastructure build up remains a key priority for the below players, as well as disruptors like SoftBank and companies with a presence in growth markets like India, such as Bharti Airtel.

- **Nippon** is a global leader in telecom innovation. Their home market is Japan, where their offering ranges from fixed and mobile service for corporate and individual customers, to data centres and IT solutions for large corporate clients.
- **China Mobile** is a cornerstone of telecoms in China, helping the country's ongoing digital transformation. It offers nationwide coverage of mobile and broadband among other services to its extensive subscriber base.
- **China Telecom** is another crucial Chinese player, with a focus on not only fixed-line services, but also mobile. It serves both corporate and individual customers by pushing forward the rollout of fibre-optic broadband and next-generation networks.

Europe

The European market is more fragmented than the US and thus less competitive. Regulations and linguistic differences mean that while cross-border offerings from the likes of Vodafone and Telefonica, countries will have their own unique competitive dynamics. EU-wide regulation will arguably lessen this fragmentation over time.

- **Deutsche Telekom** is a German-based global player. It offers a wide range of services in its home country across mobile, broadband, and IT solutions. Known for a strong innovation culture, it also battles in the US market, through a majority ownership stake of T-Mobile, a disruptive player in the US mobile market. Its cheaply-priced

fixed wireless broadband offering, in addition to its acquisition of Sprint have laid down a strong challenge to the established US internet providers.

- **Vodafone** has a presence across European markets, with an incredibly well-known brand and widespread coverage. The company has put a strong focus on the 5G rollout for its individual and business consumers in recent years, often funding the heavy capex associated with this rollout through the sale of telecom tower assets.
- **Orange** is the market leader in France across broadband and mobile offerings. Investment in recent years has focused on the rollout of fibre optic connection to its large customer base. In addition to its homebase in France, it has also pursued growth opportunities in the African market, now having operations in 26 countries overall (and 220 countries and territories through Orange Business Services).
- **Telefonica** operates under the O2 brand in many European countries. Its comprehensive offering is the market leader in Spain (under the brand Movistar). It has unlocked the value of its telecom tower infrastructure assets through the creation of its participation in a towers-specialist joint venture, Telxius, with KKR and Pontegadea.

Emerging Markets

Growth-type investments in the sector are now more frequently found in developing markets such as Central America and Africa. As consumers in these regions increase their incomes and wealth, they demand not only voice, but also the data connectivity enjoyed by their peers across the world, providing opportunities for clever management teams able to raise significant capital and use it wisely to provide the infrastructure needed to enjoy this service. Two examples are featured below.

- **Airtel Africa** is a subsidiary of Bharti Airtel, an Indian company. Its strategy focuses on 14 emerging markets in Africa. Its basic mobile services of voice and data are supplemented by a growing mobile money business. It continues to expand network coverage and modernise its infrastructure to both retain existing customers and add new users eager to take part in the digitalisation of their countries.
- **Millicom**, which has the brand name of Tigo, is a provider of fixed and mobile services in Latin America. The company previously held operations across Africa, but is now focused solely on Latin America, with major operations in Guatemala, Columbia, Honduras, and Bolivia among others. It targets countries that have traditionally been underserved connectivity solutions. By improving the infrastructure and level of internet access in these locations, Millicom can have a major impact in connecting communities across these countries and thus pushing forward economic development.

5. Overview of the Telecom Infrastructure Sector

We now focus on the telecom infrastructure sector that is the focus of this paper. As a critical component of the telecom industry, telecom infrastructure serves as the foundation for communication networks, enabling the seamless transmission of voice, data, and multimedia content. This section explores the key elements, technologies, and trends within the telecom infrastructure sector.

Telecom infrastructure comprises both physical and digital components. Physical infrastructure includes a diverse range of assets, such as towers, antennas, fibre-optic cables, satellite systems, and data centres. These assets are strategically deployed to ensure widespread coverage, efficient data transmission, and reliable connectivity across various geographic areas.

Connectivity Infrastructure

Towers and antennas form the backbone of wireless communication networks, providing the infrastructure for mobile operators to transmit signals to and from mobile devices. These structures are strategically located to optimise coverage and network capacity. As the demand for mobile data continues to surge, the deployment of additional towers and small cell sites becomes crucial to meet the increasing capacity requirements.

Fibre-optic cables play a vital role in the transmission of high-speed data over long distances. With its ability to carry vast amounts of data at lightning-fast speeds, fibre-optic infrastructure has become essential for delivering broadband internet

services and supporting the growing demand for data-intensive applications. Telecom companies and infrastructure providers invest in the deployment of fibre-optic networks, either underground or overhead, to connect homes, businesses, and institutions.

Satellite systems offer an alternative means of communication, particularly in remote or geographically challenging areas where traditional terrestrial infrastructure may be limited. Satellites enable global coverage and facilitate various applications, including telecommunication services, television broadcasting, and internet connectivity. Satellite operators and manufacturers play a crucial role in launching, maintaining, and operating these systems.

Data Infrastructure

Data centres are fundamental to the digital infrastructure of the telecom sector. These facilities house servers, storage systems, and networking equipment that store and process vast amounts of data. Data centres support critical operations such as cloud computing, content delivery, and data storage for telecommunication services, online platforms, and businesses relying on digital operations. As the volume of data continues to grow, data centres are constantly evolving to meet the increasing demands for storage, processing power, and network connectivity.

Technological advancements are shaping the telecom infrastructure sector, enhancing its capabilities and opening new opportunities. The deployment of next-generation networks, such as 5G, promises faster speeds, lower latency, and improved connectivity. 5G infrastructure involves a combination of upgraded towers, small cells, and advanced network architecture, enabling innovative applications like Internet of Things (IoT), smart cities, autonomous vehicles, and immersive multimedia experiences.

Another key trend in telecom infrastructure is the convergence of telecommunications and IT infrastructure. The rise of cloud computing, virtualization, and software-defined networking has led to the emergence of network function virtualization (NFV) and software-defined networking (SDN). NFV allows network services to be virtualized and run on commodity hardware, while SDN separates the network control and data plane, providing greater flexibility and agility in managing network resources.

The telecom infrastructure sector presents attractive opportunities for long-term institutional investors seeking stable and predictable cash flows. Telecom infrastructure assets often offer long-term contractual agreements and stable revenue streams, making them an appealing investment avenue for insurance companies, pension funds, and other institutional investors. The essential nature of telecom infrastructure and its role in enabling connectivity positions it as a resilient asset class that aligns with the investment objectives of long-term investors.

In conclusion, the telecom infrastructure sector is a critical component of the broader telecom industry, providing the physical and digital infrastructure necessary for seamless communication and connectivity. From towers and fibre-optic cables to data centres and satellite systems, telecom infrastructure plays a pivotal role in meeting the increasing demands for high-speed data transmission and reliable connectivity. Understanding the evolving technologies, trends, and investment potential within the telecom infrastructure sectors allows potential investors to make informed decisions and capitalise on the long-term value this asset class can offer.

6. Methods of Institutional Investment in Telecom Infrastructure

Some routes to introduce telecoms into a portfolio are given below:

Public-Private Partnerships

Historically, investment in infrastructure such as for telecoms was done through collaborations between private and public sector entities called Public-Private Partnerships. These schemes are set up to finance, develop and eventually deploy and operate a set of infrastructure and associated services, combining efforts and resources of both parties.

They are usually associated with projects involving a large capital outlay. They may also be deployed via any one of the following models in which the private company conducts any one of the following:

Fig 7: PPP Delivery Models spider chart

Equity

The telecom sector is made up of (i) telecom equipment, (ii) telecom services, and (iii) wireless communication. Additionally, many different types of telecom products and services are in deployment, as explained in further detail elsewhere in this primer.

Therefore companies may buy equity listed from any of these various listed companies. Unlisted equity may also be sought, but may prove a challenge to both buy and sell due to its illiquidity.

Valuations and dividend yields vary depending on the maturity level of the geographic market in question. Companies in markets with more potential for growth are typically less likely to pay out dividends (although this is not always the case). The table below shows average Price to Earnings ratios and dividend yields for telecom companies across a range of geographies.

Region	**Average PE ratio**	**Average dividend yield**
Asia Pacific Emerging Markets	29.1x	1.2%
USA	22.4x	0.4%
Europe	13.2x	2.0%

Middle East and Africa	11.1x	3.5%
Latin America and Caribbean	10.1x	0.9%

Table 2: Telecom equity valuation multiples and dividend yields
Source: Bloomberg.com

Corporate Bonds

Companies could alternatively purchase bonds issued by the various types of telecom companies. Infrastructure projects tend to be highly leveraged and therefore debt financing may be the more accessible route to telecom investments.

These provide both a steady income and less risk of default than most corporate bonds due to the defensive nature of telecom companies to the economy.

The yield curve of investment grade corporate bonds from telecom companies as at the end of November 2023 is shown below. These bonds are from companies across the world. The trendline in red shows a relatively flat term structure.

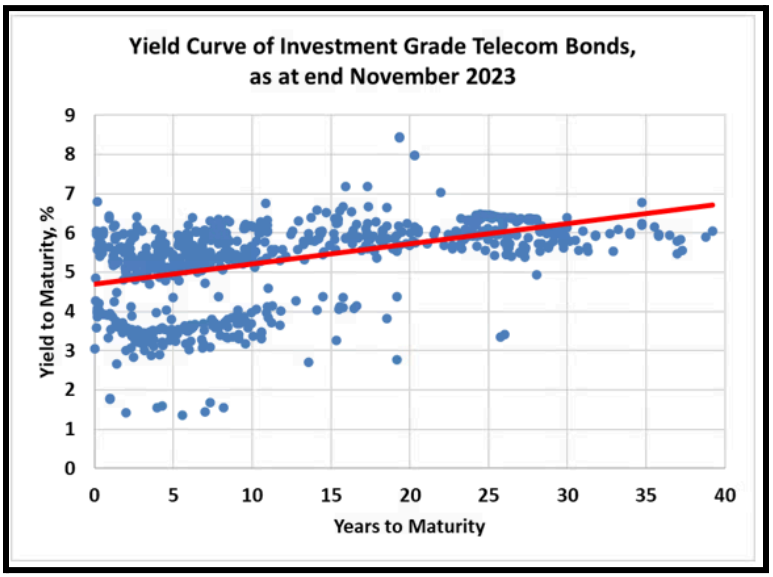


Fig 8: IG telecom bonds yield curve
Source: Bloomberg.com

Alternative Debt Securities

Since debt tends to dominate the leveraging of infrastructure projects, besides corporate bonds, other forms of debt have emerged over the years. Examples are listed below:

- **Telephone Bonds:** Over the last four decades, there has been an emergence of a particular type of bond issued mainly by telephone companies. These bonds behave more like commodity bonds than utility bonds depending on the level of competition that exists between telephone companies in the region/country.

- **Green/Sustainability Bonds:** A newer type of bond emerging is known as green bonds. These support more stringent action being taken towards net zero, with investments funnelled into sustainable projects. Funds could invest in these types of infrastructure green bonds to ensure their own efforts towards sustainability are also covered.

REITs

Other channels of investment could be in telecom infrastructure REITs. These offer the chance to own and operate telecom infrastructure assets, such as telecommunications towers, fibre cables and wireless infrastructure, as well as data centres.

REITs benefit from relatively steady demand for their assets. For example, telecom companies need communications towers to support mobile networks, therefore requiring companies to typically sign long-term leases with REITs to guarantee access to essential infrastructure. This guarantees consistent long term income.

Specialist ETFs

These ETFs generally hold a diversified portfolio of telecom related stocks which may also reduce company specific risks. The yield obtained will depend on the performance of underlying stocks in the ETF.

7. Risks of Investments in Telecom Infrastructure

Regulations and Policy

Telecoms is a highly regulated industry. Changes in government policies, licensing requirements, and regulations can significantly impact the profitability of investments in the sector. Regulatory changes can include spectrum allocation rules, net neutrality, and data privacy laws.

Technological Disruption

The telecoms industry is subject to rapid technological changes. Investments in outdated infrastructure can quickly become obsolete, causing financial losses. The emergence of new technologies such as 5G, satellite internet, and the shift to IP-based networks can disrupt existing infrastructure.

Competition

The telecom sector is highly competitive. Existing players and new entrants can put pressure on pricing, reducing profit margins. Competition can also lead to costly infrastructure build-outs to keep up with rivals.

Market Saturation

In many developed markets, the telecom industry may be saturated. The number of new subscribers is limited, and growth primarily comes from subscriber upgrades or additional services. This saturation can limit revenue growth opportunities.

Economic and Business Cycles

The telecom industry is sensitive to economic downturns. During economic recessions, consumers and businesses may reduce spending on telecom services, impacting the revenue of telecom infrastructure providers.

Cybersecurity

With the growing reliance on digital networks and data transmission, telecom infrastructure is vulnerable to cybersecurity threats. A cyberattack can disrupt services, damage reputation, and result in financial losses.

Capital Intensity

Building and maintaining telecom infrastructure requires significant capital investments. The cost of deploying and upgrading networks, especially for technologies like 5G, can be substantial and take a long time to recoup.

Market Demand and Shifts

The demand for specific telecom services or technologies can change rapidly. Investing in infrastructure for a service that becomes less popular or is replaced by a more advanced technology can lead to financial losses.

Geopolitics

Geopolitical tensions can impact telecom infrastructure investments. For example, governments may limit access to certain vendors or technologies, affecting the supply chain and deployment of infrastructure.

Natural Disasters

Telecom infrastructure, including cell towers and data centres, can be vulnerable to natural disasters such as hurricanes, earthquakes, and floods. These events can cause damage and disrupt services, resulting in financial losses.

Environmental and Sustainability Concerns

Increasing concerns about the environmental impact of telecom infrastructure, such as energy consumption and e-waste, can lead to regulatory changes and reputational risks for companies.

Legal and Liability Risks

Telecom companies may face legal challenges related to issues like antitrust, intellectual property disputes, or consumer protection, which can result in financial penalties and reputational damage.

8. Examples of Institutional Investment in Telecom Infrastructure

Pension fund companies are shifting some allocations from investment in traditional asset classes such as fixed income and equity to alternative assets such as telecom tower infrastructure. This is beneficial not only for risk / return purposes, but also works well in a time of rising inflation, has strong cashflow generation characteristics, and helps pension funds to meet their sustainability goals. Many institutional investors are now looking at such types of infrastructure for long-term inflation-protected returns. Below we explore some examples of telecom infrastructure investments by major pension funds around the world.

Canada

Caisse de dépôt et placement du Québec (CDPQ)

The second largest pension provider in Canada CDPQ is investing in telecoms and sustainable mobility. One example is electric vehicle charging infrastructure in India. In the past CDPQ has invested heavily in greenfield infrastructure such as roads and railways in India. CDPQ's goal is to invest in resilient infrastructure assets which can last for a long duration, thus creating value for the stakeholders. Telecoms is one such sector, with unlimited investment boundaries offering a stable rate of return for institutional investors. At the time of writing, CDPQ is in talks to acquire a 50% stake in ATC Telecom Infrastructure Private Limited (ATC TIPL), an Indian subsidiary of the Boston-based American Tower Corp (ATC). The CDPQ is interested in investing in the Asia Pacific region (with a focus on India) as the market has a lot to offer in terms of depth, diversity and annual deals.

Ontario Teachers' Pension Plan

One of the largest pension funds in the world, with net assets of $247bn (CAD), Ontario Teachers' Pension Plan is investing in a wireless communication network, Diamond Communications. The company specialises in the expansion of wireless networks to enhance internet connectivity and cellular services in remote areas. Diamond Communications is one of the largest telecom companies in the USA, holding over 4,000 wireless communication infrastructure platforms and over 300,000 managed properties in the country. Ontario Teachers has prior experience of investment in digital infrastructure, such as recent investments in New Zealand; in December 2022 they made an agreement with telecoms provider 2Degrees Mobile to invest in their existing cellular towers and acquire their newer towers.

Canada Public Sector Pension (PSP)

PSP has collaborated with EQT Infrastructure to buy telecom operating firm Radius Global Infrastructure in a deal worth US$3 billion. Radius generates revenue from 9,188 assets that are situated in approximately 7,024 communication sites in 21 countries.

OMERS

OMERS is involved in tower investment in Australia, with two major deals in 2022. One deal was with the owner and operator of mobile tower assets Stilmark, a telecom tower company. The other deal was with TPG Telecom, for a portfolio of more than 1,230 mobile towers.

Other

UniSuper

Australian pension fund UniSuper has invested US$677 million in European telecom towers business Vantage Towers to expand their digital infrastructure footprint across the region. As of May 2023, UniSuper had acquired a 5% stake in Vantage Towers, making it the third-largest asset in its $15bn (AUD) private markets portfolio.

GIC

GIC from Singapore is the biggest single institutional investor in the sector representing 27% of the total direct acquisitions between 2017-2023.

Global Picture

The below chart shows the split by region of direct acquisitions of telecom towers originated by sovereign investors, often alongside other institutional investors. In aggregate Canadian public pension funds contributed more than 50% of the capital invested.

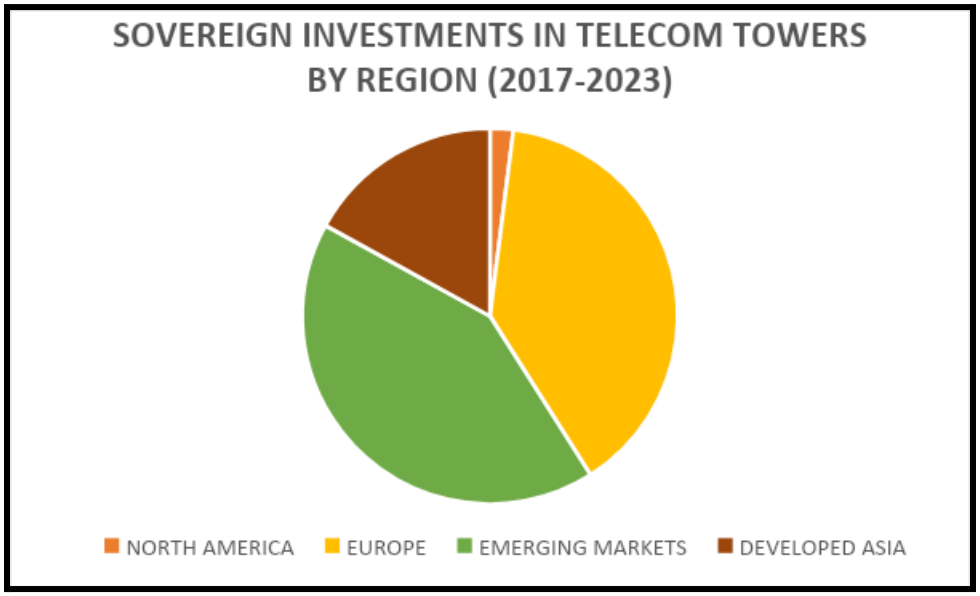


Fig 9: Graph of geographical split of sovereign investment in telecom towers 2017-2023
Source: https://globalswf.com

9. 2023 Trends in Telecoms

To conclude we look at two hot topics in the telecom industry at the time of writing in 2023.

Convergence Wars in Mature Markets

A typical consumer in developed markets have become accustomed to ultra fast internet wherever they go:

a. At home, they enjoy an excellent wired broadband connection from their fixed or cable service provider.
b. On the move, they connect to their mobile network operator's (MNO) wireless data connection (e.g. 4G or 5G).

The providers of each of these services have tended to differ in most countries. However, as high speed internet service becomes more and more of a commodity (at least in urban areas), companies in each market are looking to extend their share of the overall connectivity pie. In the long-run, this should increase competition and be good for consumers[2].

Broadband providers such as Charter Communications in the US currently have mobile virtual network operator (MVNO) contracts in place with MNOs like Verizon. Charter now wants customers to get their entire connectivity from Charter: broadband from Charter at home and wireless data (via Charter's cable and Verizon's wireless network) on the move. Broadband providers like Charter can offer relatively cheap wireless service to the customer as they can use their own vast

[2] https://www.fiercewireless.com/wireless/2022-year-telecom-convergence-moore

cable infrastructure to transfer data for most use cases, and only pay to use Verizon's wireless infrastructure in the limited cases when needed.

MNOs eg. T-Mobile in the US are hoping users notice that their 5G connection is now fast enough for almost all internet use cases. The user might then stick with T-Mobile for its wireless data offering. But as importantly, they could cut their broadband connection at home. Instead moving to a fixed wireless home internet offering. Fixed wireless internet is cheaper than traditional wired broadband. However, it is naturally constrained in the volumes of customers it can serve successfully by the capacity of the wireless networks. For example, T-Mobile may only be able to offer sufficiently fast fixed wireless internet to 3 houses on a particular street before it would run into capacity issues.

The ultimate winners of the convergence wars in the US remain to be seen - but the outcome will be telling for markets around the world. To date, MNO's have been winning significant broadband market share through their cheaper price point fixed wireless offerings. This has been reflected in the stock market outperformance of MNOs versus cable companies during 2022 and 2023. However, some industry experts maintain that the capacity constraints described above will soon slow the rapid growth of fixed wireless, and that the more interesting long-term trend to keep an eye on is cable companies winning wireless market share.

Telecom Companies spinning out their Physical Infrastructure Assets

Telecom companies had long viewed their tower assets as a capital intensive cost centre. Stock investors prefer capital light businesses that pay for the use of infrastructure such as the towers as an operating expense rather than through hefty capex up front. This has led to many of these tower assets being spun off into separate tower specialists eg. American Tower. These tower companies have enjoyed incredible multiples. Investors view them as a steady stream of cash flows into the future. They will benefit from increasing digitalisation over time, regardless of the particular trend or device that wins popularity. They also have low operating expenses.

Telecom companies themselves have not enjoyed such love from the stock market. They are seen as capital intensive businesses that are beholden to both the demands from consumers for constant connection and no drops in coverage, as well as internet content providers hoovering up more and more of the public's attention span to data rich video each year. This has left them in precarious finance positions - high leverage has left them extra exposed in a rising interest rate environment. Making the prospect of immediate cash in exchange for selling infrastructure assets in order to reduce debt even more appealing. Eg. Millicom is considering a spin off of its tower assets across different geographies in Latin America through carving out a new towers-only subsidiary to IPO - "Lati"[3]. This tower company would win business from other wireless providers in these regions who would avoid the need for capex to build out their network.

Appendix I: Glossary of Telecom Key Terms

The rest of the primer contains an extensive glossary of key terms in telecoms, explained in both layman's terms and in technical descriptions.

[3] https://www.millicom.com/2022annualreport/unlocking-the-hidden-value-of-our-towers-infrastructure/

Term		Definition
Antenna	Layman's Terms	An antenna refers to an essential part of radio telecommunications equipment that bridges the gap between electronic and electromagnetic signals. It can either capture or transmit electromagnetic signals. This means that information is transmitted from one point in the form of electric signals which moves through cables to a second point that receives the signal e.g. data moving via electricity in coaxial cables to be picked up at a cell site. The signals are transformed into electromagnetic waves which is a form that can be picked up by the antennae. **NB:** Electromagnetic waves are created as a result of vibrations between an electric field and a magnetic field. The equipment involved includes the components, (either individually or in combination), that are needed to operate a wireless communication network for the purpose of radio telecommunications. Such components include but are not limited to: ● cell sites; ● transmitters; ● receivers; ● signalling and control equipment.
	Technical Description	An antenna is a specialised **transducer** that converts electric current into electromagnetic (EM) waves or vice versa. Antennas are used to transmit and receive non-ionizing electromagnetic fields, such as ● radio waves, ● microwaves, ● infrared radiation (IR) and ● visible light. **NB**: A transducer is a device that converts energy from one form to another, usually converting a signal in one form of energy to a signal in another form. A transmitting antenna receives current from a transmitting device. From this current, the antenna generates EM waves at a specific frequency that radiate out through the air, where they can then be received by one or more other antennas.
		Average revenue per unit (ARPU) is a measure of the profitability of a product based on the amount of money that is generated from each of

Average revenue per user (ARPU)	Layman's Terms	its users or subscribers. It indicates which company is doing the best job of maximising revenue from its subscribers/users. The metric is calculated using the following formula: **ARPU = Total Revenue / Number of Users** Although earnings is commonly used as a comparison metric, it may vary, hence to gauge a company's value, telecom industry analysts usually turn to either one of the following metrics: 1. price-to-sales ratio (stock price divided by sales) 2. **average revenue per user (ARPU)**, which offers a useful measure of growth performance 3. churn rate, the rate at which customers leave (presumably for a competitor offering a better service, or the same service at a lower cost) ARPU is however the **key** metric in telecommunications, and is declining in many markets around the world following various policy changes and deregulation occurring worldwide.
	Technical Description	Average revenue per user measures the amount of money that a company can expect to generate from an individual customer. It's calculated by dividing the business's total revenue by its total number of users. This metric is used by businesses to measure the factors that are contributing to the organisation's overall revenue, therefore it helps companies analyse their growth patterns and compare their success to competitors. For example, determining whether the current monetization strategies are working as intended, would be reflected by the ARPU trending upward over time as improvements are implemented. For all companies, regardless of industry or size, long-term profit generation boils down to one single question, "How much is a single customer worth to a business. The go-to-market strategies employed to achieve growth (e.g. sales & marketing, product development) are all dependent on the answer to the question stated above. A rational, well-run company should be hesitant to continue spending significant amounts of capital if the potential return from customers is insufficient. The exception is if growing the user base takes precedence over monetizing the users for the time being, but eventually, the company must become more profitable.

Therefore, a company's ARPU essentially sets a ceiling on the amount that can be spent to fund growth and expansion plans.

Increasing ARPU	Decreasing ARPU
• Increased Average Selling Price (ASP) Per Unit – i.e. Significant Market Share with Pricing Power	• Forced Reduction in Pricing to Increase Customer Demand – e.g. Threat of New Market Entrants
• Strategic Customer Targeting – e.g. Low Churn, Affluent Customer Base	• Difficult to Monetize Customer Base – e.g. B2C, Younger Demographic with Minimal Discretionary Income
• Extensive Upselling/Cross-Selling Opportunities	• Standalone Product with Few Upselling/Cross-Selling Opportunities
• Differentiated Product/Service Offering with Strong Branding Leading to Premium Pricing	• Weak Branding Strategies (i.e. Forced to Offer Discounts)
• Lack of Market Competition and/or Threat of Undercutting by New Entrants	• Overcrowded Market with Low Differentiation

Table 3: Factors affecting the movement of the metric APRU
Source: wallstreetprep.com

Broadband

Layman's Terms

Broadband means a wide range of frequencies over which information can be transmitted. A simple way to compare broadband and narrowband Internet connections is to picture a highway. Only one car can travel at a time on a one-lane highway (narrowband). However, when a highway is six or eight lanes wide (broadband), more traffic can drive on the road at the same time. In the past, dial-up Internet connection was the norm. Now in the Internet today, data connections are 'always on' which enables one access to multiple media sources and a wide range of information at the same time. That is broadband.

In shorter words, broadband is a high-speed internet connection that allows you to enjoy everything the online world has to offer.

There are a few types of broadbands;

1. FTTC (Fibre To The Cabinet)
2. FTTH (Fibre To The Home) / FTTP (Fibre To The Premises). Can be used interchangeably.

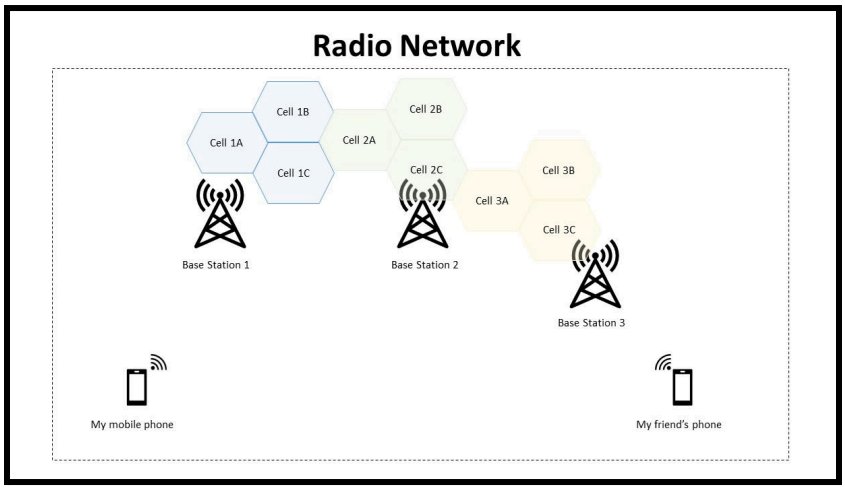
These terms simply mean – how close the fibre comes to a building, house and/or end user. The closer it comes, the faster the connection.

In the UK, 98.8% of fibre connections in the country are FTTC, (but FTTH and FTTP offer the fastest connections).

NB: Before broadband, internet access was achieved with dial-up connections that were very slow by today's standards. This was sometimes known as narrowband internet. Broadband is much quicker and allows us to do a lot more.

	Technical Description	In telecommunications, **broadband** is the wide-bandwidth data transmission that transports multiple signals at a wide range of frequencies and Internet traffic types, which enables messages to be sent simultaneously and is used in fast internet connections. The medium can be coaxial cable, optical fibre, wireless Internet (radio), twisted pair, or satellite. Broadband is always connected and removes the need for dial-up. Its importance is far-reaching; it allows for high-quality and quick access to information, teleconferencing, data transmission, and more in various capacities, including healthcare, education, and technological development. In general, however, the two defining characteristics of broadband are that it is high-speed and that it is available at all times. Both of these characteristics serve to distinguish broadband from older dial-up connections. Not only was dial-up Internet connection slower, but it was only available when specifically requested by the user.
Cable	Layman's Terms	Cables in telecoms refers to the infrastructure used to transport voice and data communications between different locations within a building or across multiple buildings.
	Technical Description	Cables in telecommunications fields are wirings that are used to transmit electromagnetic waves. They are also referred to as *electromagnetic wave guides*. The cables are used when connecting a number of end users to a central point known as an 'Access Node' or 'Point of Presence' (POP). Each Access Node contains the necessary electronic transmission (active) equipment to provide the applications and services to the subscriber. Each Access Node, within a large municipality or region, is connected to a larger metropolitan or urban optical fibre network. Types of cables include: ● Data Centre Cables ● Telephone Cables ● LAN Cables ● Coaxial Cables (Copper Cables) ● Fibre Optic Cables (Newest technology) For traditional cable, data is transmitted via electricity. It uses coaxial cables to transmit data. Inside that coax cable is a copper core insulated with aluminium, a copper shield, and an outer plastic layer. These cables are however more susceptible to weather events (like extreme cold, storms, etc.) and electromagnetic interference than fibre-optic (the newest technology of cables) because it uses electrical signals. Based on the type of signal sent and received, the cables can also be

		classified as below: ● **transmission lines** - when **electric signals** are transmitted; ● **waveguides** - when **electromagnetic signals** are transmitted; ● **optical fibres** - when **light signals** are transmitted.
Carrier	Layman's Terms	A telecommunications carrier is a business involved in data transfer or communications. These include companies that engage in phone, internet, television, multimedia transfer, or data exchange. Popular examples in the UK include Three Network and BT Group.
	Technical Description	A carrier refers to a company that is authorised by regulatory agencies to operate a telecommunications system. Other terms used that refer to the same thing include mobile network operator, mobile phone operator, mobile operator, cellular company, and wireless service provider. A company aspiring to become a carrier normally starts by applying for a radio spectrum licence from the government. The radio spectrum or frequency range that it applies for depends on the kind of technology the company wishes to employ. These frequency ranges are usually offered by the government to interested parties through auctions. When the company succeeds in its bid to become a wireless carrier, it then has to build the necessary infrastructure in order to offer mobile services to its subscribers. These services can range from voice, SMS, MMS, to Web access. Some of the biggest carriers in the world (based on the number of subscribers) include China Mobile, Vodafone, SingTel, America Movil, and Telefonica. In the US, the largest carriers are Verizon and AT&T.
Cell	Layman's Terms	A network for wireless communications consists of a large number of base stations to efficiently use radio spectrum to cover the service area. A cell is the geographic area that is covered by a single base station in a cellular network. An analogy of this is that, the cellular network consisting of a network of base stations is comparable to a district with a number of hospitals serving different postcode regions to increase NHS efficiency. The cell would therefore refer to the single/set of postcode regions served by a singular particular hospital in the district.
		A cell is a geographical area that defines the cellular coverage zone created by the base station of a mobile network. The base station, also known as a cell tower, is equipped with transceivers that transmit and receive radio signals at licensed frequencies between the network and mobile phones.

	Technical Description	Mobile networks are also called cellular networks because they consist of a large number of interconnected cells as illustrated in figure 10 below.  **Fig 10: Graphic illustration of a cellular network** Cells can be classified based on their range and capacity. Key types include: ● Macro cells, which are large cells that are usually used in remote, sparsely populated areas. These cells have a high reach. ● Micro cells, utilised in densely populated areas and usually with a low reach of about 1 kilometre. ● Pico cells which are normally used to cover a small area like buildings or blind spots of bigger cells. ● Selective cells, which are a 360-degree coverage cell and umbrella cells used to cushion the effect of handovers between micro cells.
Fibre Optic Cable	Layman‘s Terms	Optical fibre cabling is used to transfer information via pulses of light, which pass along one or more transparent plastic or glass pipes. In some cases, this can be more than several hundred pipes. Each of these strands is little wider than an average hair and is normally surrounded by a further layer of cladding which is also in plastic or glass but constructed at a different density to the main inner strand. They run underneath oceans. It has replaced all copper cables and permits 10-100 times faster transmission than traditional copper wire, which means faster, more efficient cell phones and Internet connections.
		A fibre optic cable is a network cable that contains strands of glass fibres inside an insulated casing. A fibre optic cable consists of one or more strands of glass, each only slightly thicker than a human hair. The centre of each strand is called the core, which provides the pathway for light to travel. The core is

	Technical Description	surrounded by a layer of glass called cladding that reflects light inward to avoid loss of signal and allow the light to pass through bends in the cable. The two primary types of optical fibre cables are single mode and multi-mode. Single-mode fibre uses extremely thin glass strands and a laser to generate light, while multi-mode optical fibre cables use LEDs. These cables are designed for long-distance, high-performance data networking, and telecommunications. Fibre optic cables carry communication signals using pulses of light generated by small lasers or light-emitting diodes. Single-mode optical fibre networks often use Wave Division Multiplexing techniques to increase the amount of data traffic that the strand can carry. WDM allows light at multiple different wavelengths to be combined (multiplexed) and later separated (de-multiplexed), effectively transmitting multiple communication streams through a single light pulse. Compared to wired cables, fibre optic cables provide higher bandwidth and transmit data over longer distances. Fibre optic cables support much of the world's internet, cable television, and telephone systems.
Fixed Wireless vs Mobile Wireless	Layman‘s Terms	**Fixed Wireless Network** Fixed wireless internet is when an internet service provider wirelessly transmits internet (using signals) to a specific, fixed location, allowing devices within that location to connect to the web. It is a type of broadband where the connection signal is broadcast from a fixed point to a receiver, rather than being sent through cables as with most traditional broadband solutions. Cable broadband is widespread throughout the UK but commonly runs into issues when attempting to serve hard-to-reach areas. This is where fixed wireless networks are used. **Mobile Wireless Network** Mobile wireless internet allows portable devices to be connected to the web as the user moves from location to location through a service provided by a mobile phone provider. For example, a user of Vodafone using mobile internet on their cell phone at home, then later whilst moving onto the bus and later on in the shopping mall.
		Fixed Wireless Network Fixed wireless network refers to the operation of wireless devices in fixed locations such as homes and offices. Fixed wireless internet is broadcast from towers through airwaves to receivers that the service provider will have installed on the user's property. For fixed wireless internet connections to work, the receiver needs to be within around 10 miles from the fixed wireless internet service provider's tower. Instead of laying miles and miles of fibre to connect a single home, fixed wireless uses wireless technologies to cover the last miles to the customer. Data travels over a pre-existing hard-wired network to a ‘fibre backhaul tower’ where it then travels over the air up to five miles away.

	Technical Description	The data can be relayed from tower to tower, similar to how a cell network operates, in some cases up to 50 miles away from the fibre network, until it reaches a home equipped with a special receiver. In theory, fixed wireless broadband is an option for anyone who is near enough to a mast and has a clear line of sight between them. Even if you are not near an existing mast, most providers will be open to installing one in your area if there is enough backing from other locals. It's unlikely that those living in cities would use fixed wireless, as it's not a viable option due to the number of visible obstructions and ease of using existing cable broadband solutions. However, there are plenty of people who would benefit from fixed wireless internet. Homes and businesses in rural locations are the ideal use case, as cable broadband often can't be installed in these areas due to a lack of infrastructure and the cost associated with expanding it. People who struggle with traditional broadband in general, whether because of poor signal, damaged cables, or no cables at all, can all look to fixed wireless as a potential answer to their problems. Those needing temporary WiFi might also find that fixed wireless broadband is the most suitable solution. Fixed wireless devices usually derive their electrical power from utility mains, unlike mobile wireless devices, which tend to be battery powered. This type of connection is also usually more stable than mobile wireless, which uses radio towers that can be adversely affected by weather, interference from other towers, and changes in consumer usage. Weather won't have an extreme effect on fixed wireless connections if they are installed correctly. Fixed wireless can be used in areas with limited access to cable or fibre connections while still providing the same high-speed internet services. **<u>Mobile Wireless Network</u>** A mobile network (also wireless network) route's communications in the form of radio waves to and from users. It is composed of base stations that each cover a delimited area or "cell." When joined together these cells provide radio coverage over a wide geographic area. This enables a large number of portable transceivers (e.g., mobile phones, pagers, etc.) to communicate with each other and with fixed transceivers and telephones anywhere in the network, even if some of the transceivers are moving through more than one cell during transmission. An obvious advantage is that it allows users freedom of movement unencumbered by wires. A wired network, on the other hand, would make use of cables that connect devices to the network. Such devices are often desktop or laptop computers but can also include scanners and point-of-sale machines. People often assume that all wireless networks are Wi-Fi, however the two are not synonymous. Both use radio frequencies, but; ● there are many different types of wireless networks across a range of technologies, e.g:

		1. Bluetooth 2. ZigBee 3. LTE 4. 5G ● whilst Wi-Fi is specific to the wireless protocol defined by the Institute of Electrical and Electronic Engineers (IEEE) in the 802.11 specification and its amendments.
Fixed Wireless vs Broadband Service	Layman's Terms	**Fixed Wireless Network** Fixed wireless internet is when an internet service provider wirelessly transmits internet (using signals) to a specific, fixed location, allowing devices within that location to connect to the web. It is a type of broadband where the connection signal is broadcast from a fixed point to a receiver, rather than being sent through cables as with most traditional broadband solutions. **Broadband Service** Broadband is an 'always on' high-speed internet connection that allows you to enjoy everything the online world has to offer.
	Technical Description	**Fixed wireless** Fixed wireless internet connections rely on radio waves broadcasted from towers to receivers installed on the user's property. It's also called a point-to-point link and Fixed Wireless Access (FWA) internet connection as it eliminates dependence on cable or phone lines. It even works seamlessly in areas with no cellular service. Fixed wireless connections depend on small stations to transfer data at high speeds. As the stations are clustered together, fixed wireless connections deliver internet speeds much faster than 4G with lower latency. **Broadband Service** In telecommunications, **broadband** is the wide-bandwidth data transmission that transports multiple signals at a wide range of frequencies and Internet traffic types, which enables messages to be sent simultaneously and is used in fast internet connections. The medium can be coaxial cable, optical fibre, wireless Internet (radio), twisted pair, or satellite. Broadband is always connected and removes the need for dial-up. Its importance is far-reaching; it allows for high-quality and quick access to information, teleconferencing, data transmission, and more in various capacities, including healthcare, education, and technological development. **Differences between Fixed Wireless and Broadband** While both fixed wireless and broadband are wire-free internet solutions, they have some differences. The main differences are described further below: **Latency** Latency refers to the time it takes for an internet signal to travel from the transmitter to your device and back. Lower latency can result in

		higher-speed internet. Fixed wireless internet offers low latency due to its point-to-point connection. On the other hand, broadband internet has higher latency because the signal goes from one cell tower to another, increasing the distance and time it takes for data to be transferred back and forth. **Bandwidth** Fixed wireless internet has higher bandwidth due to low latency. Fixed wireless connections are limited to the building where they are installed, and since the number of users per connection is limited, this results in comparatively higher bandwidth. In contrast, broadband has lower bandwidth as the network tower is shared with a lot of other users in the same area. **Speed** Fixed wireless is usually much faster than mobile broadband services. However, it is limited to densely populated areas because it requires line-of-sight connectivity. With fixed wireless, you can expect speeds of at least 40Mbps, with some providers offering speeds of up to 1000Mbps. On the other hand, broadband tends to offer much lower speeds. **Which is cheaper: fixed wireless or broadband internet?** In terms of price, mobile broadband is almost three times cheaper than fixed wireless internet. With mobile wireless broadband, you don't have to pay for additional equipment, installation, and other charges that fixed wireless internet may incur. Mobile data packages are also more affordable in some areas as compared to fixed ones.
IP (Internet Protocol)	Layman's Terms	Internet Protocol (IP) is the principal set (or communications protocol) of digital message formats and rules for exchanging messages between computers across a single network or a series of interconnected networks. Think of an analogy with the postal system. IP is similar to the Postal System in that it allows a package (a datagram) to be addressed (encapsulation) and put into the system (the Internet) by the sender (source host). However, there is no direct link between sender and receiver. The package (datagram) is almost always divided into pieces, but each piece contains the address of the receiver (destination host). Eventually, each piece arrives at the receiver, often by different routes and at different times. These routes and times are also determined by the Postal System, which is the IP. However, the Postal System (in the transport and application layers) puts all the pieces back together before delivery to the receiver (destination host). Note: IP is actually a connectionless protocol, meaning that the circuit to the receiver (destination host) does not need to be set up before transmission (by the source host). Continuing the analogy, there does not need to be a direct connection between the physical return address

<table>
<tr><td></td><td></td><td>on the letter/package and the recipient address before the letter/package is sent.</td></tr>
<tr><td></td><td>Technical Description</td><td>The Internet Protocol (IP) is a protocol, or set of rules, for routing and addressing packets of data so that they can travel across networks and arrive at the correct destination. Data traversing the Internet is divided into smaller pieces, called packets. IP information is attached to each packet, and this information helps routers to send packets to the right place. Every device or domain that connects to the Internet is assigned an IP address, and as packets are directed to the IP address attached to them, data arrives where it is needed.

Once the packets arrive at their destination, they are handled differently depending on which transport protocol is used in combination with IP. The most common transport protocols are TCP and UDP.</td></tr>
<tr><td>Mobile Generation (3G, 4G, 5G etc)</td><td>Layman‘s Terms</td><td>Mobile networks have matured over the last two decades from a data speed perspective, but they continue to evolve to enable many new use cases for people and IoT (Internet of Things) devices.

1G, 2G, 3G, 4G and 5G are the five generations of mobile networks where G stands for Generation, and the number denotes the generation number. 5G is the latest generation, whereas 1G networks are now obsolete.

<table><tr><th>Term</th><th>Stands for</th><th>Launch Year</th></tr><tr><td>1G</td><td>First Generation</td><td>1979 (Obsolete)</td></tr><tr><td>2G</td><td>Second Generation</td><td>1991</td></tr><tr><td>3G</td><td>Third Generation</td><td>2001</td></tr><tr><td>4G</td><td>Fourth Generation</td><td>2009</td></tr><tr><td>5G</td><td>Fifth Generation</td><td>2019</td></tr></table>
Table 4: Evolution of mobile generations
Source: commsbrief.com</td></tr>
<tr><td></td><td>Technical Description</td><td>A network generation is a type of cellular network generally referred to by its number, starting with 1G and going all the way through 2G, 3G, and 4G to the most recent developed generation: 5G. They are referred to as generations because that is how they were institutionally defined.

As the developers responsible for cellular network technology, telecom giants primarily set specific standards for network capabilities. They used their knowledge of contemporary advancements not only to expand the potential range and power of their existing networks but also to define the scope of what the next generation of systems would be able to achieve.</td></tr>
<tr><td>Mobile Network</td><td>Layman‘s Terms</td><td>A mobile network operator (MNO) is a telecommunications service provider organisation that provides wireless voice and data</td></tr>
</table>

Operator (MNO)		communication for its subscribed mobile users. It is similar to a carrier, but the operator has complete ownership and control of its telecommunications infrastructure.
Mobile Virtual Network Operators (MVNO)	Layman's Terms	MVNOs are companies that offer mobile services but do not own or operate their own network. Instead, they use a network run by a mobile operator. For example, giffgaff is an MVNO – it doesn't have its own network but instead offers its services using O2's mobile network. In the UK, there are four mobile network operators – O2, EE, Three and Vodafone. Each of these not only offers mobile services of its own but also acts as a host network for two or more MVNOs. The MVNOs, or virtual networks, benefit from having the same coverage as their parent network but without the expensive overheads. The savings tend to be passed on, with MVNOs often undercutting their parent networks with cheap mobile deals.
Network	Layman's Terms	A telephone network refers to a telecommunication network that links the telephones to perform voice calls or telephone calls between two or more persons and is thought to be the first electronic network. Telephone networks frequently employ analog techniques, which differs from the digital technology employed by computer-based networks.
	Technical Description	A telecommunications network is a collection of terminals, links and nodes which connect together to enable telecommunication between users of the terminals. Networks may use circuit switching or message switching. Each terminal in a network must have a unique address so messages or connections can be routed to the correct one. Examples of telephone networks include: 1. Public Switched Telephone Network (PSTN) - PSTN is known as a landline network in which all phones are connected simply to a single telephone exchange. Audio calls can be made over the traditional telephone network using analog telephone connections. 2. Integrated Services Digital Network (ISDN) - ISDN refers to a collection of communication protocols that allow audio, video, information, & other communications network services to be transmitted across the PSTN's digitalized circuits. The Integrated Services Digital Network (ISDN) connects the traditional analog network (PSTN) with digital capabilities. 3. Voice-over-IP (VoIP) connections allow users to perform phone calls via the Internet. VoIP solutions like cloud telephony give customers all the features of a traditional phone system while also taking advantage of the Internet's benefits.
Wireless Network		Computer networks that are not connected by cables are called wireless networks. They generally use radio waves for communication between the network nodes. They allow devices to be connected to the network

	Layman‘s Terms	while roaming around within the network coverage.
	Technical Description	A wireless network is a computer network that uses wireless data connections between network nodes. Wireless networking is a method by which homes, telecommunications networks and business installations avoid the costly process of introducing cables into a building, or as a connection between various equipment locations. Administration telecommunications networks are generally implemented and administered using radio communication. This implementation takes place at the physical level (layer) of the OSI model network structure. Examples of wireless networks include 1. cell phone networks 2. wireless sensor networks 3. satellite communication networks 4. terrestrial microwave networks 5. wireless local area networks (WLANs) - Links two or more devices using a wireless distribution method, providing a connection through access points to the wider Internet. 6. Wireless Metropolitan Area Networks (MAN) - Connects several wireless LANs. 7. Wireless Wide Area Network (WAN) - Covers large areas such as neighbouring towns and cities. 8. Wireless Personal Area Network (PAN) - Interconnects devices in a short span, generally within a person’s reach.
Towers	Layman‘s Terms	A structure with devices for sending and receiving mobile phone signals.
	Technical Description	A cell tower, telecom tower or mobile mast is a structure equipped with antennae and other necessary electronics, transmitters, receivers and power sources needed to relay a mobile phone signal. When you make a call, your mobile phone connects to the nearest available cell tower (or the nearest mobile mast on your provider’s network) and that tower sends your outgoing signal, as well as sending incoming voice and other data back to your handset
Transceiver	Layman‘s Terms	An electronic device which is a combination of transmitter and receiver.
Small Cell Sites	Layman‘s Terms	The small cell network is a new form of wireless infrastructure that consists of a densely packed system of numerous antennas distributed in living and working spaces. They’re a miniature version of the macrocells that we know as cell towers. At a very small scale, they serve the same function — acting as base stations to handle cell signals for both voice and data. Small cell networks are meant to use a number of miniaturised base

		stations (or nodes) to compensate for the shortfalls of traditional cell towers in meeting 5G's capacity demands. The intent is to make networks more efficient, more manageable, and less costly.
	Technical Description	Small cell technology refers to a type of wireless communication infrastructure that is designed to enhance network capacity and coverage in areas with high user density or limited space. It involves the deployment of small, low-powered cellular base stations called "small cells" to supplement the existing network. Small cells are typically compact and have a lower range compared to traditional cell towers. They are very flexible and can be installed on street lights, utility poles, buildings, or other structures, allowing for more localised and targeted coverage. By bringing the small cells closer to the end users, small cells help alleviate congestion and improve data speeds and can also improve the overall voice quality. Small cell nodes come in three major forms: ● **Microcells** with a range of two kilometres or less. ● **Picocells** with a range of 200 metres or less. ● **Femtocells** with a range around 12 metres (or 40 feet). A swarm of small cells working together can relay data across a city or a region — handing off signals between each other. With the number and density of nodes they make possible, small cell networks work to support specific features of 5G. Transmitting over short ranges and using little power, they're built for versatility and a low carbon footprint.
Spectrum Licences	Layman's Terms	Permission given by a telecommunications governing agency to an entity, that gives that entity exclusive rights to use a frequency band for a particular application, such as radio broadcasting. Licences are designated for a specific geographic area, such as rural areas, metropolitan areas, regions, or the entire nation.
Voice over IP (VoIP)	Layman's Terms	Voice-over-Internet protocol (VoIP) is communications technology that allows users to interact by audio through an Internet connection, rather than through an analog connection. Voice-over-Internet Protocol converts the voice signal used in traditional phone technology into a digital signal that travels through the Internet instead of through analog telephone lines. For example, Whatsapp Messenger.
	Technical Description	Voice over Internet Protocol (VoIP), is a technology that allows you to make voice calls using a broadband Internet connection instead of a regular (or analog) phone line. Some VoIP services may only allow you to call other people using the same service, but others may allow you to call anyone who has a telephone number - including local, long distance, mobile, and international numbers. Also, while some VoIP services only work over your computer or a special VoIP phone, other services allow

		you to use a traditional phone connected to a VoIP adapter.
Virtual Reality (VR)	Layman‘s Terms	Virtual reality is the term used to describe **a three-dimensional, computer generated environment** which can be explored and interacted with by a person. That person becomes part of this virtual world or is immersed within this environment and whilst there, is able to manipulate objects or perform a series of actions.