The Race to 5G

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Arthur D Little

Content

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Executive summary

5G will soon become widely available, as first movers have already launched commercial 5G networks. In addition, operators have already launched business models consistent with Arthur D. Little's five 5G deployment models, which were anticipated in 2017. Operators' current efforts indicate that "gigabit broadband to the home", "future corporate networks", and "digital industrial ecosystems" have been the biggest drivers for accelerated 5G deployment thus far. We expect the next-gen mobile user experience driven by 5G to accelerate towards the second half of 2019.

During the 2019 Mobile World Congress, there was again a strong focus on 5G, with numerous announcements regarding individual operators' pilots, partnerships and devices. However, there has been little transparency on individual countries' actual 5G advancements. To address this, ADL developed its Global 5G Leadership Index to identify the leading 5G nations across two dimensions – infrastructure and level of commercialization.

By assessing more than 40 countries globally, we have identified South Korea as the clear leader in the race to 5G, followed by the US. Regionally, Asia-Pacific appears the most advanced, while the US has more operators involved in 5G and is among the first to launch commercial services. Gulf Cooperation Council (GCC) countries are also jockeying for the lead, while Europe generally lags due to heterogeneous infrastructure and fragmentation, as well as unresolved spectrum allocations, given that auction processes are still ongoing in many countries. All leading countries have in common that they have already allocated 5G spectrum. These countries have enabled operators to roll out 5G networks quickly, many commercially, in 2018, and to trial use cases successfully. Markets with high-performance backhaul infrastructure rate higher, as this capability allows them to roll out 5G faster. Finally, countries demonstrating high tendency to adopt new services, as well as with operators and private enterprises pushing for 5G-enabled digital use cases, are more advanced.

The competition for 5G leadership will further increase in 2019, with dozens of commercial network launches expected worldwide, enabled by new spectrum allocations.

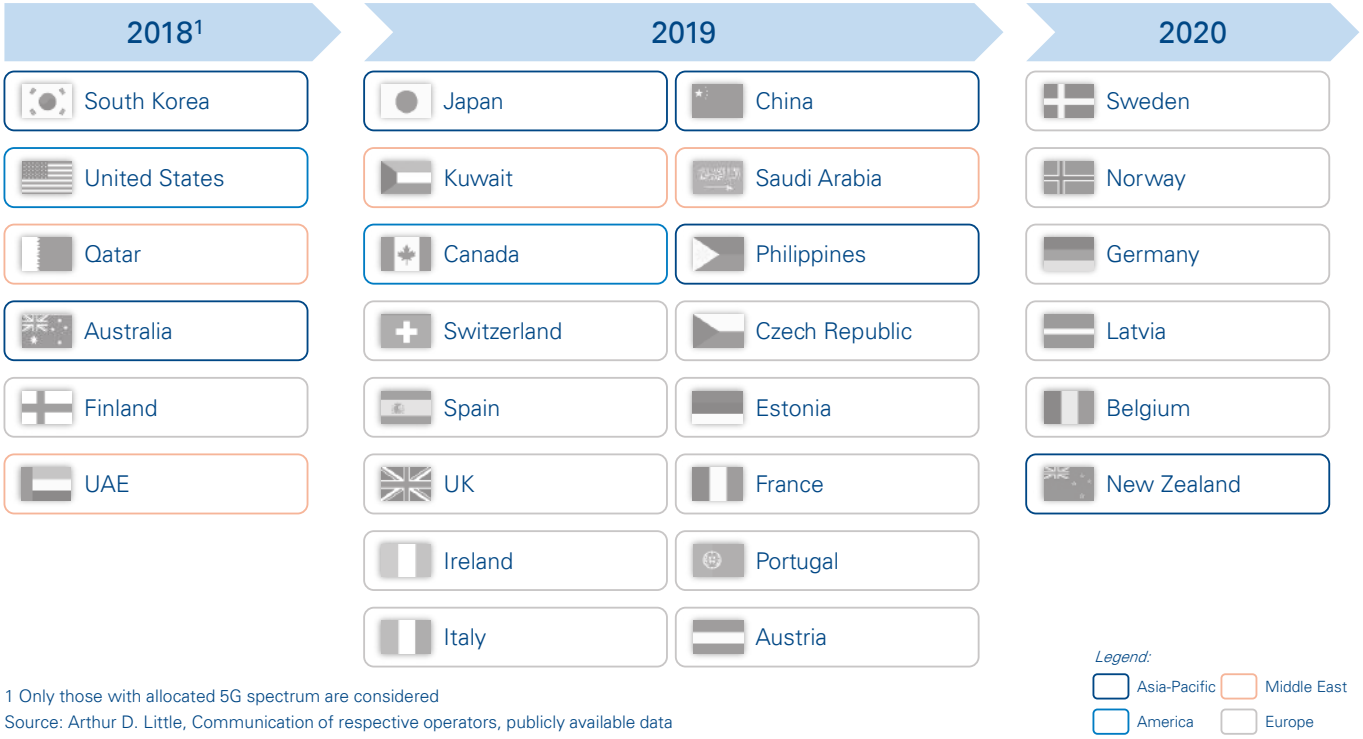
1. 5G will soon become widely available – and first movers have a significant lead

In recent years, we have seen 5G trials from major vendors and mobile operators across the world. In 2018, the first operators switched on their commercial 5G networks with allocated spectrum in Korea, Qatar, the UAE, the US, Australia and Finland. We expect an increasing number of commercial 5G networks to go live all around the world in 2019 and 2020.

5G is no longer futuristic, but will soon become widely available and tested by operators' initial business cases. First movers have a considerable lead, and have positioning themselves for long-term 5G-enabled value creation.

In this report, we examine the progress made in each of the five 5G deployment models that we anticipated in 2017 in our report, "5G Deployment Models are Crystallizing"[1]. Furthermore, we will present the Arthur D. Little 5G Leadership Index, which benchmarks countries across various dimensions to identify the leading countries in the race for 5G, as well as those that must redouble their efforts to catch up.

Figure 1: 5G network deployments

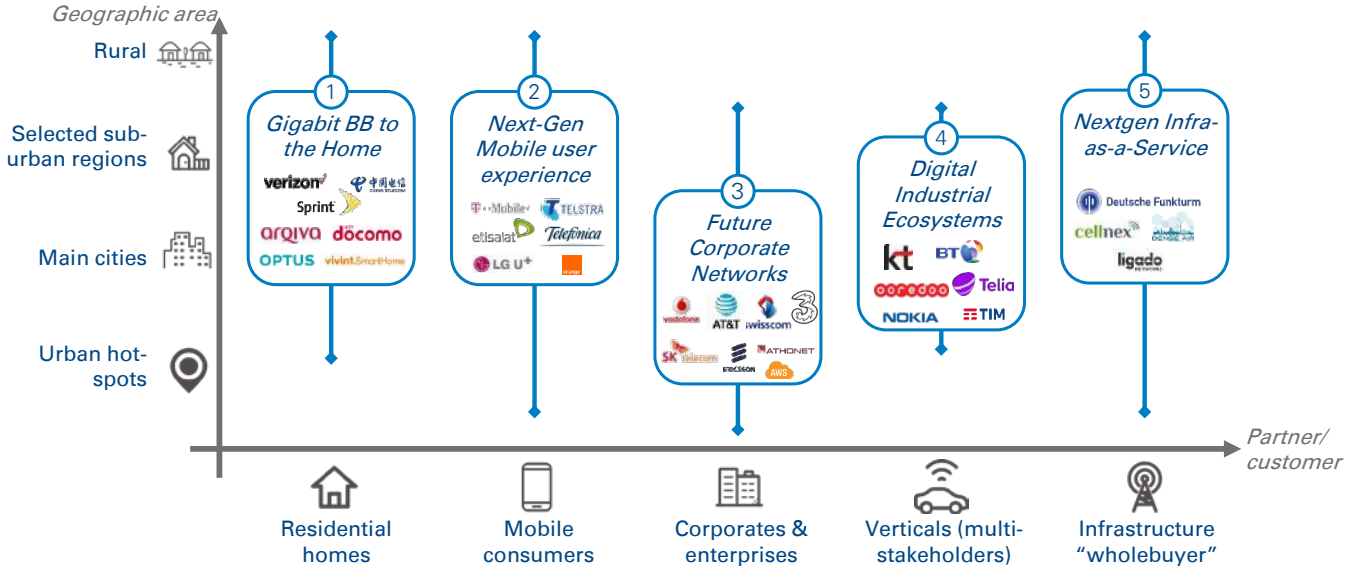


1 Only those with allocated 5G spectrum are considered
Source: Arthur D. Little, Communication of respective operators, publicly available data

2. Arthur D. Little's predicted 5G deployment models have been validated by global announcements

In 2017, we published our widely cited report, "5G Deployment Models are Crystallizing"[1], based on the first steps of operators. We anticipated five 5G deployment models covering different use-cases and customer groups. Since then, we have been closely monitoring global operator initiatives which have further confirmed the validity of deployment models through trials, pilots and commercial launches.

Figure 2: Selected 5G case studies along the Arthur D. Little deployment models



Source: Arthur D. Little, Communication of respective operators, publicly available data

Case study: FWA by Verizon (Model #1)

In our 5G deployment models report we described Verizon's deployment of 5G-based FWA in 11 cities in the US. In October 2018, Verizon commercially launched its 5G-based FWA offer in four cities in the US using millimeter wavelength spectrum in the 28/39GHz bands. With the use of millimeter wavelength spectrum, in combination with massive MIMO and beamforming, Verizon has been able to achieve 300-1000 Mbps in a radius of 1km per site. This allows the system to automatically switch to the strongest beam and therefore increase coverage. Verizon is aggressively marketing this new offer into the market via offering free installation (which may take up to 4 hours), free Apple TV 4K or Google Chromecast Ultra, and a three-month trial free of charge to new customers. If customers are unsatisfied, Verizon will uninstall the service without extra cost.

Figure 3: Verizon 5G FWA Deployment

Source: Company information, publicly available data, Arthur D. Little

1 http://www.adlittle.com/5Gdeployment

Case study: Next-Gen mobile user experience by LG U+ (Model #2)

LG U+ has deepened its 5G site deployments in one of the most competitive 5G markets in the world, having already deployed over 10,000 5G sites together with Huawei. Having switched on its live network at the same time as the other Korean operators in December 2018, LG U+ initially targeted use cases including 4K IPTV and UAV (unmanned aerial vehicle) autonomous drones. Widespread adoption is now dependent on the availability of devices.

Figure 4: LG U+ 5G Network Rollout

Source: Company information, publicly available data, Arthur D. Little

Case study: Olympics in PyeongChang 2018 by KT (Model #4)

KT set up a 5G ecosystem with a platform to connect multiple broadcasters, athletes, sponsors and viewers. Everyone was capable of connecting to the platform and providing or consuming different services. Applications ranged from live holograms for viewers to drone connectivity for additional camera views. Furthermore, KT connected 250,000 users simultaneously in and around the Olympic Village, with the ability to deliver AR- and VR-based applications.

Figure 6: Hologram example of Olympic Games 2018 by KT

Source: Company information, publicly available data, Arthur D. Little

Case study: Smart factory by Swisscom (Model #3)

Medical manufacturer Ypsomed collaborates with Swisscom, using 5G to automate production of injection pens across the entire value chain. It digitalizes goods tracking through indoor localization, using installed sensors and a 5G mobile edge cloud. Additionally, real-time evaluation of machine data and quality inspection by means of augmented reality technologies are enabled by the stability and data throughput of 5G.

Figure 5: Swisscom & Ypsomed smart factory

Source: Company information, publicly available data, Arthur D. Little

Case study: Neutral host 5G densification service by Dense Air (Model #5)

Dense Air, a neutral infrastructure provider, acquired spectrum in five different countries (Ireland, Belgium, Portugal, New Zealand, and Australia) to offer a new class of wholesale shared "neutral host" 5G mobile network densification and extension services. Dense Air thereby complements mobile operators' macro-cells with a dense micro-cell network to increase coverage and capacity in technically difficult or commercially uneconomic locations.

Figure 7: Dense Air densification & extension services

Source: Company information, publicly available data, Arthur D. Little

3. Key 5G rollout drivers

Although a few countries have started to deploy 5G networks, only a few are focusing on the traditional mobile mass market (consumer) to enhance user experience. This is mainly due to still-limited B2C market pull for 5G; we do not expect this to emerge until late 2019 or later as 5G devices become more readily available from nearly all of the major vendors. Furthermore, only a few companies globally have pursued the infra-as-a-service model, and it is, in itself, not yet a major driver for 5G advancement.

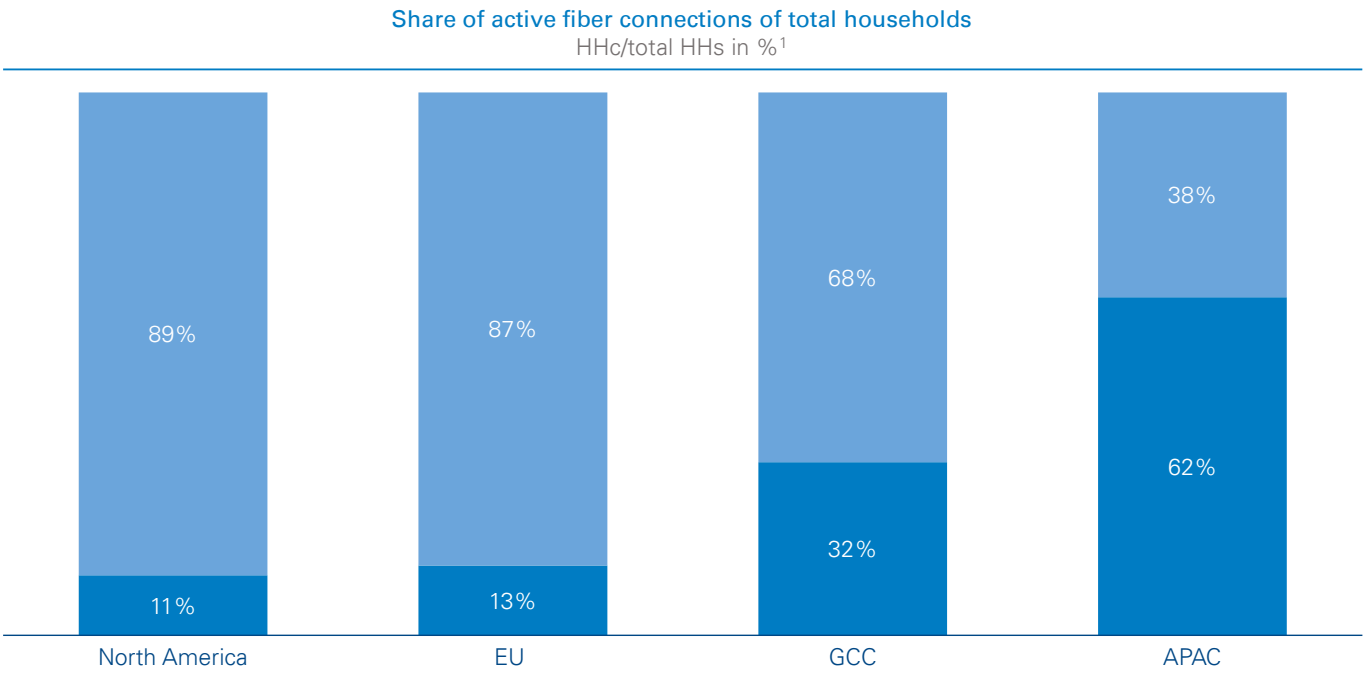
Overall, we see the three deployment models, gigabit broadband to the home (Model 1), industrial digitalization through corporate networks (Model 3), and digital industrial use cases (Model 4), as the key use cases triggering most 5G network advancements.

3.1 Gigabit broadband to the Home (Model #1)

In our report "The race to gigabit fiber"[2],we outlined that fiber coverage and take-up in many countries was far behind leading nations such as Korea, Japan, Qatar, and Singapore. 5G fixed-wireless access (also referred to as fixed wireless broadband) could overcome current roll-out obstacles and therefore help to accelerate high-speed coverage in countries with low fiber penetration. Many MNOs and others have identified this opportunity and focused significant efforts on this use case. We see this primarily happening in North America (particularly in the US) and Europe, a development that is consistent with the limited current fiber penetration in those regions.

Economically, depending on population density, morphology, and other factors, broad coverage with gigabit speeds can be, on average, 40–60 percent less investment heavy through fixed wireless access. However, once deployed, fiber assets provide (at minimum) a complementary or enabling role.

Figure 8: Fiber penetration in different regions



1 Only countries included in the index sample
Source: Arthur D. Little, iDate, European Commission, Only countries included in the index sample

2 www.adl.com/GigabitFiber

3.2 Future Corporate Networks (Model #3)

In our report "5G Deployment Models are crystallizing", we described the advancement of 5G in terms of technical specifications. Compared to previous technology transitions, 5G can address significant problems corporate campuses have with existing technologies such as wi-fi, 4G and fiber/LAN. 5G is the first technology to combine the advantages of all three technologies by enabling higher throughput, lower latency and stronger security[3] than wi-fi or 4G. Furthermore, it removes the limitation of physical connections, as well as low signal reach and handover (wi-fi), for mobility use cases such as smart robots. There is clear demand from MNOs and enterprises across the world that deploy either campus solutions for high throughput in high-density consumption areas, or 5G networks for IoT applications. Many industrial IoT applications, in particular, will rely on the low latency, high reliability and security characteristics of 5G. The hundreds of 5G trials and deployments of these use cases support our hypothesis that campus solutions are an important driver for 5G advancement and roll-out.

Figure 9: Future Corporate Networks – case examples

Source: Arthur D. Little

3.3. Digital Industrial Ecosystems (Model #4)

While future corporate networks are normally deployed on specific campuses, Digital Industrial Ecosystems include multiple partners, providers and end users, typically across wider areas. These digital industrial ecosystems are limited by the current generations of wireless technologies, and will heavily depend on the technical advancements provided by 5G to enable new use cases. Smart cities, for example, require reliable full network coverage that can connect extremely high numbers of devices (handsets, machines, sensors, etc.) within condensed areas, while handling high data throughput with ultra-low latency (especially relevant for autonomous vehicles). They also give operators the opportunity to cooperate with multiple stakeholders, such as universities, hospitals, cities and corporates. The example of Oulu in Finland demonstrates this emergent thesis. Telia aims to create a 5G ecosystem in the Nuottasaari industrial area in Oulu, which will allow local industrial companies and logistics operators to develop new digital operating models.

Figure 10: 5G smart city Oulu

Source: Arthur D. Little

3 Stronger security from 1) Flexible location of network functions 2) Isolation of groups of network functions through network slicing 3) Replacement of functions under attack via cloud-based technologies and 4) Stronger encryption standards than those used in 4G

4. Models #2 (Next-Gen Mobile Broadband) and #5 (Next-Gen Infrastructure-as-a-Service) are evolving as well, albeit more slowly

Adoption of the 5G-enabled next-generation mobile user experience may begin to emerge towards the second half of 2019. The big US and South Korean operators have rolled out their 5G networks across considerable areas, and other countries will follow soon. As device manufacturers begin releasing their new smartphones (e.g., Samsung, LG, Huawei), more and more operators will experiment with 5G mobile services and tariffs. Among the first movers is Telstra Australia, which is offering free device upgrades to the newest 5G Samsung smartphones as soon as they are available. Still, Apple's announcement to only launch 5G iPhones from 2020 indicates that broad adoption might be delayed compared to other deployment models.

The Infrastructure-as-a-Service model (#5) will also follow soon, as new players such as Dense Air (above), as well as established players such as Cellnex and DFMG, are deploying this model in various cities. The deployments have been dependent on cities and institutions' push for neutral infrastructure providers – public initiatives such as the "5GCity" by the European Union in Barcelona may be the necessary kick-start for further deployments via infrastructure providers, which will allow for increased infrastructure density and network coverage at optimized CAPEX levels. Cities such as Vienna are also driving the accelerated 5G roll-out themselves and considering multiple deployment models, among these model 5 in order to ensure sufficient investment in strategic locations and push future 5G use cases .

5. Arthur D. Little's 5G Leadership Index assessed 40+ countries

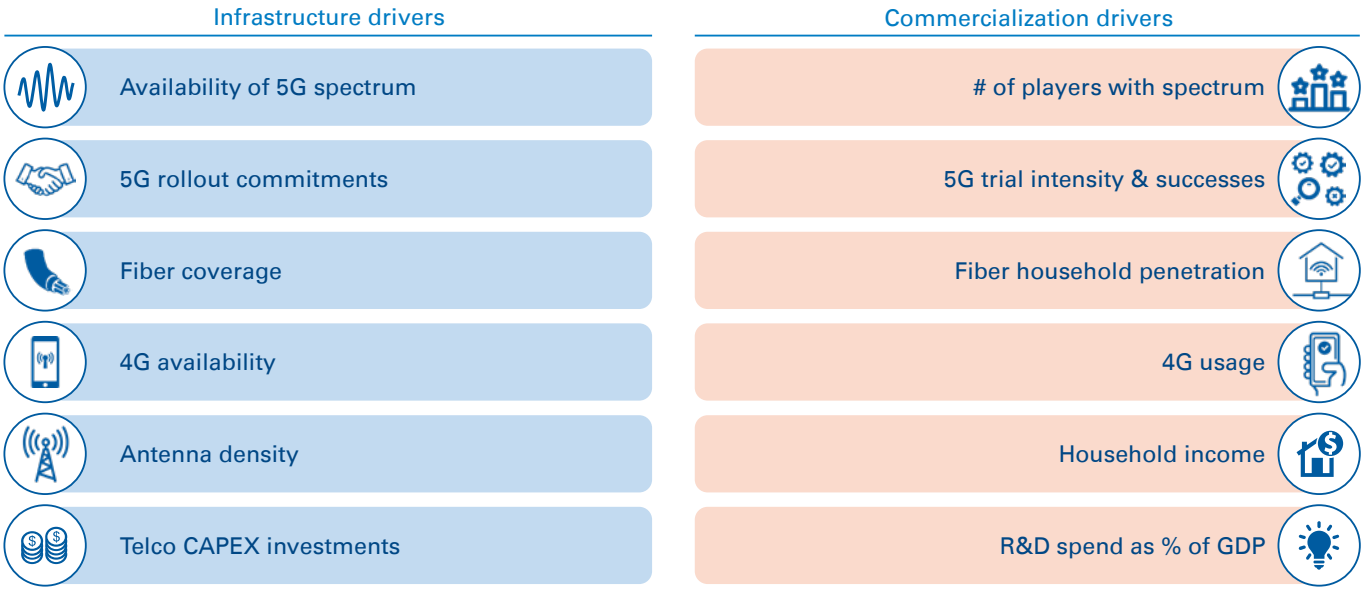
Regardless of technical advancements, operators are shaping the race for 5G leadership on a PR basis. This leads to statements such as "T-Mobile completes first 5G call using 600MHz"[4] , "Vodafone Spain makes the first standard 5G call"[5] and "The world's first 5G phone call made in Tallinn"[6] , all using specific definitions to claim the wording "world's first 5G call". Indeed, the pressure on operators to announce 5G success is an important indicator of the advancements in 5G. This does not, however, tell the whole story.

To address this, ADL has developed a comprehensive 5G Leadership Index to define the 5G statuses of various countries. This goes well beyond the public statements of operators. The 5G Leadership Index consists of two main dimensions, infrastructure and commercialization, which are defined in the table below.

Infrastructure dimension assesses the already-licensed 5G spectrum necessary for 5G leadership, as well as the statuses of 5G roll-out commitments from operators to invest in 5G-related assets. Additionally, the current state of fiber coverage, 4G availability, and antenna density have been assessed, as this indicates the infrastructure basis in a country from existing technology roll-outs, all of which enable a successful and fast roll-out of 5G. Finally, we assess the CAPEX level of the active MNOs in a country to estimate their willingness to invest in their own networks.

Commercialization drivers give an overview of both the market/push and demand/pull for commercial 5G service adoption. By looking at the number of 5G players and the success and intensity of 5G trials, the tendency of operators and enterprises to trial and commercialize innovative use cases is assessed. Furthermore, we include the level of resources used for R&D spending as an indicator of a country's propensity to develop new technologies. Strength of the market pull is determined by analyzing willingness to adopt new technologies – share of households with active fiber connection and 4G usage statistics are the key indicators for this. Household income indicates the health of a country's economy, and high household income is an indicator of a greater capacity to adopt new technologies.

Figure 11: ADL 5G Leadership Index drivers.



Source: Arthur D. Little analysis

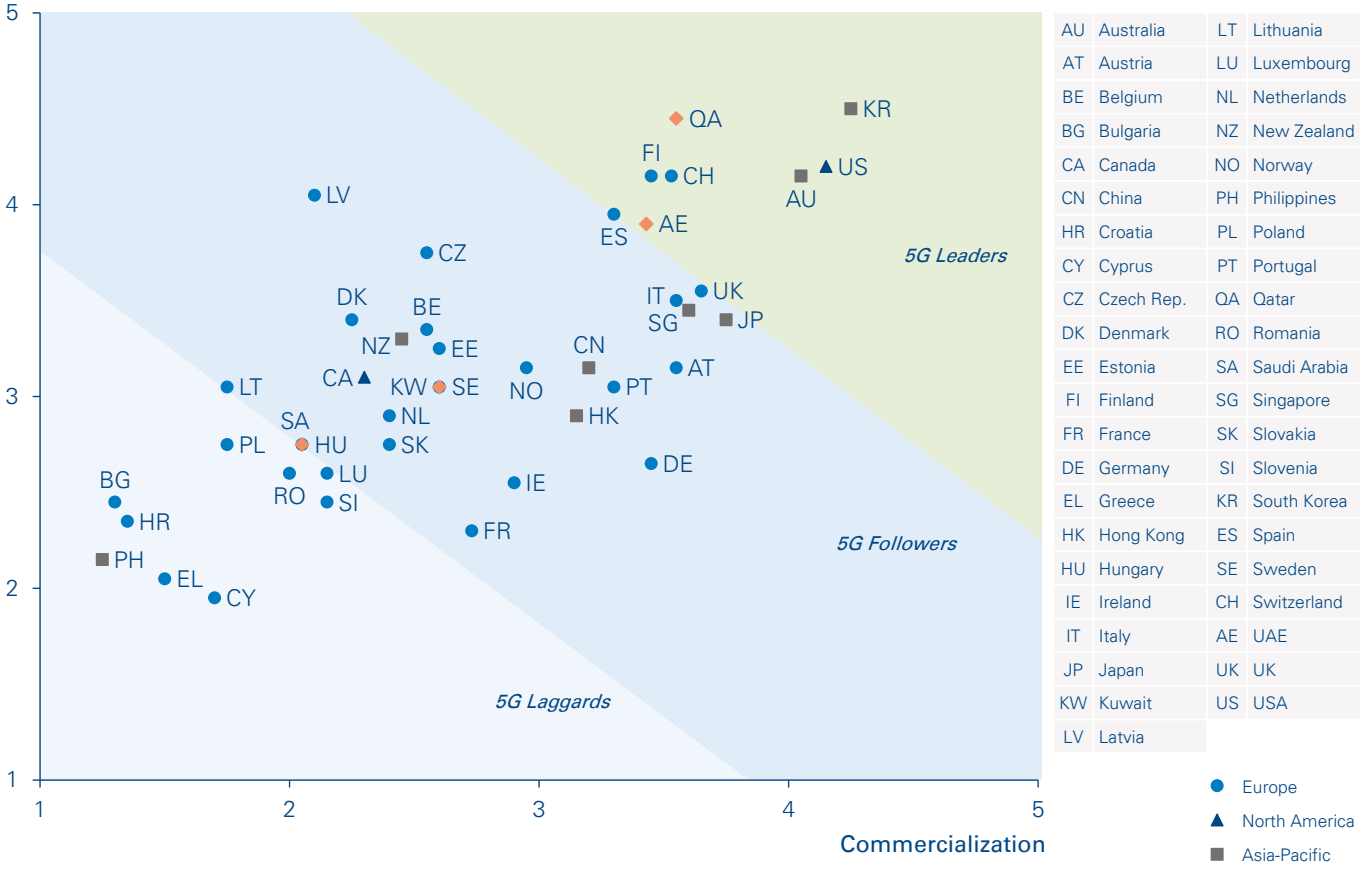
4 https://www.digitaltrends.com/mobile/t-mobile-600mhz-5g-ces-2019/
5 https://bit.ly/2Xq0wKL
6 http://estonianworld.com/technology/the-worlds-first-5g-phone-call-made-in-tallinn/

6. There are eight countries (and four fast followers) leading the 5G race

In this first report, we have assessed 43 countries from four different continents against the 12 criteria described above. The APAC region has advanced furthest, driven by South Korea and Australia. South Korea leads, with the US in close second place, as operators are investing in nationwide coverage and initial commercial deployments. The GCC countries are also ahead, with Qatar and UAE leading the region. Europe, overall, lags due to heterogeneous infrastructure and fragmentation, as well as outstanding spectrum allocations, with the auction process still ongoing in many countries. Only a few European markets, including Switzerland and Finland, are keeping up with the leading countries.

The leading countries all have in common that 5G spectrum has already been allocated, and operators have announced ambitious goals for 5G launch, implemented the first networks, and trialed initial use cases successfully. Additionally, the leading markets demonstrate high willingness to adopt new services supported by high 4G usage and fiber take-up, as well as several competitors to foster fast 5G roll-out. Overall, they do not face any major limitations, be these in terms of infrastructure, regulation, market demand for 5G applications, economic strength, or competitive dynamics.

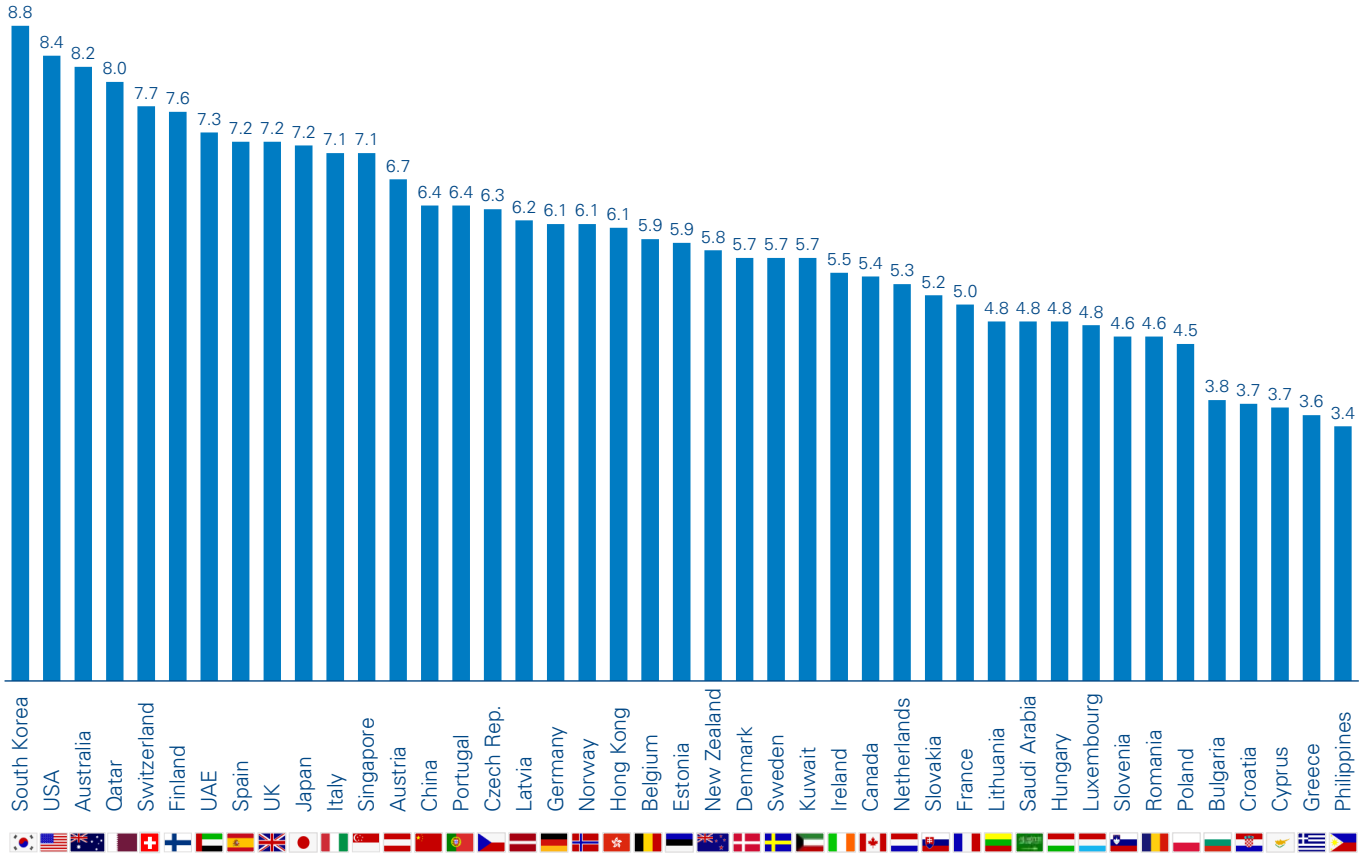
Figure 12: Results of the Arthur D. Little 5G Leadership Index.



Source: Arthur D. Little, Eurostat, World Economic Forum, The World Bank, Euromonitor, ITU, iDate, Opensignal, online research, expert interviews

Beyond the eight leading countries, we see four fast followers. On the one hand are Japan and Singapore, which are very advanced in terms of technology adoption, 5G trials and infrastructure availability, but lack allocation of 5G spectrum – or so far only use it on a temporary/trial basis. However, we anticipate that after regulators award spectrum to operators, these countries will close the gap. On the other hand, the UK and Italy are in a situation in which their regulators have recently auctioned spectrum and operators have jumped to acquire it. They are well advanced in terms of trials and face competitive pressure to roll out their 5G networks, but rank low in some infrastructure dimensions (e.g., NGA coverage and 4G availability).

Figure 13: ADL 5G Leadership Index ranking.
Index (Values of 1-10)



Source: Arthur D. Little, Eurostat, World Economic Forum, The World Bank, Euromonitor, ITU, iDate, Opensignal, online research, expert interviews
Index value: 1=minimum, 10=maximum

7. Commercially mature devices and pricing are critical enablers of broad 5G adoption

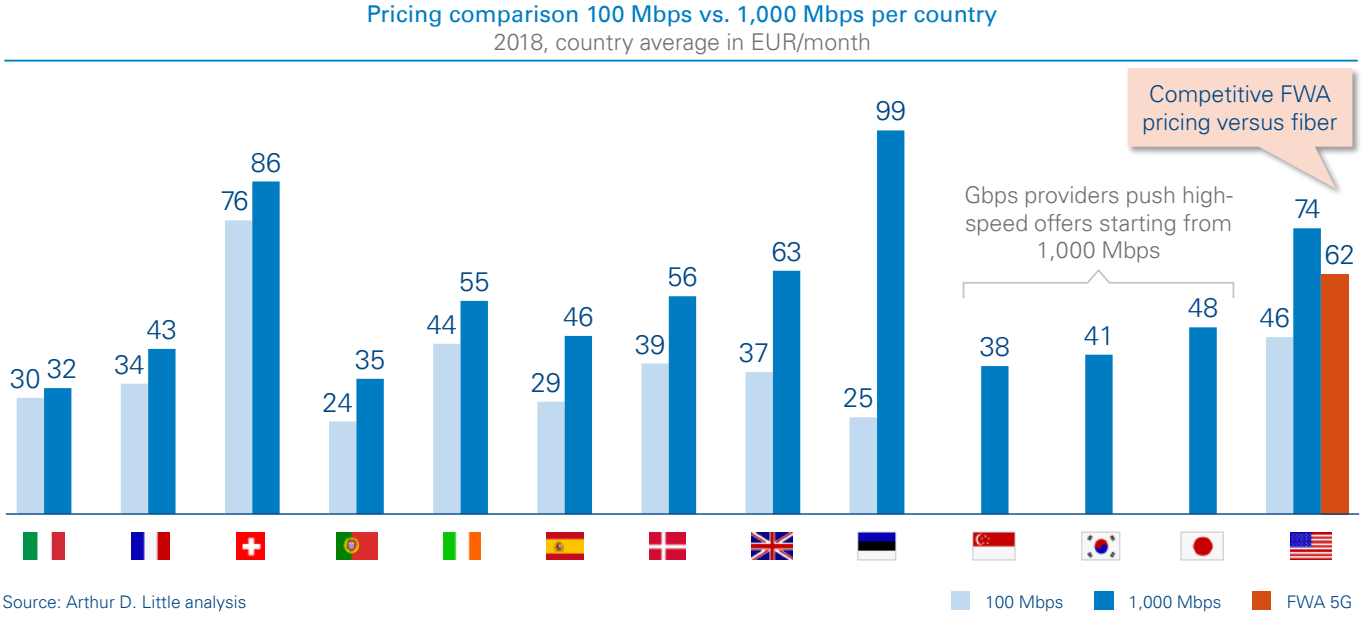
The ADL 5G Leadership Index clearly identifies countries that have taken leading positions in the 5G race. However, there is still a long way to go before we see fully developed and operating 5G ecosystems. Moreover, 5G roll-outs in most countries will still be limited to certain geographic regions, such as large cities and industrial areas, in the short to medium term.

While the first chipsets and necessary radio equipment already enable industrial applications, private users are not yet equipped with handsets to use the new services provided over 5G. However, vendors have started to announce and present the first devices supporting 5G; e.g., Huawei Mate X and Samsung Galaxy Fold, as well as modems announced at MWC 2019. We expect adoption to accelerate in Q3/4 2019 and foresee that dozens of operators will launch 5G services commercially, eventually improving their countries' rankings.

Beyond the need for commercially mature devices, operators must define strategically sound pricing strategies for new 5G services. Fixed wireless access based on 5G has proven to deliver gigabit speeds, and is thus a viable alternative to fixed services. However, premium prices will prevent fast adoption rates, as the perceived value add, especially for B2C customers at this point, is limited and will only evolve over time. The benchmark in the chart below shows that Verizon has competitively priced its 5G FWA offering[7] versus market competition, with >300 Mbps actual download speeds priced between its 100 Mbps and 1,000 Mbps fiber products. Operators charging excessively high prices for gigabit-speed broadband offers risk low adoption rates.

The price point of Verizon's FWA offering is also below the gigabit fiber offering from rival AT&T (80 EUR), which is also available in many of the same cities, e.g., Houston. With a heavy push for market adoption in selected cities through discount campaigns, and the offering made more attractive by free installations, we expect the result to be fast uptake of 5G in those areas.

Figure 14: Verizon FWA pricing



Source: Arthur D. Little analysis

7 Which promises 300-1,000 Mbps download speeds

Conclusion

While the leading countries have a head start, there is still time for followers, and even laggards, to make up lost ground by learning from others' trials, and then focusing on the most promising emerging business cases and targeting their network roll-outs appropriately. We believe operators should invest in business cases built around three deployment models – gigabit broadband to the home (#1), future campus networks (#3) and digital industrial ecosystems (#4). This will significantly improve roll-out effectiveness and allow operators to have commercially viable solutions in place, upon which they can drive further network upgrades and business cases over time. Governments looking to improve their countries' stature must accelerate spectrum allocation processes at attractive costs to enable operators and enterprises within their jurisdictions to join the 5G race. In doing so, they will enable their countries to become leading 5G markets, with all of the benefits that implies.

We believe 5G will drive the take-up of innovative services and could transform telco operators from simple connectivity providers into broad service and solution providers in multiple industries. At the same time, 5G opens up opportunities for non-telco players, in particular enterprises and neutral urban infrastructure providers, to enter the mobile arena to participate directly in shaping the future digital ecosystem of other companies, cities and whole countries.

The competition for 5G leadership will dramatically increase in 2019, with significant commercial network launches expected worldwide, enabled by new spectrum allocations and driven by increased commercial demand.

The race is most certainly on!

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Arthur D. Little

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