



DOCUMENT

195.10.01

Small cell siting challenges and recommendations

August 2018



www.5gamericas.org



www.smallcellforum.org

Small Cell Forum accelerates small cell adoption to drive the wide-scale deployment of small cells and encourage the delivery of fully integrated HetNets.

We are a carrier-led organization. This means our operator members establish requirements that drive the activities and outputs of our technical groups.

We have driven the standardization of key elements of small cell technology including Iuh, FAPI, nFAPI, SON, services APIs, TR-069 evolution and the enhancement of the X2 interface.

Today our work is organized around three main campaigns – global technology alignment in the 5G Era, a drive for progressive local, national and international policy for network densification and enterprise engagement for better connectivity.

The Small Cell Forum Release Program has now established business cases and market drivers for all the main use cases, clarifying market needs and addressing barriers to deployment for residential, enterprise, rural & remote, and urban small cells.

The Small Cell Forum Release Program website can be found here: www.scf.io

All content in this document including links and references are for informational purposes only and is provided 'as is' with no warranties whatsoever including any warranty of merchantability, fitness for any particular purpose, or any warranty otherwise arising out of any proposal, specification, or sample.

No license, express or implied, to any intellectual property rights is granted or intended hereby.

©2007-2018 All rights reserved in respect of articles, drawings, photographs etc published in hard copy form or made available in electronic form by Small Cell Forum Ltd anywhere in the world.

If you would like more information about Small Cell Forum or would like to be included on our mailing list, please contact:

Email info@smallcellforum.org

Post Small Cell Forum, PO Box 23, GL11 5WA UK

Member Services memberservices@smallcellforum.org



About 5G Americas: The Voice of 5G and LTE for the Americas

5G Americas is an industry trade organization composed of leading telecommunications service providers and manufacturers. The organization's mission is to advocate for and foster the advancement and full capabilities of LTE wireless technologies and their evolution to 5G, throughout the ecosystem's networks, services, applications and wirelessly connected devices in the Americas. 5G Americas is invested in developing a connected wireless community while leading 5G development for all the Americas.

5G Americas' Board of Governors members include: AT&T, Cisco, CommScope, Ericsson, Intel, Kathrein, Mavenir, Nokia, Qualcomm Incorporated, Samsung, Shaw Communications Inc., Sprint, T-Mobile US, Inc., Telefónica and WOM.

5G Americas is headquartered in Bellevue, Washington. More information is available at www.5gamericas.org or at 5G Americas' official Twitter handle @5GAmericas.

If you would like more information about 5G Americas or would like to be included on our mailing list, please contact:

Email: info@5gamericas.org

For a full list of members and further information visit our website www.5GAmericas.org



Executive summary

Mobile network operators' (MNOs') drivers to deploy non-residential small cells are changing rapidly. Filling coverage gaps was the initial priority, but now MNOs are embarking on densification too – deploying a layer of targeted capacity to deliver consistently high performance and quality of service even in areas of the heaviest usage. Densification involves large numbers of cells, even for LTE, and the numbers will increase in 5G because of its increased capacity requirements, higher spectrum bands and support for new services such as smart city applications.

With many MNOs expecting to deploy at least 10 times the number of outdoor urban cells in 5G that they currently operate in 4G, deployment challenges will arise which, if not addressed in a timely fashion, threaten to derail the business case for outdoor densification, or at least force some operators to delay or scale back their plans.

The most pressing challenges relate to the time and cost to deploy a small cell. For every cell, an MNO needs to gain site and equipment approvals; negotiate fees with the city or other landlord; deploy, provision and maintain the base station; ensure it has appropriate backhaul and power; and conform to the city's aesthetic and environmental regulations. All this can take up to two years per cell. Sprint has said it takes a day to deploy a small cell, but a year or more to get the permit, at a high cost for every individual site. That situation is clearly untenable in the era of large-scale densification.

The more cells that need to be rolled out, the more it will be economically non-viable to negotiate a different set of approvals, fees and processes for every site. Ideally, MNOs would like standardized rules and fees that apply across a whole country or region. In practice, fees are likely to be subject to individual negotiation by each city, but at least a set of guidelines, including caps, could be established on a state or federal basis, and blanket deals devised for a whole city, as was recently achieved in San Jose, California.

In other areas, the mobile industry believes processes could be standardized and streamlined to reduce the time to approve and activate a small cell to just a few weeks. That would accelerate the progress of densification and greatly reduce the administrative costs. For instance, Small Cell Forum has worked with the GSMA and IEC to devise common equipment classes, which allow small cells to be exempted from approval processes, provided they adhere to certain limits on power, size and so on (this already exists for many classes of Wi-Fi equipment).

Despite tensions between the interests of cities, states and the FCC, significant progress has been made in the USA over the past year to move towards national frameworks, and further Congress legislation and FCC rules are being debated this fall. In addition, 20 states have so far passed legislation aimed at easing deployment of wireless infrastructure, often by imposing timelines for approval of equipment, and introducing new rules on rights of way and city structures.



Meanwhile, the mobile industry has been working to make it easier to allay the concerns of cities in areas like aesthetics and environment, designing a wide range of new form factors which can be easily hidden in existing street furniture, or even pavements or trees. The industry is also cooperating on 'cookie-cutter' deployment processes which will make it quicker to roll out small cells at scale while minimising disruption for citizens.

5G Americas and Small Cell Forum believe the progress made so far in the USA will help define blueprints and best practice elsewhere, but the momentum needs to be maintained to ensure operators can meet the intensified demands of 5G.

This white paper sets out the reasons why densification is becoming urgent; the benefits it will deliver; the barriers that still remain; and the work done so far to address them. It also sets out a clear set of guidelines, designed to help cities and other stakeholders and regulators to adopt a common, streamlined approach which will maximize the benefits of densification for all sides.



Contents

1.	Densification trends – drivers and early deployments	1
1.1	Drivers to greater densification.....	1
1.2	Barriers remain to densification	4
1.3	Site issues make some small cells cost-prohibitive	5
1.4	Impact of site issues on the pace of densification.....	6
2.	What will change in 5G?	8
2.1	5G will drive densification to huge scale	8
2.2	Density will support new 5G traffic patterns	9
2.3	Virtualized architectures will add to small cell site complexities	12
2.4	New spectrum bands for 5G.....	13
3.	Government and regulatory objectives for 5G	15
3.1	Small cells help meet government 5G objectives	15
4.	What is required to make these levels of densification happen?	17
4.1	Site acquisition.....	17
4.2	Site approval	17
4.3	New site types	18
4.4	Power issues.....	18
4.5	Local planning/zoning laws & rights of way	19
4.6	Leasing and tax arrangements	19
4.7	Installation	19
4.8	Simplified RF compliance	19
4.9	New partnerships.....	20
5.	Progress to date	21
5.1	New guidelines proposed by the FCC BDAC working group	21
5.2	State legislation to date.....	22
5.3	Federal legislation and the latest FCC proposals.....	24
5.4	The latest FCC proposals	24
5.5	Operator and city initiatives	25
5.6	Other initiatives.....	26
6.	Recommendations for rules to address siting challenges	28
6.1	Wireless deployment and rights of way (ROW)	28
6.2	Wireline advocacy.....	29
6.3	One-Touch Make-ready	29
6.4	National database.....	30



7. Deployment processes must be streamlined too..... 33

7.1 How new form factors could simplify deployment..... 33

7.2 A best case deployment process for small cells..... 35

7.3 Addressing the power issue..... 36

7.4 Environment and aesthetics 38

8. Summary 43

Tables

Table 1 State legislation to date 23

Figures

Figure 1 Key drivers to embark on large-scale densification. Source: Rethink/SCF survey of 78 MNOs worldwide, March 2018. Operators were asked to list their three most important drivers (chart sums to 300) 3

Figure 2 Operators’ top three drivers to densify, as above, broken down by selected regions. 4

Figure 3 Key barriers to embark on large-scale densification. Source: Rethink/SCF survey of 78 MNOs worldwide, March 2018. Operators were asked to list their three most important barriers (chart sums to 300) 5

Figure 4 Breakdown of mobile network operating costs. Source: Rethink MNO survey 2018 6

Figure 5 Forecast pace of deployment of non-residential small cells in dense environments, with and without the early removal of the key barriers outlined above. 7

Figure 6 Forecast deployments of 5G or 5G/multimode non-residential small cells 2019 to 2025 by region, Source: Rethink/SCF market status update March 2018..... 8

Figure 7 Deployment plans for 5G NR Standalone. Source: SCF Operator Survey November 2017..... 9

Figure 8 Global Mobile data traffic forecast 2016-2021. Source: Cisco VNI... 10

Figure 9 The market opportunity for Industry 4.0. Source: Accenture..... 11

Figure 10 Connected devices in use 2014-2022. Source: Ericsson..... 12

Figure 11 A virtualized RAN architecture, Source: Wind River..... 13

Figure 12 Number of small cell 5G connections per spectrum band (NB many cells will be multiband so the numbers are larger than the number of access points)..... 14

Figure 13 The fragmentation of small cell approval processes between different agencies..... 18

Figure 14 Installation classes simplify deployment rules needed for RF compliance of small cell sites 27

Figure 15 Summary of recommended solutions to facilitate small cell siting. Source: 5GA/SCF 2017 28

Figure 16 A high power eNodeB in small cell form factor..... 33



Figure 17	An example of small cell pole deployment with only power supply is required to the pole.....	34
Figure 18	An example of a strand mountable eNodeB.....	35
Figure 19	Example of an HFC power solution. Source: CommScope	37
Figure 20	Cluster power solution supporting a C-RAN deployment. Source: CommScope	38
Figure 21	Metro concealment options for small cells. Source: CommScope	39
Figure 22	A canister design, and attached to a pole. Source: Kathrein.....	40
Figure 23	Small cell integrated into manhole cover. Source: Kathrein	41



1. Densification trends – drivers and early deployments

In the early years of small cell deployments, the chief priorities were to improve indoor coverage, initially in the home; to fill ad hoc gaps in outdoor coverage; and to supplement capacity in a localized way via urban or indoor hotspots. All of these patterns were beneficial to operators because they enabled them to improve capacity, coverage and quality of service at relatively low cost. However, they did not involve large numbers of access points.

1.1 Drivers to greater densification

For the past two years, the drivers to deploy small cells have shifted in focus towards large-scale densification. Operators are looking to increase the capacity in their LTE networks in a far wider range of locations, to address rising consumer and enterprise use of mobile broadband. A few operators are already planning hyperdense networks in the 4G era¹, and they expect the trend to intensify with the migration to 5G.

According to a survey of 78 Tier 1 and 2 mobile operators worldwide, conducted in March 2018 by Rethink Technology Research, some operators will go macro-first with 5G, especially among the very early adopters, but these will only account for 22% of those starting deployment between 2019 and 2022. A far larger percentage (63%) will use the new radios to densify selectively while retaining 4G as the primary wide area network, for at least the first three years of commercial 5G (15% were undecided).

Whether operators are densifying with 4G or 5G, there are several key drivers to do so. In SCF's most recent Market Status Update, 78 mobile operators were asked to list all their drivers to densify. They were then asked to select their top three drivers, from a list of those which were cited most commonly. Figure 1 indicates the results.

The most important drivers relate to increased capacity, and the cost of that capacity.

- In all, 40% of operators placed 'dense capacity to support enhanced quality of experience' in their top three, since that can affect key metrics like churn reduction and customer satisfaction.
- Meanwhile, 38% said that reducing the overall cost of capacity was a top three reason to invest in small cells. Total cost of ownership of the network, and of data delivery, is increasingly significant to the overall model, as MNOs look to support rising levels of data usage, and rising customer expectations of a high-quality experience. They need to do this profitably, even though, in many markets, there is a return to unlimited data plans.
- The third most important driver was also related to increasing capacity, but with the main motivation being to support brand new services,

¹ SCF defines hyperdense as >150 small cells per km²



rather than just improving the QoE for current ones. Among the new services cited were interactive video and gaming applications, and augmented reality in stores and museums, both of which require high levels of targeted capacity close to the user.

- In addition, many operators are interested in improving their capacity and costs by relying more heavily on shared spectrum, with technologies like LTE-LAA and MulteFire. These technologies will run in the 5 GHz and 3.5 GHz bands, which are inherently suited to small cells because of their limited range at allowed power levels.
- Related to this is the rising operator interest in edge compute, and the potential to support new consumer and enterprise services by combining computing and storage resources with connectivity at the edge of the network. Small cells, edge compute and shared spectrum can be combined to create dense, localized networks targeted at a city, enterprise or particular vertical market (27% of operators say the ability to build these targeted sub-nets is a driver to invest in small cells).

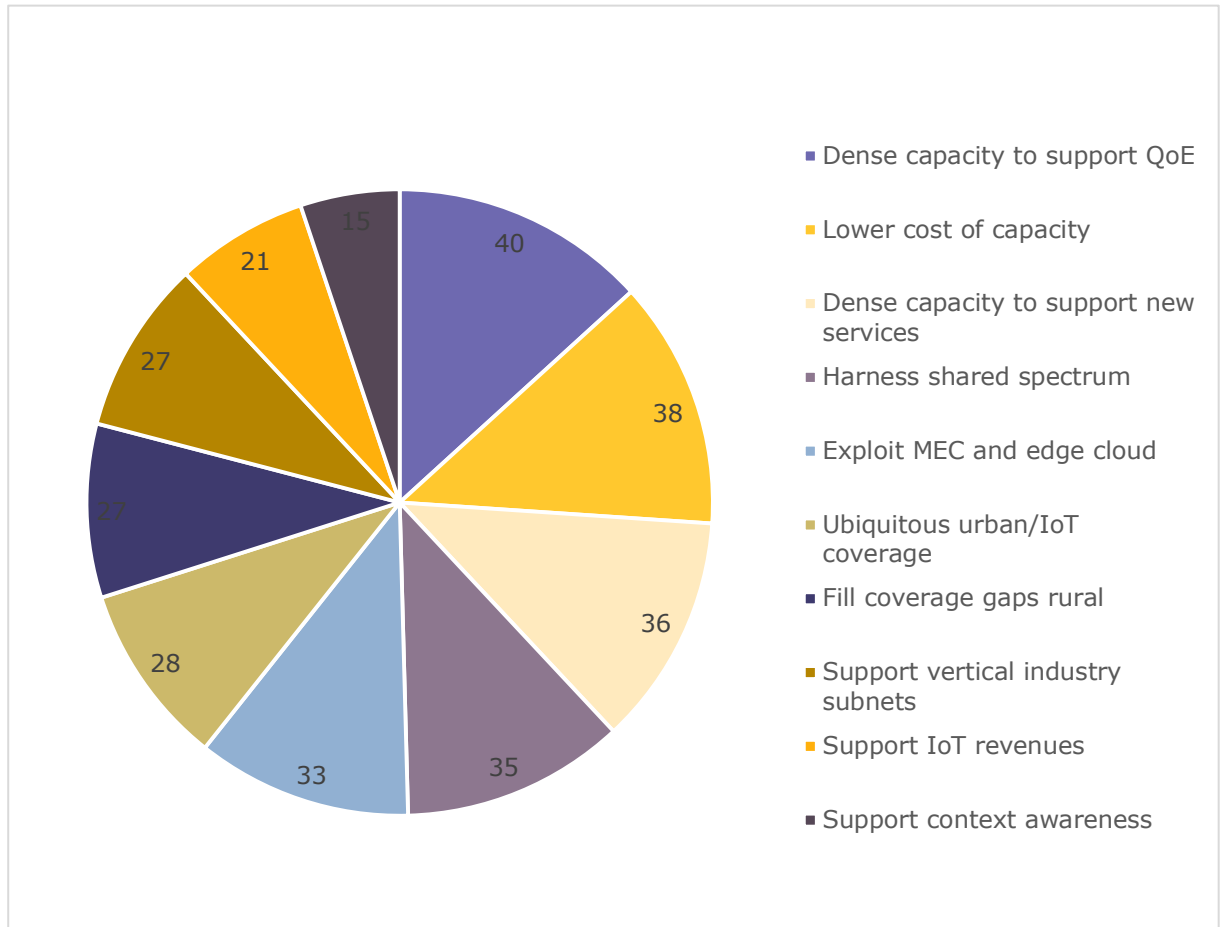


Figure 1 Key drivers to embark on large-scale densification. Source: Rethink/SCF survey of 78 MNOs worldwide, March 2018. Operators were asked to list their three most important drivers (chart sums to 300)

There are regional variations in the key drivers to densify. The results of the same survey, for selected regions, are shown in Figure 2. This shows that the priorities for densification do vary in different parts of the world. In North America, operators are more interested than their counterparts elsewhere in shared spectrum, new capacity-rich services and sub-nets to support vertical industry use cases.

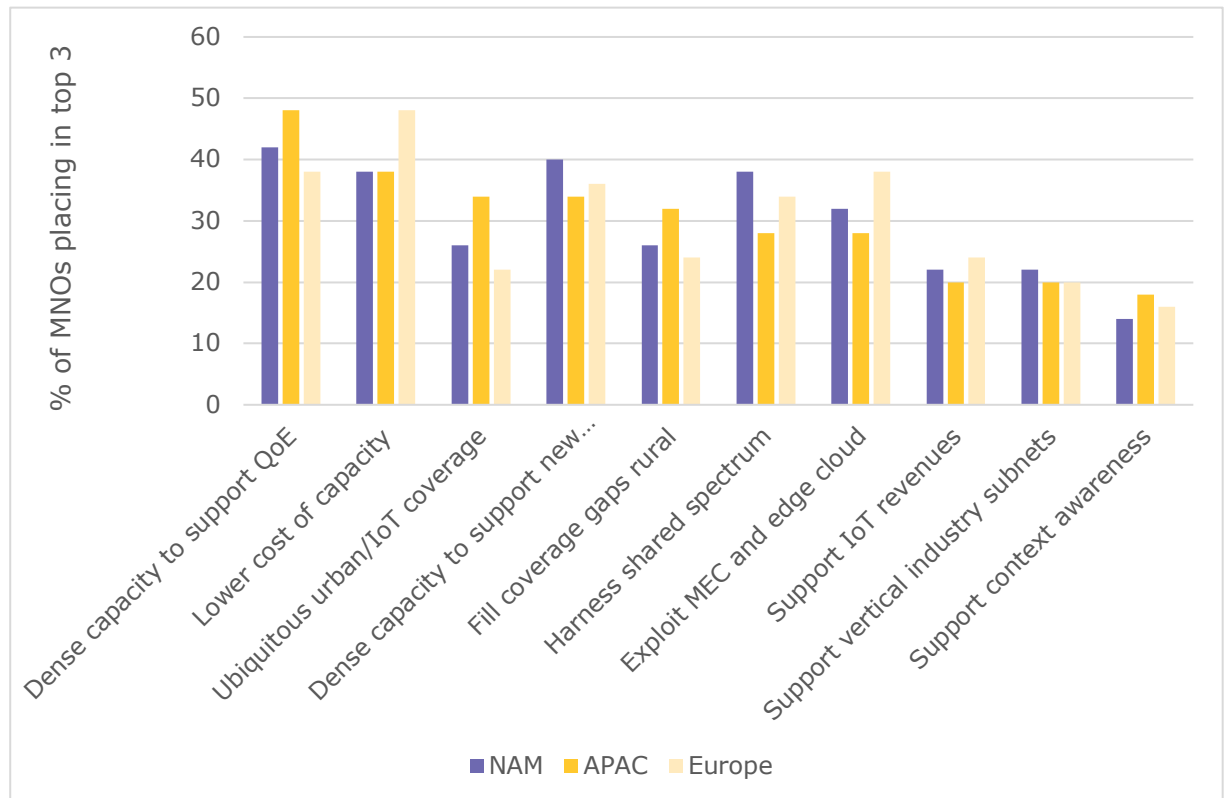


Figure 2 Operators' top three drivers to densify, as above, broken down by selected regions.

1.2 Barriers remain to densification

These commercial drivers to increase capacity, support new revenue streams and boost cost efficiency are all proven and increasingly urgent. However, there are still barriers to densification, which currently make the business case hard for many operators.

The most important barriers, as Figure 3 highlights, relate to uncertainty about total cost of ownership (58% place this in their top three). Many of those uncertainties, in turn, relate to site, equipment and backhaul costs. Four of the top 10 barriers relate to these aspects of densification, with 47% saying that the cost and availability of suitable sites is a top three challenge. In addition, backhaul costs, site approvals and equipment approvals are all top three issues for between one-fifth and one-third of carriers.

Between them, site, backhaul and approvals issues could cause an operator to postpone the start of a densification project, especially an outdoor one, by an average of two years and two months, according to the survey.

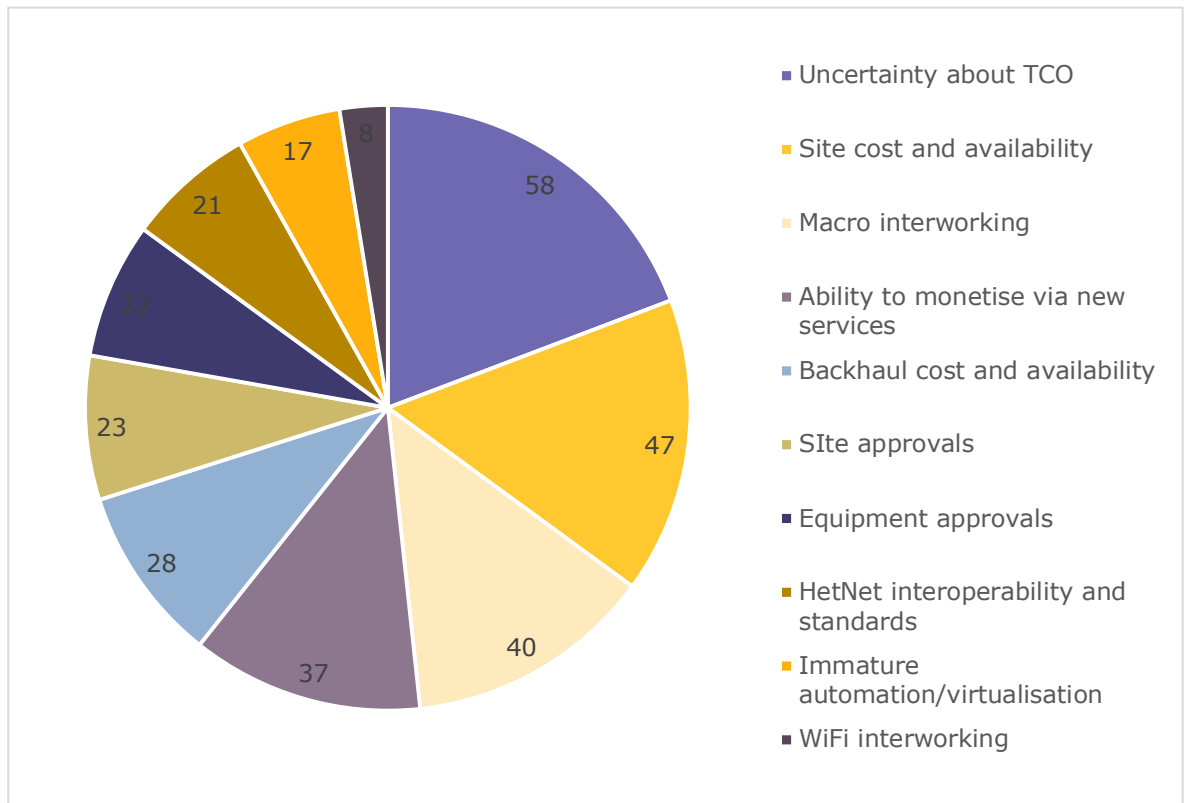


Figure 3 Key barriers to embark on large-scale densification. Source: Rethink/SCF survey of 78 MNOs worldwide, March 2018. Operators were asked to list their three most important barriers (chart sums to 300)

The details of these site and regulatory barriers will be explored later in this paper, but the primary challenges include:

- Regulatory frameworks at national and local level are fragmented, preventing a scalable, cookie-cutter deployment process.
- This means that it can take many months, and even up to two years, to obtain approval to use a site.
- Local authorities can delay or forbid deployments for aesthetic, environmental or public health concerns but these rules are not consistent from city to city.
- Approval of equipment and sites is not standardized and few countries have a WiFi-like 'fast track' approval, or exemption, for small cells which conform to certain requirements (e.g. size, power)
- Fees for use of public infrastructure are inconsistent and sometimes so high that they break the business case for small cells in a particular city.

1.3 Site issues make some small cells cost-prohibitive

Such issues have certainly held back deployments so far. Many operators are looking to adopt software-driven techniques such as Network Functions Virtualization (NFV) to improve the cost of ownership, and the commercial agility, of their platforms. But in a dense network, the gains from these new software techniques are outweighed strongly by the cost of the physical aspects. An operator can deploy digital software platforms to transform processes,

customer engagements, service variety and cost – but remains reliant on a friendly regulatory framework to make it possible to modernize physical infrastructure too.

The biggest costs in deploying and running a mobile network relate to sites and fiber, because these have to remain physical and cannot be virtualized; and because they involve approvals and leasing fees. These fees, plus deployment and maintenance labor costs, are far less susceptible to price erosion than the increasingly software-based base stations or packet cores, so they are becoming, as a percentage, an even bigger portion of the capex and opex spend.

Figure 4 shows a typical breakdown of network operating costs, indicating the high percentage of opex which goes on regulatory and rental/lease fees for sites and fiber. Many operators in developed mobile economies have set targets to reduce absolute opex by 25% or more by 2022. Given the increase in site numbers in a typical 5G network, that will entail reducing per-site opex costs by an even greater amount. A consistent, quick and cost-effective process to gain approval for small cell sites, and then deploy those access points, would make a significant contribution to the goal.

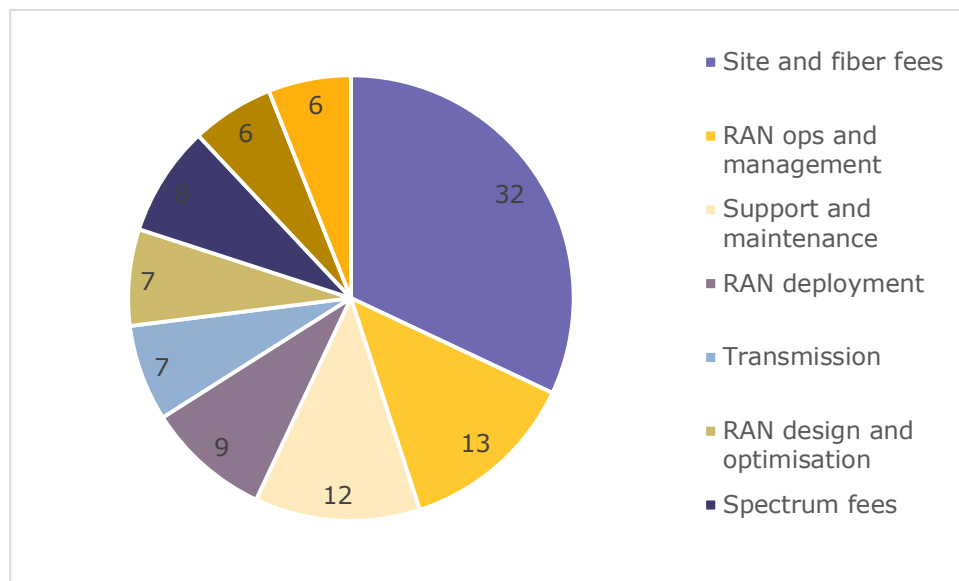


Figure 4 Breakdown of mobile network operating costs. Source: Rethink MNO survey 2018

This only gets worse as operators start to densify and build larger numbers of small base stations, since each one carries that site and backhaul cost. If an MNO wants to deploy 10 outdoor small cells per macro, it would need the costs to be well below 10% of those of a macro to make the cost case for densification – but that is not yet true.

1.4 Impact of site issues on the pace of densification

A streamlined approvals process and a highly automated small cell network, which minimizes labor cost, are both essential to the business case. Neither are fully developed today, with the result that, according to the SCF/Rethink operator survey, 23% of MNOs (as of March 2018) would ideally like to start at-



scale small cell deployment within one year, but only 7% believe that will be practical because of barriers.

Of those surveyed, 65% said improved ease of deployment would be a trigger to roll out small cells at scale, while 46% said easier access to sites would, on its own, be that catalyst.

By our calculations, these deployment barriers will have a significant impact on the pace and scale of densification for as long as they remain unaddressed. If the regulatory barriers to deployment were removed today, the deployment of small cells in dense or hyperdense environments would reach almost 14m by 2025. By contrast, the current SCF/Rethink forecast sees only 6.3m cells installed in those environments by 2025 (those assume there will be a gradual improvement in the regulatory framework, though this will be regionally varied and will not take full effect, in most areas, until 2021).

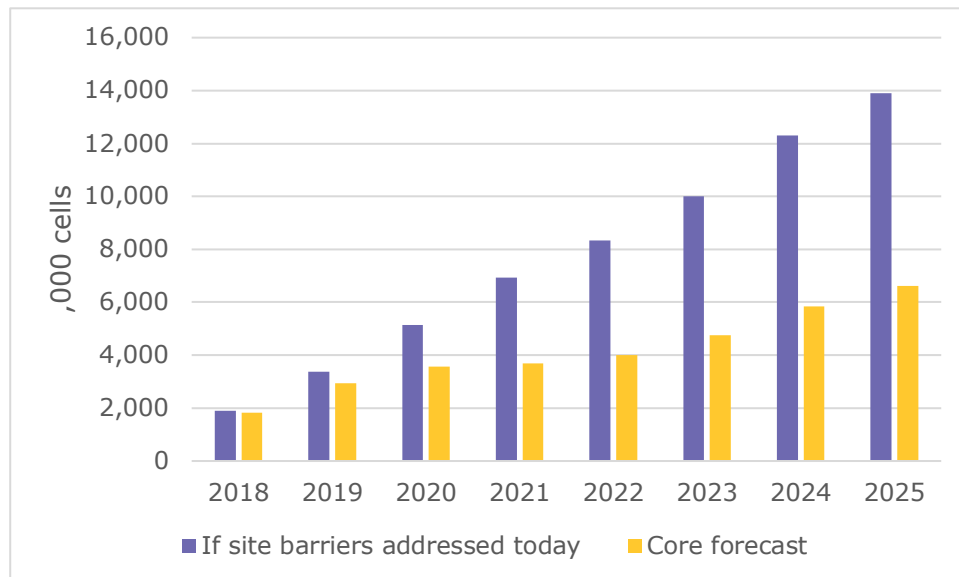


Figure 5 Forecast pace of deployment of non-residential small cells in dense environments, with and without the early removal of the key barriers outlined above.

Clearly this level of wasted opportunity will have a significant impact on the performance of operators and their suppliers, as they move into 5G.

2. What will change in 5G?

In the 5G era, the challenges of supporting densification will become even more daunting. Operators' business cases will require them to deploy small cells at a faster pace and at greater density, which will make it even more essential to have streamlined regulatory and installation processes.

2.1 5G will drive densification to huge scale

One of the biggest changes that operators will make as they move from 4G to 5G will be scale. Far more cells will be required, with a greater diversity of equipment form factors and site types. By 2020, the average densification project will involve 100-350 cells per km², and these will be mounted on many types of infrastructure and integrated into street furniture and even vehicles.

Figure 6 indicates the numbers of 5G non-residential small cells which SCF forecasts will be deployed between 2018 and 2025, showing the rapid acceleration of deployment which 5G will drive from 2022.

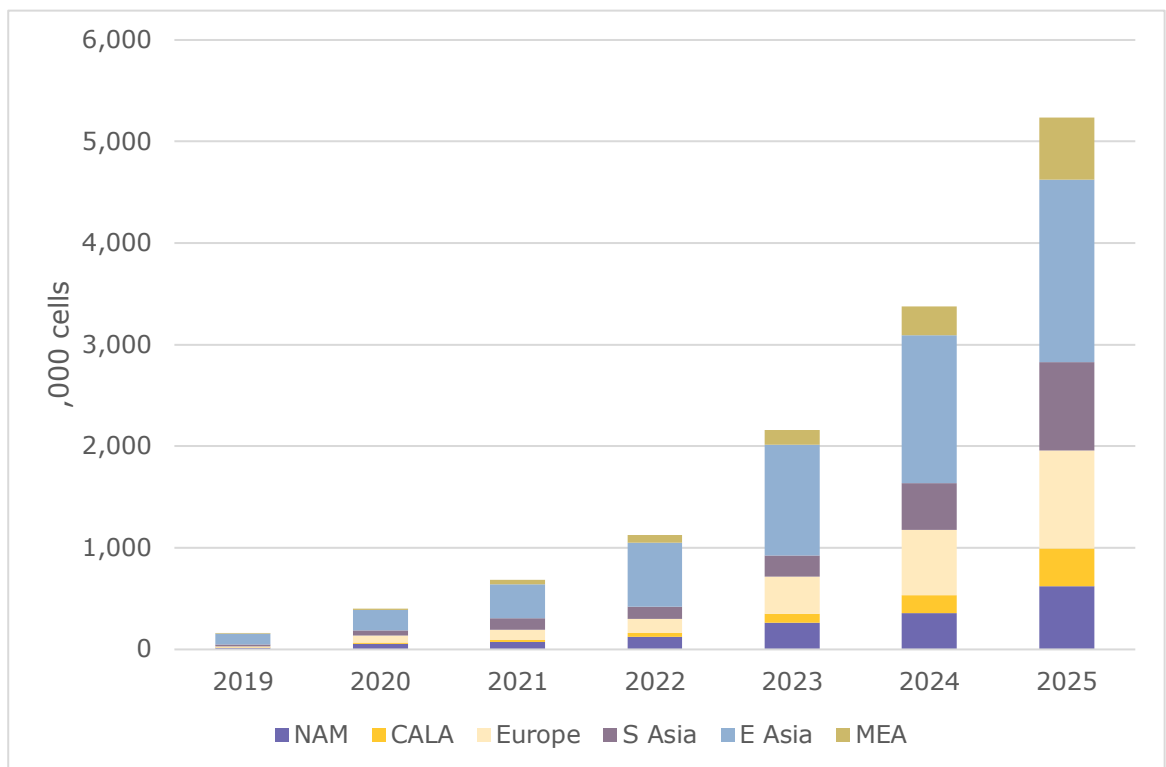


Figure 6 Forecast deployments of 5G or 5G/multimode non-residential small cells 2019 to 2025 by region, Source: Rethink/SCF market status update March 2018

Meanwhile, 29% expected to be macro-first in the early years of 5G and 13% did not know.

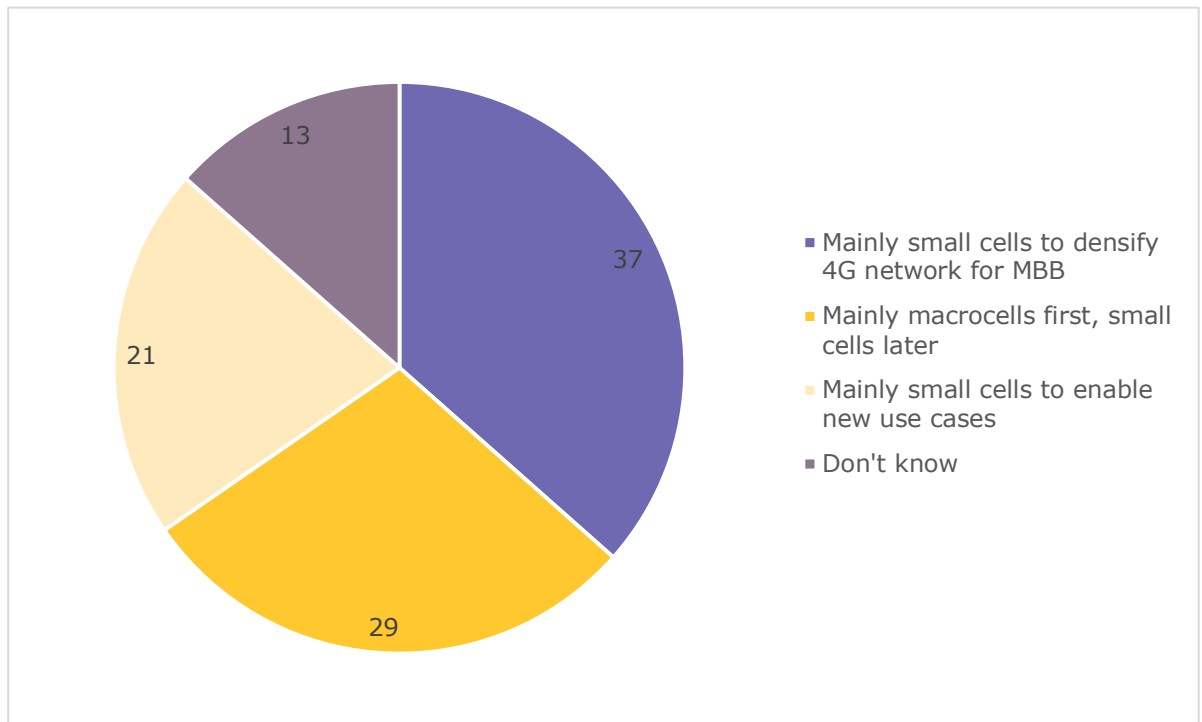


Figure 7 Deployment plans for 5G NR Standalone. Source: SCF Operator Survey November 2017

2.2 Density will support new 5G traffic patterns

These higher levels of density will be required to support new usage patterns and mobile data services. According to the Cisco Visual Networking Index:

- Global mobile data traffic is forecast to increase sevenfold between 2016 and 2021, reaching 49.0 exabytes per month by 2021.
- By 2021 there will be 1.5 mobile devices per capita. There will be 11.6bn mobile-connected devices by 2021, including M2M modules—exceeding the world’s projected population at that time (7.8bn).
- Mobile network connection speeds will increase threefold by 2021. The average mobile network connection speed (6.8Mbps in 2016) will reach 20.4Mbps by 2021.

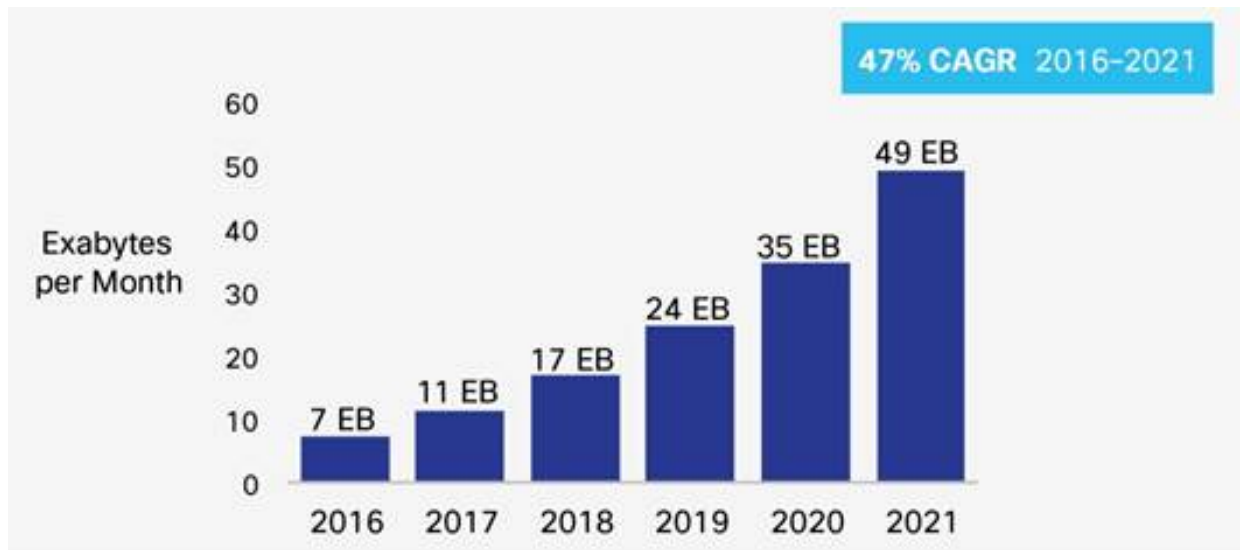


Figure 8 Global Mobile data traffic forecast 2016-2021. Source: Cisco VNI

CAGR = Compound Annual Growth Rate

In addition to the explosive rise in data usage by consumers, industry experts forecast a huge demand and growth of the Internet of Things (IoT), or connected devices, driven by emerging applications and business models, supported by standardization and falling device costs

Accenture estimates the IIoT (Industrial Internet of Things) could add \$14.2T to the economy by 2020. The global market for IIoT is projected to grow at a 7.3% CAGR through 2030 (sees Figure 9).²

² (Source: Pete Wassell (Augmate): AR Smart Glasses and the Industrial IoT)

Industry 4.0 Market Opportunity 2020 - 2030

AR Smart Glasses and the Industrial IoT

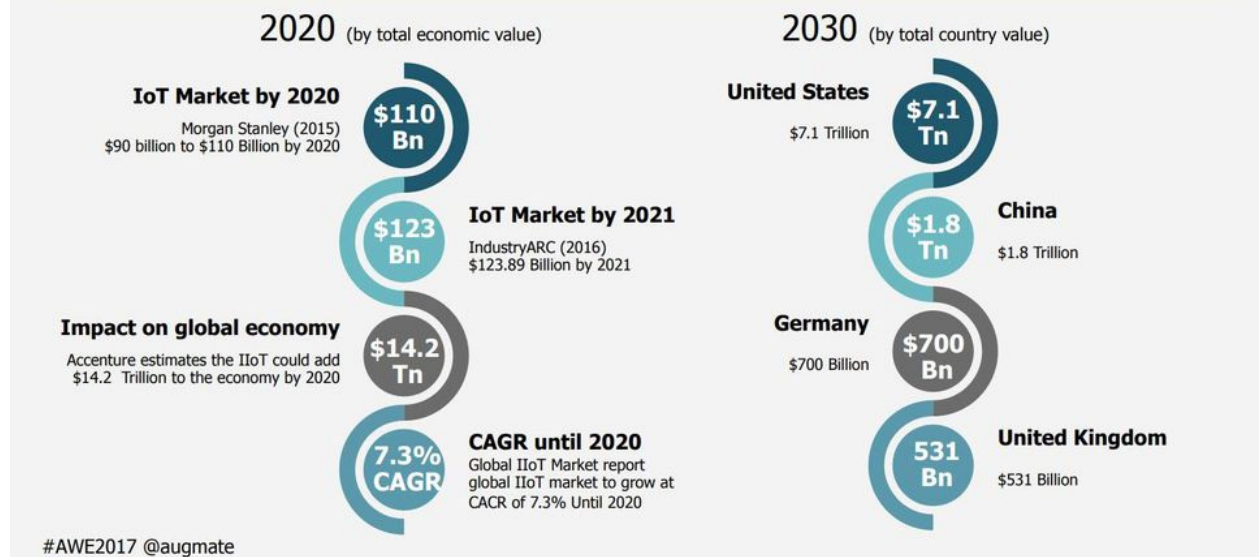


Figure 9 The market opportunity for Industry 4.0. Source: Accenture

The simultaneous rise in smartphone and IIoT usage will mean a huge leap in the number of cellular-connected devices in play by the early 2020s, some of them with critical availability requirements. Very high levels of device density, whether that it is a stadium during a ball game or to support smart lighting in a city, will rely on small cells, close to the user, to maintain good quality of service for so many end points.

Ericsson's latest Mobility Report highlights this trend, finding that:

- In 2018, mobile phones are expected to be surpassed in numbers by IoT devices.
- There will be around 400m IoT devices with cellular connections at the end of 2016.
- Around 29bn connected devices¹ are forecast by 2022, of which around 18bn will be related to IoT.

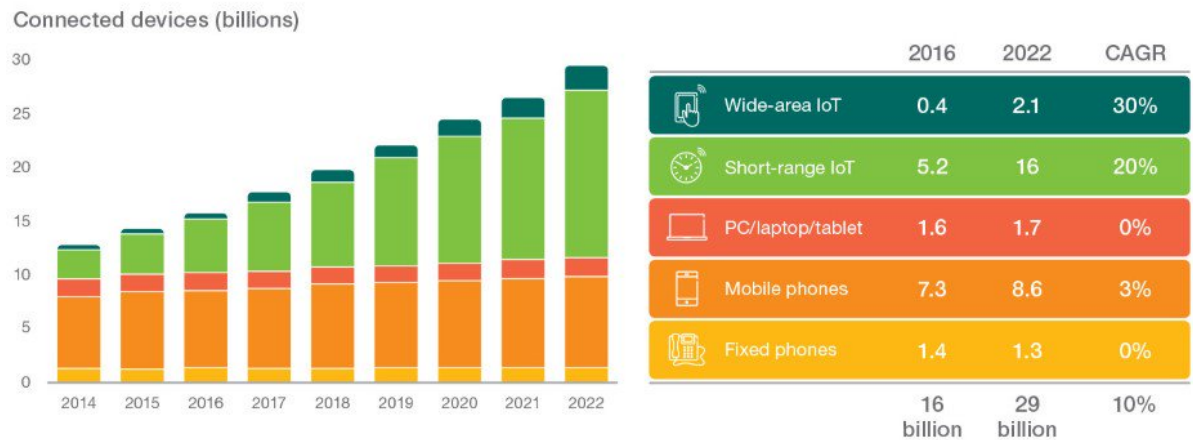


Figure 10 Connected devices in use 2014–2022. Source: Ericsson

2.3 Virtualized architectures will add to small cell site complexities

The 5G networks will have to handle large data sets that are produced by these huge numbers of connected devices, as well as high traffic levels from emerging applications such as virtual reality. To support these efficiently, MNOs will need to adopt new network topologies such as Cloud-RAN, virtualized RAN (vRAN) or open RAN (oRAN), together with integrated edge compute.

These can be implemented in all layers of the network, but in the small cell area, the result is a cluster of radios linked to a common controller, which may be integrated with an edge compute node.

The Cloud-RAN or Centralized RAN architecture separates the base station into two parts, the digital Baseband Unit (BBU) and the Remote Radio Head (RRH), centralizing the baseband processing functions on a 'master base station' to improve radio resource management.

The vRAN is an extension of that architecture, which implements the baseband functions as virtual network functions (VNFs) on standard hardware, supporting flexible allocation of baseband resources to the various cells and reducing operating cost. Operators can pool or adjust radio resources, depending on traffic, for improved performance and user experience. vRAN is an essential step towards a dense 5G network implementation. For instance, data traffic for IoT use cases will require network resources to be under smart control at a granular level to improve utilization efficiency.

oRAN is a logical next step to open up various interfaces in RAN network in order to mix and match RRUs from one vendor with virtualized BBU software from another vendor. This will allow the MNO to move away from proprietary, end-to-end solutions which result in high operational costs.

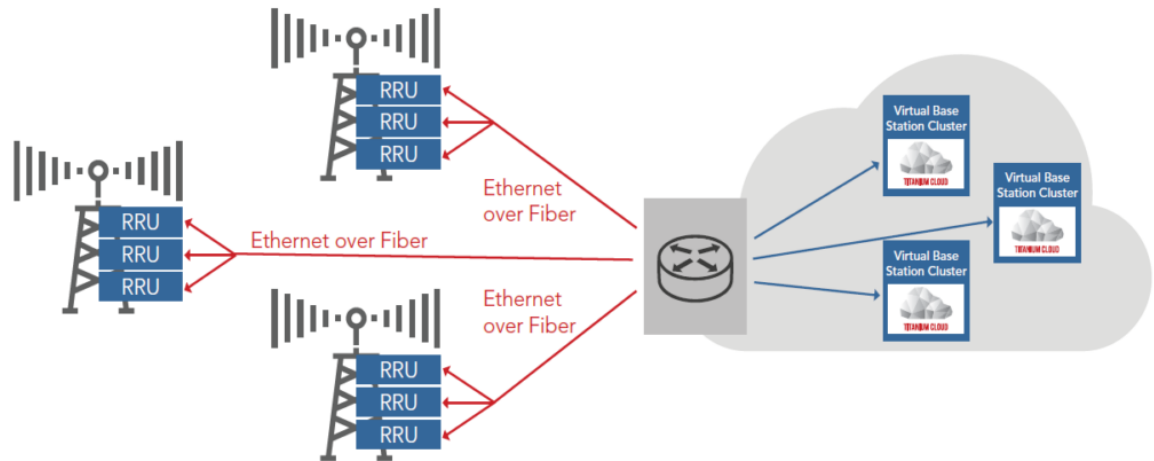


Figure 11 A virtualized RAN architecture, Source: Wind River

In the small cell environment, the new architectures have implications for sites and deployment. The baseband functions will require centralized controllers or servers, which may be combined with edge compute resources in an IT-focused location such as a city building. At the radio end, there will be a rising number of stripped-down radio/antenna units, separated from the BBU, can be lighter and more easily adapted to a wide variety of site types.

2.4 New spectrum bands for 5G

One of the most important changes which 5G will introduce will be the ability to use high frequency spectrum, such as the microwave and millimetre wave (mmWave) bands above 20 GHz, for mobile broadband. These will open up a large amount of currently untapped capacity, with sufficient spectrum to support very high bandwidths, and so enable very high data rates; and to support new entrant service providers alongside the established MNOs.

However, increased path loss in mm wave range compared to sub-6 GHz spectrum severely limits the coverage radius from base stations. Further, building penetration loss is high and diffraction effects are diminished in mmWave band. Because of their limited propagation, these high bands will mainly be used to build out dense small cell networks, outdoors or indoors. They will lend themselves to hyper density, but while that will provide a large leap in capacity, it will also require large numbers of sites with power and backhaul.

In the first wave of 5G deployment, sub-6 GHz bands will be used first to bridge the bandwidth gap between existing 4G LTE networks and future mmWave 5G implementations.

Figure 12 shows the SCF/Rethink forecast for the number of small cell 5G connections which will run in each area of the spectrum between 2019 and 2025.

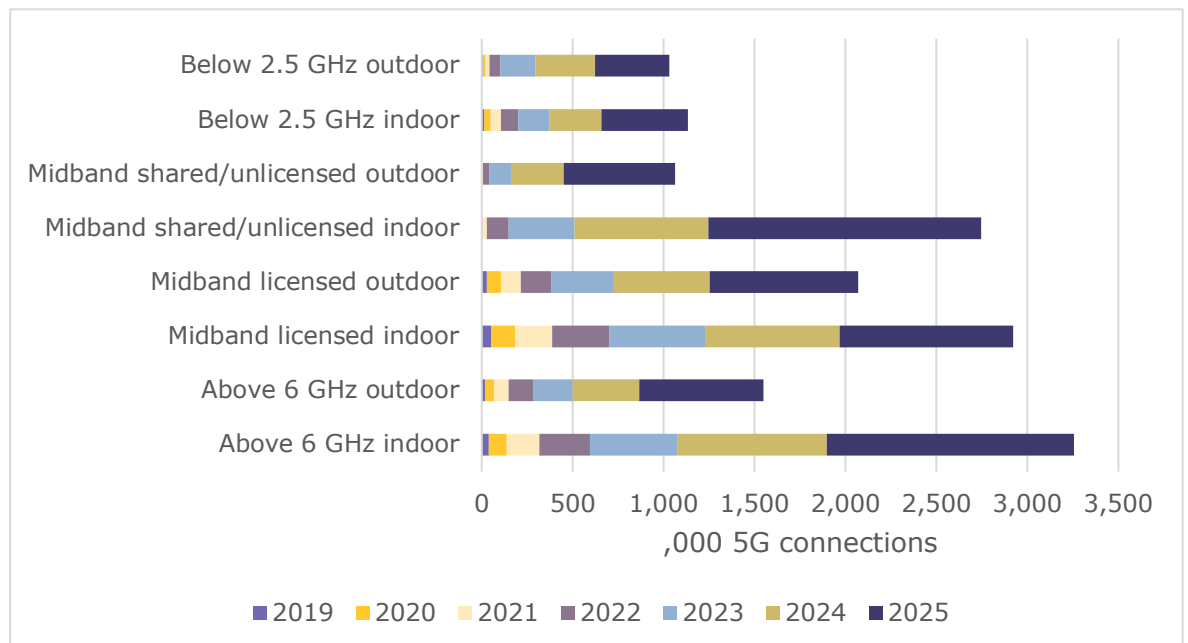


Figure 12 Number of small cell 5G connections per spectrum band (NB many cells will be multiband so the numbers are larger than the number of access points)

Sub-6 GHz infrastructure will continue to take advantage of the significant amount of available spectrum from 2.5 to 2.7 GHz, adding frequencies between 3.3 and 3.8 GHz, and, in some geographies at least, from 4.2 to 5 GHz . These will potentially be able to support up to 400 MHz of continuous spectrum enabling wide channel bandwidths. Sub-6 GHz infrastructure promises to increase spectral efficiency for legacy cellular bands, and expand capacity and coverage at data rates that are up to 10 times faster than existing LTE in comparable frequency bandwidths.

Sub-6 GHz and mmW 5G systems will rely on beamforming and phased array technologies to optimize signal link and data rate, leveraging large numbers of antenna elements configured in massive MIMO (multiple input, multiple output) architectures.



3. Government and regulatory objectives for 5G

5G is at the heart of many government and regulatory policies round the world, because its benefits should reach well beyond MNOs' enhanced business models or new consumer services, and enable better access for all industries, to support new business processes and service models.

By deploying small cells in urban areas, operators are able to support those 5G objectives by providing significantly higher capacity in those areas where it is most needed, as well as improved coverage in areas where building blockage would otherwise reduce the signal strength and achievable data rates from the nearest macro base station sites. Although capable of higher traffic capacity (that is, numbers of concurrent users), because their coverage area is relatively low these cells require significantly less RF power than macro base stations.

This brings economic benefits to the operator and a much-improved user experience (for those within range of the small cell and others who remain on the macro, since that becomes less heavily loaded as users migrate to the small cell).

3.1 Small cells help meet government 5G objectives

Small cells create several opportunities to meet the objectives that regulators set out to achieve with 5G. Some of these are as follows:

Improved access: Small cells provide a cost-effective means of improving consumer access to mobile services. They improve coverage in hard-to-reach indoor environments, without the need to deploy large numbers of outdoor base stations. They deliver truly broadband mobile services within existing spectrum. In rural and remote areas, small cells allow customers to access services which would otherwise be hard for operators to serve economically, thereby promoting inclusion, reducing the digital divide and expanding opportunities for remote communities to be fully connected.

Cost effectiveness: In urban areas, small cells allow for cost-effective deployments, which can help bring the social and economic benefits of mobile broadband to more users and companies. Equipment costs are generally lower than for macro base station sites and the number of sites can be optimized to provide additional capacity in locations where it is most needed. It is therefore necessary for administrations and local authorities to revise and streamline the administrative requirements to fully realize these cost benefits.

Visually unobtrusive: In public spaces, the impact on the environment of small cells is minimized due to their relatively small and unobtrusive form factor. Their visual impact on the surroundings can be further minimized as they can be mounted on existing lampposts, walls, etc. It is therefore important that local planning laws take these aspects into account and are not unduly restrictive to the deployment of small cells in public spaces.



Spectrum efficiency: Indoor small cells can reuse existing mobile operator spectrum for operation, including both currently unused frequencies and frequencies already used by outdoor sites. This helps to address spectrum shortages, which are a significant regulatory concern in the run-up to 5G.

More generally, small cells open up the use of higher frequencies whose range might be excessively limited for wide area operation, increasing the overall use of available spectrum. They can also operate in lower frequency bands, reducing their transmit power accordingly to avoid interference. To fully realize these efficiencies in urban scenarios, the handover and/or reselection parameters need to be optimized for users of the small cells to allow inter-technology handover and reselection (3G-4G-5G) and indoor-outdoor handover (between small cells and the macro layer).



4. What is required to make these levels of densification happen?

As briefly outlined in Chapter 1, achieving massive densification requires a new approach to small cell deployments, from site acquisition to RF planning, integration with existing infrastructure, installation and network optimization. Sprint has said it takes a day to deploy a small cell, but a year or more to get the permit, at a high cost for every individual site. That situation is clearly untenable in the era of large-scale densification.

We outline some of the key challenges below.

4.1 Site acquisition

Generally, MNOs have teams of site acquisition personnel that are given search areas or search rings that have been provided by radio frequency (RF) engineers who design the wireless network. As networks densify the search areas are shrinking and becoming more specific. Any location found within this area, if it meets the height requirement on the search area request, should be a viable candidate for the RF engineer to evaluate. The site acquisition team will often be required to submit multiple candidates for the RF engineers to review.

4.2 Site approval

For traditional mobile network base stations this can take several months and involve obtaining regulatory approvals from several local, city and federal government agencies. Figure 13 indicates the fragmentation of the regulatory landscape, and the different authorities and stakeholders which may be involved in approving the site and equipment for just a single small cell. Clearly, if every cell has to go through a process which may take up to two years to complete, the cost and scalability of the network is severely compromised.

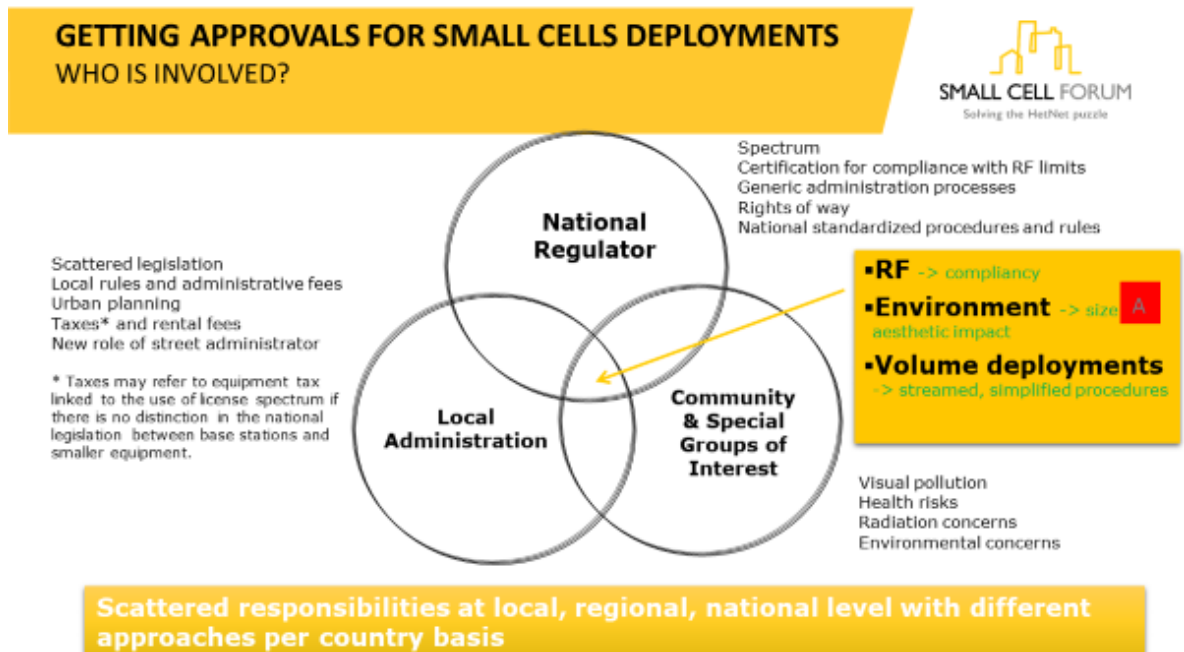


Figure 13 The fragmentation of small cell approval processes between different agencies

4.3 New site types

Densification involves identifying new site solutions such as pre-approved electric utility poles, street light poles, securing lower radiation heights on roof tops or traditional cell towers. The goal is to minimize zoning review and regulatory approval timelines but these new site types still need to be included in the regulatory framework in many cases.

4.4 Power issues

As well as increased numbers of sites and backhaul connections, densification introduces far more places where grid power must be available. That gives rise to several issues:

- **Cost:** the cost of connecting a small cell is not significantly less than connecting a macro tower, with estimates of between \$5,000 and \$15,000 per location. For a small cell that serves only a couple of hundred people, the cost accounts for a far larger share of day one capex compared to the macro site.
- **Space constraints:** there may not be room for a dedicated power source on a site such as a lamp post.
- **Tapping power from existing buildings and/or getting municipal approval** involves negotiations with building owners, tenants and local agencies, and takes time.
- **Power backup:** small cells need to be protected from outages caused by street accidents, storms and even rodents, especially if they are supporting IoT services with critical availability requirements. Some cells deployed to fill coverage gaps in critical areas will require battery or diesel backup, which should be part of any deployment plans prior to



day one rollout. But for backup, the solution may take up more space than the cell itself, or even require additional permits.

4.5 Local planning/zoning laws & rights of way

Such installations would need to comply with existing planning rules, which are usually set at a local level. The local administrative process is intended to assure that specific requirements are met and the installation and operation of equipment is compliant with the norms; however, the more complex the process the more time it requires. In many cases, operators deal with these issues through local partners.

4.6 Leasing and tax arrangements

Telecommunications leases exist between the telecom provider and a landlord. These agreements are put in place in order for the carrier to lease space on the landlord's property, rooftop or tower, to place their equipment for a specified length of time. The carrier normally enters into a lease with a standard timeframe of 20 -25 years, in exchange for monthly or annual payment to the site owners. The biggest costs for most site deployers are franchise fees and real estate taxes. These mean that each pole attachment can cost \$400 in a costly location like New York City. Operators like AT&T have argued that fees imposed by cities should be capped at \$50 a year for access to a section of the public rights-of-way, with an additional \$50 a year for specific ROW infrastructure access. Some states have passed legislation that caps pole attachment fees.

4.7 Installation

Installation locations for urban small cells are typically determined during the RF planning and design phase discussed. When selecting the appropriate locations, the following considerations should also be taken into account:

- Power source availability
- Backhaul connectivity options
- Special environmental conditions
- Local zoning requirements

It may be very challenging to tick all these boxes in a location which also fits well with the MNO's coverage or capacity target.

4.8 Simplified RF compliance

A complication for small cell deployment is the way RF compliance is factored into the design of the installation, in terms of ensuring safe working distances for installers and the general public from the radio transmitters. Currently, different types of rules are used in different nations and states which makes it difficult for the industry to develop low-cost repeatable deployment processes. In some regions, rules are based on high power macro sites which are overly complex for low power small cells. SCF and GSMA have proposed a harmonized



set of installation rules for RF compliance, with simplifications for lower power sites (see 5.3).

4.9 New partnerships

In order to obtain ready to install site solutions, MNOs have to form new partnerships with site owners such as utility power companies in urban cities, rural authorities, city and local government agencies, private building owners and communities.

Time to market is key to the carriers in building out their networks for densification. Hence site acquisition personnel should be encouraged to form strategic relations with a variety of site owners such as utility power companies, tower companies and approach various governmental regulatory agencies to simplify the approval processes such as zoning and building permits.



5. Progress to date

The challenges associated with 5G densification are significant, but important progress has been made in the past year towards a more standardized and rational framework for approval, siting and deployment. The USA has taken a lead in many aspects of this move towards a new legislative and regulatory environment, designed to deliver the benefits of enhanced mobile connectivity to cities while supporting a viable business case for the MNOs.

The most recent developments are summarized here.

5.1 New guidelines proposed by the FCC BDAC working group

There are over 39,000 local governments (including townships, counties, and other municipalities) in the United States, with enormous diversity based on geography, size, resources, aesthetics, existing infrastructure, regulatory and legal framework, history, culture, and community priorities.

The FCC Broadband Deployment Advisory Committee (BDAC), Model Code for Municipalities Working Group was charged with developing a model code for local governments across the country to act as a non-binding, flexible guideline to help to speed broadband deployment across the USA States³.

In April 2018, the Working Group developed the following set of guiding principles to focus its work:

1. Contribute to the swift and safe deployment and expansion of broadband throughout the United States.
2. Ensure the benefits of broadband networks and infrastructure reach all communities.
3. Promote competition, access, and diversity in the deployment of both wired and wireless broadband infrastructure and the provision of broadband services.
4. Develop guidelines for the use of public assets to ensure the best overall outcome for all current and potential residential and commercial broadband users.
5. Develop guidelines for predictable, network-level planning and implementation, which also helps to minimize adverse impacts to municipalities and local communities and maximizes benefits.
6. Promote transferring of knowledge to local governments to help enable and accelerate broadband deployment.
7. Recognize the need to allocate resources to digital inclusion and innovative business models to drive broadband adoption and close digital divides.
8. Promote innovation, economic and job growth, and improved quality of life through broadband access and usage.
9. Promote fair labor and safety standards for workers and the public.

³ <https://www.fcc.gov/broadband-deployment-advisory-committee>



10. Balance the use of public rights-of-ways to support and enhance robust and competitive broadband services in a manner that is consistent and balanced recognizing the differences among technologies.

5.2 State legislation to date

As of July 2018, 20 state legislatures have enacted small cell legislation that streamlines regulations to facilitate the deployment of 5G small cells, mainly in line with guidelines set out by the CTIA and the WIA.

These states are Arizona, Colorado, Delaware, Florida, Hawaii, Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, North Carolina, New Mexico, Ohio, Oklahoma, Rhode Island, Tennessee, Texas, Utah and Virginia.

These laws all take into consideration the unique circumstances of their state and local environment, but have sufficient in common that baseline principles can be established including:

- Streamlined applications to access public rights-of-way.
- Caps on costs and fees.
- Streamlined timelines for the consideration and processing of cell siting applications.

However, other states have rejected similar legislation, or failed to introduce it, and in California last year, a law that was passed by the state Congress was vetoed by Governor Brown.

Table 1 provides some examples of the legislation enacted by some of the states. Source: National Conference of State Legislatures⁴

⁴ <http://www.ncsl.org/research/telecommunications-and-information-technology/mobile-5g-and-small-cell-legislation.aspx>



State	Summary of legislation
Hawaii	Establishes a permitting, application, review, and approval process for small wireless providers or communications service providers to install wireless facilities on state or county solely-owned utility poles, or install associated utility poles, in the right of way.
Illinois	Provides that an authority (a unit of local government with control over rights-of-way) may not prohibit, regulate, or charge for the collocation of small wireless facilities. Provides that small wireless facilities shall be classified as permitted uses and not subject to zoning review and approval under specified circumstances.
New Mexico	Establishes provisions for the deployment of cellular network nodes in public rights-of-way.
Ohio	Modifies the law regarding wireless service and the placement of small cell wireless facilities in the public rights-of-way.
Oklahoma	Establishes procedures for the collocation and deployment of small wireless facilities and utility poles within a right-of-way. Establishes the permitting process for wireless providers utilizing small wireless facilities in certain areas. Establishes permitting process for wireless providers installing and maintaining utility poles in certain areas.
Tennessee	Authorizes a municipality, county, or the State to develop an application process, fee, and rate structure for installation of small wireless facilities on structures used for electric distribution, lighting, traffic control, and signage. Prohibits an Authority from certain practices and establishing certain restrictions relative to small wireless facilities
Virginia	Establishes parameters regarding applications for zoning approvals for certain wireless support structures. Applications for certain new wireless support structures that are 50 feet or less above ground level, and for the co-location on an existing structure of a wireless facility that is not a small cell facility are exempt from requirements that they obtain a special exception, special use permit, or variance.

Table 1 State legislation to date



5.3 Federal legislation and the latest FCC proposals

In July 2018, bipartisan legislation was introduced in the Senate by Republican John Thune (chairman of the Senate Commerce Committee) and Democrat Brian Schatz (a ranking member of its Communications Sub-committee).

The so-called STREAMLINE Small Cell Deployment Act would require state, local and tribal authorities to make decisions on small cell siting applications within 60 to 90 days, or the application would be automatically approved. The new laws would also mandate that fees charged by cities must reflect the actual costs to local governments.

Steven Berry, CEO of the Competitive Carriers Association, said: "Small cells are the technology of tomorrow, but unfortunately, there are lots of barriers that prevent them from being rolled out on a broader scale. This bill helps reduce these barriers, in part by putting reasonable processes and timelines in place for small cell applications."

5.4 The latest FCC proposals

The FCC and municipalities engaged in various clashes during 2017 as the regulator sought to impose a common framework for small cell siting, but many cities resisted, in order to keep hold of their ability to decide their own rules.

However, there have been steps forward in 2018. On March 23, the FCC voted to approve Commissioner Carr's proposed wireless infrastructure reforms, designed to help ensure the USA is 5G-ready and bring more broadband to more Americans. According to the recent Accenture report, the reforms will cut nearly \$1.6bn in 5G deployment regulatory costs, and free up capital for 55,000 new cell sites and 17,000 new jobs.

Until now, all small cell installations have had to be reviewed under both the National Environmental Policy Act (NEPA) and National Historic Preservation Act (NHPA), which were devised for large towers. In comments preceding the vote, FCC chair Ajit Pai noted that deploying a single small cell in downtown Milwaukee cost \$15,000.

According to Carr, only 0.33% of the federal reviews actually resulted in changes to planned deployments, but they consumed tens of millions of dollars each year and caused significant deployment delays. Nearly 30% of the cost of deploying each small cell came from NEPA and NHPA reviews, which if eliminated would save "at least \$1.56bn" during the 5G roll-out process, he said, citing Accenture.

The FCC order exempts most small cells from NEPA and NHPA reviews.⁵

Meanwhile, the FCC is expected to introduce a fresh round of proposals later this year. The operators have been submitting their recommendations in advance of those. For instance, T-Mobile wrote in a filing: "We further urge the

⁵ "Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment" (WT Docket No. 17-79), <https://www.federalregister.gov/agencies/federal-communications-commission>



Commission to ensure that fees charged by state and local governments are cost-based, non-discriminatory, and publicly available.”

Sprint echoed earlier AT&T’s proposals around caps on fees for city furniture locations, suggesting a guideline of \$500 in application fees for the first five sites, with a \$50-per-site charge after that; \$50 a year maximum for ROW usage fees on new poles; and the same amount again for attachment to “publicly owned vertical structures”. These figures largely tie in with the caps now introduced now in the 20 states listed above.

5.5 Operator and city initiatives

As the above illustrates, there has been significant progress in the USA to introduce a regulatory process which meets the objectives of governments, operators and users. However, there are still municipalities which resist the new rules and are hesitating to adopt legislation based on the new model. The biggest blow came in October 2017, when California governor Jerry Brown vetoed a state bill which would simplify the process of installing small cells, saying cities should be able to manage their own rights of way. In the wake of that decision other mayors, including those in Chicago, said they opposed a state law to streamline processes for siting and deploying small cells.

It is important, therefore, that other initiatives make progress in parallel, in the USA and in countries where legislation is less advanced.

An example is a deal recently announced between AT&T and the City of San Jose, which was subsequently followed by similar arrangements between the city and Verizon and T-Mobile.

AT&T says it has agreed to pay the city about \$5m over a maximum 15-year period to access municipal site assets like light poles, throughout the metro area, in order to deploy about 170 small cells. AT&T will make additional payments to San Jose to hire or retrain staff, to speed up local permitting processes. The deal includes an upfront fee of \$850,000 to fund new public works staff, and another \$1m to help overhaul the city’s permitting processes as overall.

The city will get new revenue and blanket coverage of small cells and some of the fees will be placed in a fund to improve city services and open up high speed internet access to underserved citizens.

The operators get blanket approval for small cell deployments, provided the equipment stays within certain guidelines on size, power and so on. This will also be important for IoT deployments, and for AT&T’s FirstNet roll-out, which will require ubiquitous coverage. In Verizon’s agreement, the operator will also fund telematics services for San Jose’s vehicle fleet.

There were hopes that this landmark agreement could form something of a blueprint for other cities, saving operators from having to start from scratch in every negotiation. Indeed, FCC Commissioner Jessica Rosenworcel released anonymized versions of the agreements as an example of how “more



streamlined and uniform practices can help speed deployment". And San Jose Mayor Sam Liccardo tweeted: "We hope our lease agreements—now posted on the @FCC's website—can serve as a model for other US cities."

In fact, AT&T and Verizon were quick to point out that the financial terms would not be applicable to all cities. Of course, the business case is relatively easy to make in a city like this, which would be a key business target because of the wealth, heavy usage patterns and enterprise focus of its population. In less commercially attractive locations, the fees might be considerably less. AT&T pointed out that, if the same scale of charges were adopted everywhere, it would cost \$2bn for one operator to deploy outdoor small cells nationally.

However, while financial negotiations might vary according to each city's circumstances, other aspects, related to approvals and exemptions, could be far more uniform. If other cities follow San Jose's lead, MNOs could see their processes streamlined.

And despite the cost of such deals, this is still likely to be cheaper, for a dense deployment in a major city, than negotiating and paying for each individual location to be approved.

Another advantage of a blueprint approach would be that the cities would feel they had taken an equal role, alongside the telcos, in devising it. One of the major problems for many municipalities is that they believe the FCC has not taken their views sufficiently into account in its policy making. San Jose representatives said they are now talking to other cities about the deal.

5.6 Other initiatives

Organizations such as SCF and GSMA have been involved in influencing regulators in many parts of the world to adopt best practice from the USA and elsewhere, and facilitate densification. For instance, SCF and GSMA were instrumental in defining standardized classes of equipment, which complied with international standards and regulations on human exposure to RF electromagnetic fields. The aim is to offer globally harmonized equipment classes which could then be easily approved by regulators everywhere, because they would be guaranteed to meet guidelines on emissions and other factors such as weight and size.⁶

The approach is based on international standards, such as IEC 62232 Ed.2.0, and aims to support consistent and simplified authorization regimes for RF compliance facilitating the deployment and putting into service of low power RF transmitting equipment such as small cells. Alternative approaches to demonstrating compliance using more complex evaluation techniques from IEC 62232 Ed.2.0 are equally acceptable. The proposed installation classes are applicable for general public exposure limits based on the 1998 guidelines of the International Commission for Non-Ionizing Radiation Protection (ICNIRP).

⁶http://scf.io/en/documents/182_Simplifying_small_cell_installation_Harmonized_principles_for_RF_compliance.php

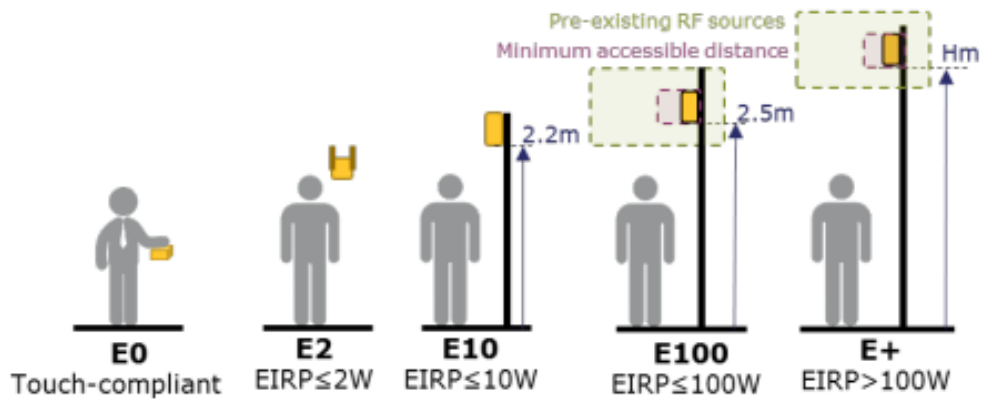


Figure 14 Installation classes simplify deployment rules needed for RF compliance of small cell sites



6. Recommendations for rules to address siting challenges

In 2017, SCF and 5G Americas drew up a list of recommendations to ease the process of approvals and deployment for small cells. These are summarized in Figure 15.

Key challenge	SCF Recommended solutions
Streamlining the regulatory approval for small cell equipment	Standard industry classifications of equipment with common documentation of compliance and conformity to be used when defining related policies; some of these classes can be exempt from approval process or to light regulatory regime.
Scaling the planning application process to support large numbers of cells	Common rules on which equipment classes can be exempt or subject to fast track approval; batch process for groups of cells, to decrease the approval time and reduce workload of local administrations.
Securing sufficient suitable sites with power and backhaul	Simplified common frameworks to ease the opening up the access to street furniture and other existing assets. Census of available assets per municipality. Open access to administrative buildings.
Cost of installation	Adopt simplified rules of installation that would enable non-skilled workers to deploy (based on classes of equipment and complexity of installation). Reduce administrative charges (e.g. installation, operation, periodical revision taxes).
Radiofrequency compliance	Follow international recommendations for installation classes and provide information
Administrative complexity	Single executive to coordinate all approvals (e.g., in a smart city program) Streamlined paperwork and filing to minimize the approval processes and reduce the workload of the administration.

Figure 15 Summary of recommended solutions to facilitate small cell siting. Source: 5GA/SCF 2017

In this paper, 5GA and SCF members have collaborated to come up with a more detailed set of recommendations for best practice, which will be the basis of conversations with national and city regulators in the USA and beyond.

These are summarized below.

6.1 Wireless deployment and rights of way (ROW)

Efforts are needed to streamline deployment and reduce fees for deployment of 5G technology in the ROW

- Jurisdictions should only charge cost-based, non-discriminatory fees to access the ROW and to use municipal poles in the ROW.
- Applications should be reviewed within the FCC shot clock time limits of 90 days for collocations and 120 days for new poles in the ROW. Permit applications that are not acted on within these shot clock time



limits should be deemed approved and include all permits necessary for construction.

- Jurisdictional moratoria on applications for 5G technology should not toll any shot clocks.

6.2 Wireline advocacy

Ensure that pole owners follow the Commission's intended pole-attachment processes and timelines.

- Do not allow utilities to require a "pre-application" process before they will accept an application for attachment. Amend the pole rule to follow the wireless Shot Clock and Section 6409 rules and have the timeline start immediately upon submission of a request for access. This will prevent utilities from evading the timeline imposed by the Commission.
- Eliminate the additional 14-day cost estimate phase of the timeline, which prolongs the pole attachment process, without adding value.
- Require pole owners to provide a breakdown of the pole owners' "actual costs" in of the cost estimate for make-ready work.
- Adopt automated databases and notifications systems, such as those provided by NJUNS as a "best practice" for all utilities and attaching parties.

6.3 One-Touch Make-ready

The Commission should create rules for a streamlined application, permitting and make-ready process that utilize a one-touch make-ready model in the communications space to expedite the deployment of broadband infrastructure. The rules should provide pole attachers with a single contractor, single-trip solution for simple make-ready work which expedites make-ready work and provides adequate staff and resources to support all sizes of projects.

For wireless attachments, the Committee encourages streamlining the approval by electric utilities of contractors to perform work on wireless attachments in the power space, although electric utilities may reserve work in the power space on their own facilities as needed. The rules also should balance every community's interest in safety and continuous service.

Finally, these rules should be uniform across all jurisdictions and for all entities. Therefore, the Committee encourages the Commission to seek to compel all jurisdictions, including municipally-owned utilities, rural electric cooperatives and reverse pre-emption states, into a unified one-touch make-ready process.

To ensure consistent understanding of the various types of make-ready work, the Commission should adopt the following categories for transfer/attachment activities:

- Simple Make-Ready Work in the Communications Space - Simple transfers where existing attachments in the communications space could be transferred without any expectation of a service outage(s) or



facility damage and which do not require splicing of any communication attachment or relocation of existing wireless attachments.

- Complex Make-Ready Work in the Communications Space - Transfers and work within the communications space that would be reasonably likely to cause a service outage(s) or facility damage, including work such as splicing of any communication attachment or relocation of existing wireless attachments. Any and all wireless activities, including those involving mobile, fixed, and point-to-point wireless communications and wireless internet service providers, are to be considered complex.
- Make-Ready Work in or above the Power/Supply Space – Make-ready work in or above the power space, including make-ready work to prepare for wireless attachments in the power space. Such attachments could be for any and all wireless uses, including mobile, fixed, and point-to-point wireless communications and wireless internet service providers.
- It would be up to the attacher and its qualified contractor (reference this Working Group’s “Make-Ready Contractor Management proposal) performing the work to make the reasonable determination as to whether work in the communications space is to be deemed simple or complex, subject to the pole owner’s right to object to such determination.

6.4 National database

Increased broadband development will require the involvement of every resource possible. This extensive application of new resources also will require a change in the delivery model currently in operation. Because the availability of rights of way is limited, it will necessitate that those rights of way, and the infrastructure contained in them, be shared.

This is not a new concept, as communications, power, water and sewer facilities have been sharing these areas since their respective inceptions. In fact, for most utilities, roadways and roadsides establish the only viable public routes within which one can install equipment to provide service. As demand increases, the clamor for scarce space will become an area of contention and delay, and as a consequence the country will experience restricted development unless solutions are created to alleviate this congestion.

Understanding the problem, and to whom the problem should be addressed, is paramount to developing a practical solution, and access to data describing infrastructure assets in common rights of way is the best way to achieve such an understanding, and organizing our regulations, laws and practices around that data will create the most effective solution.

Within the owner community, an effort is underway to improve communications about deployment opportunities to gain efficiencies. The National Joint Utilities Notification System (NJUNS) has been developing a notification system to identify joint construction savings opportunities amongst utilities. A database that identifies construction plans geographically not only would help attachers



capitalize on use opportunities but could help utilities identify possible efficiencies in right of way infrastructure development.

This proposal addresses the need for a database of information tied to geographic locations of infrastructure elements, which is an important national function. Such a database either could be developed and maintained centrally or could be accessed through a common data interface function, depending on the best use of resources and existing data. The dilemma associated with this proposal is that, while the need is clear, the requirements are defined and the limitations are visible, it will take substantially more than a part-time focal effort to develop the business design, financial considerations and technical implementation of such a function.

This proposal provides high-level information for the development of a common database that would house data concerning infrastructure projects and addresses the problem of a lack of knowledge regarding the ownership of current and planned infrastructure projects, the lack of coordination by infrastructure builders, and a lack of cost efficiencies that is a possible by-product of the first two problems.

One use case for the proposed database will be presented as an example of its intent.

1. A database should be built and populated to adequately represent the available common infrastructure elements, including routes, locations and rights of way.
2. This database would be commissioned by the FCC as a public resource, with its development to be funded by the user community in the form of usage fees or licenses. This database should be built and operated by industry experts but overseen by the Commission in the context of a public/private partnership.
3. This database could be developed as an aggregation of existing databases, or information from different databases, currently operated by owners as well as a new subset of databases covering those elements not currently recorded by the owner.
 - If an owner provides database access, such owner should be compensated by usage fees, upcharges in rental fees, or federal funds.
 - If an owner undertakes data entry in a new database, such owner should be compensated by usage fees or federal funds.
 - Operators of a public database should be compensated for their development efforts by usage fees or federal funds.
4. Population of this database would be encouraged by requiring federal program participants – those regulated as well as those receiving funding –to submit entries to the database.
5. The use of the database for efficient access to basic pole information, such as pole locations, specifications and attachments, would be balanced against



respecting the need for security by the pole owners. This database would serve as a clearinghouse for all necessary information that a new attacher would need to efficiently plan for its attachment to another entity's poles.

Another use of this database would be to manage workflow and to track progress on approved attachment projects by incorporating workflow automation to improve the consistency, efficiency and speed of the pole attachment process.

7. Deployment processes must be streamlined too

Another key challenge in the economics of densification is the complexity of deploying and installing the access points. This section examines best practice and other ideas for streamlining the process, making it more repeatable, consistent and automated.

7.1 How new form factors could simplify deployment

Today with the advancement of silicon technology with higher density microchips, we start seeing eNodeBs (base stations) in small cell form factor that can have transmit power at 40W and no longer limit to the sub 1000mW range.

Today the small form factor enables us to deploy in some situations where it used to require a Baseband unit (BBU) on the ground with Remote Radio Head (RRH) and antennas to be installed on the tower. The Small cell here more means a small integrated BBU and RRH in a model and maybe the only external device is the antenna.

For the purpose of this paper we are also talking about the devices that are going to be deployed outdoors rather than indoor deployment scenario. They are called small cell because they are built for simple installation.

This small form factor of size of about 20x10x12in (HxWxD) and weighs approximately under 70lbs can have transmit power of 40W and coverage radius up to 1.5 miles is available and deployed today.

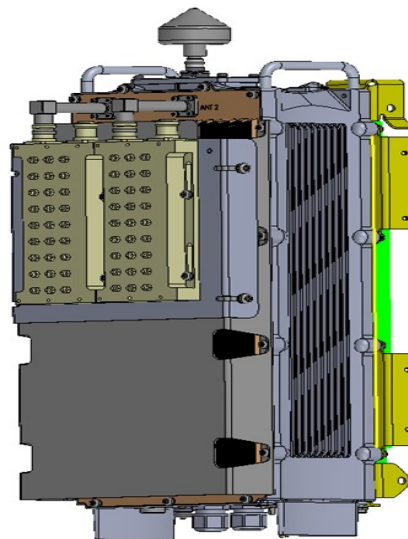


Figure 16 A high power eNodeB in small cell form factor

This small cell form factor helps with site preparation and installation. The only thing is needed is power and, in some cases, backhaul connectivity.



Figure 17 An example of small cell pole deployment with only power supply is required to the pole

Above is an example of the same small cell mounted on a pole using wireless backhaul.

The compactness of the device has helped tremendously in site installation process. For pre-installation here, all we need is to have power supplied to the pole. The main eNodeB unit can be mounted by using mounting straps. In this instance, the wireless backhaul unit can also be easily mounted on the pole and is powered via Power over Ethernet from the eNodeB equipment. The antenna is mounted on top of the pole and connected to the eNodeB via the antenna cables. The whole installation process used to take a few days to complete now can be accomplished within less than 2 hours and in a number of instances less than one hour.

One of the better use case of advancement in small cell form factor is the strand small cell deployment leveraging the cable network. In this case the eNodeB is integrated with a cable modem in strand form factor. The unit is connected to the cable network for backhaul and also for power via a single coax cable. In this case, the installation is real simple, the installer just hangs the unit on the strand, then connect a coax cable from a cable strand tap to the device, and voila within less than 30 minutes arriving at the site we have a complete eNodeB hung on the strand and ready for radio transmission. Figure 18 below shows an

example of a strand mount on the cable network strand. The size of this strand is 18" x 7" x 8" in (LxWxH) and weighs less than 20 lbs. An example of the unit deployed on a cable network deployment is seen in Figure 18.



Figure 18 An example of a strand mountable eNodeB

7.2 A best-case deployment process for small cells

In order to simplify deployment, the new radio platform is designed with Plug-and-Play (PnP) feature to simplify the deployment process. There are several ways to perform PnP operations. An example of a PnP implementation is as follows:

The unit on power up will perform:

1. Device self-test

The small cell device is powered up and performs its own diagnostic to ensure all components are in good order.

2. Network discovery

In this stage, the device will perform network discovery function to figure out which type of backhaul and which method that the device need to connect back to the core network. The key function here is that the device will self-discover the type of backhaul it is being connected to the core network: private vs. public backhaul. The device will discover all necessary parameters and network topology so it can set up connectivity to the device's network management system for the device's configuration.

3. Self-establishment of connection to management

Once the network topology has been determined, the device will go through the connection establishment setup to be able to connect to the designated network management system to manage the device.



4. Self-identification

At this stage the small cell device can send info like the LAT/LONG and hardware serial # to the Element Management System (EMS).

An implementation can require some pre-configuration of minimal configuration on the EMS for the identified devices, and at time of installation, the installer can call the Commissioning centre to associate the radio device identification with the pre-configuration data prior to power up. Upon receiving the identification message, the EMS now can provide the assigned configuration data to the device.

The process can be improved to zero touch PnP, where there will be no re-configuration of radio device is required. In this case a little more intelligence needs to be built in the EMS where the EMS can generate all relevant RF configuration for the device based on the LAT/LONG that the device reported.

5. Network configuration of radio device

The EMS configures the device and also update the software on the device to the designated software version should it be necessary.

At this point the unit is ready to operate.

6. Device performs self-optimizing network (SON) to fine tune configuration parameters.

Before the radio device goes into full operation, the device may want to perform some of the SON parameter fine tuning.

The PnP process simplifies the commissioning of a new radio device. Together with the radio device small form factor, the installation and commissioning of a new small cell today can be completed in less than an hour to a few hours max. A process that usually require several days of preparation and commissioning of a new traditional macro cell site!

7.3 Addressing the power issue

As outlined in 1.3, ensuring that every site has reliable power at an affordable cost can be a challenge in a large-scale deployment of small cells. Applying a macrosite solution to power is impractical because the costs scale with the number of sites.

One emerging solution is to combine the cell's two key requirements – backhaul and power – by running both power and optical transmission along the same path or even within the same cable. This can be done via hybrid fiber coaxial (HFC), which is the main technology deployed by the modern cable TV providers

in North America. Small cells can harness the power-carrying capability of the integrated coaxial cable.

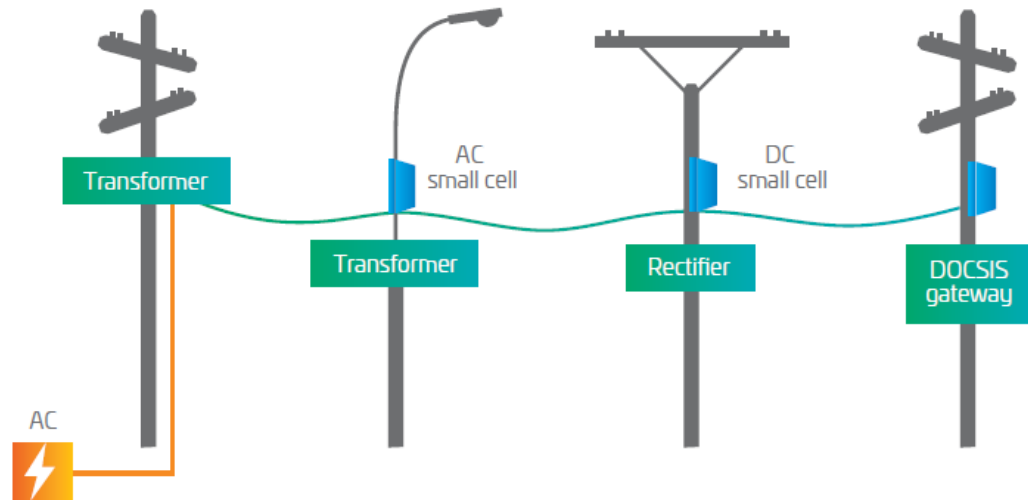


Figure 19 Example of an HFC power solution. Source: CommScope

There are other power solutions where HFC is not available. These include:

Twisted pair: Using the power-carrying capability of the legacy copper telephone networks, or remote feed telecommunications (RFT) circuit.

Power over Ethernet (PoE): The latest PoE standard, IEEE P802.3bt (PoE++), is expected to be finalized in 2018 and will support up to 71.3 watts (dc) per device port⁶. This means it is too limited in terms of power restrictions and distance (up to 100 meters) for most small cells, but there are solutions that enable operators to use the technology over longer distances. CommScope’s Powered Fiber Cable System, which includes a PoE extender, increases the span up to three kilometers, for instance. However, the power limitation remains, and many 5G small cells will require fiber to achieve the necessary performance.

Distributed power connectivity: In very dense environments, HFC can be used to deliver power and connectivity from a central location to a cluster of neighboring small cells. A suitable centralized location could be anywhere that has access to power and the optical network, such as an outdoor distribution cabinet, telecom closet or macro base station location. This approach takes advantage of advancements in dc power delivery. Such improvements have increased the efficiency of dc-dc conversion to more than 95% and enabled the use of higher voltage levels to transport more power over long distances more efficiently. HFC makes it possible to power and connect dozens of small cell locations—spaced 200 meters apart—from a single location with local grid power and room for power backup. This also cuts out the time and cost of a utility drop.

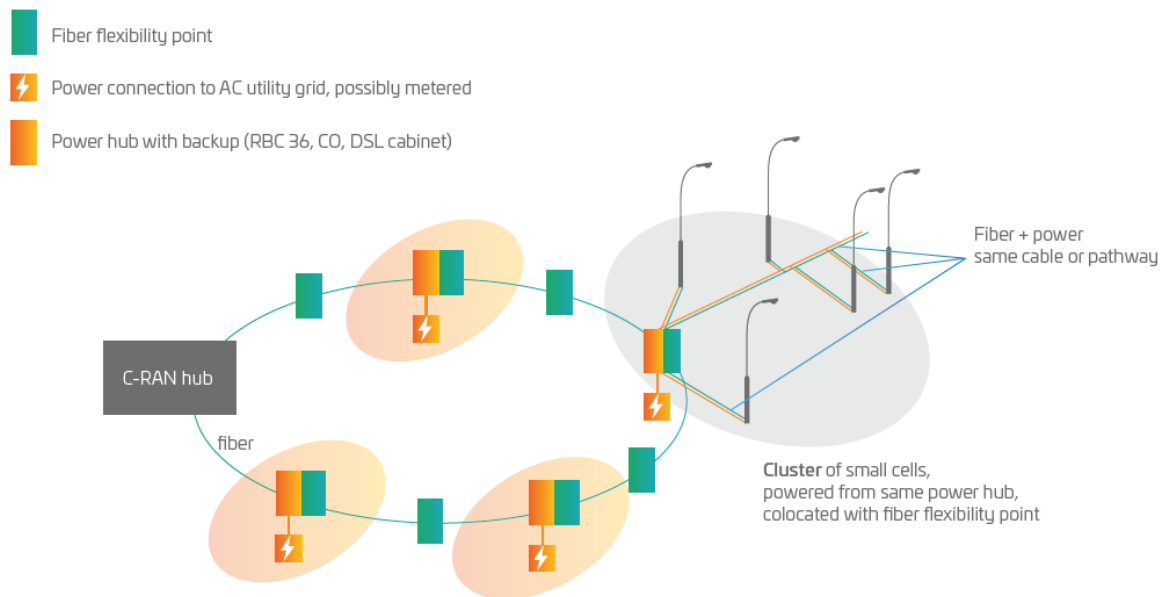


Figure 20 Cluster power solution supporting a C-RAN deployment. Source: CommScope

7.4 Environment and aesthetics

Small cells are designed for high traffic public areas which are often outdoors (e.g. in parks or city centers). Engineered into robust enclosures suitable for deployment in unsupervised exterior environments, their small form factors – as illustrated in 7.1– allow MNOs to position them closer to the subscribers.

However, this closeness means they can be very visible to citizens, and breach regulations on aesthetics, especially in historic centers. And LTE and 5G mean far larger numbers of cells. While forecasts vary, it is not inconceivable to imagine 2-5 times more 5G sites than LTE sites.

In addition to growth in the number of sites, we also expect a trend towards more street level deployments vs rooftops and 40m towers typically used for LTE. This is because the line of sight (LoS) requirements of mmWave force implementations to have as few obstructions as possible between antenna and user devices. That means, practically, deployments on poles, the sides of buildings, and street furniture.

Combined, these two realities, namely more sites, and more visible sites, are creating a demand for an increased focus on the aesthetics and acoustics of small cell installations, both by individuals and municipalities. These demands are not only niceties, but are increasingly becoming mandatory to even acquire new sites.

There are many existing and emerging approaches to minimizing the visual impact of small cells on their surrounding environment, while keeping them optimally located to support good quality connectivity.

Typical examples of small cell placement locations include:

- Mounting on existing structures, such as building exterior walls or rooftops.
- Mounting on vertical utility structures, such as utility poles, lampposts or traffic lights.
- Mounting on ceilings in indoor locations or sheltered outdoor locations, such as train stations, venues, or stadiums.
- Mounting on street furniture such as bus shelters, advertisement panels, newsstands.
- Mounting on specially designed facilities that conform to the surrounding environment, such as artificial trees in community parks and similar public areas.
- Aerial CATV cable-strand mounting, using existing cable service lines.

Figure 21 shows some of the ways in which small cells can be concealed within city furniture.

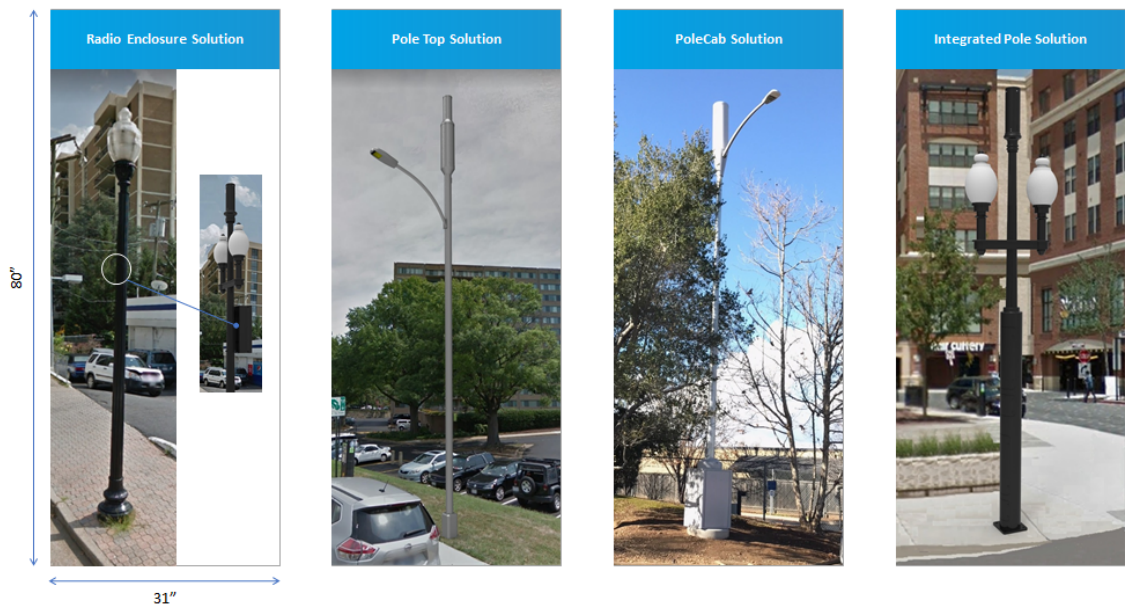


Figure 21 Metro concealment options for small cells. Source: CommScope

In addition to sensitive siting, engagement with municipalities, the typical owners of assets, have highlighted the need for products that blend into the environment and avoid noticeable antenna, and do not create any undue noise. In some cases, the municipality mandates the use of specific shrouds to house all the products and ancillaries for small cell operations.

These requirements drive some obvious product attributes such as size and volume. But other aspects such as paintable products to match pole color and fanless solutions, lead to creation of new thermal designs.

Stealth techniques are also being mandated to blend products onto or into the actual site locations, for example, cannisters in the shape of a pole, attached to the pole, as seen in Figure 22.



Figure 22 A canister design, and attached to a pole. Source: Kathrein

Small cells can even be disguised within manhole covers, as seen in Figure 23.

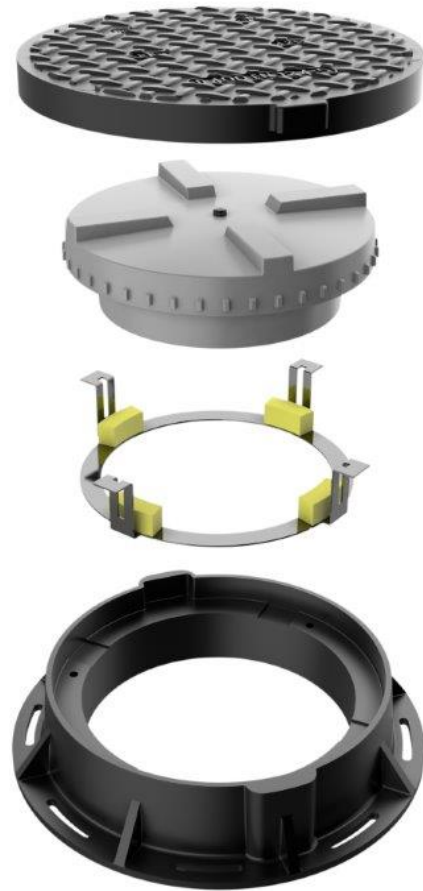


Figure 23 Small cell integrated into manhole cover. Source: Kathrein

Integration of LTE base stations into street lighting has been tried already in several projects, such as [Philips SmartPoles](#). The Nokia-driven industrial collaboration [LuxTurrim5G](#) aims to build a smart lamp post platform, which enables business opportunities for digital service. The light poles will have



integrated mmWave base stations as well as sensors and services related to surveillance, navigation, weather monitoring and advertisement.

In short, going forward, with either LTE densification or 5G deployments, while creating design challenges, stealth design will continue to be an integral and critical part of small cell products to achieve municipal acceptance and street asset usage.



8. Summary

To conclude, 5G Americas and Small Cell Forum believe that regulatory change at national, state and city level is required to reduce the time and cost of deploying small cells at scale. If the challenges of siting for outdoor cells are not addressed in a timely fashion, many of the benefits which governments, regulators and cities hope to derive from 5G – such as smart city platforms and the Industrial IoT – will be severely compromised.

We believe significant progress has been made and there is a growing understanding between MNOs, regulators and cities about the mutual benefits of densification. There is also rising awareness that solutions do exist to ease the process of small cell deployment, while remaining sensitive to city concerns about disruption and aesthetics. It is now urgent to build on these beginnings to arrive at a unified and simplified approach to wireless deployment regulations, built around these core principles.

- Small cell siting should be streamlined where possible to use local infrastructure policies and design guidelines
- Small cells are similar to Wi-Fi access points - no specific planning permissions should be required to roll out such networks
- To simplify and provide uniformity of networks, national rules should be established for rights-of-way for the deployment of small cells. This is for both the access to the property as well as the administrative paperwork –the same policies should apply nationally.
- Scaled down administrative processes should be used for instances of small cells deployments; this will also speed up the administrative flow of documents through local planning.
- Standard deployment procedures for small cells should be developed and established.