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The road to 5G: The inevitable growth of infrastructure cost

Network cost could double as operators strive to meet demand for increased capacity and deploy 5G. How can they maintain their profits?

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Each generation of technology opens new opportunities for telecommunications players. But when 4G launched in 2009, mobile operators didn't see the great returns they'd captured in with earlier generations. Despite their investments in 4G infrastructure, revenues showed flat or tepid growth. In a few regions, including Europe and Latin America, revenues even dropped after 4G's introduction.

Now 5G technology is under testing and poised to launch in some markets later this year. Mobile operators are preparing with a mixture of resignation and anticipation. They know that it will open opportunities to capture value from new 5G use cases and widespread adoption of the Internet of Things (IoT). At the same time, they are keenly aware that they'll have to increase their infrastructure investments in this technology. Meanwhile, operators will still have to upgrade their 4G networks to cope with growing demand. In an analysis of one European country, we predicted that network related capital expenditures would have to increase 60 percent from 2020 through 2025, roughly doubling total cost of ownership (TCO) during that period.

This conundrum raises important questions about investment strategy and future profits for mobile players. In this article we will focus on the infrastructure investments required to enable 5G. The related article, "Network sharing and 5G: A turning point for lone riders," focuses on network sharing, one investment approach that could reduce cost and risk.

When will operators invest in 5g infrastructure?

While many things on the road to 5G are uncertain, it is easy to envision the emergence of new and innovative use cases. To understand how these will change infrastructure requirements, we grouped them into three categories: enhanced mobile broadband, IoT, and mission-critical applications. These use cases will require network performance to increase 10-fold over current levels across all network parameters, as measured by latency, throughput, reliability, and scale. To get there, mobile operators must invest in all network domains, including spectrum, radio access network (RAN) infrastructure, transmission, and core networks (Exhibit 1).

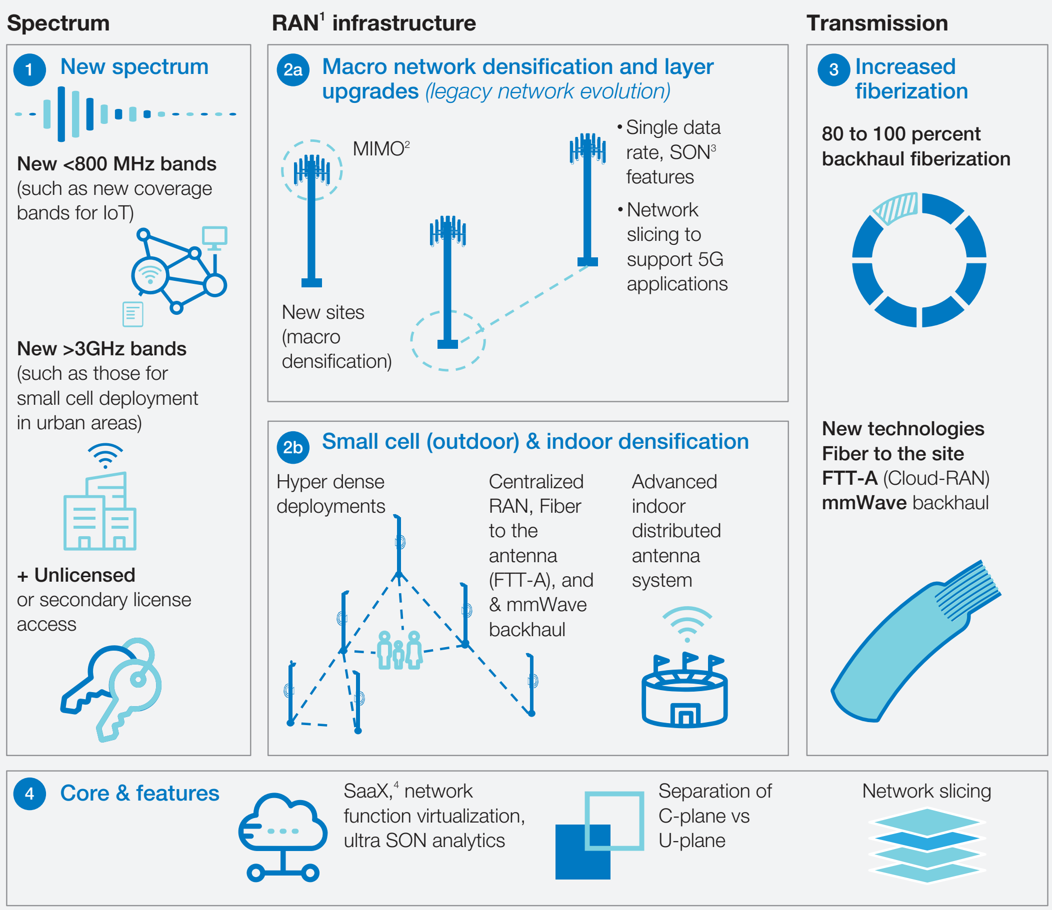
Many elements of current 5G technology build on 4G networks, rather than representing a complete departure—and that means mobile operators can take an evolutionary approach to infrastructure investment. For instance, operators could begin by upgrading the capacity of their existing 4G macro network by refarming a portion of their 2G and 3G spectrum, or by acquiring additional spectrum when available. This way, they can delay investments in 5G by evolving to LTE-and LTE-Pro features, such as 4x4 or massive MIMO (a multiple input, multiple output technology). This evolutionary approach will be the natural path for most operators, allowing them to minimize investments while the incremental revenue potential of 5G remains uncertain.

When network upgrades are no longer sufficient to support the increased traffic, operators will need to build new macro sites or small cells. That point in time will vary by location, but simulations show that most operators will need to embark on significant new build-out between 2020 and 2025 (Exhibit 2). That shift will be the primary driver behind network cost increases.

How will infrastructure evolve across domains?

Although mobile operators will take different approaches to 5G infrastructure investment, we identified some trends for all network domains.

Exhibit 1 **Growing demand related to new 5G use cases will trigger investment across all network domains.**



1 RAN = Radio access network
2 MIMO = Massive-multiple input and multiple output
3 SON = Self organizing network
4 SaaX = Software as a ...

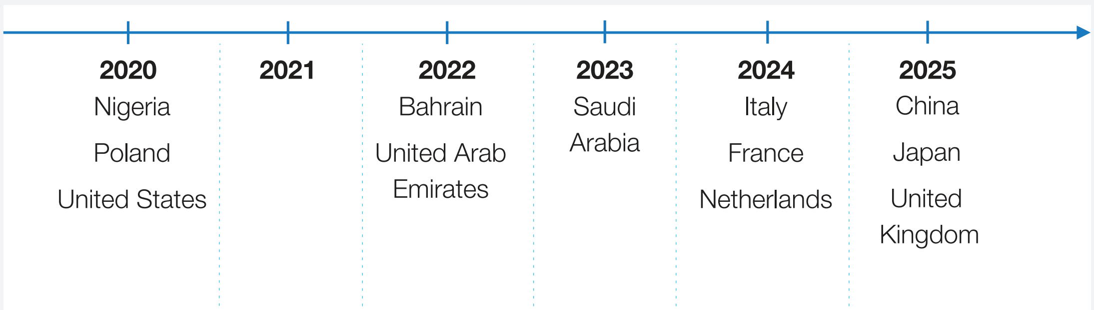
Source: Expert interviews; McKinsey analysis

The race for spectrum will continue across high and low bands

There is still low spectrum coming to auction in low bands in many countries, but most countries will primarily use them for increasing 4G traffic over the short term. Mobile players are testing spectrum from 3.5 gigahertz to 80 gigahertz for 5G. Most, however, are focusing on acquiring 3.5 gigahertz bands over the short-to-medium term, followed by 26 gigahertz and 28 gigahertz bands. (These bands will be the first up for auction in most of the world). The new spectrum will give operators greater bandwidth and a consequential increase in

Exhibit 2

The point when operators begin running out of capacity in at least 50 percent of sites will vary by country[1].



1 Includes examples of select countries. Assumes current spectrum ownership. The years shown represent the point when at least one operator in a country runs out of capacity.

Source: McKinsey analysis

air capacity. Consider the European Union, which is now releasing up to 400 megahertz bandwidth on 3.5 gigahertz.

Even if new spectrum is introduced, mobile operators will need to increase their infrastructure investment significantly to overcome certain limitations. For example, high-frequency spectrum provides extra capacity but comes with much greater propagation limitations. Trials of 3.5 gigahertz spectrum indicate that its range falls to about 400 meters outdoors, compared to the much higher range seen with current spectrum, and has lower indoor penetration. The 26 gigahertz and higher spectrum bands will have even greater propagation limits.

As new spectrum is introduced, mobile operators will need to improve radio interfaces and antennas to increase efficiency of new spectrum. As handset and traffic demand shifts out of legacy 2G and 3G, operators can increase capacity by refarming spectrum from these bands to 4G and 5G. Announcements from operators indicate that most European telecommunications groups are planning to shut down their 3G networks around 2020. In the United States, operators will decommission 2G before 3G.

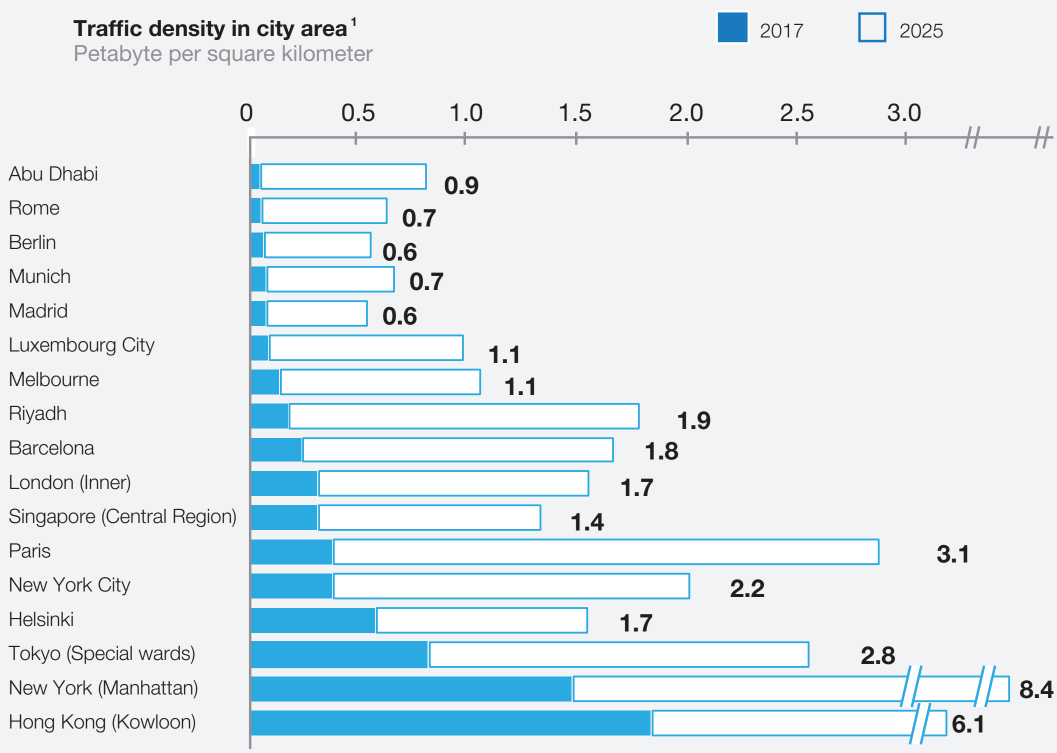
Over the long term, the new spectrum may facilitate large-scale adoption of unlicensed access. Once that occurs, operators will face additional challenges related to controlling spectrum access.

Operators will shift toward small-cell solutions to satisfy urban capacity

In rural and suburban areas, as well as along roadways, operators can handle increased traffic simply by densifying existing networks with macro sites. In many highly populated urban areas, by contrast, they'll need to rely on small-cell solutions for two reasons: a higher concentration of traffic, as measured by traffic load per square kilometer, and the use of higher spectrum bands (greater than 3 gigahertz).

In one recent analysis of a European city, we found that sites with traffic density above 0.5 petabyte per square kilometer per year had a cell

Exhibit 3 **Network traffic density is growing in urban locations.**



1 Unless specified, excluded areas outside the smallest definition of "city," i.e., excluded areas outside "city" in "metropolitan" or "urban" areas.
Source: McKinsey analysis

radius of less than 200 meters, necessitating small-cell solutions. Many other major cities or urban neighborhoods, including Kowloon, Manhattan, and Helsinki, have similar density, and others will be in that situation by about 2020 (Exhibit 3). Many major cities will be at 1 or 2 petabytes per square kilometer by 2025.

Fiber-only transmission will become essential

To improve transmission, mobile operators must undertake large-scale fiberization efforts. In addition to helping networks meet capacity and latency requirements for 5G, fiberization is essential to support small-cell deployment in urban areas.

Core networks will converge

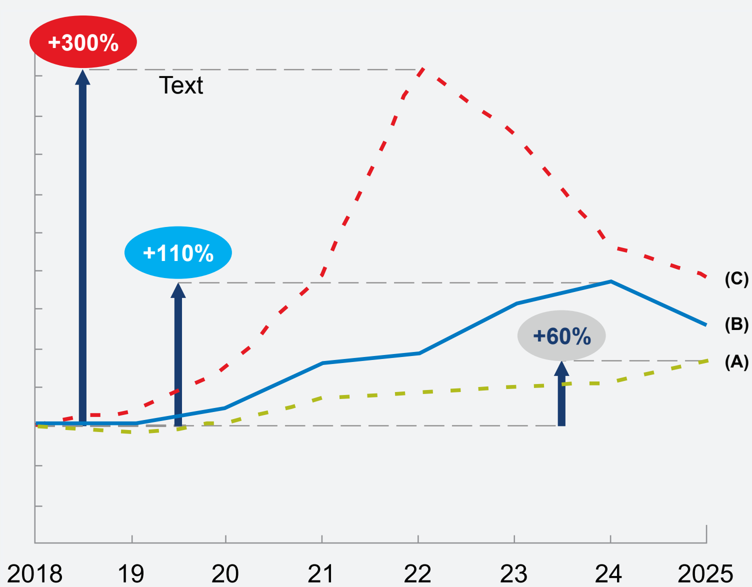
Core networks have been evolving from circuit switching and packet switching toward converged structures, such as IP multimedia subsystems (IMS). In addition to increased capacity and functionality, core networks have benefitted from broader IT advances, such as network functional virtualization and software defined networking. In addition to allowing networks to provide capacity at lower unit cost, these advances support reconfigurability and agility.

The inevitable increase in infrastructure costs

The cost and investments related to traditional 2G, 3G, and 4G networks, unlike those for 5G, will differ over time and depend on local conditions. Operators have at least two options. The first involves a lean-in strategy in which they prioritize 5G investments with the hope of accelerating commercial prospects. The second involves a more conservative approach in which they delay 5G investments as long as possible while existing networks are upgraded.

Even if operators delay 5G investments, they will need to increase infrastructure spending to cope with growing traffic. There is no reason to believe that the historic increase of 20 to 50 percent per year will change. In an analysis of one European country, we predicted that total cost of ownership for RAN would increase significantly in the period from 2020 through 2025, compared to the expected 2018 level (Exhibit 4). For instance, in a scenario that assumes 25 percent annual data growth, TCO would rise by about 60 percent.

Exhibit 4 **Total cost of ownership for mobile access networks will increase[1].**



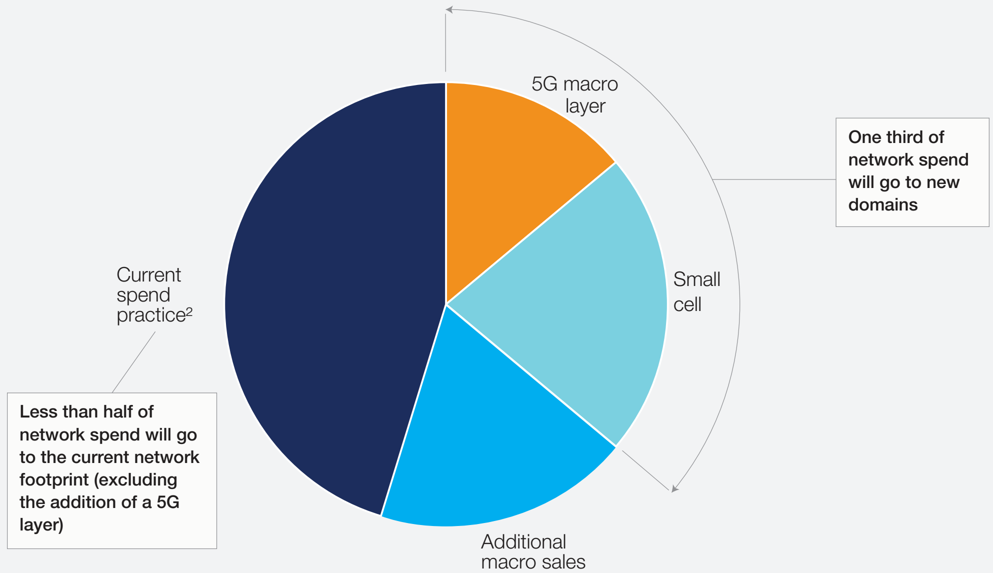
- **Scenarios consider costs associated with legacy network evolution, small-cell densification, and the addition of a 5G macro layer**
- **Scenarios:**
  (A) 25% data growth
  (B) 35% data growth
  (C) 50% data growth

1 TCO includes capital expenditures and operational expenditures for RAN and transmission but not core networks. Data are based on 3 operators in a in a European country. Results are rounded.

Source: McKinsey analysis

Exhibit 5 **The 5G layer, small cell, and additional macro sites will represent a greater proportion of network spend between 2020 and 2025[1].**

Scenario assumes 35 percent annual data growth



1 TCO includes capital expenditures and operational expenditures for RAN and transmission but not core networks. Data are based on 3 operators in a European country. Results are rounded.

2 TCO of current network footprint, including capacity LTE & LTE-Pro upgrades.

Source: McKinsey analysis

We grouped the infrastructure costs for the current network footprint into four areas: upgrades to the traditional network, the addition of new macro sites, creation of the new 5G layer, and the addition of small cells. At present, most expenditures go to the traditional network. However, as operators densify their networks through additional macro sites, small cells, and the 5G layer between 2020 and 2025, these areas will represent a greater proportion of TCO (Exhibit 5).

Mobile operators will need to develop strategies for 5G to cope with this expected growth in network cost. Standard measures will involve cost-saving efforts, but they will also need to explore more alternative approaches, such as network sharing (the joint building of new 5G networks) and new revenue models.

■ ■ ■

Only nine years after the launch of 4G, we're getting ready for the next generation. While each technology cycle brings greater opportunities to mobile operators, it also requires greater infrastructure investment. To maximize their returns on 5G, they'll need to understand how network infrastructure and the associated cost base will evolve over the next few years. With this knowledge, they'll be in a strong position to design an infrastructure investment strategy that best suits their unique needs. ■

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