

McKinsey
& Company

McKinsey Technology Trends Outlook 2022

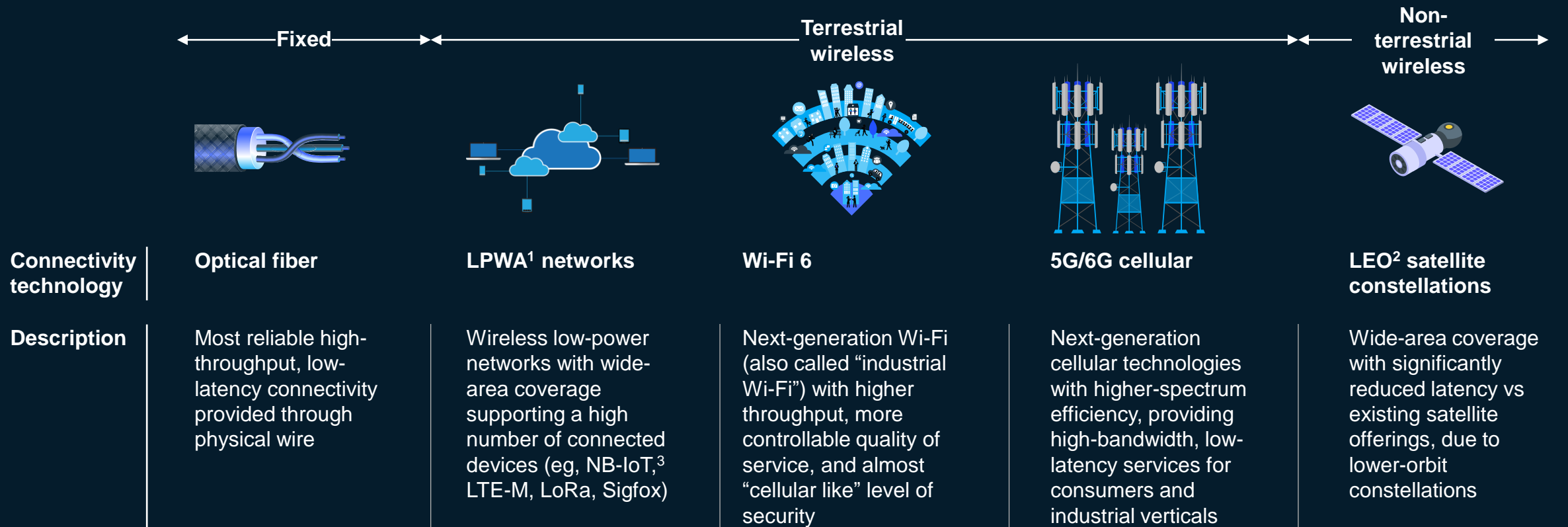
Advanced connectivity

August 2022



What is the trend about, and what are the most noteworthy technologies?

5G/6G cellular, wireless low-power networks, low-Earth-orbit satellites, and other technologies support a host of digital solutions that can help networks increase geographic coverage, reduce latency, reduce energy consumption, increase data throughput, and increase spectrum efficiency. This has led to higher-quality network access for consumers and unlocked new use cases for industrial players



¹Low-power wide-area.

²Low-Earth orbit.

³Narrow-bandwidth Internet of Things.

Why should leaders pay attention?

As advanced connectivity becomes broadly available, industries will find innovative use cases

Monetization opportunities for technology and telecom companies



Uplift in B2B revenues for telecom companies

10–20%

Overall revenue increase from developing 5G-enabled premium connectivity and B2B use cases



Exponentially growing need for network capacity

20–25%

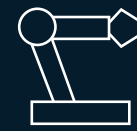
Annual rate of global data creation, which necessitates access to higher-bandwidth networks



Rapid increase in number of connected devices

~51.9 billion

Total number of connected devices expected in 2025, up from 43 billion in 2020



Impact from industrial use cases

\$2 trillion

Estimated global GDP impact, driven by operational enhancements resulting from advanced connectivity in just 4 major industries



Closing the digital divide and enhancing existing connections

~200 million

Number of individuals accessing the internet for the first time in 2021, due to new connectivity technologies

New capabilities for industrial companies and consumers

Connectivity as an enabler

Enhanced connectivity is an enabler for new and upcoming technologies

- **IoT applications** will increase the need for 5G, Wi-Fi 6, and LPWAN
- **Mobile AR/VR¹ and cloud gaming** are examples of consumer technologies dependent on low-latency, high-throughput wireless networks
- **Edge and cloud computing** technologies, coupled with advanced connectivity, will unlock full benefits of next-gen computing for consumers and industrial verticals

¹Augmented reality/virtual reality.

Why are advanced-connectivity technologies interesting, compared with what already exists?

We compared the current generation of advanced connectivity technologies with their predecessors

	Summary	Previous generation	Next/current generation
Optical fiber	Rapid growth has connected millions of people to high-speed internet	Widely used copper had lower throughput and higher cost for an operator	Modern optic fiber brought an exponential increase in throughput , much lower latency , and lower maintenance costs for telecom companies
LPWAN	Standards designed from the ground up aim to optimize for IoT devices	Relatively costly standard cellular connectivity and low-range tech such as Wi-Fi/Bluetooth drove most IoT applications	Purpose-built LPWAN connectivity standards enable more devices, higher energy efficiency , extended coverage , and lower connectivity cost
Wi-Fi 6	Significantly higher industry readiness has been enabled by improvements in security and connection quality	Wi-Fi 5 brought a marked improvement in indoor wireless connectivity and a major improvement in speed over Wi-Fi 4	Wi-Fi 6 improves upon previous standards in speed, range , and security , making it more suitable for industrial applications
5G/6G cellular wireless	Advanced cellular technology standards are replacing 4G networks, bringing new features and access to new spectrum	4G cellular technology with moderate speed provided true mobile broadband access for the first time	5G/6G offers much higher throughput, device density, spectrum efficiency, quality of service , and security guarantees with very low latency for improved user experiences
LEO satellite constellations	These satellite constellations ensure that the most remote locations on earth have high-quality connectivity	Satellite connectivity was for military and industrial applications, with limited consumer usage for internet or communication	LEO satellites aspire to reduce the cost of hardware and increase accessibility to satellite internet connectivity by providing enhanced proximity to users

What disruptions could the trend enable?

Advanced connectivity will catalyze the adoption of technologies to create disruptions in many industries

**\$1.2T–
\$2.0T**

Estimated
global GDP
impact from
disruption in just
4 major
industries



Automotive and assembly



Connectivity could enable **preventive maintenance, improve navigation, prevent collisions**, enable various levels of **vehicle autonomy and carpooling services**, and provide **personalized infotainment offerings**

Healthcare systems and services



Low-latency networks and high density of connected devices and sensors make it possible to **monitor patients at home in real time**, which could be a major boon in the treatment of chronic diseases

Aerospace and defense



From critical communications through nonterrestrial networks (NTN) to connected field assets, connectivity expansions such as 5G networks can vastly boost capabilities and performance for aerospace and defense users

Retail



Connectivity allows retailers to **manage inventory, improve warehouse operations, coordinate supply chains, eliminate checkout activities**, and add **augmented reality** for better product information







Bridging the digital divide



With broader 5G, optic fiber, and satellite internet coverage, the **digital divide for the next billion internet users is being bridged**

Current users will also see their experiences improve significantly as network speeds and latency improve, enabling use cases previously considered unfeasible

What disruptions could the trend enable? (continued)

Industry affected	Impact from technology trend
 Telecommunications	<ul style="list-style-type: none"> • Introduce new B2C and B2B service offerings, such as improved cellular services for retail customers and private 5G solutions for enterprise customers
 Aviation, travel, and logistics	<ul style="list-style-type: none"> • Track and trace products and provide data to help customers optimize supply chains using LPWA wireless technology
 Construction and building materials	<ul style="list-style-type: none"> • Building Information Modelling (BIM), onsite 3-D printing, and AR applications will all require high-speed, low-latency, expansive connectivity networks.
 Information technology and electronics	<ul style="list-style-type: none"> • Demand for smart sensors and IoT¹-enabled devices will grow as connectivity improves and cost drops
 Media and entertainment	<ul style="list-style-type: none"> • Enable high speed, value-creating entertainment experiences within limited disruptions as new devices (eg, AR/VR devices) enter the market
 Metals and mining	<ul style="list-style-type: none"> • Expand coverage to enable “smart mining” and digitization/automation practices that will enhance productivity and safety
 Electric power, natural gas, and utilities	<ul style="list-style-type: none"> • Implement a smart utility grid with smart meters, sensors, and other cloud devices
 Oil and gas	<ul style="list-style-type: none"> • Leverage advanced connectivity technologies to permit and optimize real-time monitoring of drilling and production activities, as well as digital tools and analytics to offshore operators

¹Internet of Things.

What should leaders consider when engaging with the trend?

Advanced connectivity will be a huge catalyst for change as the value chain and ecosystem continue to mature



Benefits

- **Enabler:** Connectivity is a key enabler of revolutionary capabilities of digital transformations, driving efficiency through automation and enabling technologies reliant on high-quality connectivity such as cloud computing and IoT
- **Experience:** Average consumers' experiences are enhanced with ubiquitous connectivity and significantly higher quality of service, enabling individuals to work remotely, access bandwidth-heavy services, stream higher-quality content, etc
- **Global aspirations:** Advanced connectivity technologies are aspiring to have a global footprint, as countries from the global south and north stand to benefit significantly in the future, even if the rate of adoption is uneven

Risks and uncertainties



- **Ecosystem maturity:** The ecosystems for evolving connectivity modalities such as LPWA and LEO are maturing, but so far, few players provide solutions and services in markets
- **Business viability:** Commoditization of connectivity has meant that only a few telecom companies have been able to monetize 5G well enough to get a good ROI; the trajectory of capital expenditures and maintenance costs will also be closely watched
- **Availability:** Some technologies, such as high-band 5G and LEO, may be limited by the large capital investments required to build out networks with competitive coverage and performance for mainstream use cases

What industries could be most affected by the trend?

Connectivity technologies are relatively mature with several examples of industries successfully using them to create impact in their operations and services

Cellular wireless, optical fiber, and LPWAN technologies are leading catalysts of change in these industries; applications include ubiquitous connectivity for consumers, industrial automation, and IoT applications such as smart meters

Industry affected	Implications from technology trend
 Telecommunications	Telecom companies are using advanced connectivity to introduce new B2C and B2B service offerings, such as improved cellular services for retail customers and private 5G solutions for enterprise customers
 Automotive and assembly	<p>Innovative automotive players of the future will introduce self-driving, connected vehicles packed with features that depend on high-quality network access even in remote locations</p> <p>Private 5G, industrial Wi-Fi, and LPWA networks support Industry 4.0 solutions that lift productivity, lower energy consumption, and reduce costs in factories</p>
 Aviation, travel, and logistics	LPWA wireless technology lets logistics providers track and trace products and provide data to help customers optimize supply chains, improving overall operational efficiency
 Healthcare	Connectivity will be a major boon in the treatment of chronic diseases, as AI-powered diagnostics can be conducted using data from patients while they are monitored at home using connected medical devices; this will improve patient access to healthcare while improving the overall digitization of healthcare services

Who has successfully created impact with advanced connectivity?

Leading players across industries have already leveraged advanced connectivity to optimize their operations



Automotive and assembly

Volkswagen has implemented 5G private networks in their factory in Dresden; VW replaced wired connections between machinery, and now updates finished cars with over-the-air updates and connects unmanned vehicles with edge-cloud servers

Michelin utilized LPWAN to enable real-time inventory management in 2019; using Sigfox standards, Michelin was able to gain up to a 10% reduction of the on-sea inventory and a 40% increase in estimated time of arrival (ETA) accuracy while reducing inventory ruptures caused by exceptional events like critical weather conditions

Bosch equipped their first factory with a 5G private network in 2020; the network enables a range of advanced use cases such as autonomous transport systems at scale, an automation platform connecting hundreds of end points, and robots cooperating with human factory workers by adjusting movements in real time



Telecommunications

Verizon deployed 5G private networks in NFL stadiums to enhance spectators' experience; these networks allow fans to access real-time stats and data in AR and to access a feed of up to 7 camera angles simultaneously via the 5G multiview offering

What are some topics of debate related to the trend?

Despite relative maturity, advanced connectivity technologies still spark a certain amount of debate regarding their implementation and perceived vs realized benefits



1 5G Transition

Can 5G completely replace 4G LTE? What percentage of new networks will have high-band 5G?

- Private 5G networks are a **proven technology**, with many players already **reaping their benefits**
- Other technologies, such as **IoT and automated guided vehicles**, perform much better when using high-quality networks enabled by private 5G
- However, shifting from 4G LTE to **private 5G may not be cost-effective for all players**; this would depend on a player's technological aspirations and planned use cases

2 Extraterrestrial networking

How will satellite constellations shift the balance of bandwidth from terrestrial connectivity to space-to-Earth connectivity?

- A few players are already **piloting internet services**; there are signs that consumer devices with LEO connectivity are on the horizon
- However, due to high capital expenditures and user costs, the **business model and pricing will be a challenge** for scaling up networks, nor can **LEO connectivity fully serve as a substitute for terrestrial networks** for all use cases that rely on cost-efficiency, energy consumption, or overall performance

3 Choosing LPWA standards

Will certain LPWA protocols emerge as the standards for particular industries? Or will 5G outcompete LPWA networks for IoT applications?

- Depending on availability of traditional LTE networks, a player might choose **between licensed or unlicensed cellular LPWA standards**; this choice may also be critical when dealing with **stationary and mobile devices**
- LPWA standards vary in terms of **bandwidth, cost, power consumption, range** and other features; depending on the final use case for the player, some standards might be more appropriate than others

Additional resources

Knowledge center

[McKinsey Center for Advanced Connectivity](#)

Related reading

[Connected world: An evolution in connectivity beyond the 5G revolution](#)

[Interview: Laying the foundation to accelerate the enterprise IoT journey](#)

[Unlocking the value of 5G in the B2C marketplace](#)

[Reliably connecting the workforce of the future \(which is now\)](#)

[Breaking through the hype: The real-world benefits of 5G connectivity](#)

[How tapping connectivity in oil and gas can fuel higher performance](#)

[Agriculture's connected future: How technology can yield new growth](#)

[How our latest work helps leaders get ready for the 5G revolution](#)