

# A Data-Driven Model for Urban Connectivity

Dublin City Council and the City Telecoms Association partner with Ookla in a first-of-its-kind study, offering a practical blueprint for European cities to enhance connectivity and tackle the digital divide

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Comhairle Cathrach Bhaile Átha Cliath Dublin City Council

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### Preamble

#### The need for actionable data to support smart city objectives

Cities across Europe are grappling with new challenges as the telecoms networks that underpin their competitiveness are changing at a rapid pace. Mobile sites are making the leap from rooftops and monopoles to street-level light columns with 5G, while footpaths are being lined with ducts for fibre.

The demands of this evolving infrastructure are challenging the traditional, often reactive, approach that city authorities take to telecoms development. Protecting key city priorities such as digital inclusion, urban aesthetics and environmental sustainability now requires a step-change in how cities collaborate with industry to proactively overcome barriers and capture emerging opportunities.

Independent, high-quality and actionable data is at the heart of a smart city strategy. Planning for the infrastructure needs of tomorrow must first be rooted in understanding the deficits of today. For too long, city leaders have contended with significant gaps in information in their interactions with industry — hindering their ability to understand how to best leverage city-owned assets and improve telecoms outcomes.

### The role of the City Telecoms Association in driving innovation

Motivated by the opportunity to tackle these challenges in a new, proactive and collaborative way, the <u>City Telecoms Association</u> was established to bring together a global network of leading cities in a common forum. The association focuses on developing new approaches to telecoms policy in cities, fostering diverse business models and supporting novel deployment strategies and use cases through knowledge sharing and collaboration with industry.

As part of this mission, and guided by an <u>emerging</u> <u>set of principles</u>, the City Telecoms Association supports high-impact, data-driven research that aligns with broader city priorities around telecoms and technology. Working with cities like Dublin, a founding member and current co-chair, the association has developed an ambitious pipeline of playbooks, case studies and white papers to promote information sharing among members and stimulate deeper discussions with industry. Acknowledging common telecoms challenges across cities, the association promotes collaborations to create adaptable, scalable solutions for current and future members.





### Dublin City Council collaborates with industry to accelerate telecoms vision

In 2022, Dublin City Council established a first-of-itskind 'Telecoms Unit' to centralise and streamline functions related to telecoms and digital infrastructure in a dedicated unit within the city's organisational structure. Recognised by the World Economic Forum as a global model of best practice, this unit serves as a one-stop shop for all telecoms-related activities in the city, offering a single point of contact for citizens, industry and public bodies to engage with.

To deliver on the Chief Executive's goals to ensure future capital investments and infrastructure projects in Dublin are 'telecoms-proofed', the City Council has focused on working collaboratively with industry. In recent years, for example, the Telecoms Unit has published standardised rate cards, streamlined permit processes for the use of city assets and developed comprehensive, transparent mapping of ducting infrastructure.

Despite this, the City Council has faced challenges in identifying and fully understanding the extent of 'connectivity gaps' - potential areas within Dublin where infrastructure such as mobile networks is underperforming — and in finding ways to leverage policy and city-owned assets to help industry improve network outcomes citywide.

The lack of robust, publicly accessible data on the localised quality of telecoms networks has made it difficult for the city to accurately assess the realworld network experience of citizens across every corner of the city at various times of the day and track progress over time — a level of insight that would set a new standard in Europe for a city's use of advanced telecoms data.

other cities around the world.

### Timeline of Key Strategic Milestones in Dublin City Council's Telecoms Journey

#### Smart Docklands

city testbed and issues market PIN

notice on 'Future Gigabit Wireless'.

**National 5G Strategy Paper** 

Dublin launches Ireland's first smart Dublin launches Ireland's first national strategic plan for 5G deployment in towns and cities.

#### **Telecoms Unit Launch**

Dublin launches first-of-its-kind 'Telecoms Unit' to streamline City Council organisational structure

#### **Ookla Partnership**

Dublin publishes pioneering study with Ookla, showcasing how European cities can leverage data-driven insights to transform telecoms strategy.

OOKLA



on smart bin and smart pole designs.



#### Partnering with Ookla to take the next step in a data-driven approach

Beginning in 2023, Dublin City Council took a key step forward in its telecoms journey by establishing a strategic partnership with Ookla. The collaboration enabled the city to leverage Ookla's crowdsourced network intelligence data and telecoms expertise for a state-of-the-art study of Dublin's telecoms infrastructure, aligning with the City Council's vision to provide world-class connectivity for citizens and businesses.

This report marks the first public-facing output of the collaboration between the City Council and Ookla.

It explores how a city like Dublin can harness bestin-class data to transform its approach to telecoms strategy with tangible impact — quantifying the effect of policy, optimising the use of existing assets and enhancing decision making for future developments.

The findings provide a high-level summary of the study conducted by the City Council, serving as a proof of concept for using crowdsourced network intelligence data to address common city challenges related to telecoms infrastructure.



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"To close this information gap, the City Council needed a bold new approach using best-in-class data from Ookla to support our telecoms strategy. By applying our own custom methodology, we were able, for the first time, to use Speedtest Insights<sup>™</sup> to understand network performance in Dublin across different times of day, device types and both indoor and outdoor settings — making this the most advanced city-led study of its kind in Europe to date".

— Jamie Cudden, Smart City Manager, Dublin City Council

#### Introduction

In recent years, Dublin City Council has opened access to its assets to support telecoms infrastructure. However, through proactive industry engagements, it has found that the local telecoms ecosystem has limited appetite for sharing internal information on existing connectivity gaps and future deployment plans.

As a result, the City Council's understanding of Dublin's telecoms infrastructure has been restricted to high-level mobile coverage maps published by ComReg, Ireland's telecoms regulator. This limited access to granular data constrained the City Council to a reactive approach, unable to fully grasp the real-world network experience of its citizens across Dublin.





### Methodology

The analysis in this report is based on Ookla® data collected over two distinct 12-month periods — June 2022 to June 2023 and June 2023 to June 2024 — and focuses on Dublin City Council's administrative area. With a sample size in the tens of millions, this fully anonymised, GDPR-compliant dataset represents the most comprehensive analysis of mobile network performance ever conducted at the city level in Ireland<sup>1</sup>.

In order to simplify the presentation of findings in this report, and to focus in particular on indicators that are reflective of the real-world network experience in Dublin, data related to signal strength and download speed is organised into simple 'acceptable' and 'unacceptable' categories.

The minimum performance thresholds for each category are set conservatively to ensure that only areas with a very high degree of confidence in delivering 'unacceptable' network performance are classified as having poor network outcomes. This approach aligns with the City Council's priority of identifying specific areas in Dublin where targeted policy interventions will have the greatest impact.

<b>Metric</b>	'Acceptable'	X∭ 'Unacceptable'
Signal Strength (dBm)	> -110 dBm	< -110 dBm
Download Speed (Mbps)	> 5 Mbps	< 5 Mbps

The median is the primary central tendency measure of choice for the data. This measure mitigates the distortionary impact of outliers and the existence of skewed distribution that is common in network performance datasets of this scale. The analysis is restricted to the three mobile operators with independent site infrastructure in Dublin, excluding data from MVNOs, and focuses solely on 4G and 5G performance.

Leveraging Ookla's Speedtest Insights<sup>™</sup> platform, the City Council's smart city team integrated the crowdsourced network performance data with other sources, such as internal city asset registries, mobile site location maps from Ireland's telecoms regulator (ComReg) and government data on social deprivation in Dublin (Pobal).

The City Council performed geospatial analysis and applied computer vision techniques to create a localised tile-based grid, overlaying multiple discrete datasets for visual analysis in a breakthrough methodology developed entirely in-house by the city<sup>2</sup>. This report profiles a sample of five high-impact use cases developed by the City Council to leverage the crowdsourced data and apply its custom methodology to drive better informed decision making.

<sup>1</sup>Further detail on Ookla's testing methodology is outlined in Appendix A.

<sup>2</sup>Further technical detail on the process underpinning the City Council's use of geospatial analysis and computer vision is outlined in Appendix B.

## **Use Case:** Tracking the evolution of mobile network outcomes in Dublin at the city level to assess progress and quantify policy impact

### **City Rationale**

Dublin City Council has faced challenges in monitoring the evolving performance of mobile networks in the city due to limited access to up-to-date, high-quality and representative data. The City Council aims to track how network performance is improving over time in the city, considering the experiences of citizens both indoors and outdoors. It seeks to use this data to better understand and respond to factors such as time of day, seasonality and major events, which can significantly impact network performance in different ways.

The Telecoms Unit is seeking a mechanism to measure the effectiveness of its policy interventions on mobile network outcomes in Dublin. It is aiming to establish a first-of-its-kind strategic framework based on a suite of traceable quarterly key performance indicators (KPIs) related to the extent of its success in stimulating better telecoms outcomes in Dublin.

The City Telecoms Association, meanwhile, is keen to explore how it can assess and compare the maturity of city-led telecoms strategies across Europe. Its ultimate goal is to develop a comparative international barometer that profiles cities at various stages of their telecoms journeys, leveraging data on the underlying performance of telecoms networks in different cities as a key input.

# City Realisation: Dublin benchmarks telecoms competitiveness against global peers, develops suite of KPIs to track rollout progress

For the first time, Dublin City Council has gained a comprehensive, city-wide view of mobile network performance in Dublin, with a level of detail comparable to that of commercial operators. The City Council has developed a framework to monitor year-on-year changes in network performance at both the operator and aggregate market levels, and has studied how the ongoing rollout of 5G, the deployment of additional sites and the use of new spectrum are improving network outcomes across the city.

During the study period, for example, the City Council observed a general trend of improvement in mobile network performance between 2023 and 2024, with notable increases in median 4G download speed performance (+50.8%) and 5G signal strength (+3.1%), consistent across the city and all three operators.



#### Profile of Mobile Performance in Dublin

Based on analysis of aggregate mobile performance across all technologies



The City Council identified the significant impact of 5G networks on the overall profile of mobile performance in the city. In the 2024 study period, median download speed outcomes on 5G networks were nearly

twelve times faster than on 4G, with an even greater performance differential observed during peak network load times in the mid to late evening.

	<b>(46)</b> Signal Strength (dBm)	<b>(56)</b> Signal Strength (dBm)	(46) Download Speed (Mbps)	(56) Download Speed (Mbps)
2023	-98	-97	24.58	283.72
2024	-98	-94	37.04	237.12
Change (%)	0%	+3.1%	+50.1%	-16.5%

References to signal strength and download speed refer to median 'acceptable' values at the aggregate level

By leveraging additional data from Ookla, the City Council has been able to compare Dublin's aggregate city-level network performance with that of other European cities to assess its international telecoms competitiveness. The City Council's analysis found that, while Dublin's 4G download speeds are on the lower end compared to its European counterparts, the city has established a competitive position in both 5G availability and 5G download speed performance in Europe.

#### **Operator-Level Profile of Mobile Performance in Dublin**

Based on analysis of aggregate mobile performance across all technologies



The exceptional granularity of the dataset, combined with Ookla's network intelligence expertise, enabled the City Council to gain insights into how recent market developments are influencing the overall trajectory of mobile network performance in Dublin. This level of deep technical detail had not been previously studied in Ireland.



Recent spectrum deployments in the 2600 MHz band (top) and 2300 MHz band (bottom) have increased network capacity, improving performance at peak times in Dublin city centre

The City Council observed that, while the deployment of techniques like Dynamic Spectrum Sharing (DSS) has significantly improved 5G availability and increased usage on non-standalone networks in Dublin, it has placed downward pressure on median 5G download speeds during the study period. However, the overall picture remains positive, as recent spectrum deployments in the 2300 MHz and 2600 MHz bands have boosted median 4G download speeds in the city, and the migration to 5G has improved performance in aggregate terms.



### **Use Case:** Identifying connectivity gaps to pinpoint problem areas and support data-driven policy interventions

### **City Rationale**

Dublin City Council has encountered difficulties in accurately assessing the true extent of connectivity gaps in the city at the local level. Historically, the Telecoms Unit relied on prediction-based outdoor network coverage maps published by Ireland's telecoms regulator, which often presented an overly optimistic view of mobile network outcomes in Dublin. These maps failed to capture real-world network experience, particularly indoors in the social housing units newly developed by the City Council, and during peak usage times.

The Telecoms Unit is seeking to establish a systematic process for identifying specific areas in Dublin where citizens experience poor mobile network performance, ranking them by severity and impact to guide policy intervention. It aims to pinpoint locations where all three mobile operators share overlapping network gaps, potentially requiring new site builds, as well as areas with highly asymmetric performance outcomes across operators, where the sharing of existing sites could improve the overall network experience across all operators.

Both the City Council and the City Telecoms Association are keen to explore how policy tools can be effectively mobilised to improve connectivity in areas with known network issues. The City Council is interested, for instance, in leveraging the planning system to ensure that future new-build developments in Dublin include provisions for mobile network access, similar to the existing requirements for fixed broadband access.



## City Realisation: Dublin develops catalogue of connectivity gaps, prepares discussions with operators to support new mobile sites

Map of aggregate signal strength performance in Dublin (2024). Green tiles meet 'acceptable' thresholds, red tiles indicate 'unacceptable' performance



Dublin City Council has identified a catalogue of areas in the city that feature 'unacceptable' network outcomes in terms of signal strength and download speed performance, reflecting a high incidence of performance issues like slow-loading webpages, interrupted video streams and dropped calls in these problem areas across all three operators at different times of the day. To maximise the effectiveness of its policy interventions, and considering factors such as the presence of new-build social housing units and the density of network users, the City Council has focused on narrowing the catalogue of problem areas to five key locations where it can develop a targeted policy strategy to address the infrastructure gaps.



In addition to identifying the scope of network gaps in these problem areas, the City Council has also examined how the placement of mobile sites has contributed to poor connectivity in parts of Dublin. By overlaying the crowdsourced network performance data with mobile site location information, it has uncovered areas with low site grid density.

The City Council has been able to link incidences of low site grid density and network gaps in some areas to historical factors such as rejected planning applications for mobile site developments and space exhaustion on rooftops and other suitable sites. In problem areas like Cabra, for instance, the City Council has found that the combination of greenfield parks and high-density housing has limited the ability of traditional rooftop-mounted mobile sites to deliver adequate network performance. With this data, the City Council can now engage proactively with operators to support the targeted deployment of new mobile sites in areas like Cabra. For the first time, the Telecoms Unit is properly equipped to provide robust technical rationale to inform future planning decisions around mobile site developments in areas with performance issues.

Beyond the catalogue of areas where all three mobile operators face network gaps, the City Council has also identified locations where some network users experience 'unacceptable' service while others, on different networks, are well served. For example, its analysis has discovered that Operator A network has disproportionate gaps in the south and west parts of the Phoenix Park, while Operator B faces issues in Drimnagh and Ballymun.



Lack of provisions for multi-operator sharing at key locations, such as hospitals in Dublin, results in significant indoor connectivity gaps. In this building-level analysis, users of Operator A and Operator C experience limited indoor mobile service due to an exclusive site access arrangement by Operator B. The left image highlights several buildings on the hospital campus with 'unacceptable' signal strength (marked by red tiles). The right image shows buildings in yellow where the predominant 4G frequency band in use is 800 MHz, indicating fallback to capacity-limited low-band spectrum for indoor coverage (green tiles in the right image indicate where the 1800 MHz and 2100 MHz bands are the most frequent spectrum bands in use indoors).

The City Council is using Ookla data to promote increased site sharing among operators in areas with significant network imbalances. In particular, it is now

proactively identifying locations where multi-operator access could be a planning condition for future site developments, where feasible.



## **Use Case:** Leveraging city-owned assets to support telecoms infrastructure in Dublin and identify new sharing opportunities

### **City Rationale**

Dublin City Council, like many local authorities across Europe, manages a vast portfolio of assets, including office buildings, libraries and street furniture. In recent years, it has made substantial progress in opening these assets for telecoms infrastructure deployments, mapping its assets in a centralised registry and publishing a standardised rate card to make it easier to place macro sites on rooftops and small cells on street furniture.

The City Council is now aiming to adopt a more strategic, data-driven approach to leveraging its assets to improve telecoms networks in Dublin. It seeks to assess the suitability of its assets for deploying new telecoms equipment in the five key problem areas detailed before. Additionally, where telecoms infrastructure is already in place on city-owned assets, the City Council aims to engage with operators to increase site sharing at locations hosting only one or two operators.

Regulatory initiatives led by the European Commission, such as the Gigabit Infrastructure Act (GIA) and the new European Electronic Communications Code (EECC), are pushing cities to open their assets for telecoms infrastructure on a cost-recovery basis. To assist its members in this transition, the City Telecoms Association is promoting new sharing models, including neutral host solutions, which maximise the use of existing assets while reducing visual pollution and urban clutter.

### City Realisation: Dublin develops innovative framework to optimise asset use, improves decision-making on new telecoms developments

Dublin City Council has identified a suite of rooftop spaces within its existing building portfolio that currently lack mobile network equipment or only serve a single operator. It is now assessing the suitability of city-owned rooftops in problem areas for new telecoms installations, considering factors such as building height and access to power and fibre, to facilitate discussions with operators.



Map of aggregate signal strength performance in Dublin (2024), overlaid with Dublin City Council rooftop assets and mobile site locations

To support this, it has developed an innovative map that combines crowdsourced network performance data, mobile site locations and building rooftop information from its asset registry into a unified, city-wide view of Dublin. The City Council can now assess how its assets support each operator across different parts of the city and ensure there is equitable rooftop access to safeguard market competition in the city.

The Telecoms Unit has identified a cluster of city-owned rooftops in areas south and west of Ballymun, where at least one operator currently has poor network coverage. These rooftops could potentially support additional equipment to serve multiple operators. The City Council is considering requiring multi-operator access as a licensing condition for upcoming site renewals on cityowned rooftops, where the data shows a need and it is deemed feasible.

At the many city-owned rooftop locations where physical space constraints prevent the passive sharing of equipment among all three operators, the Telecoms Unit is using the Ookla data to guide decisions on operator access, prioritising based on network needs. This approach has already been applied to support decisions on installing additional mobile network equipment at the City Council's Civic Offices headquarters, which has a significant footprint in the centre of the city.



Operator B provides 'very good' or 'good' 4G coverag across Parnell Street. However, Ookla data (bottom) exposes that the actual in-building experience is 'unacceptable' in several buildings, highlighting discrepancies between predicted and real-world network outcomes in indoor environments.



# Use Case: Assessing the impact of new site deployments to improve citizen engagement and increase community understanding of telecoms infrastructure in Dublin

### **City Rationale**

Mobile network design is evolving, leading to the proliferation of new site types that must be situated closer to network users in Dublin's residential areas. Factors such as higher frequency spectrum, modern building insulation materials and shifting usage patterns are driving operators to invest in site solutions beyond traditional macro sites on rooftops and lattice structures. In recent years, Dublin City Council has observed a surge in planning applications for 'streetworks monopole' sites — a new type of mobile site that integrates antennas and related radio equipment into a compact pole structure with a smaller footprint than traditional designs. These sites are increasingly popular with operators for their favourable cost profile and the ability to leverage a special planning exemption in Ireland<sup>3</sup>.



Example of a typical streetworks deployment

<sup>3</sup>Referred to as 'Section 254 Licences'.



The growing volume of planning applications for streetworks monopoles has placed a substantial administrative burden on the Telecoms Unit, requiring it to make challenging approval decisions with limited information. This is further complicated by the increasing number of locations where multiple operators seek to deploy separate sites in close proximity to one another.

The City Council is seeking a data-driven framework to guide future streetworks site planning approvals and ensure licensing decisions reflect each operator's relative network need in a given area. In particular, the Telecoms Unit aims to foster fair telecoms competition in Dublin, and is actively working to avoid a disproportionate, winner-takes-all deployment model that could ultimately disadvantage citizens.

In addition to supporting decision-making, both the City Council and the City Telecoms Association are prioristing data-driven strategies to enhance citizen engagement. Their goal is to foster community awareness of the importance of telecoms infrastructure in cities like Dublin and to highlight the benefits of new site deployments.

### City Realisation: Dublin conducts comparative studies of network outcomes before and after streetworks deployments, develops pioneering suite of educational materials to support community engagement on telecoms

Dublin City Council has conducted a pioneering study on the impact of recent streetworks deployments, analysing a sample of sites to assess their effects on network performance outcomes at the local level across the city. By cross-referencing streetworks site information from historical planning records and the telecoms regulator's <u>SiteViewer</u> database, the Telecoms Unit has developed a systematic process to evaluate realworld changes in download speed and signal strength outcomes before and after these deployments. In this evaluation, the City Council observed a consistent pattern of statistically significant improvements across all performance indicators in areas studied following streetworks deployments. Utilising the custom tile-based methodology detailed in Appendix B, the Telecoms Unit developed an innovative process to visualise before-and-after changes by comparing the proportion of 'unacceptable' download speed and signal strength samples observed over time.



Signal strength before streetworks deployment



Signal strength after streetworks deployment



The high-level visualisations here illustrate signal strength outcomes around streetworks sites deployed by Operator A. In each instance, users of the Operator A network experience better performance postdeployment, with fewer red tiles indicating an increase in the number of samples meeting or exceeding the minimum 'acceptable' performance thresholds. This level of deep technical insight is only possible with a large, crowdsourced dataset that captures the real-world experience of network users over an extended period. The City Council is now adapting



Signal strength before streetworks deployment

For the first time, leveraging the in-depth insights into Dublin's telecoms infrastructure unlocked by Ookla's crowdsourced data, the City Council has created a suite of educational resources to demystify the role of telecoms in everyday city life. This communications campaign, featuring informational videos on how this methodology to inform decision-making on future streetworks site approvals in Dublin. In cases where multiple operators have submitted planning applications for nearby unilateral streetworks sites, the Telecoms Unit is assessing network performance to prioritise the deployments considered of greatest need on an operator-by-operator basis. This approach promotes fairness in the planning process and aims to deliver the best possible outcomes for overall network performance outcomes in the city.



Signal strength after streetworks deployment

telecoms networks function and the purpose of new site types like streetworks monopoles and small cells, marks a step-change in the city's proactive and transparent approach to engaging citizens on proposed telecoms developments.



New-build developments that omit provisions for mobile infrastructure in the initial planning phase lead to notable connectivity gaps across operators, restricting access to essential telephony services like voice and text in deep indoor locations. This issue is deteriorating in the absence of policy intervention, as modern insulation materials, higher frequency spectrum, and the ongoing 3G network switch-off increasingly challenge the traditional outside-in approach to network design. In the university campus example (right), the lack of operator site access has left large indoor areas with high footfall offering only limited access to essential telephony service in an area of strategic national importance.



## **Use Case:** Understanding the impact of socio-economic factors on telecoms outcomes in Dublin to promote digital inclusion and tackle the digital divide

### **City Rationale**

Dublin City Council's telecoms strategy is centred on promoting digital inclusion and ensuring there is equitable access to connectivity for all communities in Dublin. Aiming to bridge the digital divide, the City Council has been working to foster an environment that encourages balanced and sustainable investment in telecoms infrastructure throughout the city.

As part of these efforts, the City Council has invested in projects like the <u>WiFi4EU initiative</u>, delivering free public Wi-Fi access at more than 30 locations across Dublin. To advance such initiatives further, however, the City Council needs access to high-quality, representative data to accurately identify instances of the digital divide in the city and address them strategically through targeted policy interventions.

Aligned with the City Council, the City Telecoms Association's emerging principles emphasise a commitment to 'connectivity for all'. The association aims to support research that helps cities better understand how socio-economic factors influence connectivity outcomes and to promote digital inclusion-focused policy tools that are scalable and replicable across member cities.

### City Realisation: Dublin launches first-of-its-kind study to examine social deprivation and telecoms outcomes



Map of aggregate signal strength performance in Dublin (2024), overlaid with HP Pobal Deprivation Index data for electoral areas



Dublin City Council is conducting a study to examine the relationship between social deprivation levels, as measured by the HP Pobal Deprivation Index<sup>4</sup>, and telecoms outcomes across the city, focusing on signal strength and download speed performance. This research aims to determine whether areas with higher deprivation feature disproportionately poorer telecoms outcomes. The Telecoms Unit is seeking these insights to support the City Council's broader digital inclusion efforts. In the initial phase of this analysis, social deprivation and telecoms outcomes are being analysed at the Electoral Division level across Dublin. The City Council is integrating crowdsourced network performance data from Ookla with Pobal's social deprivation metrics to create innovative mapping overlays, facilitating a correlation analysis between socio-economic conditions and telecoms outcomes.



Map of aggregate download speed performance in Dublin (2024), overlaid with HP Pobal Deprivation Index data for Electoral Areas

<sup>4</sup>The Pobal HP Deprivation Index is Ireland's principal tool for measuring social gradient across communities. Based on the latest Census data from the Central Statistics Office, it provides a detailed socio-economic profile of communities throughout Ireland. The index incorporates variables such as unemployment rates, educational attainment, age demographics and other key social and economic factors, providing a comprehensive insight into affluence and deprivation levels across Ireland.

### **Appendix A**

Each time a user presses "Go" on Speedtest<sup>®</sup>, Ookla's flagship product, precise, anonymous data about that mobile network connection is collected. Because Speedtest is uniquely based on consumer-initiated testing, it operates in the foreground (i.e., a user intentionally interacts with the app) and measures the full throughput capacity of a connection. This ensures that Ookla data is collected in the places consumers are using their devices, at times they care about connectivity.

Foreground testing provides the most accurate measure of internet performance capability because it is able to use enough data to flood the internet connection and measure the full capability of both the network connection and the device. A test taken with Speedtest measures the characteristics of the communication network between a device and multiple servers using Ookla's vast global server network.

The Speedtest Server Network<sup>™</sup> comprises highperformance servers in every country and major population centre, ensuring an accurate and meaningful view of networking performance by minimising the number of data links between device and server. While Speedtest measures the full throughput capacity of a network connection, Ookla goes a step further and performs file-transfer testing to multiple CDNs and cloud hosting servers for individual services like video streaming, online gaming and video conferencing. This rigorous approach to testing, coupled with the collection of billions of daily mobile network samples measuring network quality of service (QoS), distinguishes Ookla's network measurement solutions and delivers uniquely accurate assessments of real-world user experience.

To interpret this data, Ookla employs a rigorous statistical sampling methodology that mitigates sampling bias and delivers industry-leading accuracy, all while protecting user privacy. When aggregating data from all collected tests, each unique Speedtest user's results are averaged to create a single sample summarising their internet experience for that time period and geographic area. Each service provider is then evaluated based equally on the samples from each of its users, removing the potential for results to be skewed by individual outliers or short-term fluctuations in service or user behaviour.

Speedtest data is fully anonymised, ensuring that user identities remain secure and untraceable. Ookla upholds full GDPR compliance and maintains industry-leading transparency in its data collection practices.





### **Appendix B**

Dublin City Council's smart city team developed a custom, in-house methodology to overlay crowdsourced data from Speedtest Insights<sup>™</sup> with other datasets. The high-level process of this tile-based analysis is as follows:

- Capture a high-resolution screenshot from the Speedtest Insights<sup>™</sup> map.
- Retain only the white (background), red ('unacceptable') and green ('acceptable') colours.
- Apply a grid overlay to the map and colour each grid cell accordingly.
- Georeference the screenshot (all images have consistent dimensions, enabling accurate georeferencing).
- Overlay Dublin City Council's administrative boundaries.
- Calculate and extract coordinates for green and red tiles.

The screenshot below depicts the median 4G download speed performance for 2024, with a resolution of 3264 x 1834 to ensure high granularity. There are only two bins: red for 'unacceptable' (<5Mbps) and green for 'acceptable' (>5Mbps).



Raw image of median download speed performance for 4G (2024)



As mentioned, only the relevant colours are retained: white (background, no samples), red ('unacceptable') and green ('acceptable') colours. Non-red and non-green pixels are changed to white.

Whitened image of median download speed performance for 4G (2024)



The tiles are then separated by drawing a grid as shown in the image below. This ensures each cell contains only a single colour.



Whitened image of median download speed performance for 4G (2024) with grid

The cells are then filled with the corresponding colour to yield the final grid of cells.



Whitened image of median download speed performance for 4G (2024) with filled grid cells



Next, the image is georeferenced and the Dublin City Council administrative boundaries are added. Both the area outside the polygon and the grid are removed.

Georeferenced image of median download speed performance for 4G (2024) in the Dublin City Council administrative area



Computer vision is applied to calculate the number of green and red cells and compare the 2023 and 2024 study periods.

Georeferenced image of median download speed performance for 4G (2023)



Georeferenced image of median download speed performance for 4G (2024)



The data points are then plotted within Dublin City Council's internal GIS system, allowing for the overlay of additional datasets such as the Pobal HP Deprivation Index and Telecoms Unit asset registry.

Georeferenced image of median download speed performance for 4G (2024) within Dublin City Council's GIS platform



### **Appendix C**



Signal strength 4G for all providers (2023)



Signal strength 4G for all providers (2024)



Download speed 4G for all providers (2023)

Download speed 4G for all providers (2024)



Signal strength 5G for all providers (2023)



Signal strength 5G for all providers (2024)

