

5G Indoor: Trends and Challenges



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Executive summary

5G great capabilities, such as ultra-high speed, very low latency and possibility of network slicing, will be great assets for the development of consumers usages and industries use cases. 5G is expected to drive the mobile data growth over the next decade.

While both 5G and global mobile data traffic will strongly increase, data traffic will continue to be generated indoor for more than 75%.

Indeed, there are true needs of a reliable, efficient, and secure indoor 5G, both for consumers usages and B2B use cases, from massive connectivity applications that could include asset management, logistics, smart buildings, to critical connectivity such as remote control, automated vehicles, remote e-Health, and passing by wireless devices, VR and broadcasting.

Since indoor is where most of the traffic is generated, indoor is the most likely to be the incubation place for innovation and businesses of new case. Then, to support inno-

vation, a very good indoor coverage of 5G networks is needed.

However, the challenges for 5G connectivity remain indoor because of technical and non-technical issues. Indeed, some of 5G frequencies are higher but also have a poorer penetration, which is made worse by the standards of new buildings and renovation and by the topography of some busy areas. Also, willingness of operators and the complex approval process to deploy 5G in Europe from a regulatory point of view are barriers to a favourable 5G indoor development.

Levers could be used to address these challenges, such as the allocation of EU subsidies to 5G indoor scenarios, regulations to reduce the operators 'burden and measures to accelerate the approval process to allow the efficient development of 5G indoor.

In short, Europe leaders and regulators should consider 5G indoor as a priority.

2. 5G transforming mobile network



2.1. 5G is today evolving towards advanced 5G and is transforming mobile network.

Among the many advantages of 5G it is possible to highlight its ultra-high speed, its density, the significant reduction in latency, its security and reliance, and the possibility of networks slicing. All of these characteristics allow the emergence 5G of new services, and for operators, the possibility of offering dedicated uses to businesses.

From an economic point of view, 5G is a growth lever for economic development, as a disruptive innovation. It has many advantages and benefits both for consumers and industries (construction, mining, public services, health, transport, smart cities, etc.). In fact, 5G is expected to generate \$65 billion in gains in the industry sector from 2035.

For the moment, 5G networks are widely developed in many countries. According to the European Commission, 72% of European inhabited areas are covered by 5G in 2022.

In Europe, industrial applications are identified as the key lever for 5G. In Germany for

instance, a trial in a car factory has shown that 5G could be an asset considering the stable and predictable latency that is required for operation in such industry.

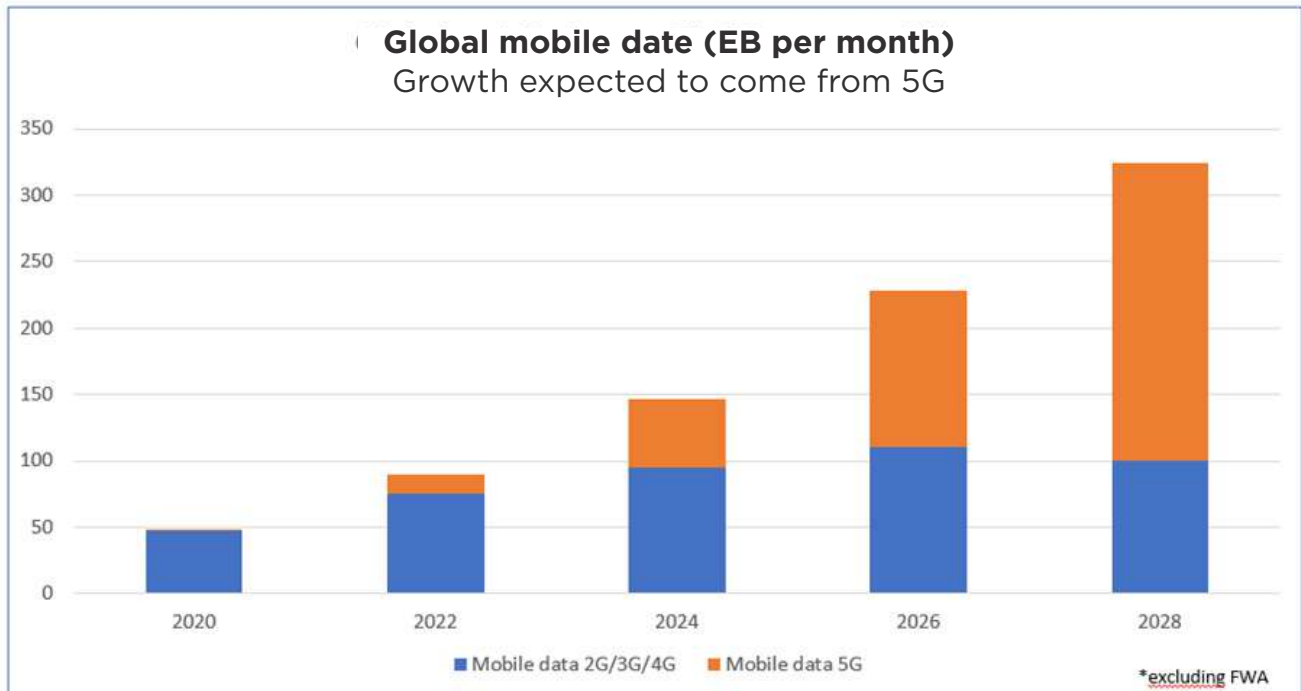
In France, a global leader in providing digital energy and automation solutions has deployed an industrial indoor 5G network as part of an experimental program. This trial validated various use cases for 5G in manufacturing sector, including augmented reality,



remote everywhere and real-time data access. From all points of view, be it B2B or B2C, 5G is considered as a major asset.

Total global mobile data traffic (B2C and B2B) has reached 90 EB per month at the end of 2022. By the end of the decade, it is expected to reach 340

EB per month, meaning it will be multiplied more than 4 times. It seems that 5G will drive this mobile data growth, since 5G's share of mobile data traffic at the end of 2022 was about 17% and that it is expected to reach 70% at the end of the decade.



Source : Ericsson

If 5G develops smoothly according to the planning of each region, the ratio of other types of

subscriptions will continue to decline, mobile subscriptions are expected to reach 5 billion.

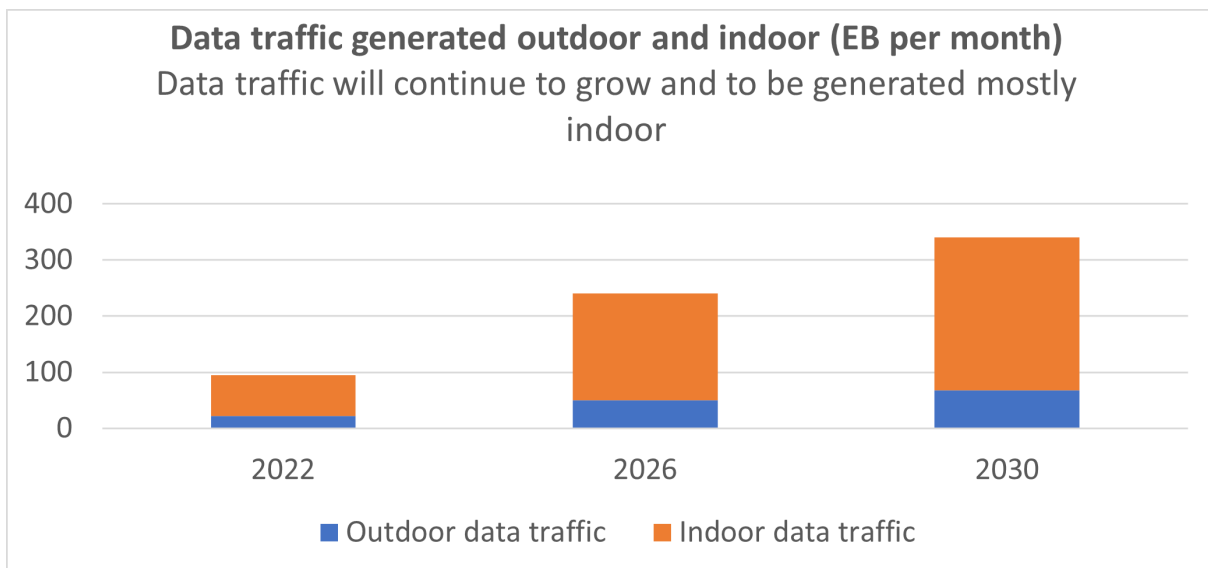
3. 5G indoor coverage of utmost importance



3.1. Most of the mobile data traffic is and will continue to be generated indoor.

Today, according to IDATE information based on data and interviews with European operators, 75% to 80% of the data traffic (B2C and

B2B) is generated indoor and this is expected to grow in the next years.



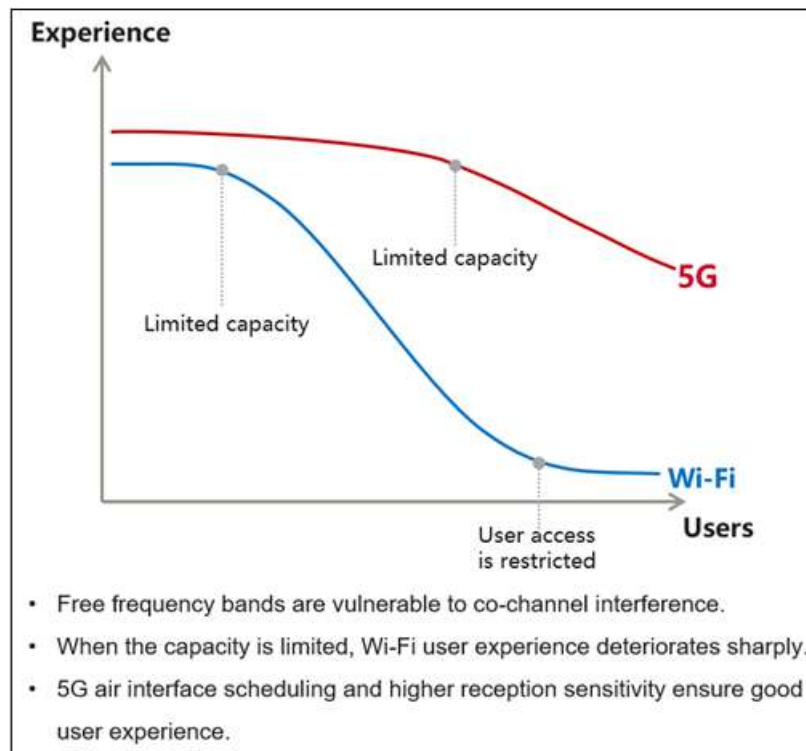
Source: IDATE

Some opinions think that this indoor data traffic should be addressed by Wi-Fi, not by 5G networks.

However, in terms of user experience, Wi-Fi is much more easily bottlenecked than 5G, especially as the number of users increases in the public indoor scenarios. This is because the frequency modulation technology of Wi-

Fi leads to severe self-interference, therefore network capacity cannot be effectively increased by simply adding Wi-Fi APs. Not to say that Wi-Fi could lead to the troubles of access authentication and network switchover, as well as cybersecurity risks.

In summary, 5G in indoor scenarios could be recognized as an irreplaceable value.



Source: IDATE

In this regard, 5G indoor is expected to be equally qualitative and efficient indoor than outdoor.

3.2. Needs of 5G indoor coverage for consumers

With already 1 billion users around the world, 5G networks are expected to be efficient and reliable. Actual applications include augmented reality, virtual reality and mixed reality that can be delivered to wireless devices, streaming of high-resolution video of which training and education videos but also entertainment...

Also, it is clear that consumers quickly adopt new technologies, and there is no doubt that they will find new ways to use 5G network at its peak. Consumers will expect 5G indoor coverage to be particularly efficient due to the new applications that will be made.

New applications may include wireless streaming cameras with 4K and even 8K resolution, or 360° videos, wireless security cameras, support for metaverse uses, cloud gaming...

It was noted that new services like cloud gaming and AR apps see a strong increase of usage hours per week by 5G users, and that 5G users are more likely to spend more time using VR content than 4G users. That means that 5G is about to be used indoor a lot more than 4G.

Main spots where 5G indoor coverage should be applied are subway stations, where millions of



3.3. Most of the mobile data traffic is and will continue to be generated indoors.

passengers and staff are passing by subway stations and where there is a high demand for high quality and uninterrupted streaming traffic, both in stations and trains.

Main spots should also include stadiums, as it was already done for the FIFA World Cup in Qatar at the Al Bayt Stadium. This use case has shown that this 5G-powered tournament saw a mobile data traffic global record of 36TBn with 5G speeds that Main spots where 5G indoor coverage should be applied are subways stations, where millions of passengers and staff are passing by subway stations and where there is a high demand for high quality and uninterrupted streaming traffic, both in stations and trains.

Main spots should also include stadiums, as it was already done for the FIFA World Cup in Qatar at the Al Bayt Stadium. This use case has shown that this 5G-powered tournament saw a mobile data traffic global record of 36TBn with 5G speeds that reached a peak of 2Gbps.

Airports or train stations are also locations where 5G indoor should be applied.

From a B2B point of view, 5G indoor is also at stake in many industries.

Unlike B2C applications, for which the mobile network is overlaid with previous generations technologies, most of 5G B2B deployments are green-field deployments. This means that

For example, in the US, some airports are



already covered with indoor 5G, and this results in smart connections across areas such as passenger processing, baggage processing and asset management. Indoor coverage is here particularly important since terminals and parking garages are often very high and large.

Shopping malls are also places that must be covered with 5G indoor: customers are expecting the connectivity to be the same as outdoor during their shopping. It can be challenging in such large places with many floors and needs in reliable connectivity for both customers and shops.

neither indoor nor outdoor deployments can rely on previous generations as the network foundation. Therefore, in order to meet the requirements of B2B applications, indoor deployment should be a priority from day one.



Source: IDATE

3.4. Strong needs of 5G indoor coverage on B2B markets

5G would allow large application in industries:

- New augmented reality, virtual reality and mixed reality delivered to wireless devices for manufacturing
- New smart building technologies to track and manage the indoor environment (for example, temperature sensors, motion sensors, light sensors all tied to the HVAC units, automated window shading and lighting systems): massive IoT applications
- Intelligent automation and real time data in manufacturing
- Object tracking, especially needed for example in a hospital (tracking beds, equipment carts, individual portable machines), airport, factories, distribution centres...
- Remote control of robotic machinery and automated vehicles, remote surgeries in hospitals: critical IoT applications
- For venues et conventions centres



In the health sector, hospitals would be very demanding concerning 5G coverage. Indeed, hospitals are usually very busy, with millions of visitors each year, including patients, staff and visitors. These people look for mobile connection and data services to connect with their close ones, which is especially needed in a hospital where they can be in a position of vulnerability. Also, the critical IoT in hospitals have special needs in terms of ultra-high reliability and ultra-low latency. For example, remote surgeries need real-time control and highly reliable coordination between humans and machines.

In factories, 5G could help to perform many tasks that are today mostly done manually, such as managing assets, checking on employees and visitors regarding safety rules, monitoring different floors, optimising performance and energy consumption of devices, transfer, and processing of large quantities of data... Smart factories are expected to be more and more developed thanks to 5G indoor coverage. It is worth to notice that most of the enterprise 5G deployments are green field deployments.

4. Challenges of 5G indoor connectivity

Difficulties lie in both technical and non-technical aspects.

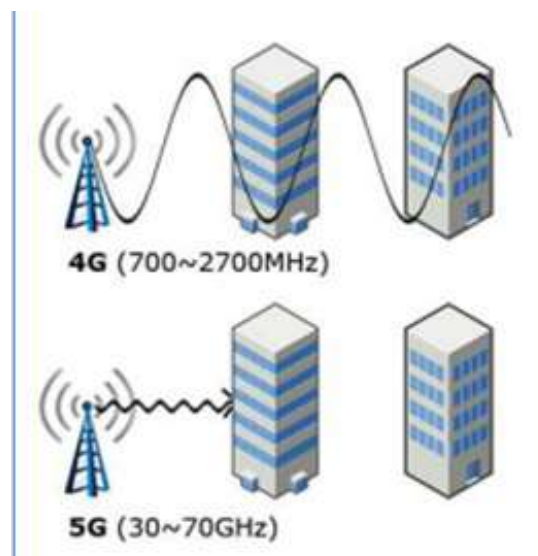


4.1. 5G is less likely to be well transmitted indoors

5G would allow large application in industries:

5G has higher frequency bands and poorer penetration. It is more difficult to cover indoors from outdoors. The introduction of

such a high-band spectrum makes it challenging to rely on outdoor networks for indoor coverage.



4.2. Unsuitable buildings

Studies have shown that the High Environmental Quality standards, today mandatory for new buildings, has a side effect. Indeed, if they require the use of highly insulating materials in both construction and renovation, in order to limit energy loss, it also reduces the penetration of radio waves.

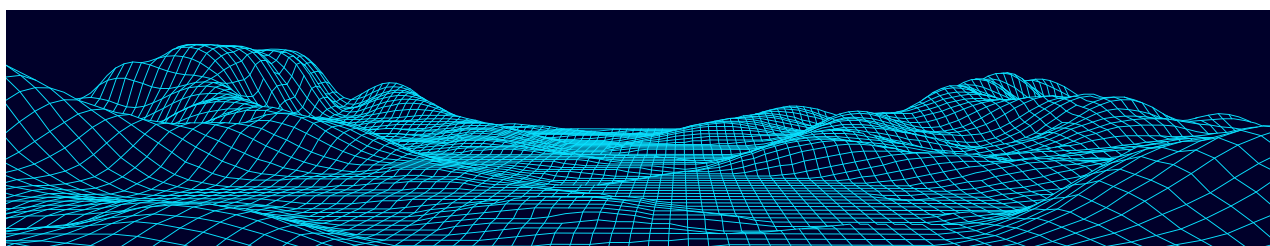
The reduction of the penetration is high for many materials used for buildings construction for supporting walls, pillars, and floors, such as ceramic, concrete and armoured glass. It is very high for metal, which is used for some buildings installations such as elevators or reinforced concrete.

Moreover, there is also a problem of distance from the ground concerning very high buildings. Difficulties has been raised with high-rise building, especially when the height

exceeds 50 meters (usually at least 10 floors). It has been found that for 5G at 3.5 GHz (80 MHz bandwidth), poor coverage results in 23% of cases and almost non-existent coverage in the rest.

It seems to be a lack of understanding of the issue in Europe. First, the need of indoor wireless coverage is not considered during the design or renovation of buildings, while there are now always built considering HQE standards. Second, it seems that building owners do not address the problem after the building is done and even though less qualitative connectivity is reported. Yet, mobile operators do offer solutions.

4.3. Challenging topography



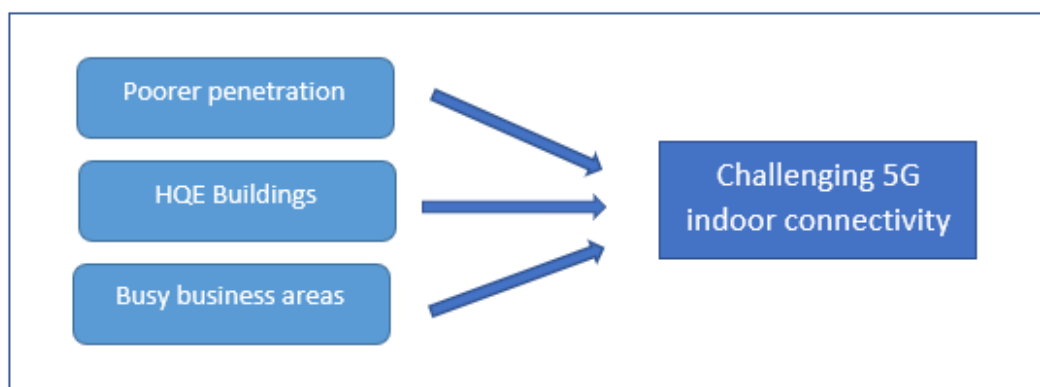
Indoor 5G is particularly challenged in some business areas: the towers being mainly located in those busy urban areas, the proximity of those buildings accentuates the obstruction of 5G frequencies.

Moreover, in those areas, congestion of the

network can occur due to increasing mobile data consumption.

5G networks should then be constructed in such high-value areas and indoor 5G connectivity should be seriously considered.

Technical aspects challenging 5G indoor



4.4. Challenging business environment to increase investment



The EU regulation has created a pro consumer environment. Hence, the retail pricing has been pushed down due to the heavy competition. Most European telecom operators have been facing lower EBITDA margins than in other part of the world.

It remains that in Europe, telcos have CAPEX to revenue ratio much higher than other

telcos worldwide. Despite this comparatively higher effort made by European players, overall CAPEX remains slightly lower and hence impact potential 5G deployment.

However, 5G indoor investment shortage is especially serious in PLMN scenarios that are not 7 x 24 hotspots, such as parking lots and stadiums.

4.5. Complex process of obtaining 5G sites in public indoor scenarios

The process of obtaining 5G sites in public indoor environments is complicated and is a major challenge for those in need of 5G networks. The complexity of the approval process and the excessive restrictions imposed by public places administrators have made it difficult to meet the high demand for

5G connectivity in these environments.

The current review of the Broadband Cost Reduction Directive should hopefully address this issue in the near future.

Non-technical challenges 3.4 and 3.5 most occur in PLMN scenarios.

5. Current Status in the EU



Europe is late in the deployment of 5G compared to some leading countries. According to the European 5G Observatory, only around 250 000 5G base stations were deployed in the European Union, while this number amounts to 1 850 000 in China and 215 000 in South Korea. The 5G base stations ratio per 100 000 inhabitants is of 57 in the European Union, against 132 in China and 415 in South Korea.

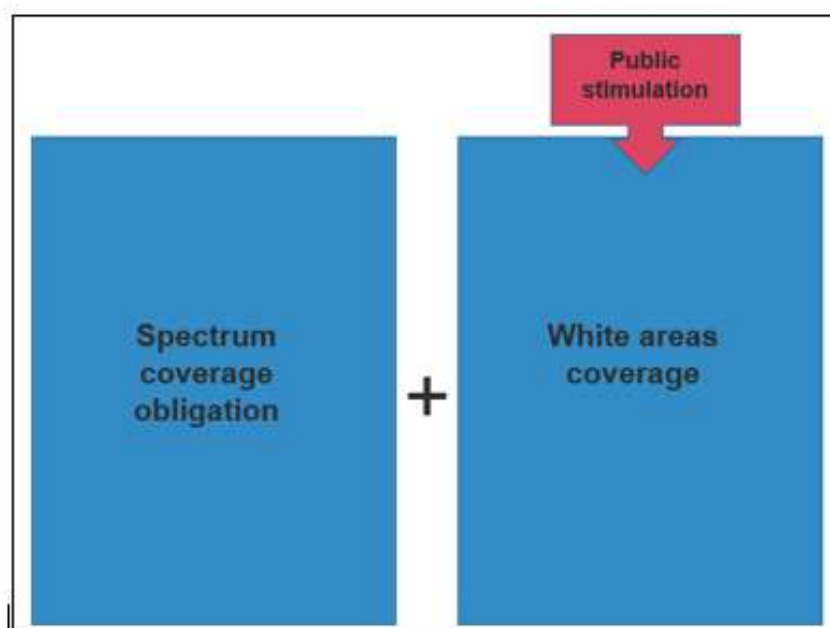
The obstacles to 5G commonly raised are diverse: fears about data protection linked to the fear of loss of sovereignty, persistent questions about the impact of 5G on health, questions about the ecological impact of the technology and equipment, etc. Most of all, financial and regulatory challenges are still

pending in the European Union.

As demonstrated earlier, it appears that indoor 5G could be the key to such developments. However, this is even less addressed in Europe than outdoor 5G. Today, the indoor coverage in EU cannot meet the user experience in 5G era and cannot stimulate the 5G deployment acceleration. EU 5G action plan does not seem to address the 5G indoor challenge.

To stimulate investment, the regulation is currently focusing on spectrum obligation (link to the operator licences) and public stimulations to cover white areas through co-investment schemes, public-private partnership, network sharing authorization or public subsidies.

Current statutin EU to accelerate 5G



6. Case studies of South Korea and Thailand



South Korea was the first country to commercialize 5G network in 2019. The milestone of two million users was passed in four months, and now exceeds 5 million. Operators have seen a 3 to 4% growth in their turnover, which suggests interesting and similar prospects for their European counterparts.

South Korea had made trials for vertical industries as media, public safety, smart factory, smart cities or autonomous vehicles. Aware that most users spend more time indoors (home or at their workplace), Korea has deployed 5G considering the challenges indoors 5G signals that can occur.

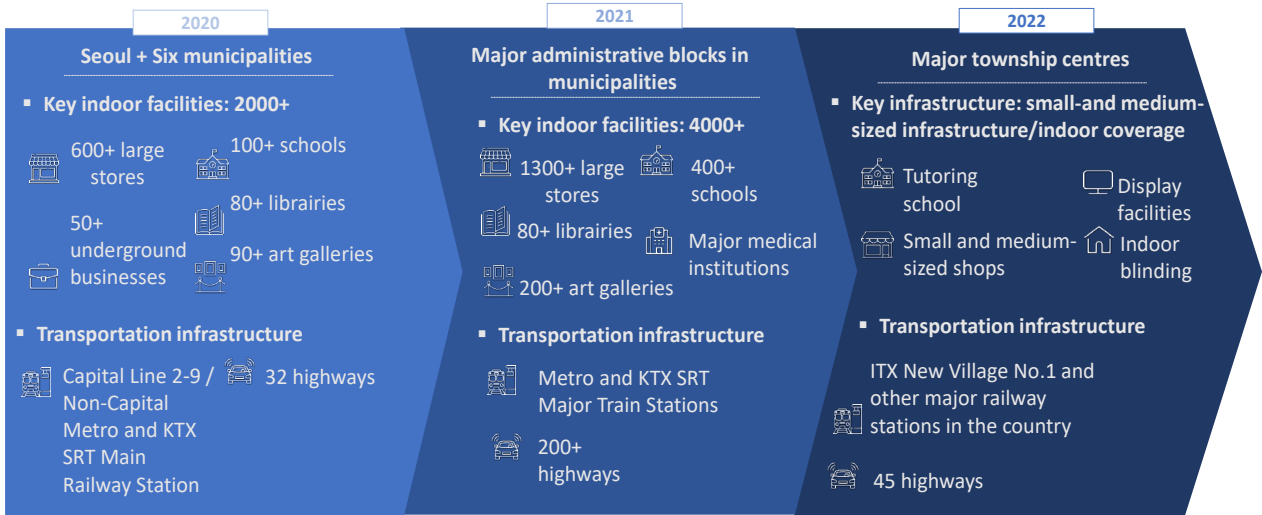
Deployment pace of 5G indoor coverage was particularly efficient from 2020 to 2022:

- In 2020, more than 2000 key indoor facilities were covered in Seoul and six other municipalities. The facilities covered were large stores, schools, art galleries, underground business, and libraries.
- In 2021, 85 major administrative blocks in municipalities were covered, leading the number of key indoor facilities covered to more than 4000. These facilities were large stores, schools, art galleries, libraries but also major medical institutions.
- In 2022, small- and medium-sized infrastructure/indoor were covered, such as tutoring school, display facilities, small- and medium-sized shops, indoor blinding.

The three major providers are now planning to expand their coverage by installing 5G base stations in over 2000 sites in Korea, including airports, department stores, subways, and office buildings.

Also, most of the transportation infrastructure are now covered: capital and non-capital line of metro, main and major railway station and highways.

Deployment pace of 5G indoor coverage and transportation line coverage for three operators in South Korea



The regulations in this country require that the indoor 5G coverage should be developed in parallel with outdoor, which could explain why they are particularly in advance for 5G indoor applications.

In Thailand, the Government strategy regarding 5G involves both indoor and outdoor

coverage. One strategy concerns 5G for social development and especially development of 5G Telehealth: community, general, and central hospitals are particularly targeted.

The regulations in this country also require that the indoor 5G coverage should be developed in parallel with outdoor.

7. Levers to address challenges of 5G indoor



To address the technical challenges associated with weak 5G indoor coverage, in-building systems (IBS) must be adopted. In scenarios such as large buildings, super high-rise buildings, and subways, independent IBS is the only choice for enhanced coverage.

The key to retaining VIP users is providing a

good indoor user experience, as 80% of user complaints come from indoor users. The P3 test also shows an increasing proportion of indoor users. With the emergence of mobile payment services, users have higher requirements for indoor network coverage.

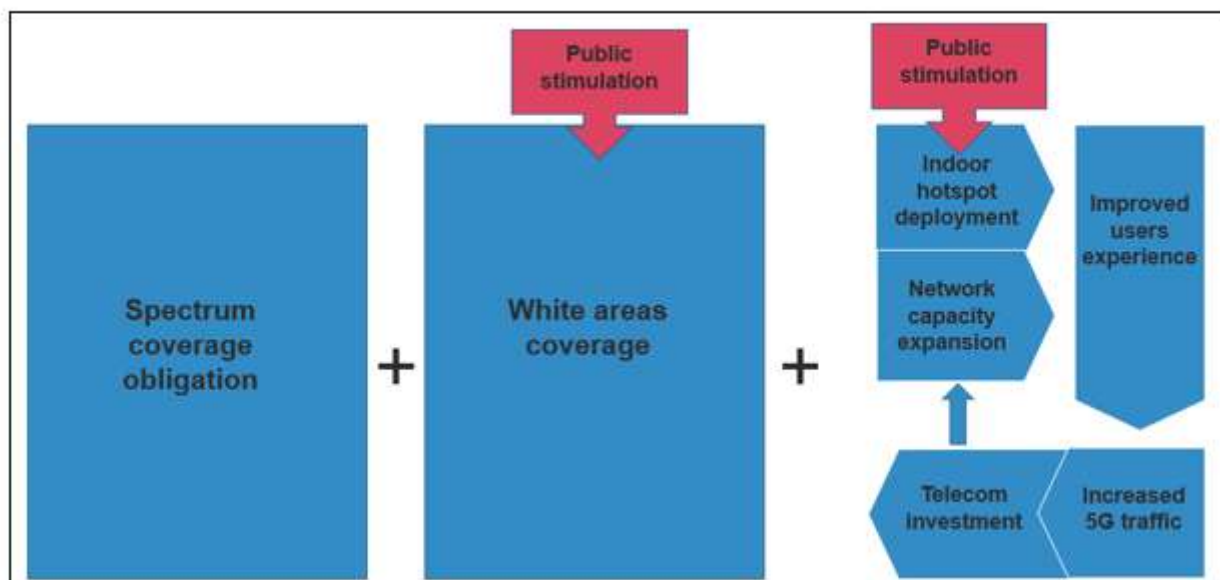
To achieve this, the best in-building solutions must be considered, which provide:

1. Better user experience: Supports multiple combinations of 5G frequency bands, including C band, and provides gigabit experience and 10GE capacity.
2. Visualized management, proactive alarms for network faults, and real-time monitoring of network quality and status.
3. Multi-service capability, supporting one network for multiple purposes, and providing network capabilities such as positioning and IoT.
4. Sustainable evolution to future mobile intergenerations (5G-Advance, 6G), improving network performance and expanding network services without changing points or cables.

For non-technical challenges that mostly take place in PLMN scenarios, We believe that setting public stimulation for better indoor coverage will improve the user experience, either through absolute network performance (speed and latency) or thanks to new services made available indoor. This improved

experience will increase traffic that will itself trigger telecom investment by operators and lead to network capacity expansion, therefore, accelerate the overall 5G pace. This virtuous cycle should become the third pillar to support EU investment in infrastructure.

Measures to stimulate 5G Indoor in EU



Major stimulation measures could be:

1. EU subsidies should be allocated to 5G indoor scenarios, which is where traffic really takes place. For instance, it might be suggested that EU set up a program similar to Wifi4EU, which is an initiative allowing municipalities to get a voucher financing free Wi-Fi hotspot in their public spaces. Such a program could be proposed to help EU local authorities to stimulate 5G indoor infrastructures.
2. Telecom regulators should set up a 5G network experience benchmark. The results of the benchmark should be made public to show the quality and stimulate the competition ...then encourage 5G indoor investment.
3. It could be useful that European telecom regulators were to develop policies to reduce/waiver the rent for indoor mobile network deployment, with the objectives to reduce the operators' burden and to guarantee them a cost-effective activity, which is today at stake.

This point is particularly important when considering the deployment of 5G indoor in public places.

This type of measures could be taken in a legal framework such as an European directive. For example, the Broadband Cost Reduction Directive, that was implemented to favour the rapid deployment of high-speed broadband, is being reviewed to take into account new technologies and market developments: it could be relevant for this Directive to take into account the development of the 5G, especially indoor.

4. Telecom regulators should accelerate the approval process for indoor deployment in public places, to adapt to the growing needs in terms of coverage and to the new use cases that are developing more and more quickly nowadays.

8. Conclusion: improving 5G indoor coverage should be a priority in Europe



To conclude, as 5G indoor will be a lever both for consumers activities and for industries new use cases, it seems that improving the 5G indoor coverage should be a priority for operators and public authorities in Europe, just as in other leading countries in the world. 5G indoor coverage quality will create a virtuous cycle of infrastructure investment.

As indoor is where traffic is generated for a vast majority, it is the incubation soil of innovation for both B2C and B2B2C use cases. 5G indoor coverage will contribute to the emergence of a new services ecosystem. 5G indoor coverage should actually be developed in parallel with outdoor.