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News & Highlights

5G Falls Short of Promised Benefits

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The hype was flowing when 5G wireless service began rolling out around 2018 (Fig. 1). According to the US wireless company Verizon, based in New York City, NY, USA, 5G would usher in "a fourth industrial revolution" [1]. The technology would also allow surgeons to perform operations remotely on patients thousands of kilometers away, permit communications between driverless cars, and offer other life-changing benefits [2,3]. Even the name "5G," which is short for "fifth generation," implied it would be revolutionary, said Prasenjit Mitra, professor of information sciences and technology at Pennsylvania State University in State College, PA, USA. "We are calling it a generational technology, and that is what we expect."

So far, however, 5G has not measured up [4]. The speed and quality of service vary from country to country—and from location to location within individual countries—but for many users, 5G has not made a noticeable difference [4,5]. In part, disappointment with 5G stems from unrealistic promises made by wireless companies, said Mitra. But a variety of obstacles has also held back 5G deployment and hindered its performance. In many areas, high costs and other hurdles have discouraged wireless providers from installing the infrastructure needed for the fastest 5G service (Fig. 2), which uses the millimeter wave band of frequencies [6]. And in some countries, wireless companies agreed to limit the location or power of 5G towers because of the risk of interference with aircraft altimeters [7]. 5G "is not going to be a disaster, but it is not going to be a miracle," said Muriel Médard, professor of software science and engineering at the Massachusetts Institute of Technology in Cambridge, MA, USA.

About every ten years, the telecommunications industry debuts a new, higher performance technology standard for wireless networks. For instance, fourth generation, or 4G, devices began to replace their 3G predecessors in 2009 and boasted downloads that were around ten times faster—although speed varied by network [8]. In turn, 5G began to supplant 4G in the late 2010s [9]. Compared with 4G, 5G is faster, offers greater bandwidth that may reduce network congestion, and slashes latency, a device's response time [10,11].

One reason that 5G appears disappointing is the misleading numbers bandied about for its speed. The International Telecommunications Union (ITU), the United Nations agency that sets standards for wireless technology, requires a maximum 5G download rate of at least 20 $Gb{\cdot}s^{-1}$ [6,12]. Even today, wireless companies and other 5G promoters suggest that consumers can achieve that speed [13]. However, the standard refers to an individual cell, or area covered by a single base station in the cellular network [14]. A user could achieve that download speed only under perfect conditions and if no one else was trying to connect to the network at the same time, said Mitra. "The whole idea that this will take us to 20 $Gb{\cdot}s^{-1}$ is crazy."

The ITU also specified that under more realistic conditions, download rates for users in urban areas should be at least 100 $Mb{\cdot}s^{-1}$ [12]. By that measure, many 5G networks around the world are performing well, but others are falling short. According to data from the Seattle, WA, USA-based network analysis company Ookla, users in the United Arab Emirates enjoy the world's fastest 5G, with a median download speed of 546 $Mb{\cdot}s^{-1}$ as of December 2022 [15]. Republic of Korea's median rate of 493 $Mb{\cdot}s^{-1}$ landed it in second place.

The United States was in 20th place at 139 $Mb{\cdot}s^{-1}$. The bottom 10% of users in the United States have download speeds that are

Fig. 1. 5G service first went online in the United States in late 2018, and the technology has been widely adopted in some countries. More than 60% of phones sold in the United States are 5G enabled. Globally, however, 5G has lagged—only about 14% of smartphones sold worldwide offer 5G capability. Credit: Wikimedia Commons (CC BY-SA 4.0).

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Fig. 2. This 5G base station in Australia receives signals from users' cell phones and passes them on to the network core so they can be routed to their destinations. Some 5G frequencies require large numbers of base stations in a small area because of interference from buildings and other objects in the environment. Credit: Kgbo/Wikimedia Commons (CC BY-SA 4.0).

below 20 $Mb{\cdot}s^{-1}$, less than the median 4G long term evolution (LTE) speed [16]. A user's network also makes a big difference, as data from another network analysis company, OpenSignal of London, UK, reveal. As of mid-2023, customers of T-mobile, the smallest of the major US wireless companies, were downloading content about twice as fast as customers of its two biggest competitors, AT&T and Verizon [17].

The data also show that 5G is slowing in some countries, likely because more users are crowding onto networks [6]. Between 2021 and 2022, median download speeds fell 11% in Germany, 23% in the United Kingdom, and a whopping 31% in Norway [15]. The United States is one of the countries bucking this trend. Over the same period, downloads in the United States got 35% faster, in part because wireless providers began using additional frequency bands for 5G [15].

Speed is not the only measure of 5G's performance. The technology offers other, less flashy benefits, Médard said. For instance, if a data packet sent by a device does not reach the intended recipient, the device must send it again, a process known as retransmission. 5G manages retransmission more efficiently than 4G, noted Médard. The upshot is a slight increase in a 5G device's battery life, although users might not notice the difference, she said.

Still, 5G has not reached its potential for several reasons. One is the deployment of the networks. A wireless network includes base stations, which pick up transmissions from cell phones and other devices, and the core, the hardware that routes these messages to recipients or connects users to the internet [18]. When companies began rolling out 5G, they first installed non-standalone networks, which rely on the same cores as their 4G LTE networks [6]. Incorporating existing infrastructure was cheaper and allowed carriers to continue providing 4G service, Mitra said. But non-standalone networks cannot take advantage of some 5G capabilities, such as reduced latency [11]. "If we were designing a 5G network from scratch, we could do it more efficiently," said Mitra.

Moreover, 5G networks have not capitalized on all the available frequency bands. Initially, wireless providers mostly transmitted at low-band frequencies below 1 GHz [19]. Low-band transmissions travel farther than those at higher frequencies and are not blocked by buildings. But they are not much faster than 4G LTE [19]. The fastest frequencies fall into the high band above 24 GHz, and the millimeter wave band between 24 and 71 GHz appeared particularly promising for 5G [6,20]. Data from Ookla on some of the few operating millimeter wave networks reveal that their median download speeds were more than 26 times faster than for the low band, with some networks reaching median values of 1.6 $Gb{\cdot}s^{-1}$ [20]. But millimeter wave signals have a very short range and can be disrupted by buildings, foliage, and weather [3]. To ensure consistent service, carriers must install large numbers of antennas, boosting costs, said Mitra. So far, wireless providers are offering millimeter wave service only in limited areas [6].

Wireless providers are now expanding their service in the mid-band frequencies between 1 and 6 GHz, which are faster than low-band transmissions but travel farther than those in the high band [21]. In early 2022, US carriers began transmitting in a portion of the mid band known as the C-band, and their users saw a dramatic jump in speed [21]. However, several countries have restricted 5G base stations near airports because C-band transmissions might disrupt aircraft altimeters, which use a neighboring band of frequencies [7]. In the US, wireless companies agreed to keep some towers near airports switched off and to operate others at lower power [22]. But that limitation ended on 1 July 2023 [23]. Greater use of the C-band could boost speeds by 10%–20%, said Mitra.

5G transmission speed will likely continue to increase as companies make better use of the allotted spectrum, but users should temper their expectations, said Mitra. "We should think of it as an incremental improvement," he said. Moreover, some of the much-touted potential applications of 5G, such as self-driving cars and connected cities that use vast amounts of data to manage their operations and services [2], have proven harder to develop than their advocates originally thought [24,25]. Nonetheless, experts are already drawing up standards for the next generational upgrade, 6G, which could debut as early as 2030 [26]. But everyone might be better served if the industry continuously improved service rather than upgrading in big steps, said Médard. "That would be more scalable and successful than having new generations all the time."

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