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Mobile Infrastructure Investment Landscape

Exploring the investments into the infrastructure that provides the mobile internet connectivity

GSMA

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Executive summary

As the use of the internet continues to grow and ever more applications rely on its smooth operation, there is an obvious need for continual investments in the underlying connectivity infrastructure. However, the internet is not a single, homogeneous entity but an infrastructure made up of many thousands of assets and networks, each with separate owners and investors making discrete investment decisions. Across all parts of the infrastructure, shifts are taking place in terms of who invests, what they are investing in, and how those investments contribute to the overall connectivity chain.

This report provides a comprehensive evaluation and quantification of investments in mobile internet connectivity infrastructure. Within the scope of connectivity infrastructure, we include all assets that make up the communication path between an end user, typically using a smart phone, and the end services provided by content and application providers (CAPs), which will often be hosted on a cloud platform. It is this infrastructure that carries the continuous flow of traffic to provide the full range of internet-based services, both those that consumers access and those that CAPs push to promote and monetise their offerings. The internet's many services are interconnected, but without robust connectivity, none of them can effectively operate or reach their audience.

The total investment in mobile internet connectivity infrastructure, averaged over the past 5 years, is $244bn annually, including spend on end-user devices. Of this, mobile network operators (MNOs) are the largest single group of investors, investing $109bn, which is 85% of total investment excluding end-user devices (45% of the total when end-user devices are included), followed by consumer spending of $95bn on end-user devices. The remaining investment is being made by tower companies, other network operators providing transport and IP transit services, enterprise spend on devices, and large CAPs and cloud infrastructure providers investing in backbone infrastructure and content delivery networks (CDNs). The recipients of this investment are primarily the end-user device manufacturers ($112bn), various equipment suppliers for transport, IP switching, mobile core and radio networks, installation service companies, and governments (providing licensed spectrum).

Although MNOs are the largest group of investors in mobile internet connectivity infrastructure, large CAPs and cloud infrastructure providers have been increasing their direct investments into the backbone infrastructure to directly interconnect their data centres and build CDN infrastructure to deliver traffic directly to MNO core networks. However, this is only a fraction of what MNOs invest. Whilst this investment adds to the capacity and efficiency of the backbone, it does however necessitate an even greater parallel investment in core & backhaul as well as access infrastructure to enable smooth traffic delivery.

We estimate that investment in access infrastructure to connect end users is around 19 times greater than investment in backbone infrastructure related to mobile internet connectivity infrastructure, and the core & backhaul network investment is around 8 times greater. CAPs have only invested in backbone infrastructure (including CDNs, as explained later in this report), and the total backbone investment (including investment by Tier 1 transit providers and other specialist service providers) makes up only 2% of the total investment in mobile internet connectivity infrastructure.

The end-user device segment is quite different. Our evaluation of end-user spend on the connectivity component of smartphone devices (quantified by using the retail cost of a basic smartphone) found that end users and manufacturers of connected devices are spending $117bn per year, making up 48% of the value of mobile internet connectivity infrastructure.

Context

Internet connectivity infrastructure underpins much of modern society. As we have covered in earlier GSMA reports on the internet value chain[1], the internet enables a wide range of services covering communication, commerce, and education and, in a growing number of regions. In a previous report, we valued the total revenue of services across the internet Value Chain at $6.7trillion in 2020. Without it, we wouldn't have access to services such as online banking, remote working platforms, and streaming services, just to name a few of the many internet-enabled services. The internet also supports innovation and economic growth by allowing businesses to operate more efficiently and reach global markets. Large online business models have evolved in a way that would not have been feasible without the investments into the connectivity infrastructure that enables them.

In this context, this report evaluates and quantifies the investments being made in the mobile internet connectivity infrastructure as part of the broader internet connectivity infrastructure and, in particular, who is investing in each segment, who are the key groups of suppliers, and how changing usage patterns, traffic flows, and distribution technologies are affecting the balance of investments across the segments.

Internet use is projected to continue to increase each year, and traffic volumes with it, through the growth of existing services, new innovations, and more applications. Ensuring that the infrastructure continues to expand and adapt to meet these needs is vital to economic growth and realising the internet's full potential to make a positive impact on society by underpinning innovation in areas such as health and education.

This report casts a light on the state of investment in internet connectivity infrastructure.

1 GSMA report: *The internet Value Chain 2022*

The investment framework

Introduction

The internet has had a fundamental effect on modern society, offering large—but not always equally distributed—benefits.

Economically, it provides a platform for businesses to reach global markets, enhance customer engagement, deliver digital services, and streamline operations. It has given rise to entire industries, such as e-commerce, digital marketing, and crypto currencies. It lowers entry barriers for start-ups by providing ready access to resources, tools, and a potentially global customer base, fostering innovation and entrepreneurship.

Societally, the internet has opened up whole new methods of communication between people across the globe through email, social media services, and video conferencing and enabled new ways of working. It offers unparalleled access to information and educational resources, empowering individuals with knowledge and learning opportunities and helps bridge social and geographic divides by providing platforms for marginalized communities to connect with each other, voice their opinions, and access services. These benefits collectively enhance economic growth, improve quality of life, and, when used for good, can promote a more connected, informed, and inclusive society and sustainable world.

As detailed in GSMA's *The internet Value Chain* report, the internet is made up of a large array of both end user and enabling services that connect and interact seamlessly. For example, opening a basic news website involves a range of analytics, ad exchanges, and content distribution services interacting, often across borders and continents. The focus of this paper is the underlying connectivity infrastructure that forms the communication path that enables all of this to happen.

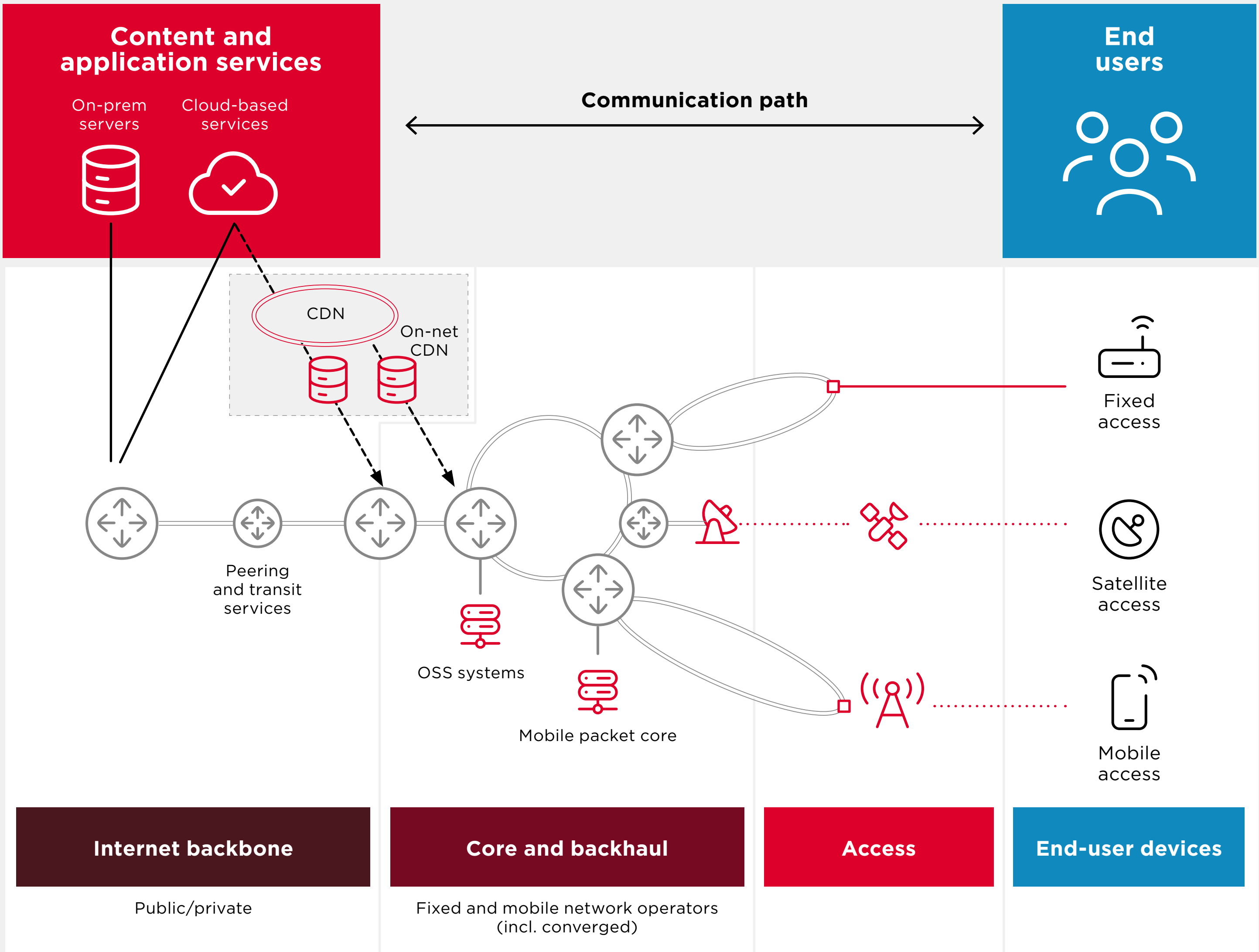
The framework for internet connectivity infrastructure investment

The internet connectivity infrastructure is formed of many different components, including end-user devices, mobile base stations, millions of kilometres of fibre and subsea cables, and a sophisticated array of interconnected switches, routers, routing protocols, and supporting systems.

To evaluate the investment in this infrastructure, we broke it down into four segments and considered the role and dynamics of each segment separately (see Figure 1).

Figure 1

Internet connectivity infrastructure framework



1. Backbone

This includes all of the connectivity infrastructure that connects the many individual networks that make up the internet, including backbone routers, fibre optics, long-distance and submarine cables used to provide peering and transit services (public and private), CDNs, and internet exchange points. Typically, CDN infrastructure is not considered part of the public internet infrastructure; it is more of a private highway that enables more direct delivery of traffic closer to users with features such as traffic optimisation, caching servers, and quality of service. However, CDNs complement the public infrastructure by providing additional capacity to deliver traffic and ultimately fulfil the same function as the public backbone of routing traffic from source to destination as efficiently as possible, so we have included it within the scope of this report.

2. Core & backhaul

This includes the backhaul and switching functionality for the access network and onward linkage to the internet backbone. It includes backhaul and aggregation and switching fabric, mobile packet core, satellite uplink, plus the OSS systems required to run the network.

3. Access

This is the connectivity access network that the end-user device connects to. In mobile networks, it is the mobile tower with the attached radio equipment transmitting the signal; in fixed, it is the copper, coax cable, or fibre route from a home or business premise back to the first connecting unit (e.g., OLT in a fibre network); in satellite, it covers the networks of low Earth orbit (LEO), geostationary Earth orbit (GEO), and other satellites providing internet access services.

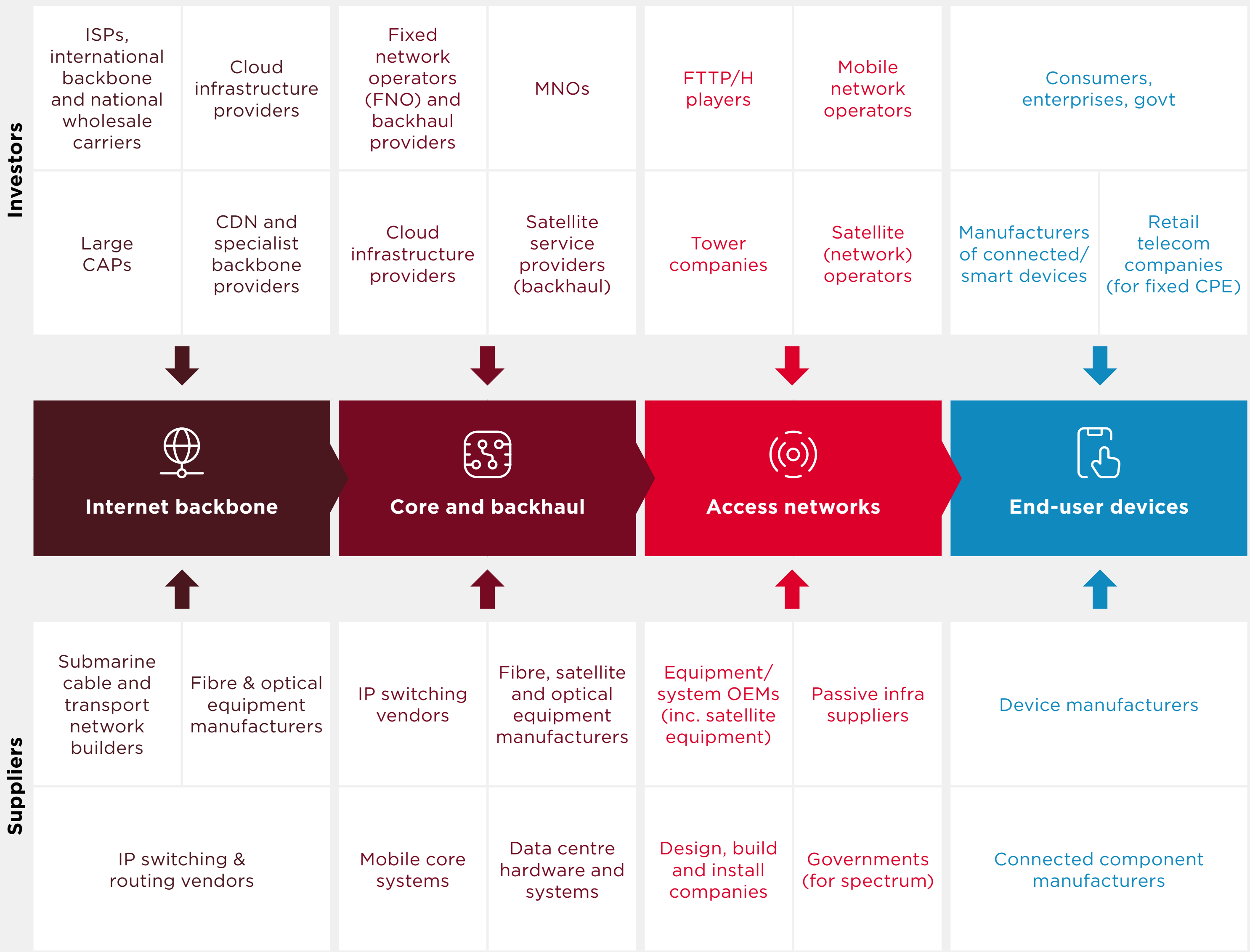
4. End-user devices

These devices, or more often connectivity components within a larger multifunction device, provide the immediate means to connect to an internet access service. For mobile phones, we have only considered the connectivity elements, not the enhanced and premium features of more expensive devices (such as application processors, memory storage, sensors, cameras, and premium displays), which transform phones into powerful computing devices; for fixed networks, we consider the network termination device, such as a Wi-Fi hub or router, to be the edge of the connectivity infrastructure.

Different groups of companies invest and operate components of the infrastructure, next to the end users who acquire the devices that connect to the access networks. We have evaluated the annual investments made globally by each group of companies and end users and determined the recipients of these investment who supply the various components that are then connected to make up the functioning infrastructure. Figure 2 shows a view of the groups of companies and end users investing (the investors) and the recipients of the investments (the suppliers).

Figure 2

Connectivity infrastructure investors and suppliers



1. Investors

There are many companies whose businesses are based on providing one or more of the many services that together make up the internet. As such, these companies invest in building up the parts of the infrastructure over which they provide their services.

Backbone: The traditional investors in this infrastructure are the large ISPs that provide transit and peering services that connect smaller ISPs. These companies very often build their network using transport services provided by wholesale carriers for international and long-distance routes. CDN service providers are also investing in infrastructure to manage and distribute traffic, which adds to the overall capacity of the internet infrastructure. The large CAPs and cloud infrastructure providers are increasingly investing directly into this infrastructure to interconnect their data centres, most notably investing in their own subsea cables, and building their own CDN infrastructure rather than buying these services from the traditional providers.

Core & backhaul: The primary investors in this segment are the fixed and mobile network operators since this covers the switching and transport elements that make up their networks. Almost all operators own and build their own core infrastructure and will also use wholesale services from other companies as part of their backhaul for resilience, capacity, and coverage requirements. Increasingly, operator core systems are virtualised, so investments are also made to build data centres to host these applications; we have included a proportion of the cloud investments, which support public cloud infrastructure that some operators are using to run their core systems. Much of the transport infrastructure that supports the backhaul networks is built by fixed-line telecom operators, either specialist wholesale providers or more often the wholesale arm of fixed operators serving the residential and enterprise markets. In the case of backhaul for mobile networks, the MNOs mostly lease this capacity, so the actual investor is the backhaul service provider, although some MNOs may still be investing in their own microwave backhaul infrastructure where local fibre is not available or when they face restrictions on deploying their own fibre. Also included in this segment is a proportion of the investments made by satellite backhaul providers that are a component of some mobile operators backhaul networks for remote sites.

Access: This segment is almost exclusively comprised of investments by network operators that provide services to end users via either fixed or mobile access (or both in the case of the many converged operators). This also includes the infrastructure investments of satellite providers that offer internet access services (e.g. Starlink). Independent tower companies also invest in this type of infrastructure by building and maintaining passive assets on which the MNOs then install their own active equipment. Note that where operators form tower-sharing joint ventures that they still partially own, we consider these to be MNO investments rather than investment by tower companies.

End-user devices: In the case of fixed networks, the main investors here are the network operators that provide a Wi-Fi hub as the termination device for their services or consumers who purchase such devices directly. For mobile networks, the end-user device is typically a smartphone, so the investor is the end user, whether consumer, enterprise, or government that purchases the device. (If subsidised or paid for monthly, we have considered this a financing agreement and the end user as the investor since they own the asset). More devices are being designed with the ability to connect to the internet, such as connected vehicles, so we have also included the connectivity component of these in this segment. It is perhaps debatable whether this category is strictly infrastructure since it does not typically appear on a balance sheet as an asset, but it is a necessary component in terms of users being able to access internet services, so we have included it within the scope of the connectivity infrastructure.

2. Suppliers

On the supplier side, the recipients of the investment are generally companies that manufacture the respective components that investors buy to build the infrastructure along with the companies providing the design and build services for each segment, whose costs are typically capitalised.

Backbone: This segment is made up of fibre optic infrastructure and advanced routing equipment; the key suppliers are the companies that make the fibre and cables (including subsea cables) as well as the optical and IP switching and routing equipment (including caching hardware). The costs of the design and installation of physical infrastructure are also included here.

Core & backhaul: Much of this segment is made of the same equipment as the backbone. The only difference is that its function here is to provide the connection between access locations and the wider internet rather than between networks, so many of the suppliers are the same, and even the equipment is similar (but potentially smaller), with the addition of the specialist equipment (e.g., gateways, satellites, and ground stations) used in satellite backhaul services. This segment also includes mobile-specific systems needed to run mobile networks, including serving gateways, packet data network gateways, and mobility management entities in LTE networks, along with their equivalents in 5G networks. Providers of the data centre and hardware systems that the software runs on are also included among the supplier group.

Access: Key suppliers of these assets are the original equipment manufacturers (OEMs) of the mobile equipment, fibre nodes in fixed networks, and satellite systems used to build LEO and other satellite services. There are also suppliers of the passive equipment that houses and hosts the active equipment, including mobile towers, cabinets, and power and air conditioning equipment. Since a portion of the investment cost is the design, installation, and civil works required to build this infrastructure, we have included the value and therefore the suppliers of these services. Radio spectrum, licensed by governments, also represents an important—and often significant—investment by MNOs to enable the access networks.

End-user devices: The predominant supplier group here is the smartphone and CPE manufacturers that provide the smartphones and Wi-Fi equipment used to access the networks. The second supplier group is the suppliers of components that provide network connectivity for connected devices.

Quantification methodology

To quantify the investment flows across the mobile connectivity value chain, we first need to consider the full internet connectivity infrastructure since in backbone and also for operators with converged core networks, there is no physical distinction between traffic that originates from or is destined for fixed, satellite, or mobile access networks. Although there are mobile-specific components in core networks (such as the serving gateways and mobility management entity), there are also IP switching components that deliver traffic for all connected access networks, which could include fixed and mobile.

We have integrated a range of sources to evaluate the global spend on each of the components and apportioned these to each segment of the connectivity infrastructure. Some components, such as mobile base station investments, clearly sit in one segment; others, such as fibre optic equipment, are used in backbone and in core & backhaul networks, so we apportioned these accordingly. For services such as satellite internet access services, where the satellite also provides other services (such as broadcast content distribution), we have taken the proportion related to internet connectivity by using an appropriate metric to apportion the investments.

For end-user device connectivity, we quantified the connectivity component of smartphones by using the retail cost of a basic smartphone,[2] which has a minimum required functionality to connect to mobile data services and enables a user to access, communicate, and interact with the full set of online services. We have used this value across the full volume of smartphones purchased each year. We have not included the additional investment that users choose to spend on more advanced devices since the additional functionality they are purchasing is related to better (and often more) cameras, faster processors, higher storage capacity, etc. and not enhanced connectivity. For connected devices, such as connected cars, we have estimated the value of the connectivity component used to connect to mobile data networks (and not low-power networks such as Wi-Fi, Bluetooth, ZigBee, etc.).

The quantification of investment is based on the investment into tangible assets. Acquisitions and corporate transactions (e.g., a tower company buying a portfolio of tower assets from an operator) are not included in the totals as we consider that to be a change of ownership of an existing asset, not an investment in new infrastructure.

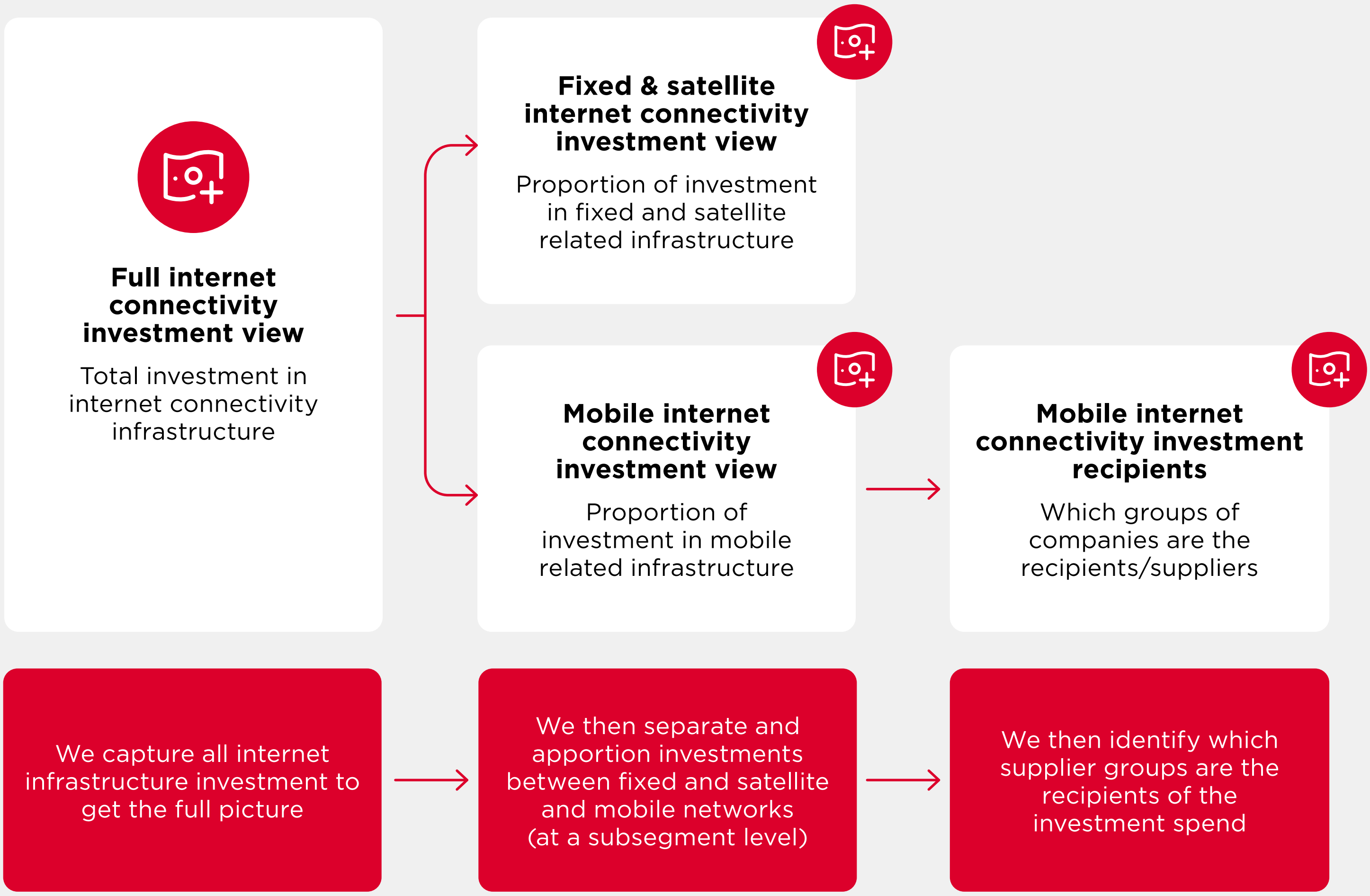
We have also cross-referenced these with data about what key players are investing, making an allowance for the fact that for each investor group, only a portion of their total capital expenditure (capex) investment is on connectivity assets. Even pureplay mobile network operators will spend a significant portion of capex on IT systems, real estate, and other fixed assets outside of the connectivity scope we are considering here. For other players, such as large CAPs and cloud infrastructure providers, their spend on connectivity infrastructure is only a small portion of their total investment. Most of their spend is on data centre infrastructure, content creation, and the applications that provide services to end users, which is outside the scope of the connectivity infrastructure. Therefore, only the portion that can be attributed to the connectivity infrastructure is included in the respective segments.

We have taken data for a five-year period (2019–2023) and averaged this to even out any cyclicality that could occur if only taking a single year as input, as well as any dips or spikes due to the COVID-19 pandemic.

2 This is an upper-bound estimate since even a basic smartphone has a full complement of features to access and use online services, not just the connectivity components.

Figure 3

Investment sizing approach



Having quantified the full investment in all internet connectivity infrastructure, Figure 3 illustrates the following steps: We apportioned the investment amounts to those supporting fixed, satellite, and mobile internet services. Similar to the approach to apportion costs between segments, some components of the core and access segments are mobile-specific and were fully allocated to mobile investment, but others support multiple access networks, so we allocated those using a relevant metric that is the primary driver of cost. In backhaul, we assessed the number of connections since deployment of fibre to access sites (base stations, optical nodes, etc.) is the main driver of investment. In backbone, we used the split of traffic volumes to allocate investment costs. (See Figure 19 in the Appendix for the full details and metrics.) The final step is to break down mobile investment into the groups of suppliers of the various components that are needed to build the infrastructure.

The investment flows

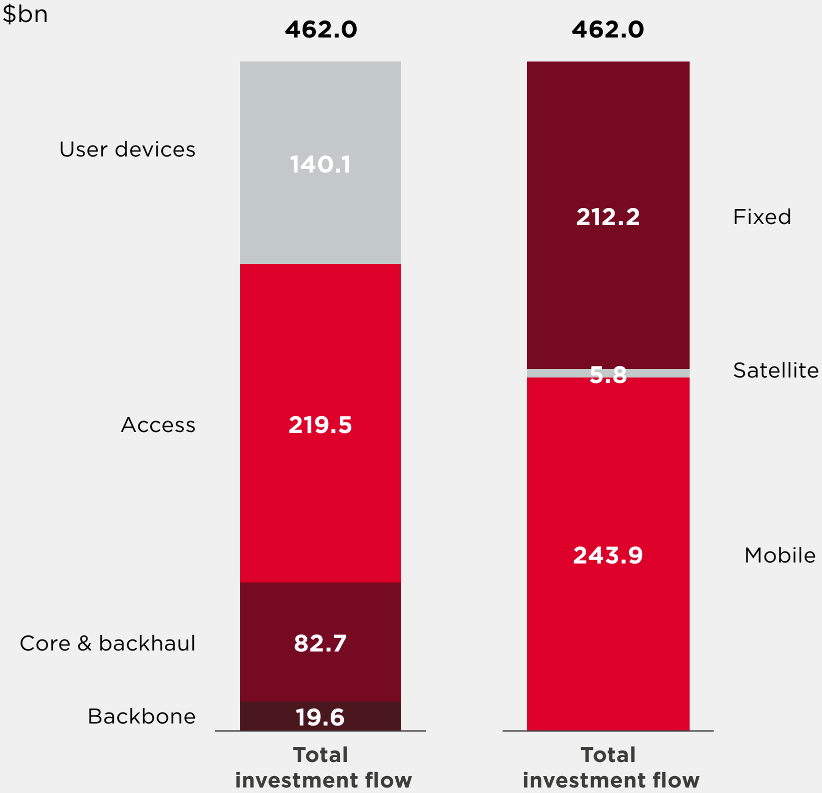
Total annual investment into internet connectivity infrastructure

As set out in the methodology above, we start by quantifying the total annual investment into internet connectivity infrastructure across all four segments, including fixed, mobile, and satellite access infrastructure and the connectivity that connects these to the internet backbone. Figure 4 shows this total investment to be $462bn per annum on average between 2019 and 2023, split by segment on the left and by internet access network on the right.

Figure 4

Total annual investment in internet connectivity infrastructure

average 2019–2023, $bn



This includes all investments made by all investors in internet connectivity infrastructure. The investments made by telecom operators only includes the network portion of capex (not wider IT, CRM, or facilities capex). For investors covering multiple industries and customer segments, e.g. cloud infrastructure providers and satellite connectivity providers, it only includes the portion of their investment attributed to the internet connectivity infrastructure.

The $462bn is split fairly equally between fixed ($212bn) and mobile infrastructures ($244bn). End-user satellite-based internet services (e.g., Starlink) are going through a period of high investment but still make up only a small fraction (1%) of the total investment in internet connectivity infrastructure.

Capital investment into infrastructure can vary from year to year, and individual investing companies will go through periods of higher and lower investment depending on their own investment plans (and influenced by their other capex needs such as a major IT transformation). But at a global industry level, network infrastructure capex has been relatively stable over the past decade.

Figure 5

Fixed, mobile, and satellite investment by segment

$bn per annum, average 2019–2023

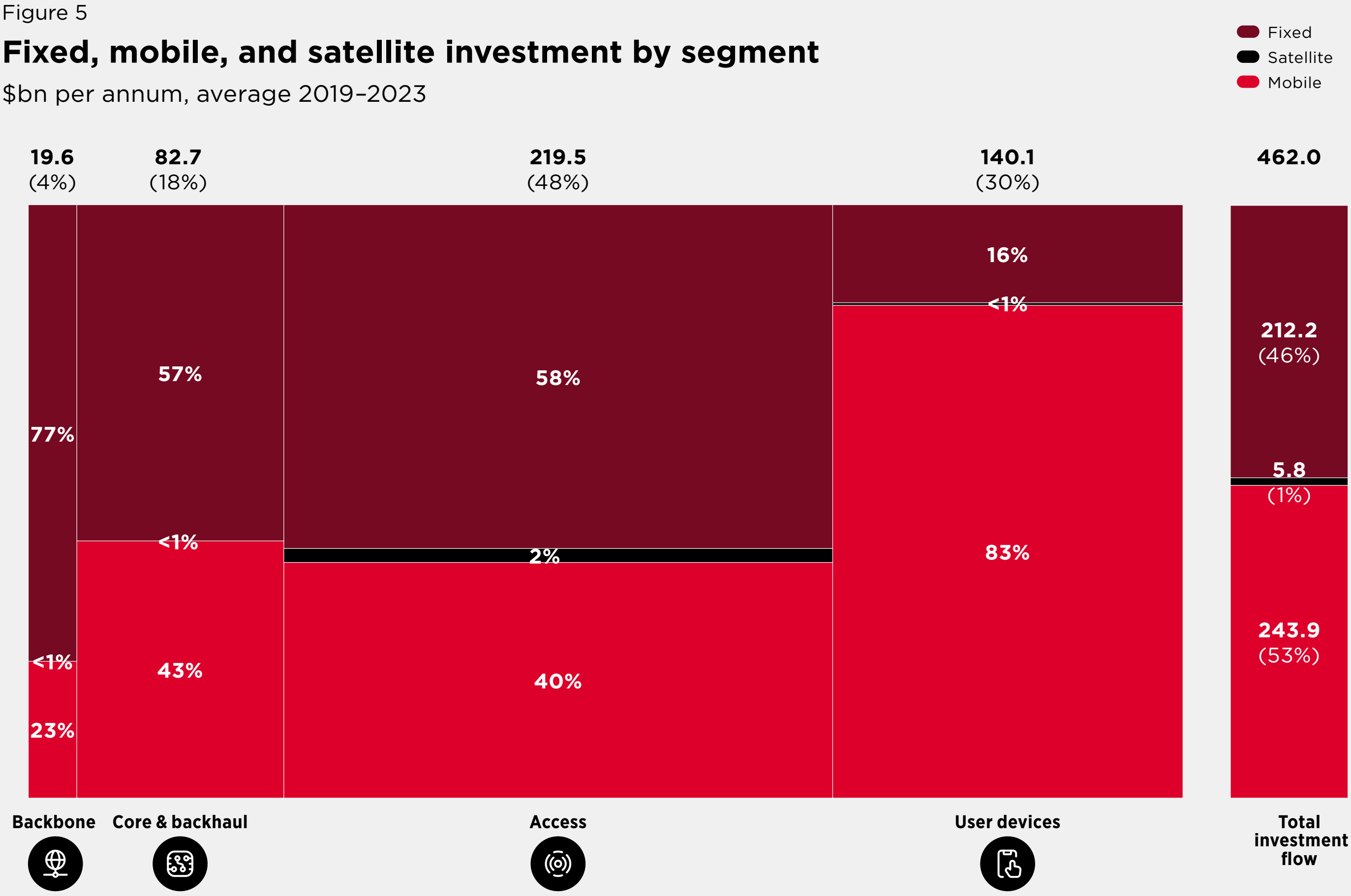


Figure 5 shows in more detail how the $462bn internet connectivity investment is distributed across the four segments as well as the split between fixed, satellite, and mobile infrastructure. The chart highlights that access networks (and we have used quite a narrow definition of access by including the backhaul transport that links the access components to core as part of the core segment) are currently the biggest area of connectivity investment.

The split in backbone essentially reflects the split in traffic carried, as apportioned based on the proportion of user traffic crossing the respective access networks.

The investment in mobile core & backhaul is higher than a pure traffic split would suggest due to the complexity of mobile core systems, which, in addition to routing switching traffic across the network, need to support a moving customer base connecting and disconnecting from the network in real time, moving between areas, and roaming onto other networks.

There is a similar pattern in access, where the complexity and cost of providing coverage across a wide geographic area as well as the need to upgrade technology and feature-sets periodically come on top of the investment in capacity needed to cope with traffic growth. Much of the investment in fixed access is driven by the ongoing upgrade of copper-based networks to full-fibre access networks, with a considerable amount of civil works and premise-by-premise installation work in many markets. This investment into fibre access is also a once-in-a-lifetime upgrade spread over a much longer period than a typical rollout of a new generation of mobile access, such as 5G. In addition to the ongoing deployment of additional capacity to meet the growth in traffic, the mobile access investment is also partly driven by the ongoing deployment of new access networks and technologies.

The large difference in the user–device split compared with the other segments is partly due to the lower volumes on fixed with one termination device per household or premise, rather than per user, and the typically longer replacement cycles of Wi-Fi routers versus smartphones.

Investment into mobile internet connectivity infrastructure

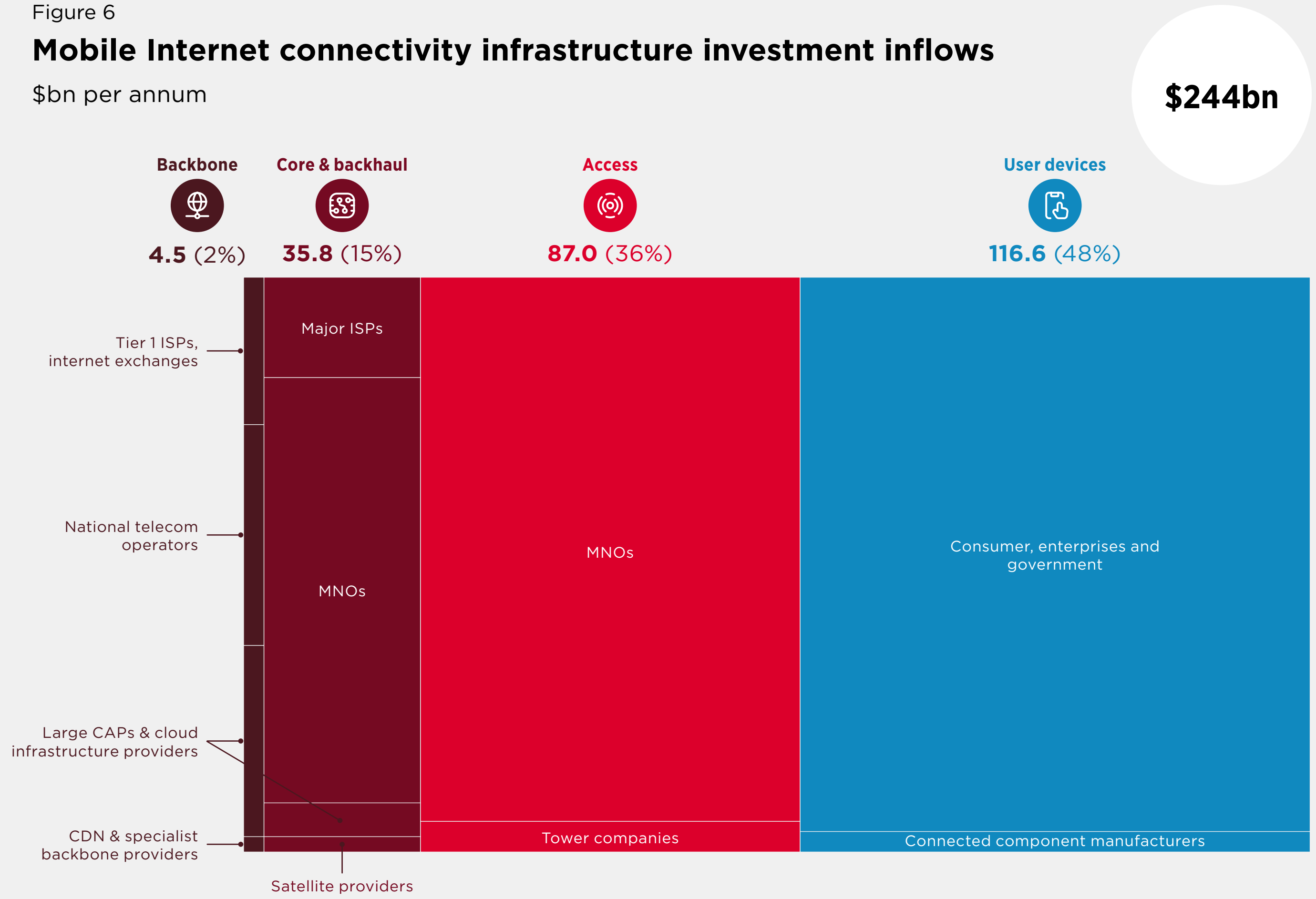
As set out in the methodology above, having identified the investment that supports or can be attributed to mobile internet connectivity infrastructure, we then examine this in more detail.

Figure 6 shows the $244bn investment in mobile connectivity broken down into the groups of investors in each segment.

Figure 6

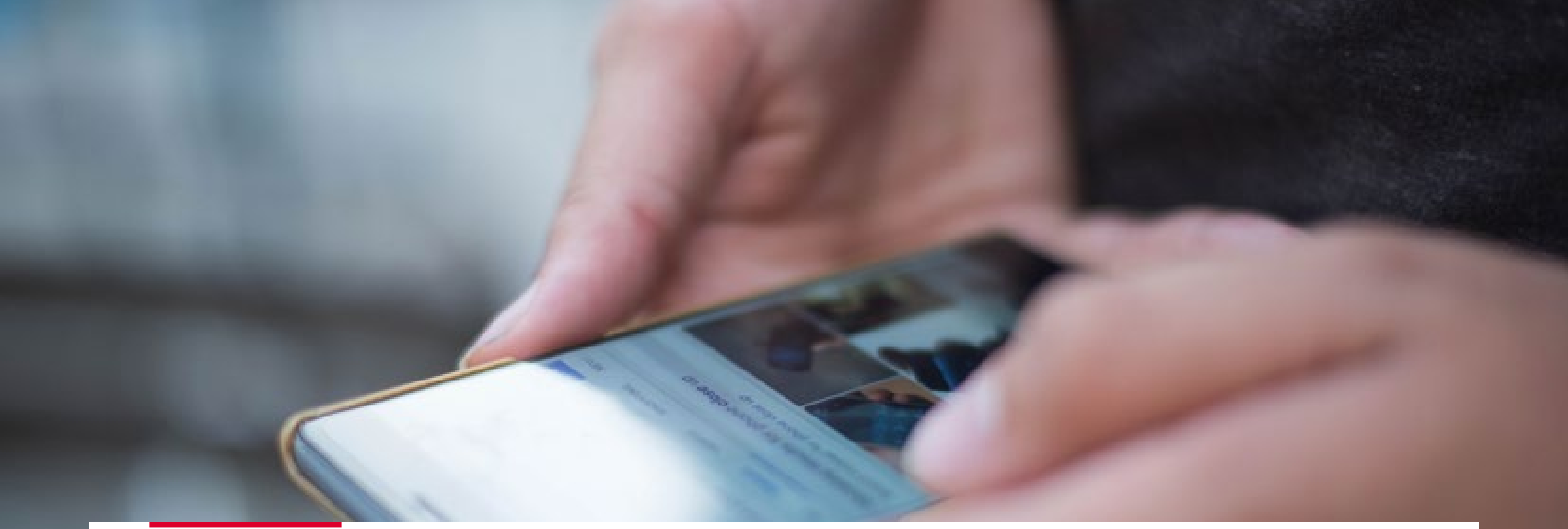
Mobile Internet connectivity infrastructure investment inflows

$bn per annum



The largest segment of investment is in user devices with $117bn (for the connectivity component, valued as a basic smartphone), driven by the large number of customers with access to devices (~4-5bn), with ~1bn devices shipped each year. These purchases are made by a mix of end users, including consumers, enterprises, and governments. Note that although consumers may purchase phones as part of a monthly rental contract, we have considered that as a financing arrangement and attributed the asset value to the end user since they are the ultimate owner of the device.

After end-user devices, the access segment has the highest inflow ($87bn), driven by ongoing investments by MNOs in next generation network rollout and capacity upgrades. Backbone and core & backhaul have comparatively lower investments due to scale, lower unit costs, and the longer life cycle of many components that make up these segments.



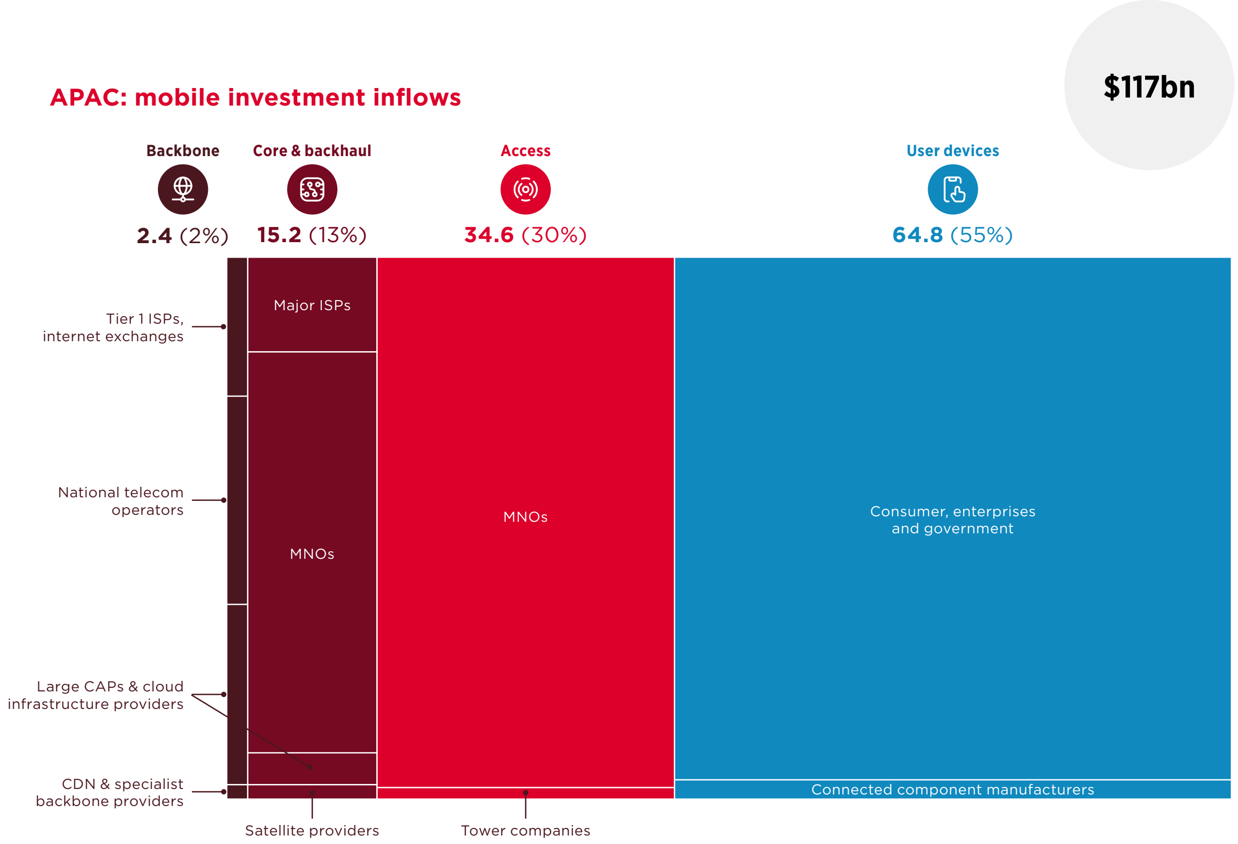
Regional breakdown of investments

Figure 7 shows the $244bn annual investment inflows broken down by region. Asia Pacific, including China, is the largest region, with $117bn of the $244bn total. North America ($55bn) is followed by Europe ($38bn), then the Middle East and Africa ($19bn) and Latin America ($15bn).

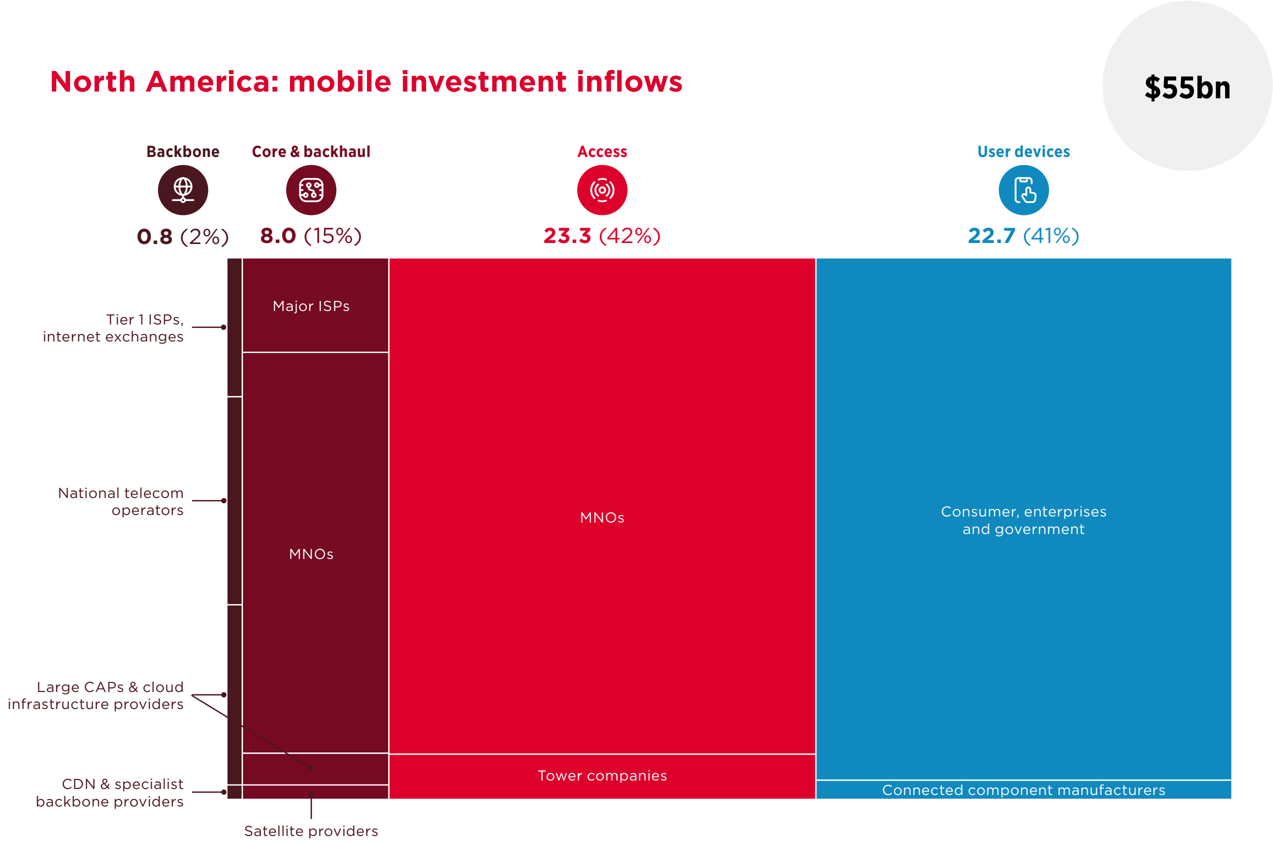
Figure 7

Mobile connectivity infrastructure investment inflows by region

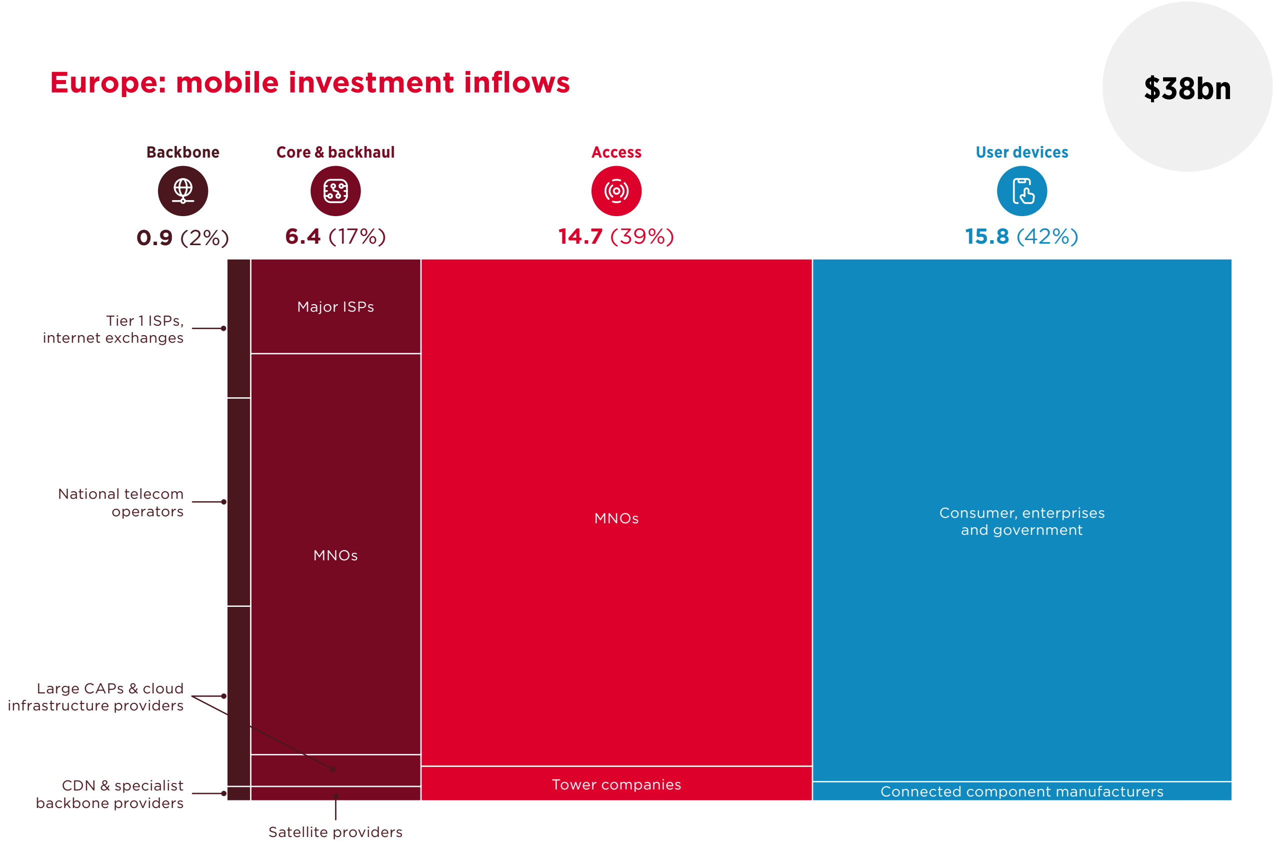
$bn per annum



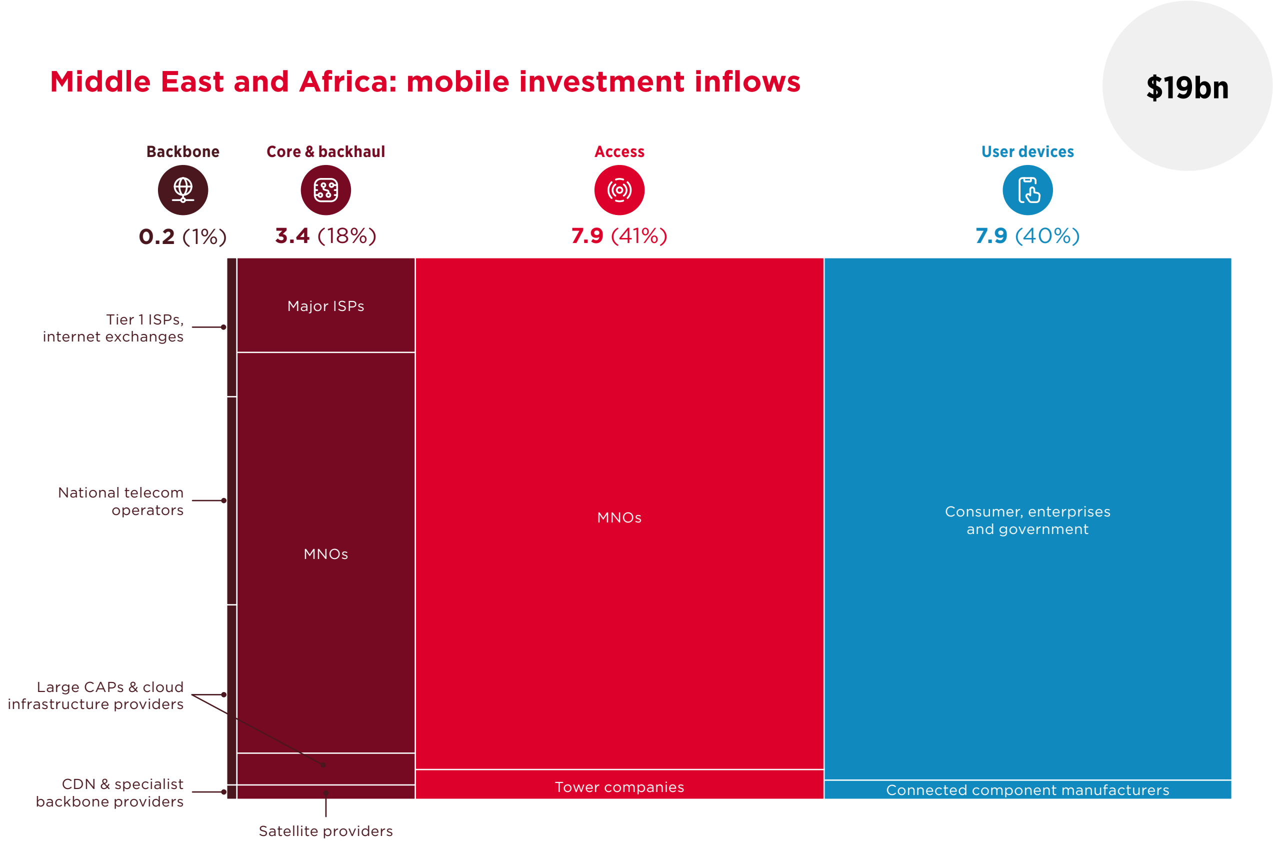
North America: mobile investment inflows



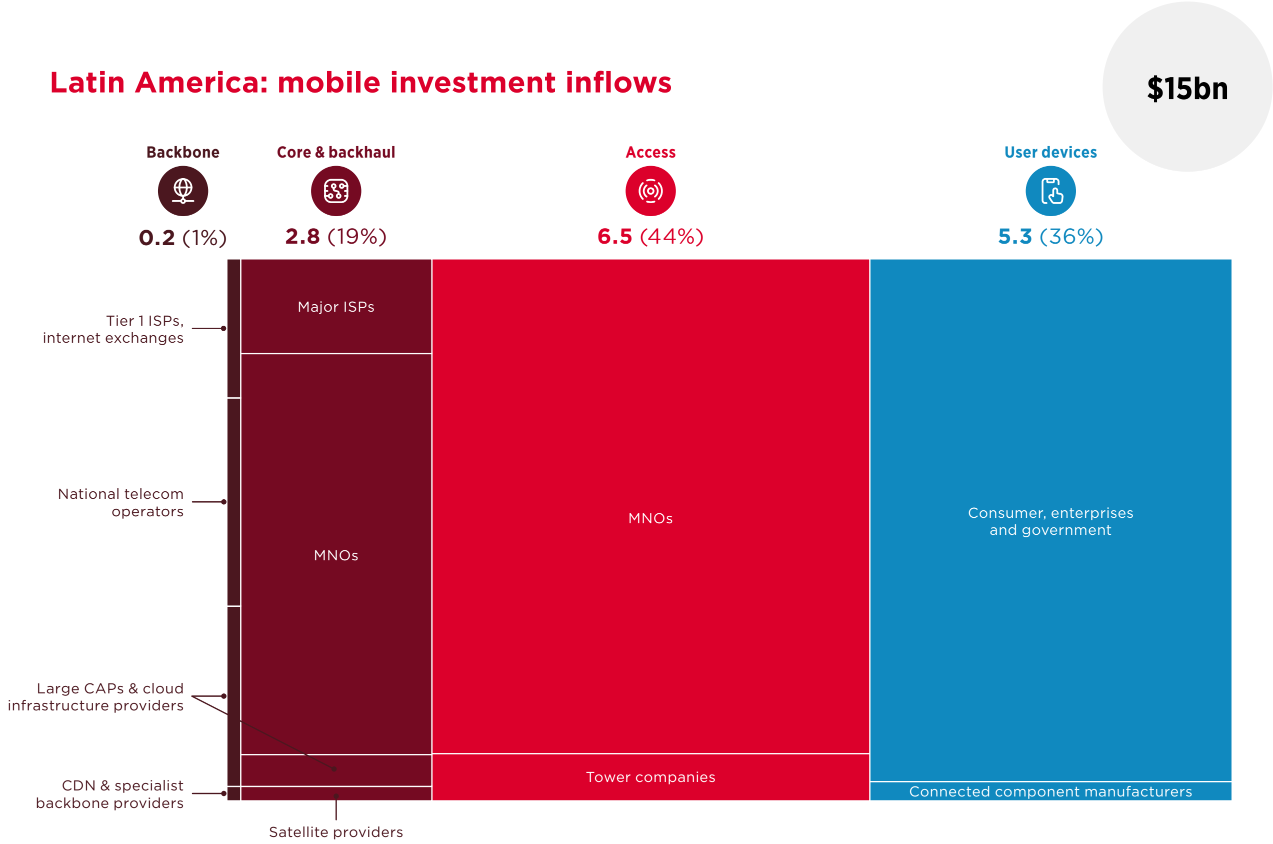
Europe: mobile investment inflows



Middle East and Africa: mobile investment inflows



Latin America: mobile investment inflows



The backbone infrastructure, by its very nature, spans and interconnects regions, so its costs have been apportioned based on mobile data volumes[3] flowing to users in the respective regions, although this does not mean that is where the actual investment is made. Some of the investment covers the cost of international connections (e.g., subsea cables, which connect regions) and also includes the routing equipment that may be located outside the region. Core & backhaul and access investments are focussed on building the infrastructure within the respective countries of the investing MNOs. For end-user devices, although smartphone prices vary between regions, we have used the same value across all regions of $90 since we are only considering a basic smartphone device. The total value is therefore driven by the volume of smartphone purchases in each region, irrespective of whether it is a basic or top-end model.

The pattern of investment across the segments is reasonably consistent, reflecting the fact that the infrastructure is largely made up of components from a global supply market. The higher proportion of end-user device investment relative to core & backhaul and access in APAC reflects the higher number of users and therefore higher volume of devices bought. It is worth noting that for all regions, a large part of the investment is spent with global equipment suppliers, which will often be located outside the region (and even if in region, are using parts and components that have been sourced globally).

3 Source: ITU Facts and Figures 2023 Traffic Data

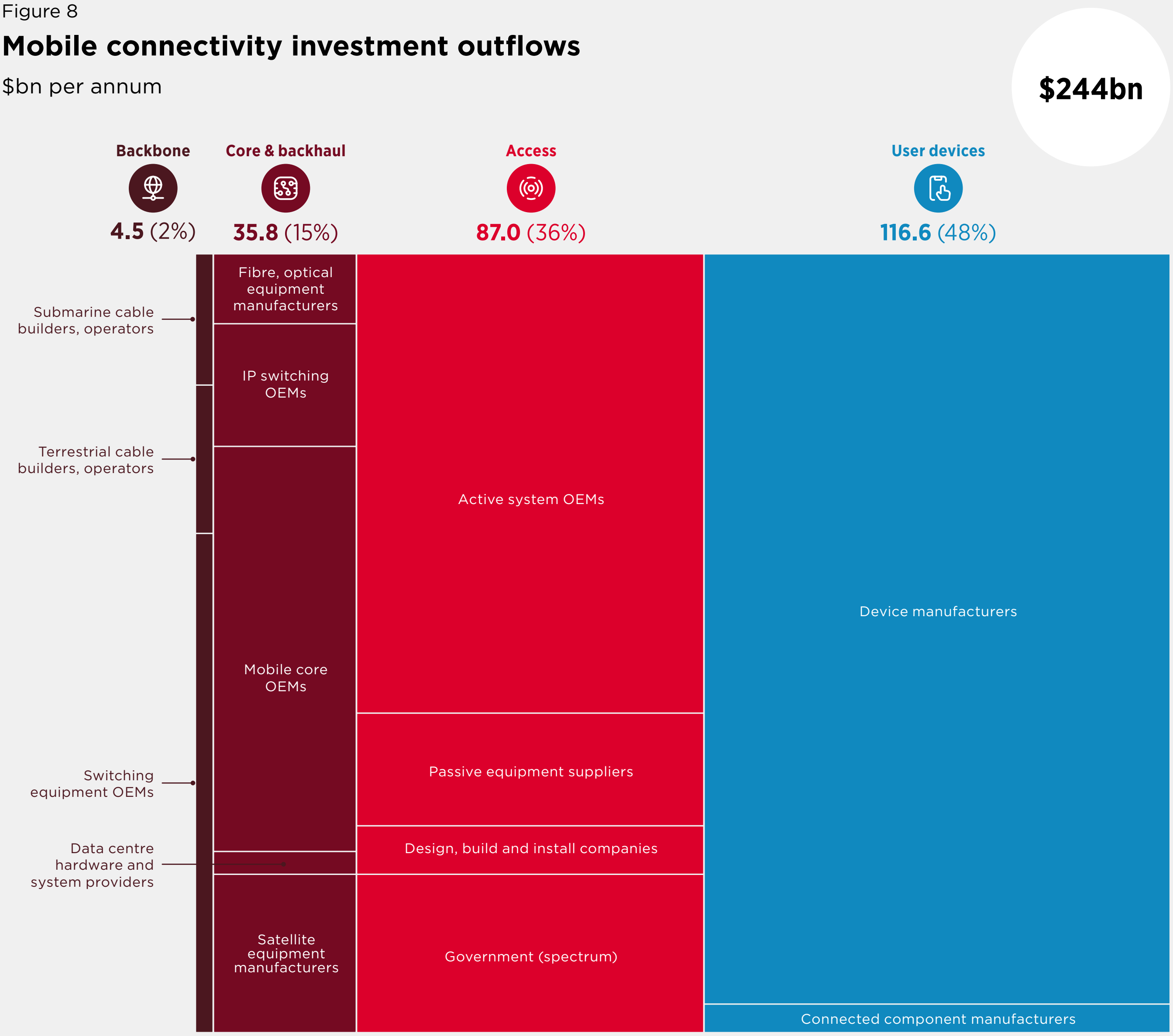
Recipients of the investment

Figure 8 shows the same total investment as in Figure 6 but broken down to show the recipients of the investment, that is, the entities that the investment is spent with to pay for the components needed to build the infrastructure.

Figure 8

Mobile connectivity investment outflows

$bn per annum



The handset manufacturers are clearly the key suppliers of end-user devices while there are a range of suppliers of components needed to build the other segments, which we detail in Figure 9.

Figure 9

Mobile connectivity investment inflows and outflows (excl. devices)

$bn per annum

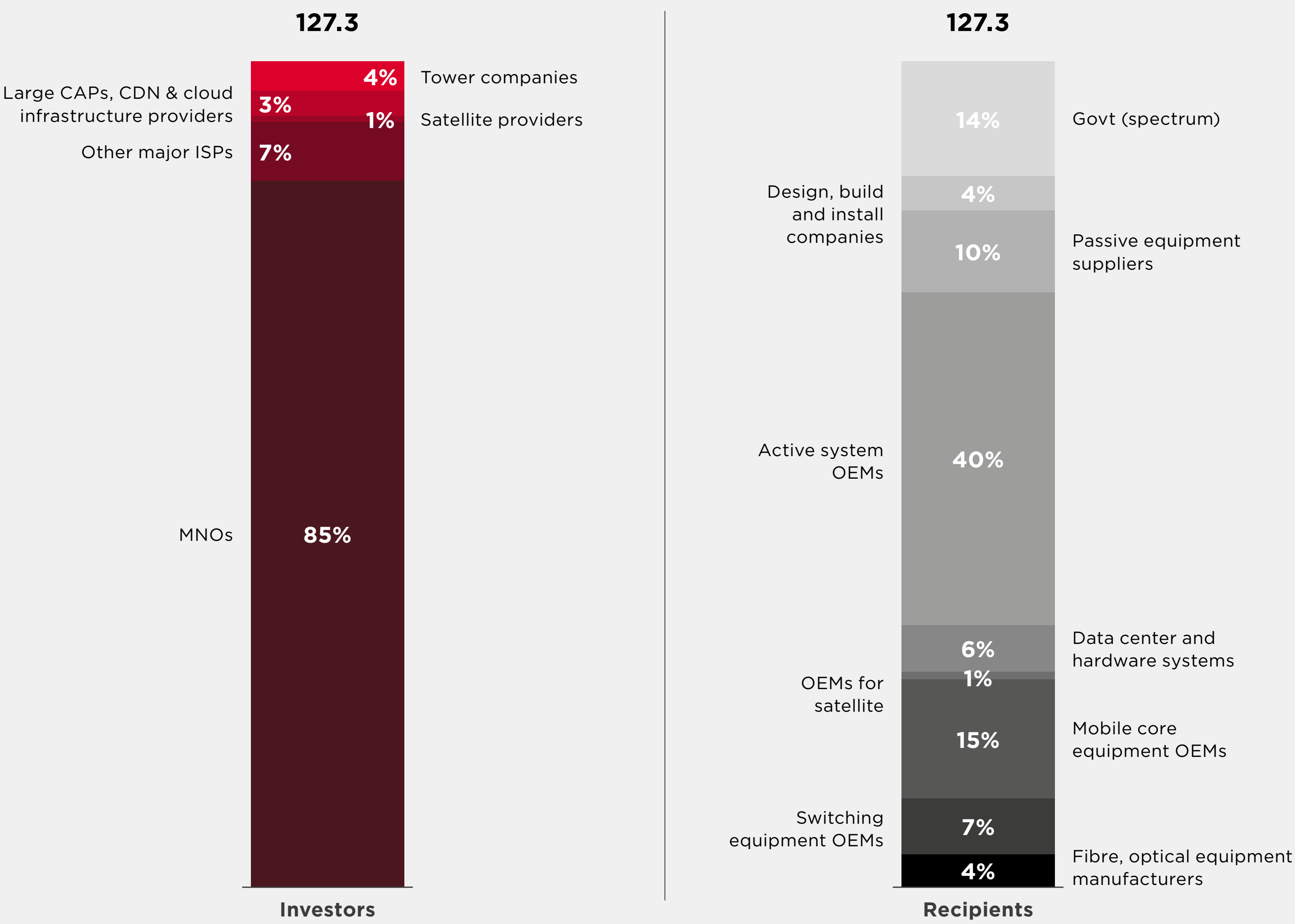


Figure 9 shows the $127bn investment in mobile infrastructure excluding the end-user devices segment. On the left, it is clear that MNOs are the primary investors in the total infrastructure, making up 85% of the total annual investment. The remainder is made up of other network operators, major ISPs, tower companies, cloud infrastructure providers, and large CAPs. On the recipient side, the OEMs are key suppliers of the active equipment needed to build the mobile access and core, and there is a range of other suppliers of passive assets (cabinets, air con, tower structures) and also the fibre transmission and switching infrastructure. The following section looks at the key investors and suppliers in each segment in more detail, taking each segment in turn.

Segment deep dives

Backbone

The internet backbone is essentially a very high-capacity routing and interconnect transport network. It consists of high-capacity transmission routes and core routers that transmit data between networks spread across regions and countries and onwards to smaller ISP networks within countries to create the global web of connectivity. CDNs (including those built into cloud service providers networks and large CAPs infrastructure) provide means to distribute and store content at multiple locations using dedicated infrastructure. Over time, these networks have extended their infrastructure to directly connect with more ISP networks and deliver a greater proportion of their traffic directly. We have included all of these investments within the scope of the backbone segment as they contribute to the overall connectivity infrastructure transporting internet traffic.

Figure 10

Backbone investors and recipients

$bn per annum

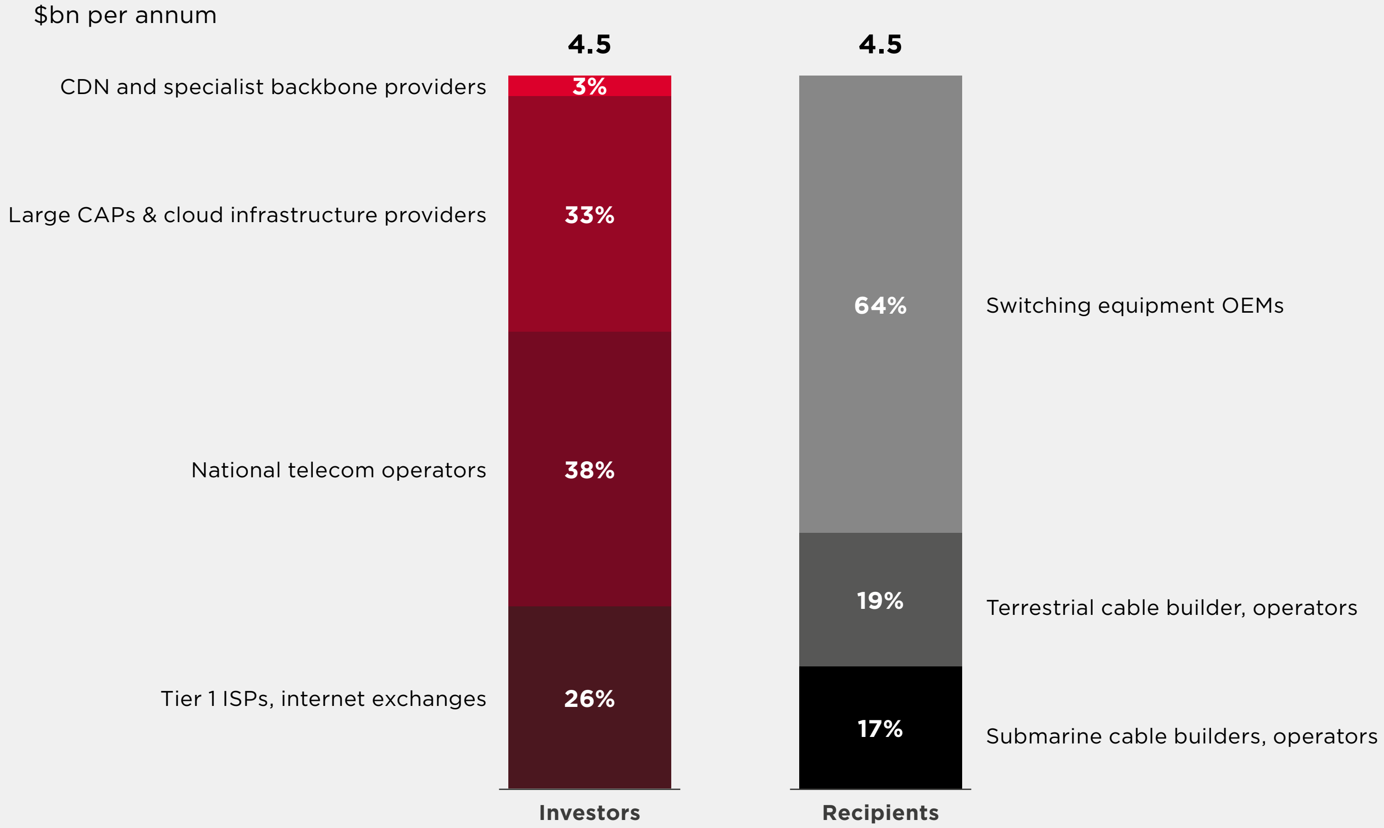
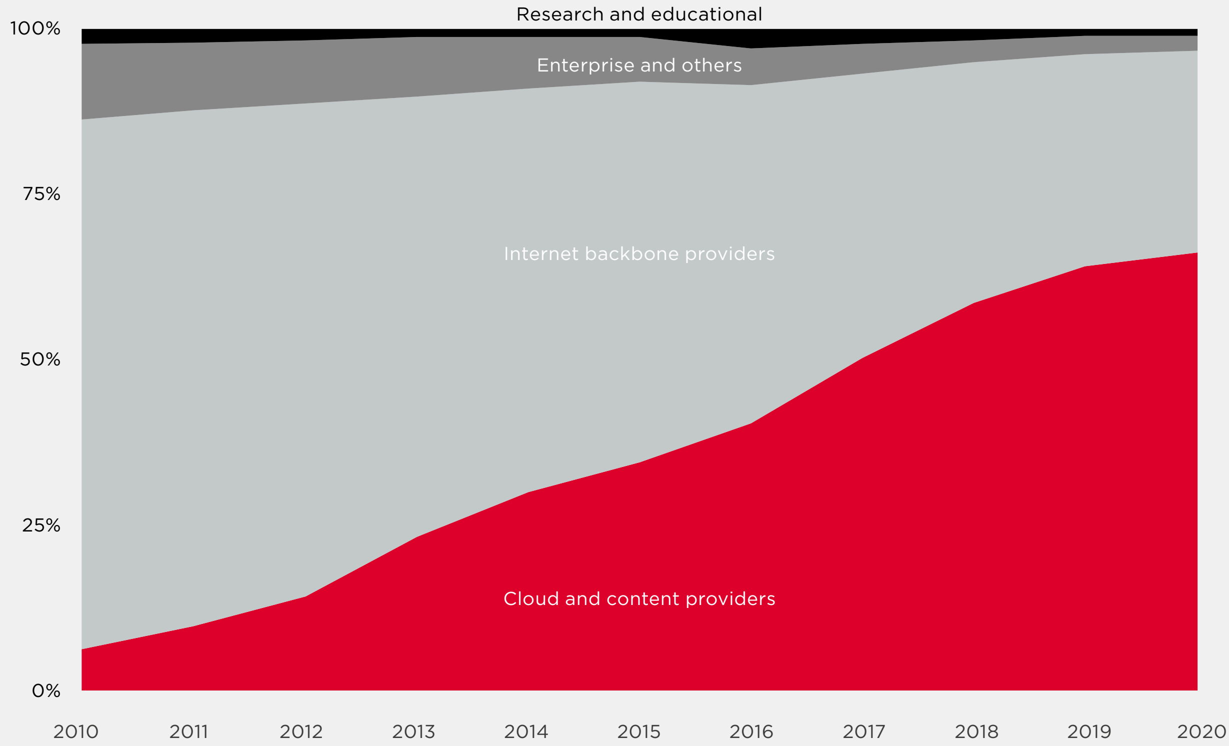


Figure 10 shows the breakdown of the $4.5bn investment in internet backbone infrastructure related to supporting mobile connectivity and traffic. Of the investors shown on the left, the Tier 1 ISPs and the national telecom companies (including wholesale operators providing transport capacity to the ISPs) are the groups that have traditionally been investing in the global connectivity infrastructure as part of extending their own networks and building up gateways to other networks in their regions and globally. The CDN providers and the large CAPs and cloud infrastructure providers are also significant investors in this infrastructure and now make up 3% and 33% respectively. Specialist CDN providers do not generally invest in transport infrastructure directly but buy these services from wholesale telecom providers to connect their switching and storage assets. In this case, the investment in transport is being made by the network operators that then provide the transport service, and the CDN providers' investment is in the routing and caching equipment connected by the transport services. The large CAPs and cloud infrastructure providers use a mix of direct investment, particularly in subsea cables, and purchased transport services and then invest in the routing equipment needed to provide the high-capacity networks that connect their data centres.

The right side of Figure 10 shows the types of companies the investment is going to. Given the primary function of the backbone, most of the investment is spent with manufacturers of the high-capacity routing equipment needed to route the massive volume of data that traverses the backbone. Connecting this equipment are the various cables that span oceans, national boundaries, and long-distance routes within countries. It is important to note that while laying a new connection often involves physical construction (either digging new routes or running fibre through existing ducts, or in the case of submarine cables laying entire new cables and building landing stations), once built, these assets can have an extensive lifespan. Once a physical fibre route is in place, adding additional capacity to existing routes is relatively cheap, requiring the connection (or 'lighting') of additional fibres or the upgrade of the end-point equipment to enable greater capacity use of existing fibres by adding additional wavelengths. It is therefore not surprising that when taking an annual view of capex investment, most of it is spent on the terminating equipment rather than on new physical cables.

Figure 11

International bandwidth use by source



Source: TeleGeography

Figure 11 shows international bandwidth capacity usage (a slightly different perspective to traffic or investment). Cloud providers and CAPs have been steadily increasing their usage of international capacity from less than 10% in 2012 to 65% in 2020. Since the cloud providers and CAPs focus on the connectivity to interconnect their data centres, the shift is even more pronounced on the routes that mirror this footprint. TeleGeography has noted that: "In 2022, content providers accounted for 92% of used capacity on the trans-Atlantic route but just 31% on the Europe-East Asia route."[4]

Some capacity will be rented or on long-term lease, but increasingly, cloud infrastructure and content providers are directly investing in designing and building their own assets, even testing and developing cable technologies. Natixis has identified that CAPs are "championing more than 20% of the new long subsea telecom cable installations."[5]

4 TeleGeography – *The State of the Network in 2024*

5 Natixis, Oct 23 Subsea Cables – The Underwater Backbone of the Digital Age

Effect of CDNs and distributed cloud

In the traditional internet model, the backbone segment routes traffic between networks on a best-effort basis with no storage or caching functionality other than basic buffers on the routers (which typically store traffic for less than 1 second at a given interface). The backbone combines with the core and access networks to deliver traffic to the end user directly from source.

Content distribution networks help optimise traffic across the backbone by providing additional capacity especially on the busiest routes. They also use caching servers to store content at multiple locations and therefore share the load of where content is served from, reducing the need for each individual request for content to need to cross the backbone. This improves the efficient use of backbone capacity, but the distribution of content from the cache to multiple end users still requires multiple individual traffic streams. The shorter, more direct route does enable higher-quality delivery to the end user, provided there is no congestion on the operator's core or access network.

As an example, Netflix deploys Open Connect Appliances (OCAs), which are effectively storage servers, directly into operator core networks. Their content catalogue is relatively static (i.e., is not updating in real time during a day) and is only updated at specific time points, which can be managed in advance, for example, distributing new releases to content servers so that it is ready to be viewed once made available to consumers. This means that a large proportion of Netflix traffic is delivered from a point within the network operator core networks directly to end users, without using any backbone infrastructure after the initial delivery.

Distributed cloud services work in a similar way by moving the compute workload closer to the end user, thereby reducing the need for all traffic streams to cross the full backbone and enabling the cloud service to hand traffic off to the core network close to its source. Edge computing is an evolution of CDNs and distributed cloud, where compute resources are placed deeper into the core and access layers. Such deployments are useful for applications that have specific quality-of-service requirements such as low latency while still leveraging the orchestration and large processing power of cloud platforms. By placing compute resources closer to the end user, the CDN providers, cloud service providers, and CAPs are able to reduce traffic flows with local caches but also have more control over the quality of service since they control more of the steps of the delivery of traffic towards the end user but still rely on the access network provider for the final connection.

Core and backhaul

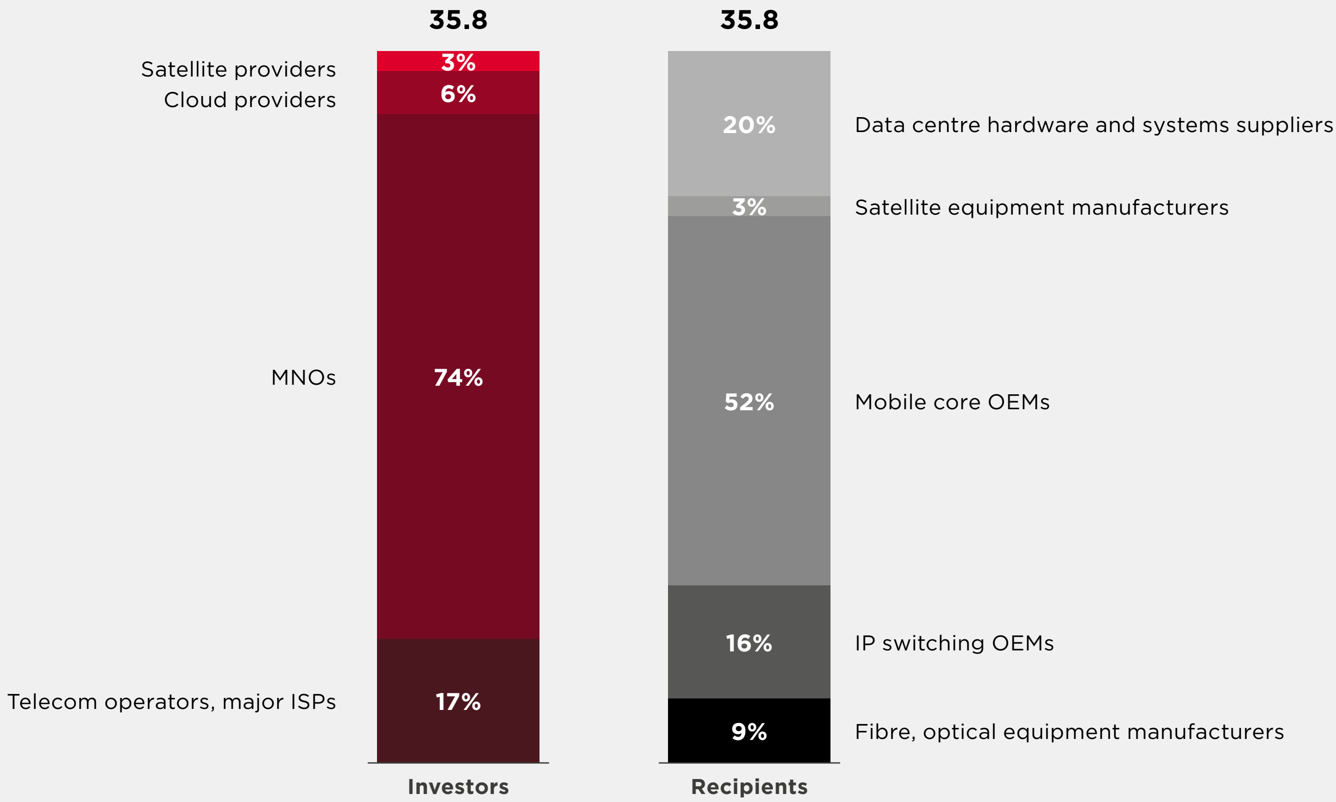
The core and backhaul components of networks provide the intelligence and connectivity needed to connect the access infrastructure. The basic building blocks are the physical transport to connect to the access infrastructure, most often fibre but also complemented with satellite and microwave backhaul routes, and the switching infrastructure. In the case of mobile networks, there is also a set of systems that manage tasks such as user authentication and session management and ensure users are able to maintain connectivity while moving across the network in real time. While these systems used to be run and hosted on bespoke hardware, they are now migrating to software applications that run in a data-centre environment.

Figure 12 shows the breakdown of the investments into this segment. The majority of investments (74%) are being made by the MNOs directly into their own networks to purchase the core switching equipment and mobile systems needed to run a mobile network. Other network operators, typically fixed-line operators, and also long-distance wholesale providers make up 17% of the total, investing in their transport networks, a portion of which are used to provide the backhaul services to MNOs to connect mobile cells sites to the core. Cloud providers are providing the investment to host some of the core applications for the MNOs as part of their overall investment in cloud infrastructure. For now, the majority of operators run these core applications in their own data centres rather than on public cloud infrastructure. Satellite providers also offer backhaul links for a small number of remote sites, which are not able to connect to the core networks via terrestrial means.

Figure 12

Mobile core and backhaul investors and recipients

$bn per annum



The right side of Figure 12 shows the suppliers of the various components needed to build the infrastructure. Mobile core systems make up the largest portion (52%), and as mentioned, since these are now software applications, it follows that investment in the Data Centre hardware and systems to host the applications is also significant (20%). The IP switching equipment and fibre equipment needed to transport and switch the data across the network and form the gateway to the wider internet make up 16% and 9% respectively. Part of the reason this is relatively low is that such transport services are just one use of the fixed networks, and the same transport is being used as the backhaul for fixed broadband networks and a range of other communications services so the portion effectively being used by mobile networks is quite low. The transport connections to cell sites have also been built up over more than two decades, and while many were initially microwave based (requiring the MNO to invest), the majority of backhaul connectivity is now made up of fibre connections so the investment focus is now on upgrading the capacity of the fibre connections.

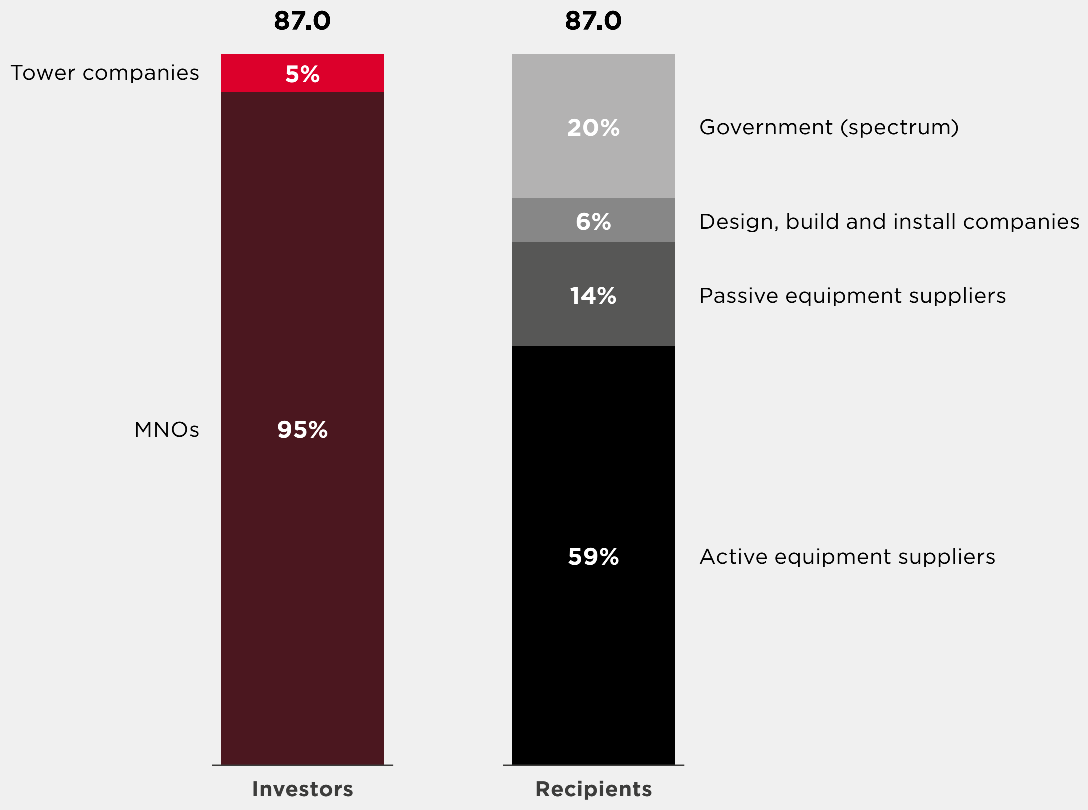
Access

The primary purpose of the access network is to provide the direct connection to end users. The access network is made up globally of millions of mobile cell sites, most obviously a physical tower with antennas and a cabinet at the base, but also including rooftop installations and complex in-building or major venue systems. The access segment includes all investment in both active and passive components.

Figure 13

Access investors and recipients

$bn per annum



The complexity and bespoke nature of every RAN site deployment means that MNOs are still by far the primary investors in access infrastructure, making up (95%) of investment, as shown in Figure 13, with a small proportion being invested by the tower companies. As mentioned, we only consider fully independent tower companies here, investments made by MNO captive tower operators, or joint ventures are classified as MNO investments.

A large portion of this investment goes on the high-tech active systems, related to 5G rollout, which, along with faster speeds and new features, provides additional capacity with new spectrum and higher spectral efficiency and is often combined with capacity upgrades for existing 4G networks. (Multi-standard RAN equipment can be used to deploy 5G and also add 4G capacity as part of a single upgrade). The right side of Figure 13 shows the type of equipment the investment is being spent on. Active equipment (that processes, transmits and receives the signals) makes up 59%. The suppliers of most of this equipment are the large mobile network equipment OEMs and the antenna manufacturers. Passive equipment (cabinets, air conditioning and power supplies, and the tower infrastructure, etc.) make up an additional 14%, with 6% of investments going to the companies that design, build, and install the towers and equipment. The labour cost of preparing and upgrading each site, as well as building new ones, is significant and forms part of the capitalised cost that MNOs invest in (and capture on their balance sheets).

Although MNOs are increasingly using tower companies for some of their sites, this only covers the passive assets, which are a small portion of the access investment. These assets also have long lifespans, and investment is mostly focussed on enhancing existing sites (strengthening towers, adding cabinet space, etc.) rather than on new site builds.

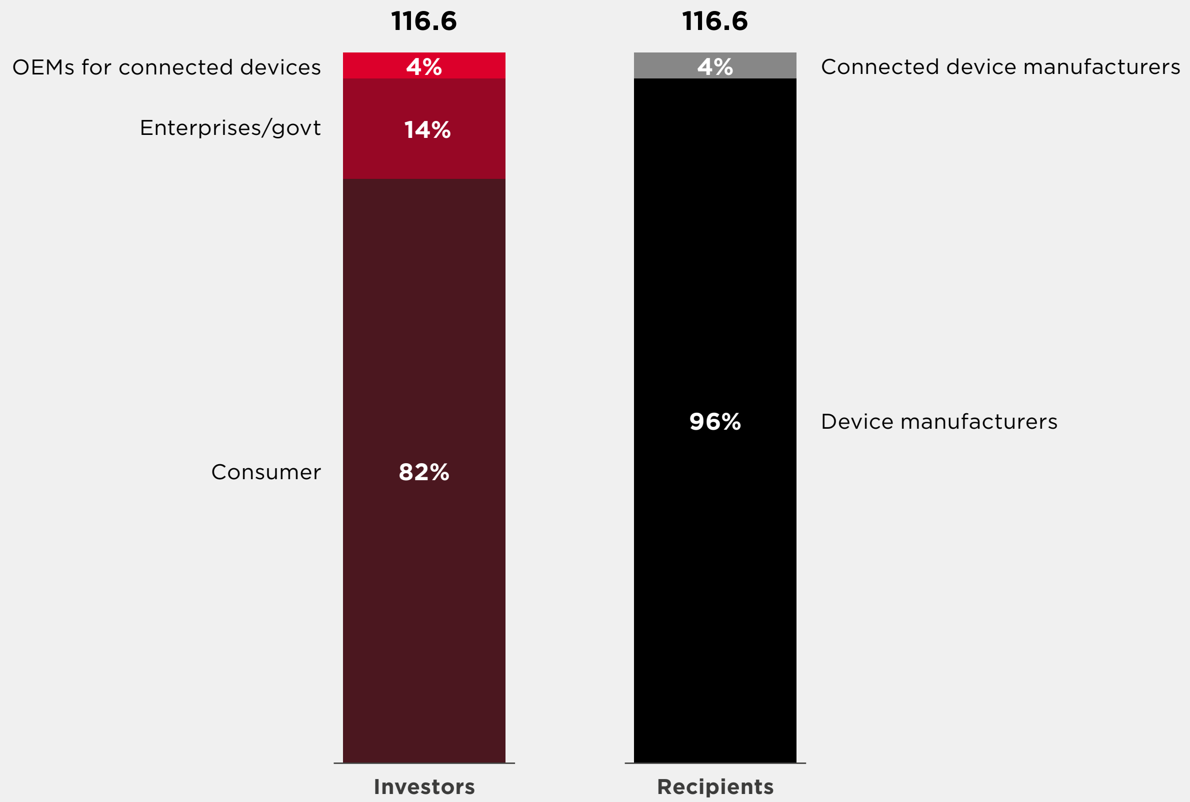
End-user devices

The fourth segment of the mobile internet connectivity infrastructure chain is made up of the end-user devices that communicate with the network and provide connectivity for all the features, services, and applications that form part of smartphones and connected devices.

Figure 14

End-user devices investors and recipients

$bn per annum



The key investors in these assets are the consumers, businesses, and governments that purchase the end-user devices, primarily smartphones, as shown in Figure 14, making up 96% of the investment (when valuing smartphones as basic connectivity, not the full retail value of the devices). This spend of $111bn[6] is driven by high replacement frequency of mobile phones (~3-4 years) and the high number of consumers with access to mobiles (~4-5 bn worldwide). The other 4% is invested by connected-device manufacturers that purchase communication modules to add to their products to enable them to connect to mobile networks. Examples include connected vehicles which use mobile networks to report on vehicle status, location, and access internet services for traffic updates, route guidance, and in-vehicle entertainment. The recipients of this investment are the smartphone manufacturers (96%) and the connectivity modules manufacturers.

6 There is an additional $1bn on mobile data devices, e.g., data dongles, included in Devices

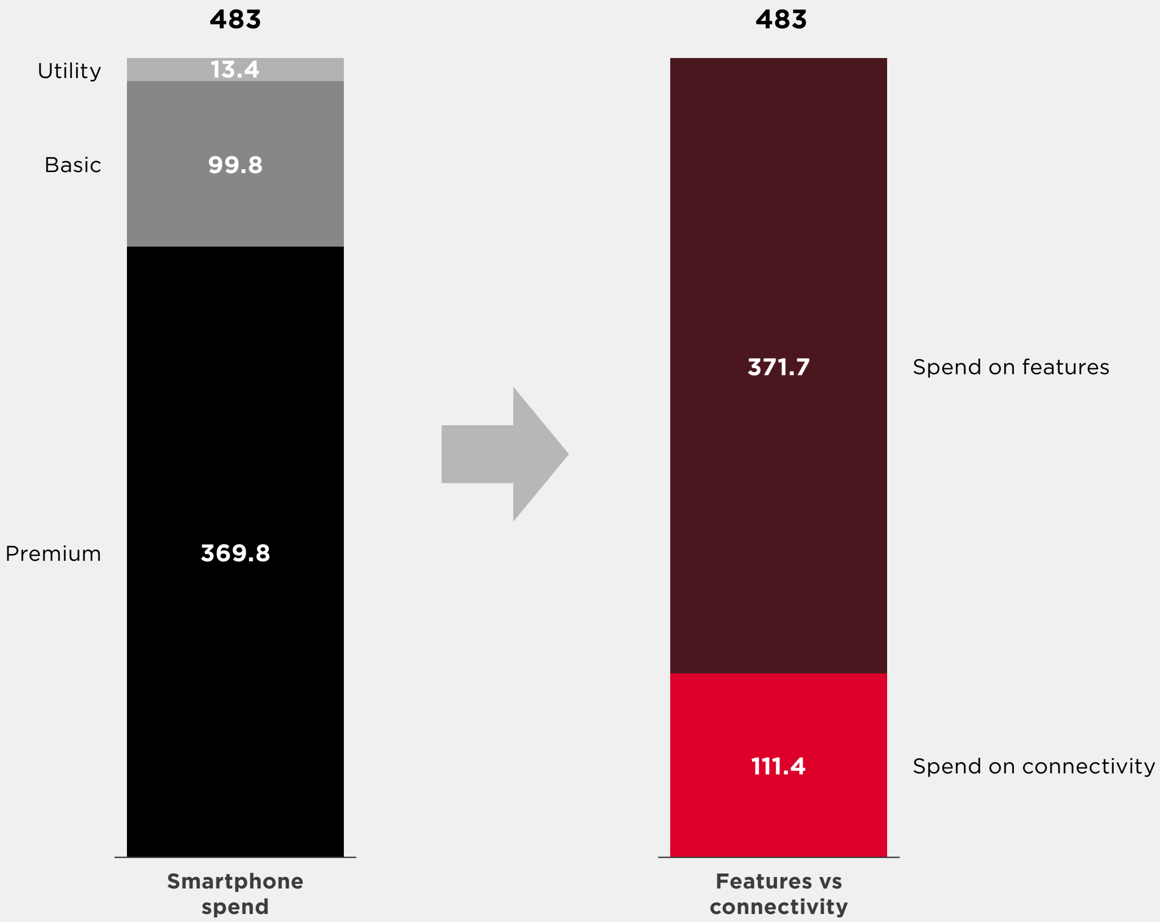
Although we have valued the connectivity component of all smartphones at the price of an entry-level device, regardless of retail value, it is interesting to note how this investment compares with the full value that end users are spending on devices. Figure 15 shows the value of smartphone purchases in 2024 split into three categories. Utility is the entry-level smartphone with connectivity and minimum features needed to access and use internet services. Basic and premium phones have added functionality, such as multiple cameras, faster processors, and more storage.

Of the total spend of $483bn on mobile devices, we estimate that only $111bn (23% of the total) is on the connectivity elements of the devices, with $372bn being spent on the additional features. However, without the connectivity component and ability to access the internet services, the value of any given device would be much diminished.

Figure 15

Total spend on smartphones by type

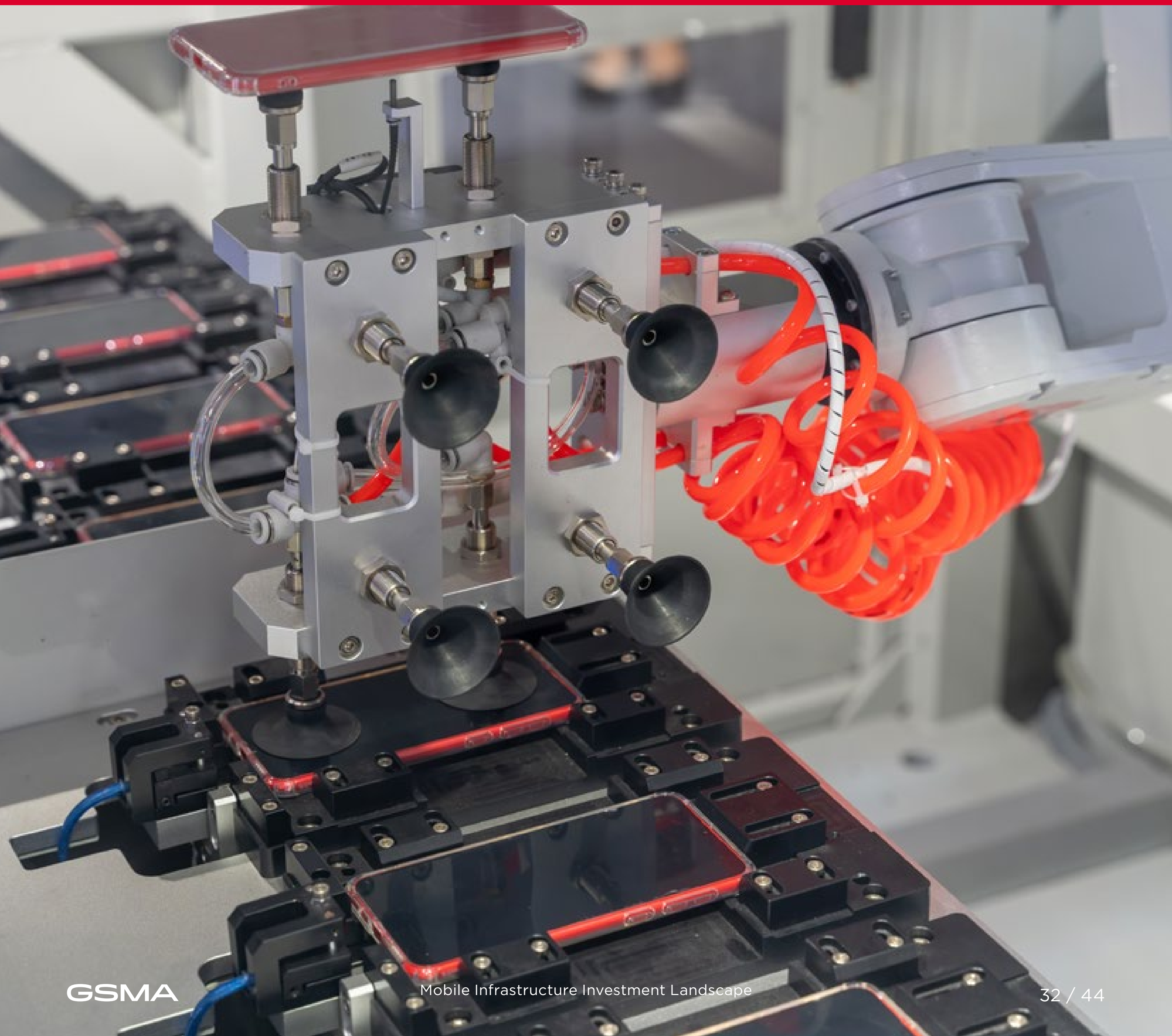
$bn



Source: Gartner, Forecast: PCs, Tablets and Mobile Phones, Worldwide, 2022 - 2028, 4Q24 Update, By Ranjit Atwal, Rishi Padhi, Namrata Banerjee, Rounak Bhattacharyya, Divyanshu Singh, 13 December 2024

Calculations performed by Kearney

Observations and outlook



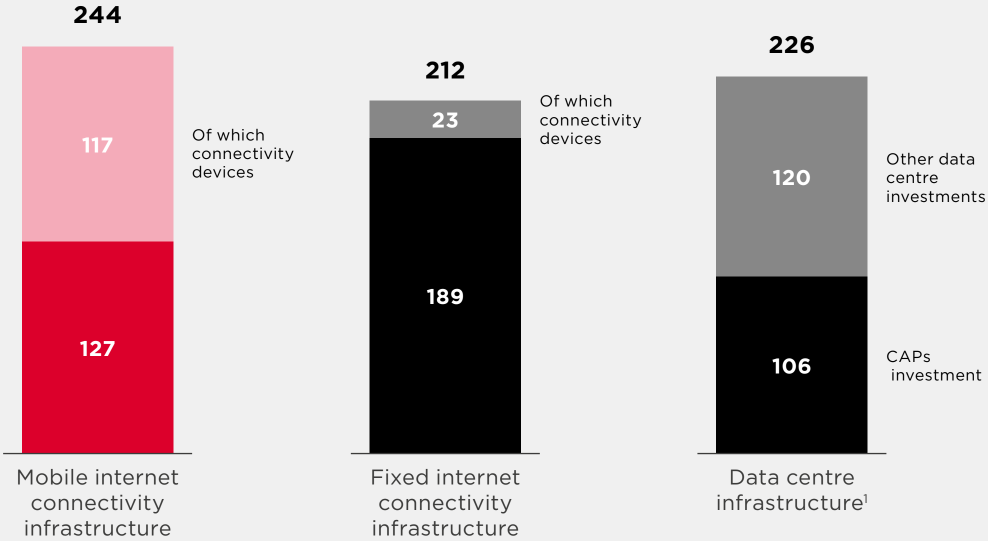
Mobile internet connectivity infrastructure investment compared with other infrastructures

To give a sense of scale of just how much the investment in the mobile internet connectivity infrastructure compares with other components of the overall internet infrastructure, Figure 16 shows the $244bn total investment in mobile connectivity alongside other infrastructure investments.

Figure 16

Average annual capex

$bn worldwide



Sources: Statista, Analysys Mason, Kearney

(1) Excludes telecom operators data centre investment captured in fixed and mobile connectivity

The $244bn annual investment in mobile internet connectivity infrastructure is comparable with the $212bn global investment in fixed internet connectivity infrastructure. Excluding end-user devices, the annual investment in mobile connectivity infrastructure is $127bn, of which 85% ($109bn) is spent by MNOs (see Figure 9), compared with $189bn in the fixed internet connectivity infrastructure. Global investment into data-centre infrastructure (primarily hosting infrastructure, not connectivity related investments) is $226bn, of which $106bn per year is by the CAPs and an additional $120bn by other data centre providers, including regional players and enterprise 'on-prem' investments.

Each of these assets and infrastructures are interdependent. Cloud-based services are offered over both fixed and mobile infrastructures. Equally, connectivity infrastructure has more value to end users when they can use it to go beyond voice calls, MMS, and on-net services and access the full array of internet-based resources and services. It is only through the combination of infrastructure investments that overall value can be realised through the provision of services and resulting economic impact.

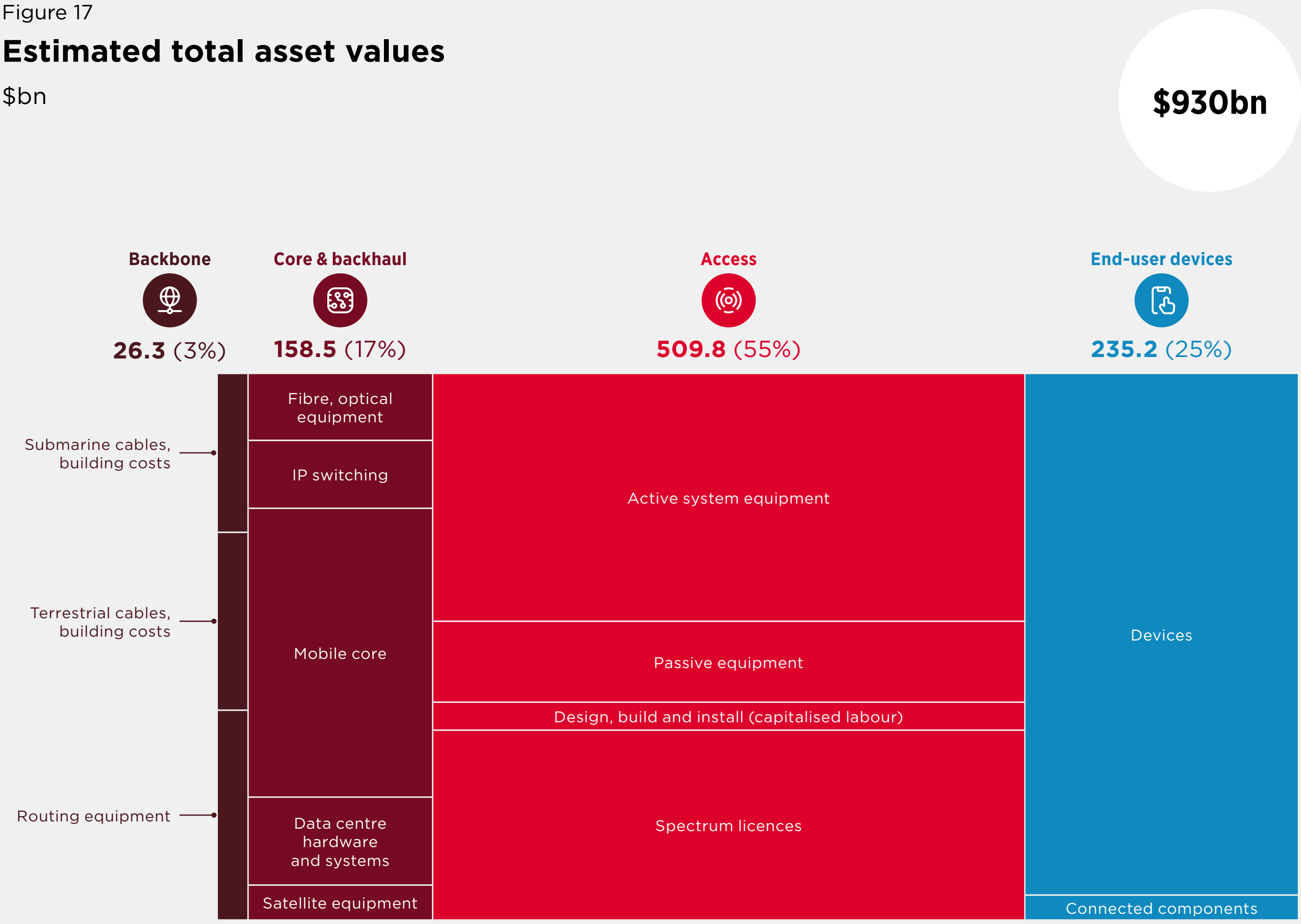
Total asset value of the mobile internet connectivity infrastructure

Although this report is focused on the average in-year investment in mobile internet connectivity infrastructure, it is interesting to consider how this infrastructure would be valued as an asset on a global balance sheet. Figure 17 shows the estimated installed asset values of the various components. This is a derived asset value based on the expected lifecycles of the underlying equipment, straight-line depreciation and assumes that the capex period 2019–2023 is representative of a longer investment period. This approach is not perfect and probably underestimates the backbone segment in particular, where assets such as subsea cables have been upgraded and life cycles extended, that recent investment may not fully reflect but is nevertheless an alternative viewpoint to reflect upon.

Figure 17

Estimated total asset values

$bn



The first point to note is the total asset value, including the connectivity component of the end-user devices segment, is around $930bn. The highest value segment is access, reflecting the cumulative investment that has gone into building 5.5m cell sites[7] around the world and constantly upgrading them. This is more than double the value of user devices, which, even allowing for the resale market, have relatively short lifecycles compared with the typical eight years for active equipment and even longer for passive assets in the access network.

Backbone and core make up a similar share of the total asset value, 3% and 17% respectively, as they do of the annual investment, which is 2% and 15% respectively (see Figure 6). The assets that make up these segments have similar lifecycles to access, with active components such as routers and mobile core having lifecycles of 7-9 years and physical assets such as submarine and terrestrial cables ranging up to 20 years.

Concentration of traffic on few platforms and private backbone

Traffic is increasingly concentrated on the largest platforms, which are investing in infrastructure for direct delivery to end-user networks, a trend particularly evident in mobile networks, where the top 5 service platforms globally make up 76% of downstream traffic[8]. This is resulting in more traffic being delivered over the private connectivity infrastructures that make up the cloud and CDN networks and less via the public backbone infrastructure.

Consequently, the overall capacity available in the backbone segment is increasing, and in fact, the companies and platforms generating much of this traffic are taking direct control of that part of the infrastructure. However, for the connectivity chain to work effectively, capacity needs to be increased in the other segments so the traffic can flow freely from end to end.

Although only a small number of cloud and content providers have the global scale to be able to invest directly in connectivity infrastructure, their impact has been greater due to the sheer volume of traffic that they distribute. A report by WIK Consult[9] for the German Federal Network Agency has noted: “By investing in the latest cable technology, CAPs gain the lowest transmission costs, giving them a (cost) advantage over most backbone ISPs. It also gives them increasing control over the network design and management of their backbone capacity.”

The cloud and content providers’ infrastructure is private (i.e., they do not sell a specific connectivity service). These infrastructure investments are the reason why, when looking at the volume of traffic, the formerly decentralised architecture of the internet has become increasingly centralised towards a few large CAPs. Increasingly, the Tier 1 and Tier 2 transit providers are being left to deal with the minority of traffic not handled by the private infrastructures or through private peering. However, although it may be handling a smaller proportion of traffic, the public backbone still provides the functionality needed that underpins the any-to-any communication nature of the internet. It is important that this functionality is preserved so that new services can continue to emerge.

However, despite this concentration of traffic, even the largest CAPs have not extended their own infrastructure directly into core and access networks (other than some placing on-net caches and edge compute resources), and there is currently no expectation that they would. As BEREC has noted regarding the EU, “Until now, CAPs have not yet invested in access networks in the EU”[10], and, apart from very experimental networks, this is true in all other regions.

7 Source: TowerXchange
8 Sandvine – Global internet Phenomena Report, March 24, p24 (Facebook, Instagram, and WhatsApp all considered as Meta)
9 WIK Consult: Competitive conditions on transit and peering markets, 2022
10 BEREC report on the entry of large content and application providers into the markets for electronic communications networks and services, October 2024, p10

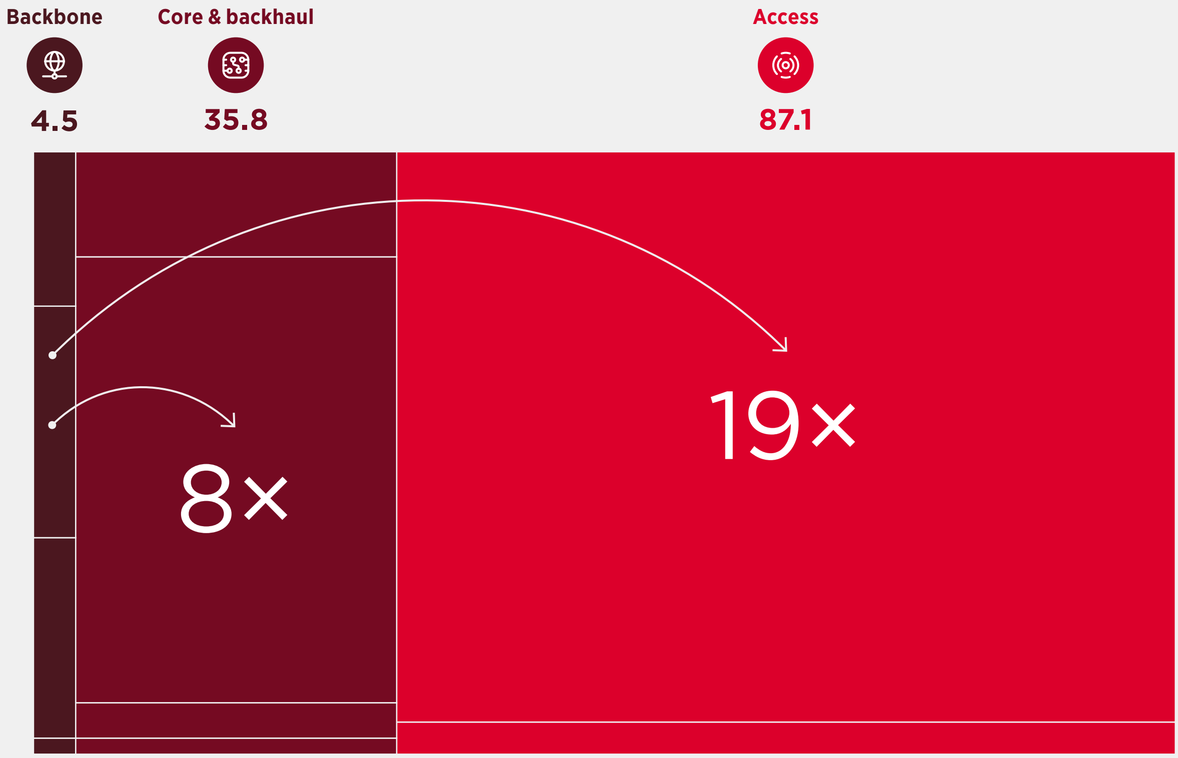
Core and access network investment requirements are several times larger than backbone

Looking at the overall investments across the segments of the mobile internet connectivity infrastructure (excluding end-user devices), as shown in Figure 18, we can see that access infrastructure is by far the largest area of investment, with annual investment 19 times larger than that going into the backbone. This investment covers upgrades to the overall service in access, including new network features and additional year-on-year increases in capacity. Although it is hard to separate the discrete benefits of this investment in terms of capacity, coverage, and feature enhancements, it is widely understood that the primary driver of investment is capacity. Most of the investment in the access segment is directed at expanding capacity to handle traffic growth and the uptake of mobile internet services. These enhancements and upgrades need to be made on physical sites covering most of the world's population and taken in aggregate this is a massive infrastructure upgrade on a global scale. It is also true that the equipment and technology that makes up the access layer is renewed on a fairly constant cycle, with the typical lifespans of the active equipment that make up much of the assets being seven to eight years on average.

Figure 18

Mobile investment by segment (excl. End-user devices)

$bn per annum



Investments in core and backhaul follow a similar pattern but less pronounced, requiring around 8 times the investment levels of backbone infrastructure. Core network systems also tend to go through a slower renewal cycle than access. The 5G standard was designed so that access networks could be upgraded before core to gain some of the more immediate benefits, and in fact, many operators that launched 5G access services years ago are only now getting round to upgrading their Core infrastructure to 5G Standalone.

Almost all of the investment in backbone infrastructure is on capacity upgrades rather than technology or feature upgrades. This means that much of the equipment that makes up the infrastructure has a longer expected lifespan, and investment is more incremental and cumulative over time rather than the renewal and generational replacement that happens in the access network.

In fact, this effect is amplified when we consider some of the developments within CDNs to cache the most popular content. Caching improves the efficient use of backbone capacity by reducing the need to transmit the same content multiple times from the source. However, the same efficiencies are not possible from the cache out to the end user across the core and access networks. There, the only practical response to increased traffic coming from the backbone is more investments in capacity to deliver it to individual end users.

As we have shown, although there are new investors in backbone when we factor in CDN infrastructure, it is important to bear in mind that backbone investments do not replace or substitute for investments in core or access infrastructure. In fact, operators of those networks need to invest at pace to ensure that those steps in the connectivity chain do not become bottlenecks.

MNOs will continue to own the core and access infrastructure

The access portion of the network will continue to be the primary business of MNOs for a long time, and the primary driver of additional investments will be the need to add capacity to meet the demands of traffic growth. Many operators have engaged in passive and active infrastructure sharing for many years now. These have helped to improve the economics of network deployments. With the virtualisation of certain RAN functions, there is the possibility for other entities to expand their roles and provide the compute resources at tower sites or in nearby edge data centres. There would still need to be a major restructuring of the asset base to enable this, replacing dedicated hardware with shared use systems, so any change would be phased in and only likely once 5G equipment reaches end of life and needs replacing.

In addition to the traffic increase and the need for MNOs to invest in capacity to complement the increased capacity and efficiency of the backbone, there is also much still to do to roll-out the full feature set of 5G networks to enable services such as network slicing and lower latency.

Connectivity function is a declining proportion of smartphone asset value

Even though the connectivity component of a device’s total value is diminishing as a proportion of the total value, connectivity remains a crucial enabling component as new features and functions are added. The connectivity function of devices is also continuously evolving as new spectrum bands are deployed and higher-end phones have the ability to access satellite networks when out of range of the mobile network.

The key driver of investment here is the number of devices. Investment in the end-user device segment will therefore evolve quite differently than the other segments. The value of the connectivity component of the end-user devices themselves will not increase, and volumes are probably at a natural plateau level. As devices become more expensive due to the additional features, it would be normal to expect life cycles to lengthen and secondary resale markets to develop further.

Conclusions

By its very nature, mobile internet connectivity infrastructure is made up of many interconnected networks and components and, similarly, many investors funding various pieces of the connectivity chain to develop their own businesses and further their own objectives. We have shown that the total investment in mobile internet connectivity infrastructure is $127bn per year on average on the backbone through to access network infrastructure, with an additional $117bn being spent on the connectivity component of devices needed to connect to the internet. When combined with the additional $189bn being invested each year in fixed network infrastructure (excluding end-user devices), this makes a total investment of $316bn in internet connectivity infrastructure. This is 40% more than what is being spent globally on data centre infrastructure.

This investment of $127bn per year is enabling mobile internet services to continue to grow and connect an ever-larger proportion of the global population. Most of this investment (85% excluding devices) comes from MNOs given the size and importance of the core and access networks. Satellite networks will help address the areas without mobile coverage, but the need for every country to have multiple mobile network infrastructures covering most of their population will mean MNOs need to continue investing in expanding capacity and continually upgrading the technology of these networks for the foreseeable future.

The investments of the large CAPs and cloud infrastructure providers to optimise delivery of their traffic and reduce their delivery costs are positive but relatively small (less than 2% of the total spend on mobile internet connectivity infrastructure). As we have pointed out, it is important to ensure that this investment is deployed in a balanced way. For the internet to work smoothly, all backbone traffic needs to be delivered by core and access networks to reach its destination. To be effective, investment in backbone infrastructure needs to be matched by a parallel and much greater investment in core and access infrastructure - an investment of between 8 (backbone versus core) and 19 times (backbone versus access) higher is needed for the balance to be maintained.

The public backbone is still fundamental to the operation of the internet, and although traffic may be declining as increasing volumes are delivered via CDNs, the public backbone still provides the essential functionality to enable end users to be able to connect with one another and access the full variety of internet-based services.

In the end, connectivity infrastructure is the foundation of the internet ecosystem, enabling all players and investors to function and thrive. While MNOs benefit from service providers to drive demand, CAPs are reliant on networks to deliver, promote, and monetise their services. Without robust end-to-end internet connectivity, the business models of CAPs, backbone and transit providers, MNOs, and end-user device suppliers would not be possible.

Appendix

Detailed definitions

1 Backbone

Sub-segment	Includes	Excludes
IP switching	Routing and switching equipment that transfers the data traffic across networks and gateways, including equipment used for wholesale ISP networks, internet Exchanges, CDN networks	
Fibre & optical equipment	Equipment used to build the transport networks that underpin the interconnecting networks, including national and international links and the capitalised installation costs	
Submarine cable and transport network	Equipment and construction cost of submarine cable systems	

2 Core & backhaul

Sub-segment	Includes	Excludes
IP switching	Routing and switching equipment that transfers the data traffic across the transport networks and gateways to/ from upstream networks	
Mobile core systems	Mobile packet core systems and OSS systems used to operate the mobile network infrastructure	
Fibre, satellite and optical equipment	Equipment used to build the aggregation and backhaul networks from access sites back to core switch locations and the capitalised installation costs	
Data centre hardware and systems	Hardware and cloud infrastructure used to host and run virtualised network core systems	Data centre investment to run non-network applications and infrastructure used to offer customer services

3 Access

Sub-segment	Includes	Excludes
Mobile		
Active equipment	All active RAN equipment providing mobile service to end users, including macro, small cells etc	Public Wifi services and radio services used to provide access tails for fixed networks.
Passive equipment	The passive equipment (shelters, air-con, structures etc) that support the cell sites	
Design & build services	Capitalised labour and services used to design, build, commission and maintain the physical sites	Recurring opex costs of sites, e.g. rent, annual inspections and non-capitalised maintenance
Spectrum	Upfront spectrum fees paid to governments/ regulators for the use of spectrum (valued at the annualised equivalent fee)	Ongoing spectrum fees and usage charges (opex)
Fixed and satellite		
FTTP/ Fibre	All capital costs of designing and deploying last mile fibre connections; includes cost from home/premise to the nearest optical node (ONT to OLT)	
Satellite	Investment in LEO satellite constellation and services and a telecom operators proportion of other services offering internet connectivity	

4 End-user devices

Sub-segment	Includes	Excludes
Mobile		
Consumer devices	Includes purchase of smartphones used by consumers to access the internet; Data dongles and mobile-wifi hubs also included Investment sizing based on the volume of smartphones sold annually and valued at a unit price of a basic smartphone. (Any additional premium paid for high-value phones may increase the specification or functionality of the device, e.g. better camera, faster processor, but does not increase the connectivity options.)	'non-smartphones' that don't have full mobile internet/app connectivity Non-mobile devices such as tablets and laptops
Connected devices	The connectivity modules used to provide connectivity via MNO networks to connected devices, e.g. the communications facility of a connected car	Excludes the value of the connected device itself and as well as all other means of connectivity like bluetooth, zigbee, WLAN,...etc
Fixed		
Access point	Includes the cost of basic fixed broadband access devices, typically a wifi hub or router;	Excludes any additional networking equipment, e.g. mesh or extenders, and any consumer devices, e.g. tablet, PC, Smart TV etc

5 Investors

Sub-segment	Includes
ISPs, international backbone and national wholesale carriers	Providers of IP transit services, internet Exchange Points (IXPs) and also the suppliers of international and long-distance transport used as part of these networks
Cloud infrastructure providers	The providers of cloud infrastructure services used to host virtualised network applications.
Large Content and Application Providers (Large CAPs)	The large content and application providers that invest directly in transport and delivery infrastructure as part of distributing their services
CDN and specialist backbone providers	Specialist providers of content distribution services often used by CAPs
Fixed Network Operators (FNOs) and backhaul providers	Telecom operators providing fixed network services (generally over fibre) used to connect mobile access and core sites. (May also have end-customers or be wholesale-only players)
Mobile Network Operators (MNOs)	Operators of mobile network services to end-users using licensed spectrum
Satellite service providers	Providers of transport services that use satellite, typical for backhaul connectivity to remote sites
FTTP/H players	Telecom operators and altets offering fixed internet access services to end-users
Tower companies	Owners and operators of portfolios of mobile cell towers (incl. rooftops) which they rent to MNOs. Only includes standalone tower companies and not the captive operations of telecom operators, nor the sharing companies owned by Telecom operators.
Satellite network operators	Operators of satellite networks that provide internet access services
Consumers, enterprises, government	End-users who purchase devices to connect to access networks and access internet services
Manufacturers of connected and smart devices	Manufacturers of connected devices (e.g. connected cars) that buy components to connect their end-products to mobile networks.
Retail telecom operators	Providers of fixed internet access services who purchase wifi hubs etc. which act as the access device to the service for end-users

Apportionment metrics

Figure 19 shows the metrics that were used to apportion total investments between fixed, mobile, and satellite infrastructures.

Figure 19

Metrics used to apportion investment costs to fixed, mobile and satellite infrastructure

Segment	Investment category	Apportionment
Backbone	Submarine and international cables	By traffic[1]
	Routing equipment	By traffic
Core & backhaul	Fibre, optical equipment for backhaul	Number of access points[2]
	Core switching	By traffic
	Mobile core systems	100% mobile
Access	FTTP/H	100% fixed
	Satellite equipment	100% satellite
	Active/passive equipment, design and build for towers	100% mobile
	Spectrum licenses	100% mobile
End-user devices	CPE	100% fixed
	Consumer/enterprise mobile devices	100% mobile
	Connected component manufacturers	100% mobile

1. Calculated as ratio of total traffic for mobile vs total, 19% of total traffic in 2024, (average of several sources including ITU, PwC and Ericsson)
2. Calculated based on number of res. and bus. prems to mobile towers (100:1)

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