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Private Markets Investment in Digital Infrastructure

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What is digital infrastructure?

The constant evolution and expansion of digital technology globally requires massive ongoing investments in infrastructure. Today information is transmitted in the form of voice, video, or data and using the latest technologies that require increasing coverage and capacity. A robust communications system—locally or globally—requires assets that connect, transmit, process, and store unfathomable volumes of data. This infrastructure falls into three primary subsectors: wireless (macro cell towers, small cells, and spectrum), wired fiber networks (metro, wirelines, or subsea cables), and data centers (hyper-scale or enterprise centers). With the projected growth in demand for internet and wireless data capacity, additional infrastructure supporting all subsectors is critical, and this should create significant investment opportunities for the foreseeable future.

The growing need for digital infrastructure

Technology evolution continues to create market opportunities within the digital infrastructure sector as the current networks are bandwidth-constrained and thus unlikely to meet growing demand. Mobile data traffic has consistently increased, and this trend is expected to continue over the next five years. The *annual* growth rate in global mobile traffic is forecasted to be 23% between 2023 and 2028.[1] The increasing need for more infrastructure to accommodate demand is consistent across all geographies. China was the largest user of mobile data in 2022 at 26 exabytes per month[2] and is expected to reach 84 exabytes per month by 2028.[3] With the forecast of increased mobile network traffic across all geographies, there will be investment opportunities globally to meet this increasing data traffic.

[1] Source: Ericsson Mobility Report June 2023.

[2] Exabyte is a unit of measurement for large data equal to a million trillion bytes. Source: Ericsson Mobility Report June 2023.

[3] As of this writing, there is some uncertainty around western access to projects in China.

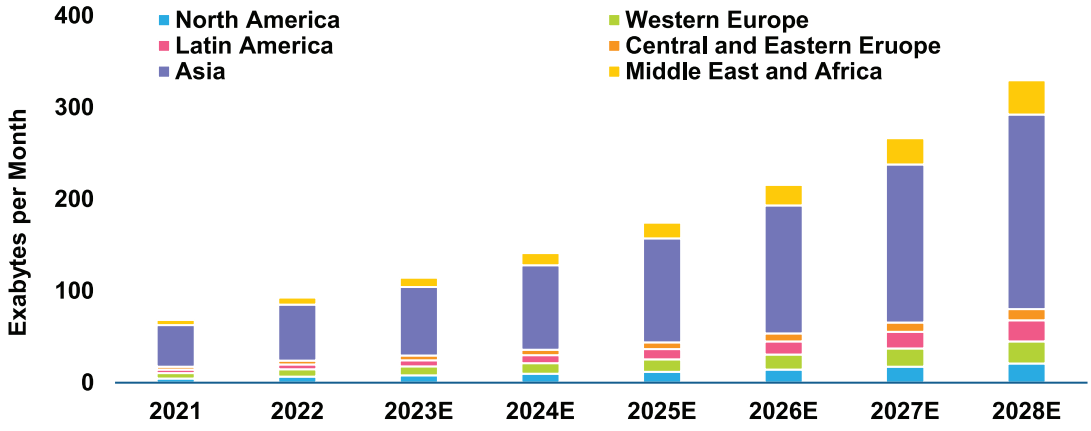

FIGURE 1
Projected Mobile Data Growth

Source: Ericsson Mobility Report June 2023.

Globally, there were 5.4 billion mobile subscribers in 2022, which accounts for 68% of the world's population. This is projected to increase to 6.3 billion, or approximately 73% of the projected population, by 2030. Mobile internet subscribers were 4.4 billion users in 2022, accounting for 55% of the world's population.[4] The continued adoption of the fifth generation of mobile network technology ("5G") should increase the number of mobile users with cheaper devices and expanded network capabilities. 5G offers the ability to move larger amounts of data faster than previous generations by using a higher bandwidth spectrum. For example, 2G used a low bandwidth that could travel a longer distance but could only support digital voice transmission technology. 3G and 4G introduced video with higher bandwidth and data transfer speeds.

[4] Source: GSMA, The Mobile Economy 2023 and Ericsson Mobility Report 2023.

As of January 2023, over 200 Mobile Network Operators ("MNOs") in 87 global markets had launched mobile 5G services. An additional 30 new markets, primarily in Africa and Asia, are expected to launch 5G capabilities in 2023, bringing the total number of 5G connections to 1.5 billion by year end. The transition to 5G networks from 4G Long-Term Evolution ("LTE") will increase data infrastructure needs. As of year-end 2022, there were just under 1 billion subscriptions to 5G networks and just over 5 billion subscriptions to 4G LTE networks, accounting for approximately 60% of mobile connections. By 2030, 5G mobile devices are expected to account for 54% of total connections with 4G decreasing to 36%.[5]

[5] Source: GSMA, The Mobile Economy 2023 and Ericsson Mobility Report 2023.

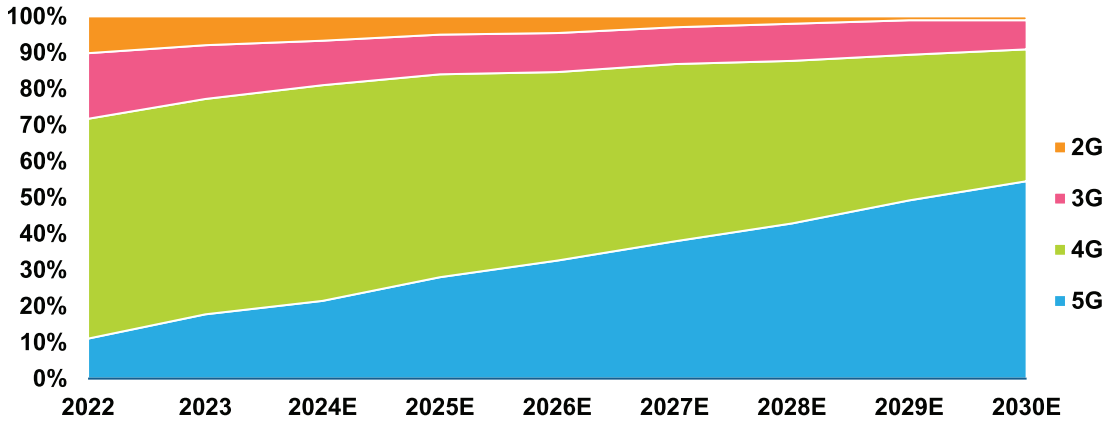

FIGURE 2
Mobile Adoption by Network

Source: GSMA, The Mobile Economy 2023 and Ericsson Mobility Report 2023.

5G technology utilizes a millimeter wave, which is a higher-frequency band of the wireless spectrum than 4G uses. The millimeter wave has a higher transfer speed, but cannot travel as far, creating the need for higher density infrastructure. 5G not only increases download speeds and capacity, it also enables new functionality and technologies that were not possible on 4G. These factors will lead to an enormous need for infrastructure expansion.

Increasing the bandwidth for 5G networks enables the continued adoption of the Internet of Things ("IoT"). IoT refers to computing and connected devices that have the ability to send and receive data. Typically, the devices are embedded with sensors, processing capabilities, software, and other technologies. Examples of IoT technologies are smart thermostats, fitness trackers, and smart cars. These IoT connections will require additional bandwidth.

There will also be growth opportunities as businesses transfer more capacity to cloud-based applications.[6] An increasing need for data centers and fiber networks will be required to accommodate the increasing amount of data storage being outsourced by enterprises. This demand creates an opportunity to invest in expanding communication networks and increasing the density of infrastructure in areas already connected.

[6] The cloud refers to a global network of remote servers that operate on the internet to provide software and storage over the internet instead of local servers.

Investment opportunities by subsector

The market outlook and opportunities for the primary digital infrastructure subsectors are summarized below.

Macro cell towers

Macro cell towers are large vertical structures that are typically found in rural areas and along roads in urban areas that lease space to businesses to attach their wireless communications equipment. The typical structure will be a monopole or lattice tower,[7] depending on the height and location of the tower.

[7] A monopole tower is a single vertical pole while a lattice tower is a structure with multiple legs and cross bracing.

The tower industry has evolved over the years and should continue to grow based on the large mobile demand explained above. In the past, MNOs primarily owned and operated cell towers for their own networks. As the demand and costs grew, independent tower companies began taking more market share and leasing tower space to the MNOs. A tower company can lease space to four or five tenants per tower, creating multiple revenue streams at each location. A tower's valuation is typically calculated as a multiple of the cash flow stream, so leasing up a tower to include additional cash flow streams will have a compounding effect on the value with little incremental costs. Lease contracts are typically five to ten years (or longer), creating a dependable revenue stream once towers are built and contracts secured. Tower companies usually do not own the land beneath their towers and instead rely on leases. Leases for tower locations are usually between 40 and 99 years, including a right-of-first-refusal if the landowner seeks to transfer the rights of the land.

The demand for new towers is expected to continue based on several factors, including the overall increasing demand for mobile data and the continued expansion of 5G globally. In addition, with the mobile data demand and increased transfer speeds of 5G, there is a need for denser tower capacity, which will require additional tower sites. 5G is also expected to gradually take more market share as lower frequency networks, such as 2G and 3G, continue to be phased out by MNOs as more 5G devices penetrate the market. To date, MNOs have announced 96 2G networks and 107 3G networks will be shut down globally.[8]

[8] Source: GSMA, The Mobile Economy 2023.

There are risks to the macro cell tower business that must be monitored with each location. Carrier consolidation or sharing networks would lead to fewer tenants

competing for tower space, decreasing overall lease revenue per tower. The expansion of small cell towers will also diminish the demand for large towers, but small cell is mostly being implemented in cities, stadiums, and other areas difficult for large cell towers to service. The long-term leases negotiated with the MNOs in the US are primarily fixed price, which involves exposure to inflation risk. MNOs in Europe typically negotiate variable rates which may mitigate inflation risk.

Small cells

Small cell networks are low-powered antennas installed in dense locations that are difficult to service with macro towers. These locations are often heavily-populated, high-usage areas that require improved signal and speed. Small cell equipment is typically situated in areas like large office towers, on streetlights and utility poles, stadiums, or transportation hubs.

Macro towers remain the most efficient way to deploy data since a tower requires just one fiber line to connect a signal back to the network, while small cells require each antenna to connect back to the network on its own fiber line. Along with speed and demand, there is increased data capacity that the small and macro towers are expected to absorb. With a 4G network, it takes five small cells to equal the output of one macro cell tower, but with 5G, it takes five times that—25 small cells—to equal one macro cell. Because of this, small cells are primarily deployed in areas where it is not possible to install macro towers or a macro tower's signal is disrupted by large buildings or stadiums.

Small cell tower investments have many similar risks as macro cells, including the threat of carrier consolidation or network sharing taking away demand. Small cells also require more up-front capital than macro towers, as the antennas need to be connected by fiber to the network. The initial lease agreements with tenants typically allow the small cell operators to break even, leaving them to rely on lease-up agreements to earn their required return. However, the increasing need of small cells for 5G expansion is improving the economics with stronger lease-up contracts.

Fiber

Optical fiber is the bundle of glass threads that connect the entire communications infrastructure. Opportunities in this segment are highly correlated with the increasing demand for data. Fiber remains the primary mode of data transport and communication between the internet, wireless towers, data centers, and households across the globe. Cell towers have regional reach limited by the short distance of wireless signals. Fiber operates on a global scale through metro networks, subsea cables, wirelines, and long-distance cables. The fiber market is competitive, as many users have their own internal fiber network instead of outsourcing the use of fiber lines. Fiber assets are owned by a diverse group of companies, from data content providers to power utilities.

The key to driving growth and value in this market is to build sufficient new fiber networks or expand existing network coverage in order to reach economies of scale. Providers with lower costs will have an advantage in this competitive pricing market. To gain stability, a fiber provider looks to secure long-term contracts with major customers such as government entities, multinational enterprises, healthcare organizations, or MNOs. Fiber can be sold to larger customers as "dark fiber," which involves selling the fiber networks directly to the enterprise who will then control the data on that fiber with their own optical gear. Smaller customers such as retailers or individual businesses can access "lit fiber," which is sold as a service and the customer can transfer data across a shared fiber network for a fee. Dark fiber will provide larger up-front cash payments to the supplier and little incremental income, while lit fiber is the opposite, with minimal initial payments to the supplier and higher incremental income.

Fiber-to-the-Home ("FTTH") is also a critical sector as the demand for broadband access directly to households continues to increase. Pre-fiber, homes were connected to the telecommunication system with copper wires that were sufficient for household landlines. Cable lines, which are a combination of copper and fiber, were an upgrade, but still do not provide the level of service to meet most users' desired bandwidth. The growth of hybrid and fully-remote working environments and streaming devices within a home, such as video services, virtual reality, and smart homes, has created an opportunity for fiber providers in the FTTH market. There is a natural barrier to entry after first movers come into an area and capture the customer base, making it costly for a competitor to lay fiber in the same area.

The main risk in fiber is the high competition that can lead to pricing constraints and potential overbuilding in densely populated areas. The need for expansion to reach economies of scale can involve risks around permitting delays to secure rights for laying underground fiber and the eventual construction project to lay the fiber.

Spectrum

Spectrum refers to the radio frequencies in the electromagnetic spectrum on which wireless communication signals travel. Commercial wireless communications are currently located at frequencies between 300 megahertz ("MHz") and 40 gigahertz ("GHz"). The frequency relates to the cycles per second at each level, which affects how far the wireless signal can travel and the volume of data transmitted.

Spectrum is a finite resource, as the same frequency cannot be exploited by different users (or applications) in the same geographic area without resulting in major interference. Because of this, regulators, such as the Federal Communications Commission ("FCC") in the US, are tasked with allocating and licensing spectrum bands. The two ways that MNOs can acquire spectrum are through government auctions or secondary market sales. In the US, the FCC auctions spectrum licenses

that specify the frequency and geographic area each license covers. Auction winners can use the licenses for their own purposes, or they can sell or lease them to MNOs as the companies attempt to keep pace with increasing demand.

5G requires a range of spectrum bands to provide comprehensive coverage as low spectrum bands provide wide coverage for basic services such as mobile voice at lower bandwidth. High spectrum bands can travel much shorter distances and provide higher bandwidth for the larger data requirements and speeds of 5G such as high-definition video and virtual reality technologies. Since 2017, the FCC has held five spectrum auctions, three of which were for frequencies that MNOs have targeted to expand 5G coverage. The auctions were for both low and high spectrum bands, specifically at 600 MHz, 3.7GHz to 3.98GHz, and 3.45 GHz.[9] MNOs and private investors participate in these auctions looking to secure regional coverage for 5G expansion. Private infrastructure firms may purchase licenses that can later be leased or sold to MNOs that require additional bandwidth in a region with a finite supply.

[9] Source: Federal Communications Commission (https://www.fcc.gov/auctions-summary).

Risks associated with spectrum include that the auction process can lead to inflated prices for licenses. Successful investors in the spectrum space understand the valuation and complex auction process in order to acquire spectrum at reasonable prices. Risk can also be associated with consolidation within the industry where fewer competitors will create less need for additional frequencies and lower the number of natural purchasers of spectrum licenses.

Data centers

Data centers are specialized buildings that house mission-critical information technology infrastructure powering the internet, corporate world, and public sector. The large annual expected growth of mobile data usage mentioned earlier will likely increase the need for data centers. Another critical demand for data centers is the shift by businesses to house their data in the cloud. Managed hosting cloud computing companies such as Amazon or Google are struggling to keep up with the pace of increasing demand and cannot rely only on building their own data centers, which is creating greater opportunity for third party data center builders and their investors who can lease capacity and services to the cloud companies.

The two main investment opportunities within data centers are Hyper-scale and Enterprise.

→ Hyper-scale is wholesale data center access where a large tenant will lease entire suites or buildings in order to run back office, cloud and content infrastructure, data analytics, and web hosting. The lease is typically in the range of five to twenty years with rent escalation typically at 3% per year. Renewal rates are exceptionally high for wholesale data centers due to the high, effectively prohibitive switching costs since many businesses cannot afford to be down during relocation. Hyper-scale infrastructure is usually the lowest cost option for large customers and will provide low but steady cash yield for a data center owner.

→ Enterprise data centers cater to the smaller scale cloud businesses that will need more services and less space. The smaller businesses will share data center space and typically pay a premium compared to the hyper-scale customers. For this higher cost, the enterprise data centers typically manage the servers for their customers.

The location of data centers is also shifting. There is a growing demand for "edge" data centers, which are data centers that are built closer to the end users. The expansion of 5G and businesses seeking to store and process data locally has created a demand for closer locations of data centers. Edge data centers can provide organizations with increased latency, autonomy, and data security.

A related aspect of data center construction and operations consideration is the electricity needed to power them. The increase in internet users and data applications such as video streaming, virtual reality, artificial intelligence, and machine learning, creates increased demand for power to run all of the servers and cooling systems within a data center. In 2022, data center electricity consumption was 240 to 340 terawatt-hours ("TWh"), which was 1.0% to 1.3% of global consumption. Although data centers' electricity consumption has become more efficient with new technologies, the growth has led to data center consumption globally increasing 20% to 40% per year since 2015.[10] The growing consumption of electricity creates risks of capacity issues on the electrical grid. Renewable power sources have become a focus for many new data centers with grid capacity issues and CO_2 emissions concerns. Green data centers that exclusively run from renewable sources are also a focus of many corporate consumers such as Amazon, Microsoft, Meta, and Google, who seek to decarbonize their businesses.

[10] Source: IEA (https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks#tracking).

Data centers also carry risks that must be addressed and mitigated. The growing concern of electricity supply and fossil fuel emissions are a focus due to the power required to run each facility. Hyper-scale data centers have single large tenants, so the center will have more customer concentration risk. This is partially offset by the longer lease contracts and price escalators. Tenants may also revert back to building their own data centers, depending on the rent price point and contract situation of the leased data center. But there is some lease stickiness because data center infrastructure is not the core competency of most customers, and using a specialized provider is typically a cheaper alternative than in-house options.

Investing in digital infrastructure

Over the last ten years, digital infrastructure has steadily become a larger percentage of the overall private infrastructure industry. In 2012, six funds were raised with exposure to digital infrastructure, raising $4 billion in aggregate commitments. This accounted for 7% of the number of total infrastructure funds raised that year and 10% of the commitments.[11] As more sector generalists began targeting the sector and

[11] Source: Preqin Global Infrastructure Report 2023.

more sector specialists focused exclusively on digital infrastructure raised capital, the digital infrastructure sector increased in overall market share of private infrastructure. Over the past two years, one-third of the infrastructure funds raised included digital infrastructure as an investment target under their strategy.[12]

[12] Source: Preqin Global Infrastructure Report 2023.

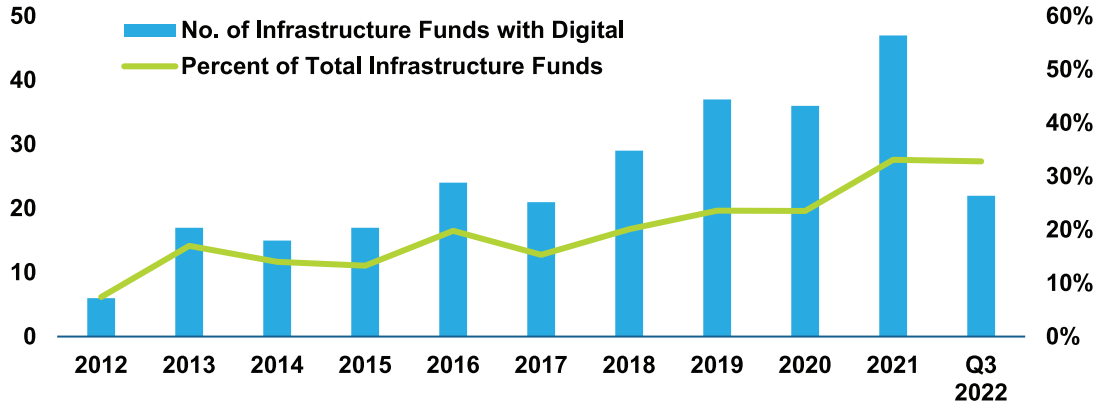

FIGURE 3
Number of Funds Raised per Year

Source: Preqin Global Infrastructure Report 2023.

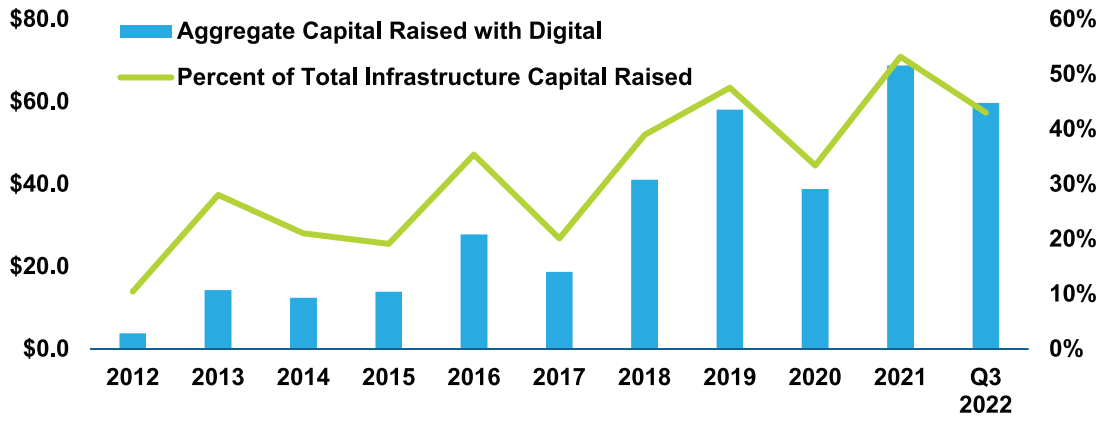

FIGURE 4
Capital Raised per Year

Source: Preqin Global Infrastructure Report 2023.

As more managers have focused on digital infrastructure exclusively or as a target sector among others, the transaction level has also increased. In 2012, just 2.5% of total infrastructure transactions by deal value were in digital infrastructure companies. The market share of deals has increased to over 20% for digital infrastructure with $110 billion in aggregate deal value in 2021.[13] The need for greater density and connectivity has led to a steady increase in deal volume year over year, and with the 5G expansion, deal flow is expected to remain strong going forward.

[13] Source: Preqin Global Infrastructure Report 2023.

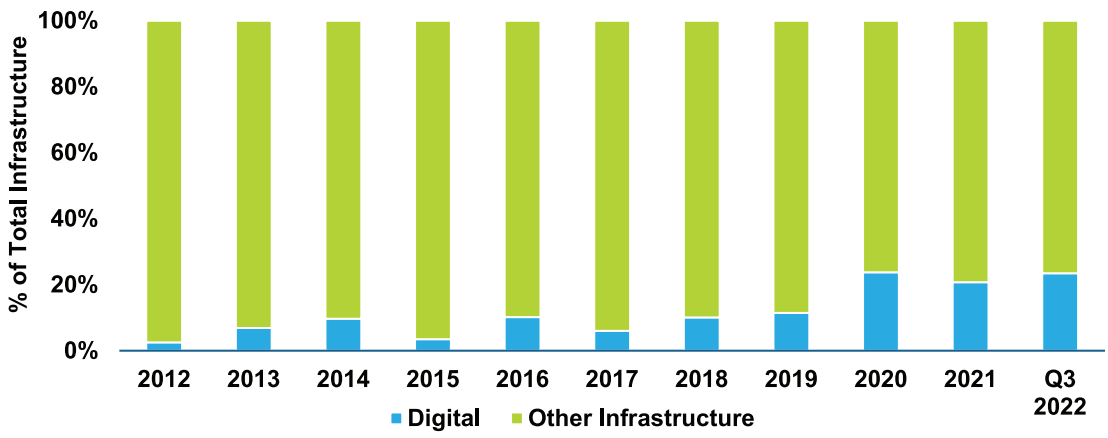

FIGURE 5
Infrastructure Transactions by Aggregate Deal Value

Source: Preqin Global Infrastructure Report 2023.

Exposure to digital infrastructure can be obtained through diversified infrastructure managers that target a certain percentage of their portfolio to digital communication assets, or through sector specialists that seek to build portfolios across one or more digital sub-sectors. Sector specialists have been increasing over the past several years. From 2012 through 2020, the average number of digital infrastructure focused managers in the market was less than four per year. Since that time, there have been 36 digital infrastructure offerings for vintage years 2021-2023.[14] Manager selection becomes increasingly essential to navigating the new offerings and emerging firms formed to take advantage of the market demand.

[14] Source: Preqin: Funds Export as of August 31, 2023.

Summary

Demand for digital infrastructure continues to grow. Global mobile traffic is forecasted to increase 23% year over year between 2023 and 2028. The continued adoption and expansion of 5G networks will enable new functionality and technologies that the existing infrastructure networks cannot cover. The growth will come from both expanding network reach and regional density, requiring additional infrastructure to support increasing data per connection.

There are several key risk considerations associated with digital infrastructure. MNO consolidation may change the demand level and distribution profile. After a merger, there may be fewer potential tenants on a cell tower, which would lower the number of revenue streams an asset could generate. There are also regulatory risks related to the release and uses of spectrum, as well as the ability to lay fiber lines in public areas. Also, electricity demands, specifically with data centers, may cause problems in areas with grid capacity constraints. In addition, the growth of the sector could attract additional investors, thus creating increased competition and driving down returns.

A key to success is to have experience and contacts that can be utilized to find the appropriate deals and locations for the towers, spectrum, data centers, or fiber networks. Understanding a regional client base is also important in targeting key assets. The ideal portfolio will be diversified by location, asset type, and customer type. For example, having an appropriate mix of high cash flow MNOs and stable moderate cash flow government contracts may create a desirable cash flow stream and risk/return profile for exit opportunities in towers or fiber networks. Data centers can have a mix of large corporations and smaller businesses that require more service but pay a premium price. Once appropriate deals are identified, establishing highly skilled management teams, negotiating favorable contracts, and analyzing asset locations will be needed to set up a successful project or portfolio.

Overall, it is an exciting time in the digital infrastructure sector. We anticipate many interesting opportunities that will appeal to institutional investors across a wide range of risk return preferences.

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