TELECOM INFRA PROJECT

Mobile Connectivity Playbook for Cities

Connected City Infrastructure Solution Group

Date: February 2022

Document version: 1.0

Confidentiality Level: GREEN [Public Access]

Overview

In Europe, 5G coverage is already extensive in urban areas, provided primarily from existing macrocell towers. Although the macrocell-based deployment of 5G services has provided some capacity relief to 4G networks, increasing urban mobile data demand is pushing against the capacity limits of the existing network infrastructure. In addition, the deployment of mmWave 5G services, which would add significant new capacity, is not practical using macrocells.

The challenges for network design that are already evident in urban 4G deployments become dominant with the transition to 5G. **Building urban mobile networks for 5G requires a new way of thinking**.

City governments and mobile network operators must develop a more cohesive approach for the installation of new, or reuse of existing, street assets as part of network densification initiatives.

This playbook identifies a lifecycle and tools that collectively help mobile network operators to improve their urban mobile networks efficiently and cost-effectively and city governments to further their digital agenda and be good stewards of the city's resources and streetscapes.

It is a deliverable from the collaboration between the city, operators, infrastructure providers and other stakeholders within the TIP Connected City Infrastructure solution group.

Resources

We have developed several resources that complement this document and help you to understand and undertake the activities described in this document more quickly.

Lifecycle Manager template	Guides the stakeholders through lifecycle stages (information gathering through to deployment). Identifies stakeholders and activities
Needs Assessment template	Establishes the current condition of an area and analyzes the communications needs
Capability Assessment template	Identifies candidate solution providers and solutions
Reference for Deploying Telecoms Equipment on Street Assets	Describes the evolution of urban mobile network physical assets. Identifies alternative street asset solutions
Network Planning reference	Details an example 4G and 5G RF design and planning exercise for a small cell deployment in a city center

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Change Tracking

Date	Revision	Author(s)	Comment
February 2022	V1.0	Neil Bullock	First publication

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Supporting European Digital Priorities

A key European Union (EU) digital priority is to ensure that all European households are covered by a Gigabit network, with all populated areas covered by 5G by 2030.

The European Commission is also working towards the development of Smart Cities in a number of ways, including achieving a smart city digital ecosystem, maximizing efficiency and flexibility, building consensus, connecting Europe, and looking towards smart and climate-neutral cities.

Furthermore, the European Commission's post-Covid recovery funds focus on strategic digital capacities (supercomputers, AI dataspaces, cybersecurity, skills) and high-speed connectivity solutions, with at least 20% of the €806.9 billion dedicated to that end.

The Telecom Infra Project (TIP) is working on several solutions that have been supporting the European economy throughout the pandemic through improved connectivity and are essential to the achievement of the EU's future ambitions under the Digital Decade. TIP's work on connectivity rollout and technology, in particular the role of open and disaggregated technologies, can contribute to many of the EU's goals including supporting the European Commission in achieving the Smart Cities digital ecosystem and fostering local economic goals.

Collaboration

Launched in 2016, TIP is a community of diverse participants that includes hundreds of companies, from hardware manufacturers and software makers to mobile network operators, edge service providers, system integrators, start-ups and many others involved in the telecommunications supply chain. TIP and its participants work together to design, build, test, and deploy end-to-end solutions that are open, disaggregated, and standards-based. TIP participant companies and institutions come from around the world and all backgrounds to build a more vibrant, collaborative telecom ecosystem that delivers solutions.

TIP has a heavy presence in Europe, with participant companies driving initiatives at both member state and European levels. TIP's European members include Telefonica, BT, Orange, Deutsche Telekom, Vodafone, Telenor, Cork Institute of Technology, Ghent University-IMEC, Schneider Electric, and SNCF, among others.

The Connected City Infrastructure project group is a large-scale innovation program within TIP that investigates how to leverage new and emerging technologies including 5G to tackle challenges cities face and deliver better city services.

The initiative will develop and provide better city services and infrastructure for citizens and businesses, promote economic output, and encourage innovation in the telecoms sector, SMEs and tech industry in general.

"Digital connectivity infrastructure, both fixed and wireless, plays a critical and increasingly important role in Dublin's economic development. Covid-19 has reinforced the importance of connectivity in our cities and towns. Having the right type of connectivity is also essential for Dublin's future competitiveness. We are entering a new era of super connectivity with the emergence of fifth generation (5G) mobile networks" – Smart City Programme, Dublin City Council

Wireless networks are essential to a city's economic and social development. Cities must develop innovative, collaborative frameworks in order to offer high quality mobile experiences for citizens, tourists and local businesses.

The TIP Connected City Infrastructure project led by Dublin City Council and the Connect Research Centre is developing commercial and technical approaches that facilitate the provision of high capacity 5G and Wi-Fi networks in Dublin's city center through the use of street assets. The project is exploring the sharing of assets to improve the business case for service providers and minimize the footprint on city streets both during and after installation.

The learnings from this project form the basis of this Playbook, toolkit and other guidance to city governments and operators in Europe and worldwide. While no two cities' circumstances are identical, many of the challenges are common and we hope that our learnings contribute to a successful program in your city.

A New Way of Thinking for 5G

In Europe, 5G coverage is already extensive in urban areas, provided primarily from existing macrocell towers. Although the macrocell-based deployment of 5G services has provided some capacity relief to 4G networks, increasing urban mobile data demand is pushing against the capacity limits of the existing network infrastructure. In addition, the deployment of mmWave 5G services, which would add significant new capacity, is not practical using macrocells. The challenges for network design that are already evident in urban 4G deployments become dominant with the transition to 5G. Building 5G networks using higher frequency bands requires a new way of thinking.

The promise of higher speeds

One of the most important promises of 5G, and one that is an immediate priority for operators, is the significant increase in data capacity.

Channels in the higher frequency mobile bands (2-6 GHz) are much wider than in the lower bands (<1 GHz) and are therefore capable of higher data transmission capacity. High frequency bands have therefore been the focus to achieve high capacity services, especially in urban areas where the demand is greatest. Each generation of mobile technology has used higher frequency bands than the previous generation.

These high frequency bands have different propagation characteristics than the lower bands.

Shorter signal range

Reduced propagation by reflection

Limited in-building penetration

Figure 1: Limitations of high frequency bands

Implication: densification

These characteristics have their benefits: since signals do not propagate so far, the spectrum can be reused multiple times across a deployment area. This yields a significant increase in capacity in an urban area. However, each cell covers a much smaller area. To meet their capacity and coverage requirements, operators must densify their networks through the deployment of additional network infrastructure at the street level.

The map below illustrates the implications of ad-hoc street-level mobile network densification in Manhattan, New York. The green circles represent existing 4G cells, the red squares represent the additional poles required for 5G densification. The cell site density and the capital cost is high.

Figure 2: Mobile network densification
Manhattan, New York (Source: NYC DOITT)

As seen here and elsewhere, the operators have built overlapping small cell networks at distinct street locations, each requiring planning, permitting, civil engineering works and infrastructure and equipment installation.

Need for collaboration

This ad-hoc approach to deployments at the street level has a number of undesirable consequences:

- City aesthetics are impacted by unsightly additions to street assets
- Unnecessary equipment clutter occurs due to the collocation of separate street facilities without regard to asset sharing
- Repeated civil works are undertaken that disrupt pedestrian and street traffic flows due to the uncoordinated installation of power and data services to street assets

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Unsightly additions | Unnecessary street clutter | Disruptive civil works

Figure 3: Consequences of ad-hoc mobile network equipment deployment

However, by taking a collaborative, holistic planning approach, city governments and their operator partners can obtain several benefits on behalf of their citizens and customers:

- Consideration of the streetscape in general and the requirements of heritage districts in particular will drive improved aesthetics
- Shared open access infrastructure and innovative design will result in the more efficient use of street assets and the reduction of street clutter. Furthermore, the use of shared infrastructure would significantly reduce the capital cost and time to deployment
- Coordination and futureproofing of civil works will mean less disruption and lower costs

City governments and operators must address these different aspects as they develop a more cohesive approach for the installation of new, or reuse of existing, street assets as part of network densification initiatives.

What triggers the collaboration process?

It is not the nascent use of street assets that triggers changes to the way of working - in practice, cities, operators and their partners can continue as they always have for some period.

However, there comes a time when it becomes increasingly clear to one or more parties that projects are taking too long, are too complicated, are too expensive, and are too narrow in vision.

The parties have different agendas to fulfil: for example, the city is internally focused on city services, social needs and bridging the digital divide, and (re)development. External parties are focused more on metrics such as capacity and coverage.

It is important for all the parties to recognize that the increasing inadequacy of the existing way of working is the **catalyst** they need to come to the table, recognize each party's agenda and talk openly and honestly about the compromises necessary for a more efficient and effective approach.

Best Practice recommendations

A different way of working

Relationships between city and operator have been transactional

The relationship between the city government, operators and their infrastructure providers has been generally transactional to date. Traditional macrocell and some small cell deployments have been on private property and the role of the city government has been limited to the planning and permitting process.

However, as operators start to densify their networks due to the issues identified in the Introduction, the city will be faced with an increasing volume of requests for the use of street assets.

In street level deployments, relationships become more complex

In the deployment of a dense mobile network on street assets, the relationships are more complex and there is more at stake for the parties. The end goal is to establish a set of relationships and a way of working that enables the stakeholders to deploy mobile networks efficiently and effectively in their city on an ongoing basis.

The value of the pilot deployment in learning change

It is necessary for the stakeholders to go through a learning process in order to reach this point of maturity.

Recommendation: Conduct a limited scope pilot deployment prior to a city-wide full-scale deployment.

By conducting a pilot deployment, the stakeholders are in a lower risk environment. It is easier to start the conversations that establish trust.

This playbook describes how to conduct a deployment using a toolkit and building on the learnings obtained in other cities. The tools can be used in a pilot deployment and in the mature state of mobile networks deployment.

The value of a facilitator

Recommendation: Engage and empower a facilitator. TIP participants with deployment experience can provide training in the use of this playbook and the accompanying toolkit.

It should be noted that a pilot deployment is the beginning, not the end, of mobile network deployment at the street level in the city. The need for network densification is projected to grow substantially over time as new use cases, such as autonomous vehicles, compound the increase in data traffic.

The life cycle of connected city infrastructure

In this playbook, we go through several phases that combine progressively more detailed analysis with consensus-building towards an optimal street-level mobile network deployment.

Phase 1: Getting Started

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Phase 2: Scope the deployment

↓

Phase 3: Outline planning

↓

Phase 4: Street level planning

↓

Phase 5: Site Implementation

Lifecycle Map

	Phase 1 Getting started	Phase 2 Scope the deployment	Phase 3 Outline planning	Phase 4 Street level planning	Phase 5 Site implementation
Action 1	Establish a city telecom working group	Identify the deployment areas	Assess the current mobile network conditions	Confirm radio equipment	Undertake preparatory street civil works
Action 2	Identify the stakeholders	Write a deployment area needs assessment	Analyze the mobile network needs	Agree street asset type and specification	Install the street assets
Action 3	Perform an initial high-level needs assessment	Develop a project plan and a task matrix	Identify the candidate street locations	Define power connection requirements	Connect power to the street assets
Action 4	Start any advance work	Conduct a stakeholder meeting	Complete the network planning	Define data connection requirements	Connect data to the street assets
Action 5				Develop detailed design and BOM	Install and bring up radio equipment
Action 6				Obtain permits	Test to confirm network performance

Table 1: Lifecycle Map

Phase 1: Getting started

Action 1: Establish a city telecom working group

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Action 2: Identify the stakeholders

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Action 3: Perform an initial high-level needs assessment

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Action 4: Start any advance work

Action 1: Establish a city telecom working group

Recommendation: If there is no existing function in the city government to administer the deployment of mobile networks, create an ad-hoc telecoms working group.

Traditional city departments have great expertise relating to their core functions and are responsible for managing key data resources such as Geographic Information System (GIS) mapping relating to the infrastructure of the city.

However, they usually do not have the required domain knowledge and are not chartered to manage the deployment of communications services that are outside of the city's internal needs.

The working group can facilitate and coordinate discussions both between the existing branches of the city government and with external parties.

Recommendation: The city executive should champion the working group to give it the necessary authority to provide direction to the other branches of government and to negotiate with external parties.

The working group can form the basis for the creation of a formal telecom unit upon the completion of the pilot stage.

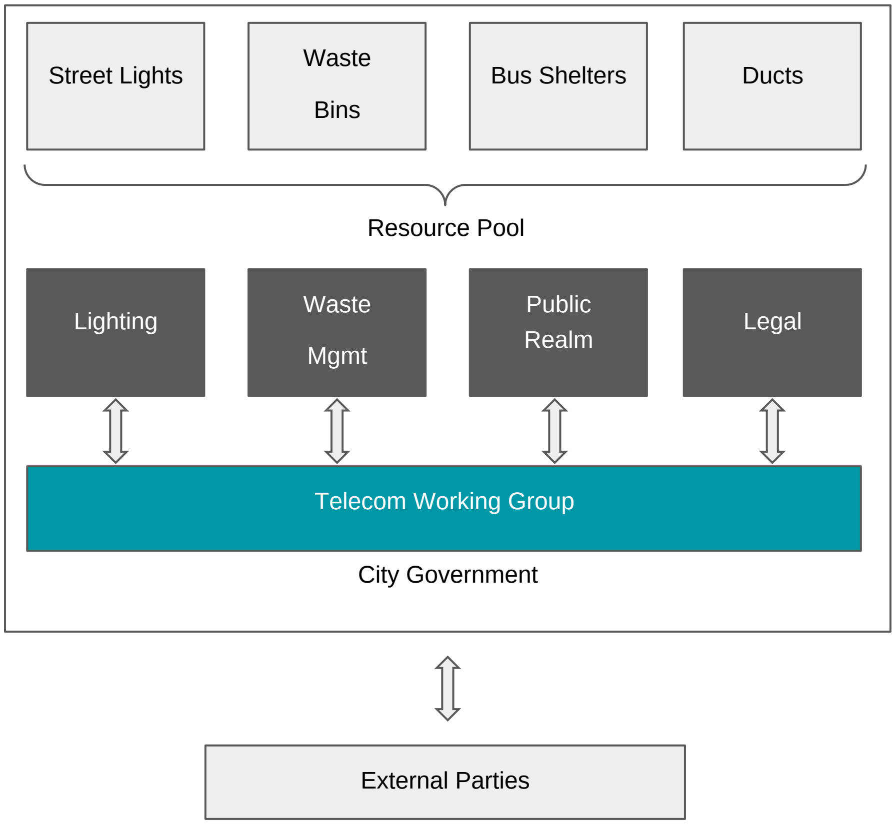

Figure 4: Example City Organization with a Telecom working group

Action 2: Identify the Stakeholders

List all the stakeholders in the project. Identify if the stakeholder is a *customer*, a *supplier* or *other* party.

- *Customer* means an entity that is the direct beneficiary of the deployment - for example, a mobile network operator (on behalf of mobile phone users), the public safety service (on behalf of citizens), and so on.
- *Supplier* means an entity which directly supplies a component of the deployment - for example, an infrastructure provider (supplying street assets), a fixed broadband operator (supplying backhaul) and so on.
- *Other* parties facilitate the project and generally are not suppliers or customers.

The list of stakeholders can be quite long, even when only the participants directly involved in the project are considered.

Identify also whether the stakeholder is internal or external to the city government. This is important when the project is organized.

Note that it is not necessary for parties to be listed as a stakeholder if they are acting under contract to one of the stakeholders with no independent role in the project.

Entities from the following list are typical stakeholders in a project:

- Street Lighting
- Waste Management
- Legal
- Environment
- Operators
- Infrastructure Providers
- Street Asset Providers
- Electricity Supply
- Fiber Provider
- Research organizations

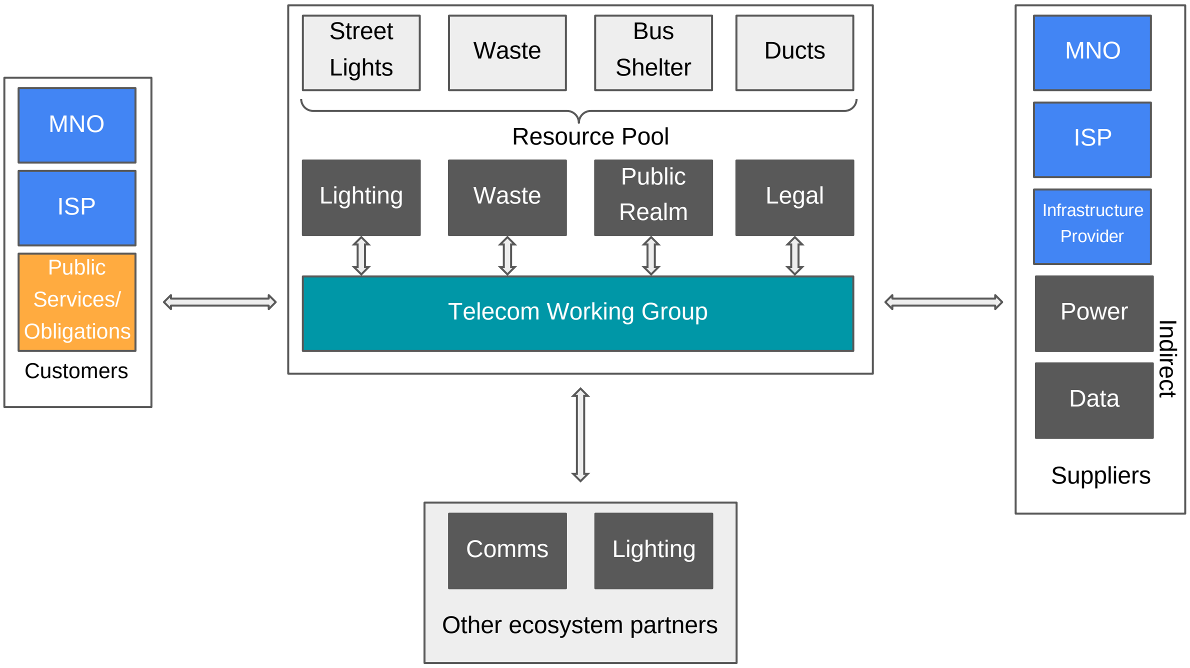

Figure 5 :Example Stakeholder Map

Action 3: Perform an initial high-level needs assessment

Recommendation: undertake an initial high-level needs assessment for the communications services of the whole of the city.

This assessment informs the discussions with stakeholders and is used as the basis for later phases of the project.

The needs assessment should be conducted in accordance with the city's usual process for information gathering such as the publication of a Public Information Notice (PIN) or Request For Information (RFI).

The stakeholders identified in the exercise in the previous section should be informed that the needs assessment has been started, to encourage their contribution.

If the assessment reveals additional stakeholders, they should be added to the stakeholder list.

Action 4: Start any advance work

In any connected city deployment, there are several items that take a long time to address. It is worthwhile to address or mitigate these items as early as possible in order to reduce project delays.

1. Determine if there are special considerations for historic / heritage districts or assets

   Frequently, the areas that are ripe for improved connectivity are those that have the greatest restrictions due to considerations for their historic importance or heritage status. These areas may need to be protected for the pilot program but ultimately will need to be addressed in a full-scale deployment

2. Develop a database of locations that are prequalified by suitability and the availability of power and data. It will substantially reduce the number of iterations of the planning cycle.

3. Determine if the electricity supply company has challenging technical or commercial requirements. Examples of the barriers that might be encountered are:

   Connection method: Small cell deployment on a street light is not supported by any of the approved connection methods. For example, separated power supplies might be required.

   Tariff and metering: Small cell power usage is incompatible with the available tariff schemes. For example, 24-hour usage might not be available, or a metered connection is required.

   Ownership: The separate ownership of street and communications assets is outside the scope of the existing supply agreement.

4. Determine what licensing framework exists

   Licensing of street assets for small cell deployments differs from typical city licensing arrangements due to the need to provide access to multiple assets in an equitable fashion. It may be possible to adapt an existing licensing framework, but it is likely that a new framework will be required.

Phase 2: Scope the deployment

Action 1: Identify the deployment area(s)

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Action 2: Write a needs assessment for the deployment area

↓

Action 3: Develop a project plan and a task matrix

↓

Action 4: Conduct a stakeholder meeting

Action 1: Identify the deployment area(s)

We consider first the scenario where you conduct a pilot deployment.

Recommendation: if you are starting with a pilot deployment, choose areas that (1) exhibit high mobile traffic and (2) are uncontroversial.

The operator must demonstrate that the street-level network can effectively offload traffic from the existing macrocell network without negative impact to its performance. This is best achieved in an area of high mobile traffic. It also satisfies the operator's need for improved network performance.

The selected area should also be practical for deployment. While high mobile service demand often occurs in historic city centers, there is much higher likelihood of pushback, which might delay or stall the pilot. It is better to seek areas with which the pilot deployment will be seen as more compatible, such as commercial districts and transport hubs. If the pilot deployment is shown to be sensitive to the visual environment then later deployment in historic areas becomes more acceptable.

Recommendation: develop a shortlist of candidate areas. The list should briefly explain why an area is selected and why any qualified candidate areas are excluded. **The list should be reviewed iteratively with the stakeholders until a consensus is reached**

Action 2: Write a needs assessment for the deployment area

Recommendation: conduct a needs assessment for the deployment area. The needs assessment should provide a complete as possible view of the area under study while being conducted in a reasonable amount of time.

Describe the area

The first part of the assessment is an objective description of the area. It focuses on general characteristics, other than communications. Upon reading it, the reader should be able to visualize the area and also understand the potential constraints. Special attention should be drawn to heritage districts and redevelopment areas. Maps and pictures should be included directly or by reference to substantiate the description.

This part of the assessment provides the context that informs subsequent conversations about the communications aspects. It is usually completed by or on behalf of the city.

Describe the existing infrastructure

The second part of the assessment is a catalog of the existing infrastructure. The infrastructure includes passive assets like street poles and ducts and active assets that are hosted by them such as power and fiber.

A qualitative description of the resources should be accompanied by human-readable maps for initial reference. The definitive Geographic Information System (GIS) resources should be made available through, for example, Keyhole Markup Language (KML) files.

This part of the assessment is usually completed by or on behalf of the city.

Describe the existing and desired service

The third and fourth parts of the assessment are directed to Mobile Network Operators, Internet Service Providers and public agencies, including the city.

In these parts, we assess the *existing levels of service* being provided and the *desired level of service* after a program of improvement.

The assessment describes the services delivered by the mobile networks, both generally and specifically to certain areas. The primary metrics are coverage and capacity.

It should be expressed in terms of customer experience and customer needs, as well as more traditional operator-specified metrics.

The assessment should also describe the location, capability and accessibility of public Wi-Fi services, if they are available.

Finally, the assessment should address public services such as public safety (for example, traffic and pedestrian safety), city and utility communications (perhaps in the form of a private network), and environment (for example, parking, air quality and noise).

The needs assessment is an important opportunity to capture the needs of an area holistically. A template that can be used as a guide for the needs assessment is available from TIP.

Alternatives to the needs assessment

Recommendation: If you decide to not conduct a formal needs assessment, you should meet with the stakeholders and jointly explore the characteristics of the area through maps, pictures and video.

Action 3: Develop a project plan and a task matrix

Recommendation: decompose the project into phases, and then into activities within those phases.

Once the project is decomposed, you should define the role (if any) of each stakeholder in each activity.

One commonly used model for the assignment of roles and responsibilities is the **RASCI** matrix model. It helps to clearly state who is working on what subtask of the project.

The different roles are defined as follows:

- **R - Responsible** - who is responsible for carrying out the assigned task?
- **A - Accountable** (also **Approver**) - who is responsible for the whole task and who is responsible for what has been done?
- **S - Support** - who provides support during the implementation of the task?
- **C - Consulted** - who can provide valuable advice or consultation for the task?
- **I - Informed** - who should be informed about the task progress or the decisions in the task?

The role of a stakeholder will depend on the specific activity, and it will often change between activities. For example:

Name	Stakeholder 1	Stakeholder 2	...	Stakeholder n
Activity x	Responsible Accountable	Support		Consulted
...				
Activity y	Support	Responsible		Accountable

Table 2: Example Task Matrix

The Responsible and Accountable roles are mandatory. All others are optional.

To avoid uncertainty, only one stakeholder should be Responsible for an activity, and only one stakeholder should be Accountable. A stakeholder can be both Responsible and Accountable. The other roles may be assigned to multiple stakeholders, if necessary.

The task matrix should be completed before the stakeholder meeting (see below)

A template that can be used as a guide for the project plan is available.

Action 4: Conduct a stakeholder meeting

The purpose of the stakeholder meeting is two-fold: to (1) review and confirm the needs assessment and (2) agree the assignment of roles and responsibilities within the project to the task matrix.

Recommendation: invite both internal and external stakeholders to the stakeholder meeting in order to facilitate communication between the different parties and resolve outstanding issues.

To ensure inclusion and balance, a facilitator should conduct the stakeholder meeting.

Phase 3: Outline Planning

Action 1: Assess the current mobile network conditions

↕

Action 2: Analyze the mobile network needs

↕

Action 3: Identify the candidate street locations

↕

Action 4: Complete the network planning

Note that this phase usually requires several iterations between the actions to find an acceptable solution

Action 1: Assess the current mobile network conditions

Recommendation: perform a granular assessment of the current performance of the mobile network in the area of study as a first step in determining how improvements can be made.

The gap between actual and desired performance in a mobile network is usually described in terms of coverage and capacity. Poor coverage is exemplified by low signal strength, dropped calls and low data rates. Insufficient capacity is exemplified by low data rates at relatively high signal strength.

Coverage is more intuitive - the further one gets from a mobile network site, or the more obstacles there are, the worse the signal strength is. Coverage can be represented on a "heat map" - a colored chart that overlays metrics of network performance on a two-dimensional geographic rendering.

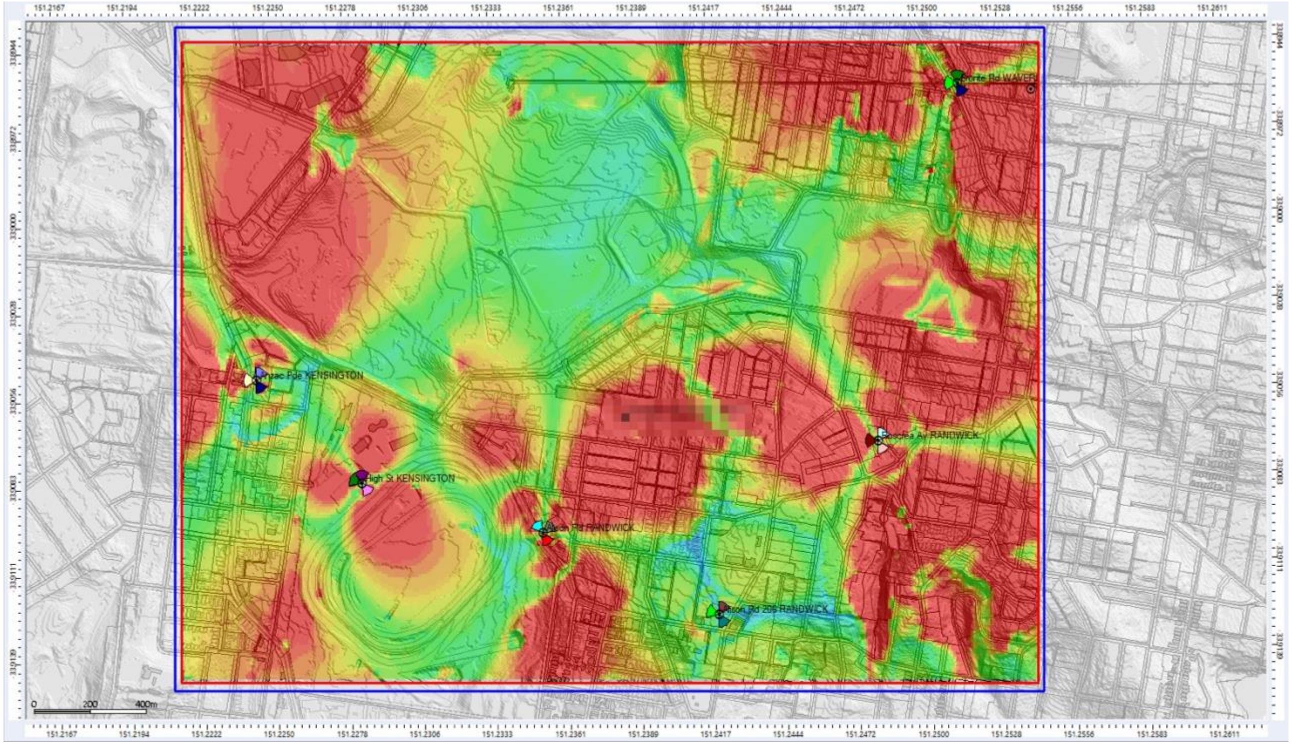

Figure 6: Example coverage heat map
(Source: R-spectrum)

Capacity relates to the ability of the mobile network to satisfy data demand. If demand exceeds available capacity, the mobile network is considered oversubscribed. This is assessed at the site level and unlike coverage there isn't a map representation.

Coverage influences capacity - if a link between a mobile network site and a device has low signal strength then the capacity of that link is diminished. If coverage is poor then the number of weak links is high, reducing the total capacity of the mobile network site.

Adding additional mobile network sites can improve both coverage and capacity. With more sites, link distance will be reduced, signal strength improved and capacity per site increased. Capacity will also increase as the number of sites increases.

However, there is a limit to this gain. If the site density increases too much, the sites will interfere with each other, and the capacity will decrease.

Successful network planning requires a careful balance between coverage, density and capacity.

Operator Collected

The mobile network operators are the source of the most accurate data about the current network performance. They can measure in real time the signal strength and data rates between the radio access network (RAN) and all of the connected user equipment (UE). This information can be translated into coverage and capacity information.

Third Party Aggregator Collected

Information about network conditions can also be collected and aggregated by third party apps running on mobile devices. This method is accurate for coverage and can provide meaningful information about capacity.

City Collected

City employees move around the city in the performance of their duties. The information about network conditions that they individually collect can be aggregated to provide a more general representation. This method collects much less data than the prior two methods. It is fairly accurate for coverage and can provide meaningful information about capacity at times of peak congestion.

Action 2: Analyze the mobile network needs

Mobile network and radio equipment characteristics

The characteristics of both the mobile network and the available radio equipment bound the possible implementations of the street-level mobile network. It is important to take them into account in order to make the mobile network needs analysis meaningful.

4G / 5G

The 5G New Radio (NR) provides improved radio performance and increased capacity in newly licensed spectrum. Many of today's 5G implementations use 5G NR while relying on the existing 4G network to establish and manage calls and data connections. This is referred to as 5G Non-Standalone (NSA)

This provides many of the benefits of 5G while reducing the initial network implementation cost. This usually means that both 4G and 5G equipment is required on the street asset.

In this scenario, the mobile network needs analysis should consider both 4G and 5G network requirements.

The operator, infrastructure provider and the city should explore whether the densification of the mobile network should coincide with the introduction of 5G Standalone, which eliminates the dependency on the 4G network and substantially reduces the equipment burden on the street asset.

Further discussion of this topic can be found in the Reference for Deploying Telecoms Equipment on Street Assets, which is available from TIP.

Radio equipment characteristics

The characteristics of the radio equipment to be used at the small cell site represent a trade-off between higher transmitter power and receiver sensitivity (which implies better coverage) on the one hand and lower cost, size and power consumption on the other.

In some jurisdictions, regulation dictates the upper bound for transmitter power for public safety reasons. In the European Union, the *Commission Implementing Regulation (EU) on specifying the characteristics of small-area wireless access points* *pursuant to Article 57* limits the transmitter power of small cells on street assets to Class E10 (10 Watts EIRP). See the Regulation appendix for more details on Article 57.

Operators may also limit power in order to mitigate interference with adjacent cells.

Initial Analysis

Each city has different physical characteristics, and an RF planning exercise will provide the most accurate guide as to the number and location of the required assets.

Collaborative

Ideally, the exercise is conducted in a collaboration between the city and the operators. In this scenario, the footprint of the existing networks and the preferred equipment are integrated into the model. This results in the most accurate representation of the existing capacity and coverage and the gaps that should be filled.

Independent

If collaborative planning is not possible, then an independent planning exercise can be conducted using a combination of the measured performance of the existing network, as described above, and some assumptions regarding the equipment that will be deployed in the street-level network. This approach is not as accurate as the collaborative approach but will yield a reasonably accurate plan.

Estimation

In the absence of an RF planning exercise, it is possible to estimate the number of assets based on the characteristics of the deployment environment. We provide the following spacing and density as a guide for the asset estimation:

Building Density	Description	Asset Density
Low	Suburbs Buildings with 1-2 floors	400 - 1000 meters 1 - 10 / km^2
Medium	City center Buildings with 3-4 floors	200 - 500 meters 5 - 20 / km^2
High	City center Buildings with 5-20 floors	100 - 250 meters 10 - 40 / km^2

Table 3: Estimation of asset spacing

Note that high density deployments will typically have in-building networks that complement the street level deployments for coverage.

Initial locations are selected using one of the techniques described above. The locations can be loosely placed at street junctions for greatest coverage and in areas of anticipated demand. If a database of prequalified locations is available, or if likely locations have already been established, these can also be used in the planning.

A lower density of locations will reduce the implementation cost, but care should be taken to anticipate increases in demand in determining the required density.

Here is an example location plan resulting from an independent planning exercise undertaken in the city of Dublin, Ireland.

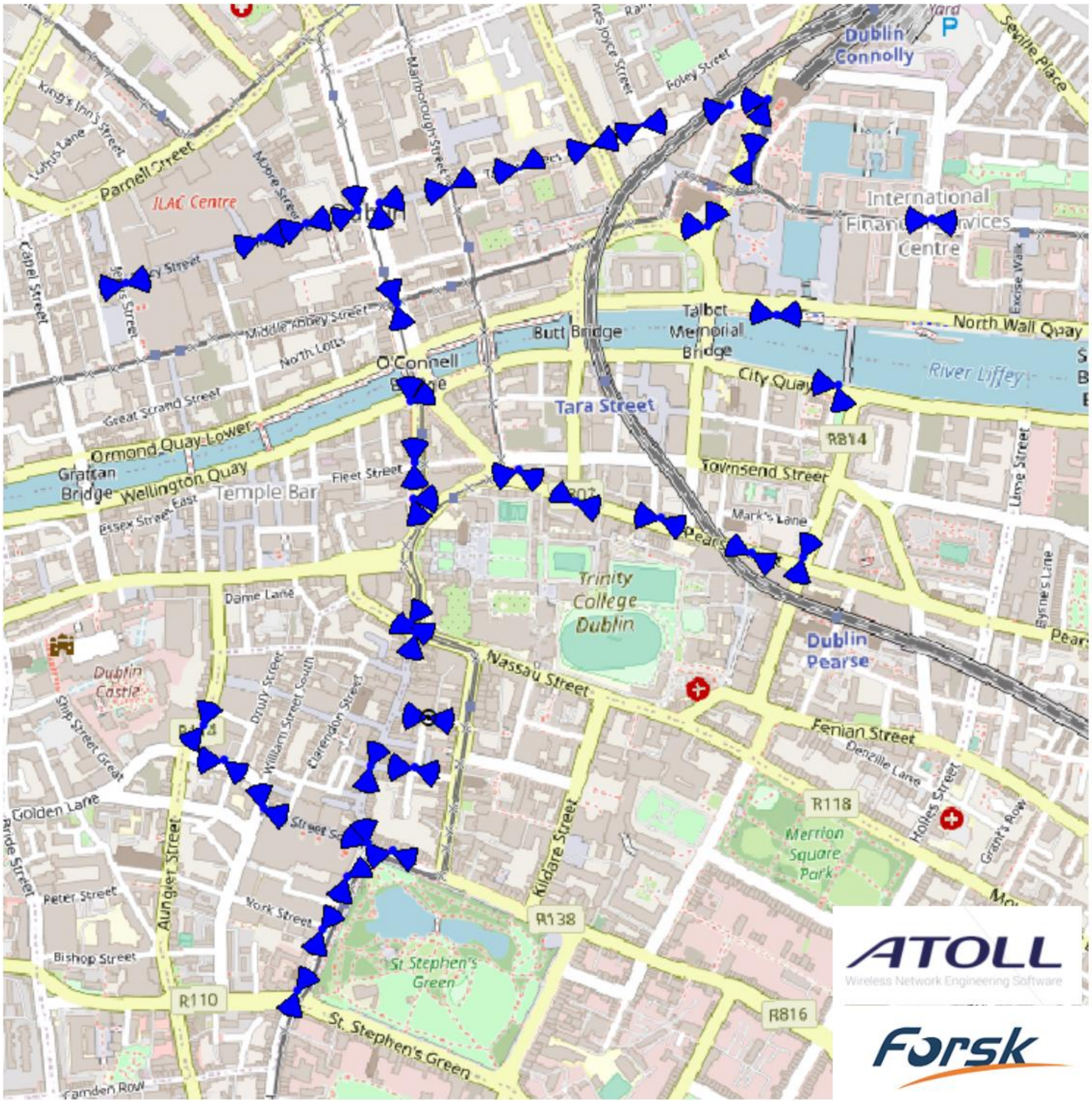

Figure 7: Initial location plan
(Source: Aspire Technology)

Action 3: Identify the candidate street locations

Recommendation: Develop a database of locations that are prequalified by suitability and the availability of power and data. It will substantially reduce the number of iterations of the planning cycle.

The location of ducts and fiber assets is often maintained across disparate geographic information systems maintained by the city and the service providers. You should consider how to merge the data from these systems into a single view in order to provide data to street assets efficiently.

Note that ducts may be installed in appropriate locations, but they may already be filled to capacity. It is helpful to indicate the available capacity as well as the location of duct assets.

There are many more street assets on the typical street than the number required for mobile network sites. However, the assets might not actually be available for variety of reasons:

- Ownership
- Existing use
- Unsuitable ground conditions for civil works

As a large part of the street assets may prove to be unsuitable, we recommend that the number of candidate assets made available for study be up to 10 times the number of sites required.

Recommendation: Perform a site visit in parallel with developing the database of locations. The site visit can reveal that some locations are good candidates while other locations are not.

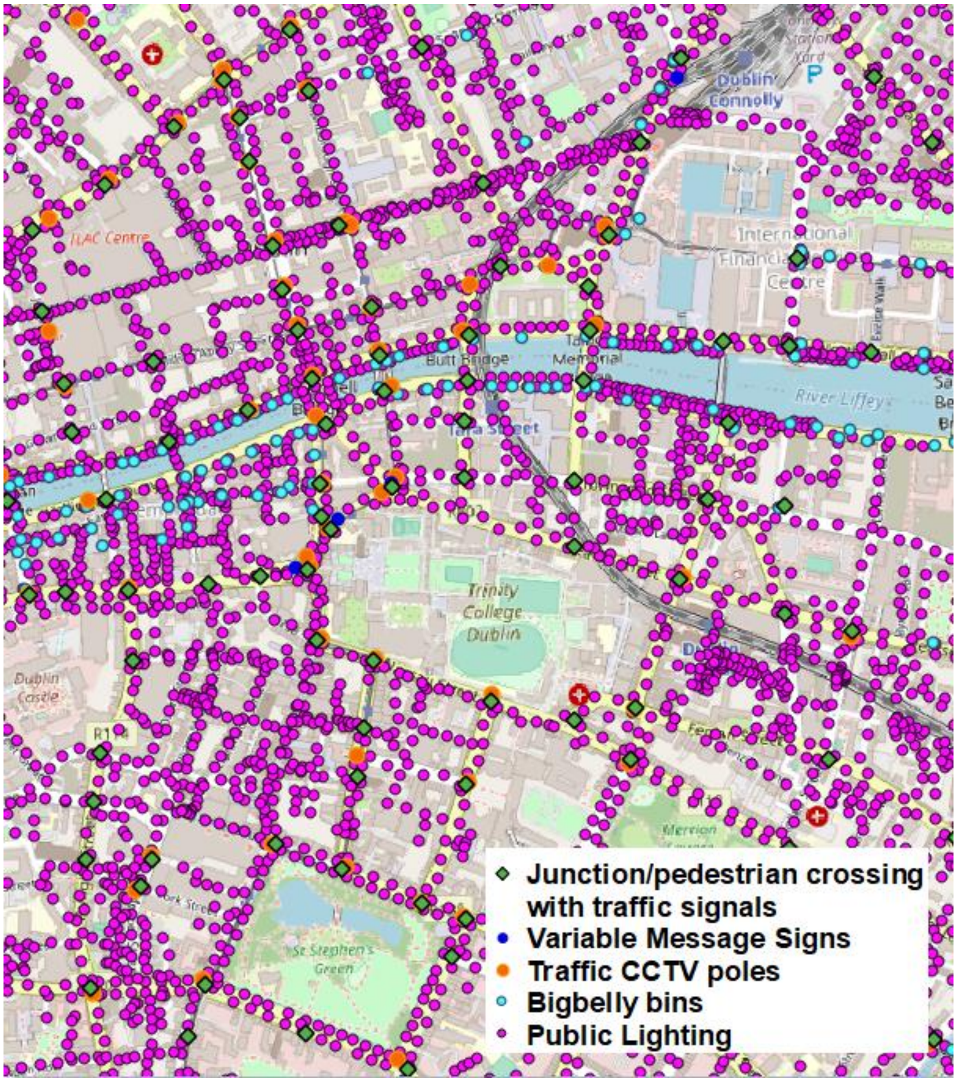

Figure 8: City-owned street assets
(Source: Dublin City Council)

Types of assets

There are a variety of street assets that might be suitable: streetlights, camera poles, traffic lights, bus and tram shelters, billboards and digital signs, building frontage and rooftops. Many of these assets are owned by and under the control of the city council.

Assets belonging to other entities might also be candidates, in addition to the assets owned by the city authority. In particular, street lighting might be owned by a separate public or regulated private utility company. Cameras for pedestrian and traffic safety are usually under the control of a public safety agency.

If there is no existing street asset at the ideal location, the options are to install a new street asset at the location, or to move to an adjacent asset. Recommended best practice is to place the small cell within 20-40 meters of the ideal location.

Note that some locations may be on private property. Securing the cooperation of the property owner should be started early.

Existing versus new assets

New assets are generally easier to deploy and use. They are designed to carry a communications equipment payload. Increased civil works are required to provide power but this is often easier than adapting an existing asset. Civil works will be required in either case if a data connection over fiber is required.

New street assets are not always incompatible with historic districts. For example, it may be better to deploy a new asset adjacent to a heritage pole rather than adapt the heritage pole.

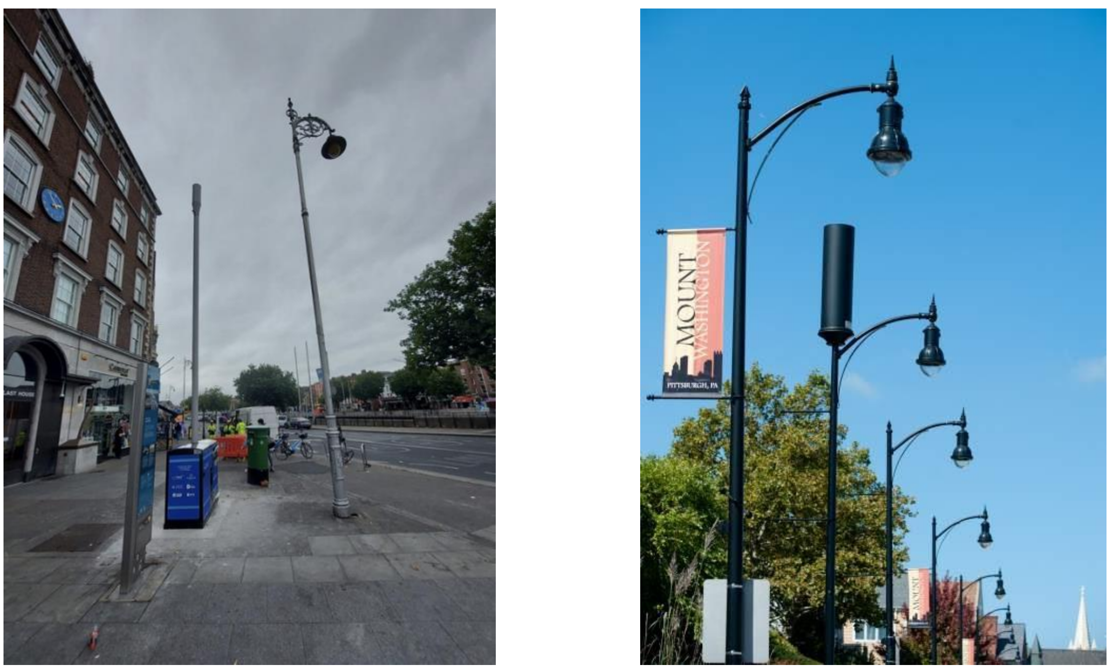

Figure 9: New asset versus retrofit in heritage district
(Source: Dublin City Council and TribLive)

Asset Evaluation

The suitability of an existing asset for use as a mobile network site should be assessed against several criteria relating to construction, installation and environment.

Criteria	Assessment
Construction	Is it structurally sound?
	What is the style – heritage, modern etc.?
	What is the material – galvanized, cast iron etc.?
	What is the height?
	Is it appropriate for small cell equipment?
	Is it due to be replaced?
Installation	Is there any health and safety risk that may hinder deployment?
	Is that asset already loaded with other equipment?
	Is there access for mounting at ground level?
	Would it require road closure?
	Is power provisioned and the supplier Identified?
	Is fiber provisioned and the supplier identified?
Environment	Is it too close to a building?
	Is it too close to other overhead services such as power lines or tram lines?
	Would it hinder sight lines?
	Would it impact traffic management?

Table 4: Asset evaluation criteria

Action 4: Complete the network planning

Important metrics

The mobile network operator assesses several technical parameters in order to determine network performance.

For the purposes of the collaboration between mobile network operator and city, it is most useful to focus on a few parameters for the network planning activity.

These are parameters that can provide an immediate indication of satisfactory network performance, that are meaningful for consumers (for example, in terms of the number of simultaneous video streams played or 2-hour movies downloaded) and that consumers can measure for themselves.

It is important to emphasize that these parameters are not the only measures of network performance, and the mobile network operator may be justified in prioritizing other parameters if necessary.

Downlink Speed

This parameter measures the speed of data transmission from the network base station (the point at which the network traffic is converted into radio signals) to the user equipment. It is usually averaged over a few seconds.

The assumption is that the network is lightly loaded and therefore the parameter represents the maximum speed that the link under test can achieve without regard to other network capacity issues.

This downlink speed metric is translated into a signal strength threshold. The area surrounding the selected asset locations is analyzed and the areas above and below the threshold are plotted.

In the example map below, the areas above the threshold are plotted in green and the areas below the threshold are plotted in yellow and red. This means that the signal strength in the areas plotted in green is sufficiently high to meet the target downlink speed metric.

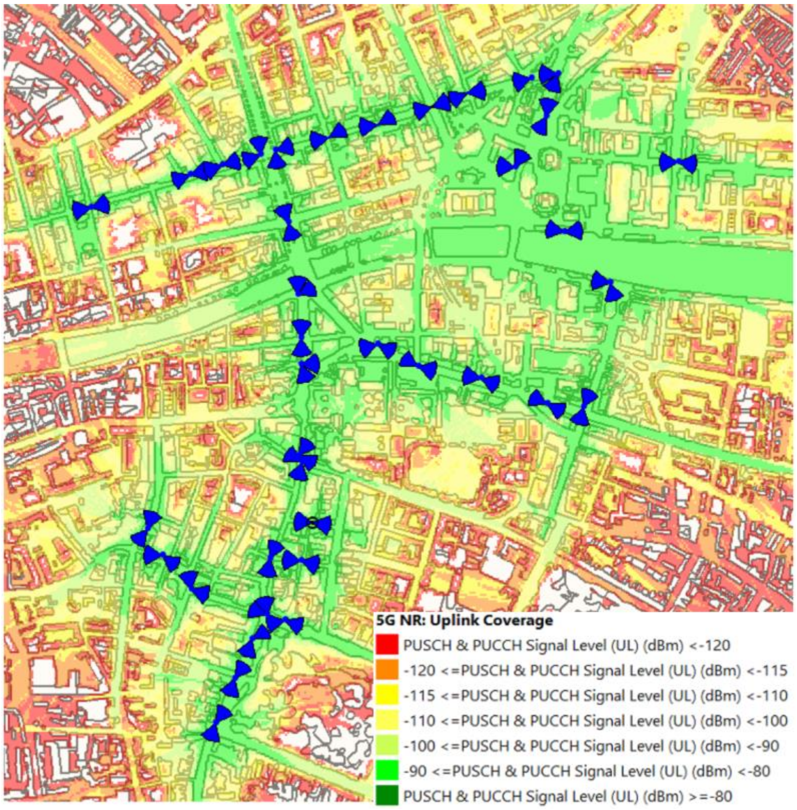

Figure 10: Example 5G downlink coverage map
(Source: Aspire Technology)

Uplink Speed

This parameter measures the speed of data transmission from the user equipment to the network. It is usually averaged over a few seconds.

The assumption is that the network is lightly loaded and therefore the parameter represents the maximum speed that the link under test can achieve without regard to other network capacity issues.

Note that the target uplink speed is much lower than the target downlink speed.

This reflects the fact that (1) user equipment generates less data than it consumes for most applications and (2) user equipment has significantly lower RF transmission power than a base station, which is only partially compensated by the large reception antenna on the base station.

Signal strength and therefore uplink link speed is lower.

The imbalance between downlink and uplink speeds is appropriate for most urban use cases. However, a different balance may be required in locations where there is a large amount of traffic generated by the user equipment; for example, where concerts are held.

This uplink speed metric is translated into a signal strength threshold. The area surrounding the selected asset locations is analyzed and the areas above and below the threshold are plotted.

In the example map below, the areas above the threshold are plotted in green and the areas below the threshold are plotted in yellow and red. This means that the signal strength in the areas plotted in green is sufficiently high to meet the target uplink speed metric.

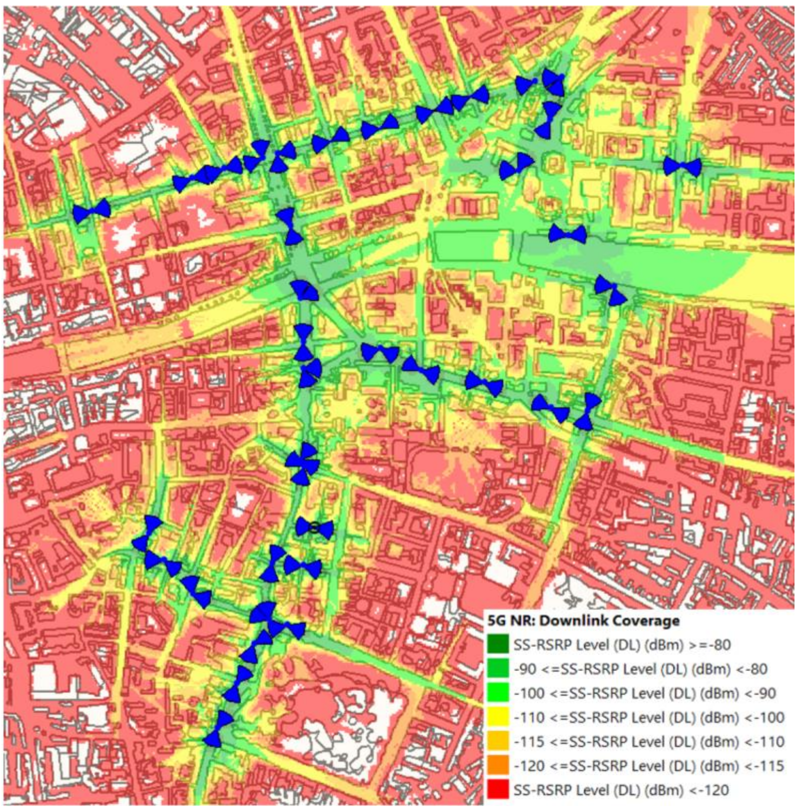

Figure 11: Example 5G uplink coverage map
(Source: Aspire Technology)

The plan findings can be broadly applied to similar, medium density city centers. More information about network planning is available from TIP.

Phase 4: Street Level Planning

Action 1: Confirm radio equipment

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Action 2: Agree asset type and specification

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Action 3: Define power connection requirements

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Action 4: Define data connection requirements

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Action 5: Develop detailed design and bill of materials

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Action 6: Obtain permits

Action 1: Confirm radio equipment

The functions of the Radio Access Network may be partitioned in a number of ways, some of which require the baseband and radio frequency processing units to be collocated, others of which allow off-site location of the baseband. The chosen approach will dictate the amount of space required at the asset.

Action 2: Agree asset type and specification

Capacity

The Commission Implementing Regulation (EU) on specifying the characteristics of small-area wireless access points pursuant to Article 57 requires that small cells attached to city-owned street assets be fully contained within those assets or have a maximum size of 30 liters external to the asset.

The 30 liter limit applies to the sum of the installed equipment; that is, it applies to all of the equipment from different radio spectrum users, which includes mobile networks and Wi-Fi services.

The regulation applies to all city-owned street assets for the purpose of exemption from permit requirements. The regulation specifically identifies light poles, traffic lights, billboards and bus stops.

Recommendation: While the regulation implementing EU EECC Article 57 applies only to existing city-owned street assets, application of the same rules by the city to new street assets that are subject to permit applications will result in greater consistency across street assets.

The street asset should have sufficient internal capacity so that, when combined with the 30-liter external capacity allowance, the radio equipment required in the asset can be fully contained.

Wi-Fi Access Points

Street assets for mobile network communications equipment are also convenient for the co-location of Wi-Fi Access Points. They are often located close to where people congregate. In more dense deployments, the short interval between street assets allows continuous Wi-Fi coverage.

In order to accommodate Wi-Fi equipment, the street asset should comply with the following requirements:

1. Sufficient space should be allocated within the asset for the access point, with airflow to allow cooling
2. The access point should be provided with power and data connections
3. The enclosure should be transparent to radio frequency signals in the 2-7 GHz frequency range to allow Wi-Fi signal propagation, or provide a method of attachment for antennas located outside of the enclosure

Other equipment

The street asset can also accommodate equipment that supports other services such as public safety and environment monitoring.

Recommendation: identify the additional services that should be supported by the street assets and incorporate them in the initial requirements document to ensure that integration into the street asset before or after installation is possible

Further discussion of street asset types

A discussion of the different options for street assets can be found in the document Reference for Deploying Telecoms Equipment on Street Assets, which is available from TIP.

Action 3: Define power connection requirements

The power connection method must be agreed with the electricity supply company. There are several aspects to consider:

Connection method: Small cell deployment on a street light must use an approved connection method. For example, separated power supplies might be required.

Tariff and metering: Small cell power usage must be aligned with the available tariff schemes. For example, the parties may need to negotiate a 24-hour usage tariff. A metered connection may be required.

Ownership: The separate ownership of street and communications assets may require the negotiation of a new supply agreement.

The power connection must comply with the standards and codes established by the electricity supply company and the national regulatory agencies.

Recommendation: The infrastructure provider should procure the power connection from the electricity supply entity. This facilitates the coordination of civil works and power connection and reduces the risk of errors or delays

Action 4: Define data connection requirements

The role of the data connection between the radio equipment at the street asset and the rest of the mobile network depends on the partitioning of the Radio Access Network, as discussed in Action 1 above.

Collocation of the baseband and radio frequency processing units at the street asset

The data connection between the baseband and the rest of the mobile network is referred to as the *backhaul* connection. The required bandwidth of the backhaul link is typically between several hundred Megabits per second and several Gigabits per second. The bandwidth is similar to a consumer fixed broadband service over fiber. The data connection requirements are usually satisfied by standard commercial broadband service.

Off-site location of the baseband

The data connection between the baseband and the radio frequency processing units is referred to as the *fronthaul* connection. The required bandwidth of the data connection between the baseband and radio frequency processing units is very high - up to 25 Gigabits per second in the case of 5G. The data connection requirements are usually satisfied by a dedicated high-capacity service or a “dark fiber” solution.

Recommendation: The infrastructure provider should procure the data connection from the fixed broadband entity. This facilitates the coordination of civil works and data connection and reduces the risk of errors or delays

Action 5: Develop detailed design and bill of materials

The design of the street asset should address the following attributes:

- Location
- Foundation works and the interface to the street asset
- Ducts for power and data connection
- Dimensions of the street asset

The design is primarily documented in the form of line drawings suitable for submission as part of a permit application.

The bill of materials should itemize all the components required to complete the street asset deployment. This includes:

- Communications and networking equipment, including optical termination unit and/or wireless backhaul
- Sensors
- Power supplies, including batteries
- Data cables
- Power cables
- Brackets and other mechanical assemblies

Action 6: Obtain permits

If the street asset already exists and the installation of communications equipment satisfies the requirements of the Commission Implementing Regulation for Article 57 of the EU EECC then no permit application is required for the installation.

Recommendation: Although no permit application is required for the installation of communications equipment on existing street equipment if the prerequisite regulatory conditions are satisfied, proactive collaboration between the operator, infrastructure provider and city government will facilitate the efficient deployment of the equipment at the site

There is misinformation in the public regarding the health effects of 5G.

Recommendation: In addition to any statutory notices, inform the public by providing information about the project and links to resources at the street asset location. This can be in the form of a Quick Response (QR) code that provides a link to a website

Phase 5: Site implementation

Action 1: Undertake preparatory street civil works

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Action 2: Install the street assets

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Action 3: Connect power to the street assets

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Action 4: Connect data to the street assets

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Action 5: Install and bring up radio equipment

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Action 6: Test to confirm network performance

Action 1: Undertake preparatory street civil works

The foundation should be prepared according to the design specification.

Ducts should be installed for the provision of the power, and the data connection if appropriate.

Recommendation: to minimize disruption, civil works for duct installation should be undertaken at the same time as the preparation of the foundation.

Action 2: Install the street assets

In most instances, the height and weight of the assets mean that a hoist must be used during installation. The hoist can be placed on the pedestrian footpath or in an adjacent parking bay.

If a crane must be used, it increases the likelihood that a road closure will be required.

Road closures should be avoided if possible. It can be difficult to coordinate road closures with installation schedules, especially if multiple locations are involved.

Care must be taken to satisfy health and safety regulations at all times.

Action 3: Connect power to the street assets

The power connection must be completed in accordance with the standards and codes established by the electricity supply company and the national regulatory agency.

The power connection must be approved by an authorized person.

Action 4: Connect data to the street assets

The data connection must be completed in accordance with the standards and requirements established by the fixed broadband service provider.

The data connection must be approved by an authorized person.

Action 5: Install and bring up radio equipment

The radio equipment is usually installed by the mobile network operator or the Wi-Fi service provider. If service is provided under an active neutral host / Network as a Service model by an infrastructure provider, the latter usually performs the installation.

Action 6: Test to confirm network performance

Once the radio equipment is correctly powered up, a member of the deployment team should connect to the site using a handheld User Equipment (UE) such as a mobile phone. The site status should also be checked via the network management platform. Once traffic passes through the cell and the site is shown as live, the installation is complete.

Appendix: Regulation

European Electronic Communications Code (EECC)

Under Article 57 of the European Electronic Communications Code (EECC), an operator may install small area wireless access points (SAWAPs), usually called small cells, and any backhaul from the small cell site to the operator network on any technically suitable publicly owned street asset. This includes light poles, street signs, traffic lights, billboards, bus and tram stops.

No individual permits are required from the local authority, except in special locations, for example, historical districts. There is a requirement to notify the national authority within 2 weeks of the equipment installation.

The City may impose reasonable and non-discriminatory terms and conditions, which must be made public at a single information point. However, no fees may be charged beyond necessary administrative charges.

In order to be eligible under Article 57, the small cell equipment must satisfy several technical criteria as defined by the commission implementing regulation:

- The equipment must be integrated within the street asset, or the visible part to not exceed 30 liters and be visually consistent
- The equipment must comply with certain RF transmission power limits and emissions limits for public safety

References

Telecom Infra Project

https://telecominfraproject.com/connected-city-infrastructure/#deliverables

Reference for Deploying Telecoms Equipment on Street Assets

Lifecycle Manager template

Needs Assessment template

Capability Assessment template

European Electronics Communications Code (EECC)

EU Directive 2018/1972: http://data.europa.eu/eli/dir/2018/1972/2018-12-17

Direct link to Article 57: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:02018L1972-20181217&from=EN#tocId85

Commission staff working document: https://op.europa.eu/s/oIAN

Regulation implementing Article 57: https://op.europa.eu/s/oIAP

FCC Small Cell Order

FCC 18-133 Declaratory Ruling and Third Report and Order: https://docs.fcc.gov/public/attachments/FCC-18-133A1.pdf

RF emissions

European Standard EN 62232:20175 - "Determination of RF field strength, power density and specific absorption rate (SAR) in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure".

Planning

Section 254, Planning and Development Act 2000 (Eire)

http://www.irishstatutebook.ie/eli/2000/act/30/enacted/en/print#sec254

Connectivity Strategy

5G and Future Connectivity - An Emerging Framework for Irish Cities and Towns

https://smartdocklands.ie/wp-content/uploads/2020/08/5G-and-Future-Connectivity-in-Ireland-Discussion-Paper.pdf

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Lifecycle Map

	Phase 1 Getting started	Phase 2 Scope the deployment	Phase 3 Outline planning	Phase 4 Street level planning	Phase 5 Site implementation
Action 1	Establish a city telecom working group	Identify the deployment areas	Assess the current mobile network conditions	Confirm radio equipment	Undertake preparatory street civil works
Action 2	Identify the stakeholders	Write a deployment area needs assessment	Analyze the mobile network needs	Agree street asset type and specification	Install the street assets
Action 3	Perform an initial high-level needs assessment	Develop a project plan and a task matrix	Identify the candidate street locations	Define power connection requirements	Connect power to the street assets
Action 4	Start any advance work	Conduct a stakeholder meeting	Complete the network planning	Define data connection requirements	Connect data to the street assets
Action 5				Develop detailed design and BOM	Install and bring up radio equipment
Action 6				Obtain permits	Test to confirm network performance

Table 5: Lifecycle Map