Canadian Radio-television and Telecommunications Commission
Conseil de la radiodiffusion et des télécommunications canadiennes

Recommendations on a new reporting standard for mobile coverage

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FarrPoint
Canada

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1. Executive Summary

1.1. Background

The Canadian Radio-television and Telecommunications Commission (CRTC) appointed FarrPoint, an independent connectivity consultancy, to provide recommendations on improving mobile coverage reporting from the industry to provide more accurate data for Canadians. This work is part of the CRTC's effort to implement a new mobile coverage reporting standard, as per Telecom Policy Direction_2023, paragraph 17(d)(ii).

Mobile connectivity has become critically important to Canadians. The CRTC has heard from many Canadians in communities across the country who do not believe they have sufficient mobile coverage and question the accuracy of current coverage maps. The CRTC recognizes that access to mobile service is essential to Canadians and is committed to working with the industry to ensure universal coverage. Coverage maps are an important tool used to track progress, design programs to fill coverage gaps and help the CRTC to hold telecommunications service providers accountable for the services they provide.

The CRTC conducts an Annual Facilities Survey to collect mobile coverage from providers and collaborates with Innovation, Science and Economic Development Canada (ISED) on validation and mapping. The Facilities survey is used to generate coverage estimates to inform Canadians and support connectivity programs. Mobile operators each generate their own coverage predictions for submission to the CRTC, with no standard definition or agreed methodologies for generating these predictions. This lack of standardization complicates efforts by the CRTC and ISED to validate the submitted data and coverage maps.

To standardize reporting, staff at the CRTC and ISED engaged the Communications Research Centre (CRC) to produce a report proposing mobile coverage standards, given their applied research expertise on telecommunications and wireless technologies.

FarrPoint was subsequently engaged to use the CRC study as a baseline for interviews with mobile operators, conduct research on mobile reporting standards at regulators in select countries, and make recommendations to the CRTC.

The work of the CRC and this report from FarrPoint will inform the CRTC's work with telecommunications service providers to develop a more robust, standardized approach for reporting mobile wireless coverage that will improve the accuracy of coverage maps and help to identify and address coverage gaps for Canadians.

1.2. Scope

FarrPoint held discussions with CRTC staff and a selection of mobile operators to examine the current process used for reporting coverage and obtain feedback on the CRC proposal.

FarrPoint also spoke with a selection of regulators from other countries (UK, France, Ireland, and the USA) to understand and compare their approaches to mapping mobile coverage and performance.

1.3. Findings

From internal discussions with **CRTC staff**, the need for data standardization and validation is critical, as inconsistent formats and naming conventions currently increase the time required for analysis. Standardization would enable the effective use of automation tools, which the CRTC has already invested in.

Validating responses is currently challenging, with minimal checks on coverage claims and changes being possible without access to independent sources of information to cross-reference. The challenges of dealing with a large diversity in the size of mobile operators were also raised.

Furthermore, different definitions of coverage footprints among operators currently hinder accurate comparisons and the identification of coverage gaps. Public feedback has highlighted discrepancies between published maps and actual user experiences, highlighting a need for better reconciliation of data.

The feedback from **mobile operators** was that they are open to revising coverage reporting arrangements but seek formal input on specific thresholds and processes through consultation. They would prefer to report on a threshold basis, as opposed to service-level reporting.

Large operators noted the challenges with the scale of coverage data that needs to be generated. Smaller operators face significant overheads in generating coverage data due to limited resources and the cost of software and supporting data.

All operators noted concerns about the impact on resources and time required and felt the existing annual data collection was sufficient.

The review of **regulators'** approaches to cell coverage measurement and reporting revealed diverse methods for achieving clear and consistent reporting. Approaches vary in data request methods, verification processes, publication to consumers, and opportunities for challenges. This feedback has been considered against the Canadian context to provide recommendations for the CRTC.

1.4. Recommendations

Based on the feedback gathered and benchmarking against the other regulators, a more comprehensive and consistent approach to collecting and reporting mobile coverage should be established that better aligns with, if not based on, actual consumer experience.

Scope

From our review of other regulators, it is clear that all data-gathering exercises need to be underpinned with appropriate legislation requiring operators to provide the information requested. The CRTC already gathers coverage information under section 37 of the *Telecommunications Act*, where the Commission has the authority to collect information that it considers necessary for the administration of the Act.

Format

It is important to establish that coverage submissions from operators are generated on a like-for-like basis so they can be meaningfully compared and overlaid with each other. This means the extent of coverage, predicted service level and any gaps can be accurately identified.

A balance must be found between achieving sufficient accuracy for the CRTC and the burden on operators, recognising that increasing the resolution (granularity) of the maps will not resolve all concerns about how well predictions reflect the real-world experience at all times and locations.

Recommendation 1

Considering deficiencies in the current data collected and noting common practice from other regulators, we recommend that a data submission format be adopted that captures predicted signal strength by technology for each pixel at a defined resolution. Service level mappings can then be applied to the data collected, based on agreed thresholds.

Recommendation 2

Balancing the scale of Canada's geography, the footprint of national operators, and the impact of very detailed coverage predictions on the need to transmit and process very large files, we believe a resolution of no less than 50 meters should be specified for operators to use when generating coverage predictions.

Recommendation 3

To further standardize responses and simplify the data submissions, we recommend considering the specification of a standard grid for operators to respond against. Operators would overlay their coverage predictions onto this grid to report the predicted signal strength for each pixel.

Recommendation 4

To support operators in moving to and adopting the new standard, detailed guidance should be published and communicated to operators on the required data format and schema for submissions.

Modelling & Thresholds

The proposed data format will provide signal strength predictions, which the CRTC will need to map to service levels so the coverage can be suitably classified. The CRC Mobile Coverage Metrics report reviews the two primary ways in which mobile coverage data is collected - by signal strength or a defined end-user service level.

The CRC report recommends that signal strength thresholds should be collected from operators and mapped to three service levels (voice, basic and advanced) using defined thresholds for each mobile technology.

Recommendation 5

We endorse the CRC approach and agree that the proposed threshold levels should be used as the basis for discussion and agreement with the operators. However, we make this recommendation with two caveats.

Firstly, we recommend that the term ‘emergency’ be dropped from the entry-level service. Whilst this is aimed at ensuring a very high confidence of being able to make a voice call, text message, or receive a Public Warning, concerns were voiced by operators that this term could be construed as a service ‘guarantee’, with the potential to expose them to legal challenge.

Operators also felt that the high service confidence was to a more stringent threshold than they would typically assume and that coverage claims would significantly shrink as a result.

The operators engaged during the study were keen to have an opportunity to comment on these thresholds and the emergency/voice service in particular.

Secondly, whilst we suggest that the CRC proposed threshold for 5G is adopted, we recommend this is regularly reviewed in light of the ongoing work being completed internationally and by other regulators to ensure this continues to reflect the associated service levels.

Recommendation 6

Each operator’s modelled coverage will vary slightly, given the large number of assumptions used and differences in each operator’s network. To allow the CRTC to understand these differences, we recommend that operators are required to provide supporting information to understand how they have undertaken their coverage predictions, and the internal processes and validation used to ensure the models are sufficiently accurate.

The CRTC can utilize this information to better understand how different operators approach their coverage predictions and assist in understanding any variation between submissions.

Recommendation 7

We expect very small operators may face challenges in undertaking coverage modelling in the format recommended due to the cost of the required software, and the skills and resourcing necessary. For this reason, we recommend that support is provided to small operators where possible in making their data submissions.

Frequency

Mobile networks, and the resulting coverage, experience regular change for a variety of reasons. Operators provided examples of network changes, such as the rollout of 5G, sunset of older technologies (e.g. 2G or 3G) and changes in spectrum usage. There will also be changes to infrastructure over time, including new sites, decommissioning and relocations.

New data needs to be obtained from operators at an appropriate frequency so that the information used by the CRTC for coverage reporting, decision making, and consumer guidance to be sufficiently accurate.

The regulators consulted for this report all obtain data on a more frequent basis than the CRTC, whilst the view from operators was supportive of the current annual frequency of submissions, believing that the pace of network change will decrease after current 5G rollouts are completed.

Recommendation 8

Considering these positions, we recommend that revised data is requested from operators every 6 months. This will allow the CRTC to better track changes in coverage and ensure that information communicated to citizens is more up to date than the current annual reporting.

Validation

Mobile coverage predictions are built on models which inherently have a certain amount of variation and are dependent on the accuracy of the input data and assumptions. A degree of variation is expected, but there is a need to confirm they are sufficiently accurate for the CRTC to have confidence in the results. It is also important to confirm consistency in coverage reporting standards between operators.

These two checks require a comparison of responses against real-world measurements.

Recommendation 9

We recommend that an approach is developed to validate coverage submissions, and work with operators to agree on an appropriate model accuracy validation process. This should include commissioning survey work to independently confirm the accuracy of each operator's predictions and quantify any variation between operators.

Recommendation 10

In addition to the work to directly validate coverage submissions on a signal strength basis, quality of service metrics should be incorporated into the reporting of mobile coverage. This would provide a basis to confirm the linking of the thresholds to service levels in the CRC proposal and better report on the end-user experience of Canadian citizens. These could be gathered in several ways, including through performance drive testing, by utilising and analysing crowdsourced data, or by collecting data directly from citizens (for instance, using an App similar to that produced by the FCC).

Publication

A key aspect of the CRTC's mobile coverage reporting is to make appropriate information available to Canadian citizens to better inform them on the availability of connectivity at both a national and local level.

Coverage information, particularly gaps in coverage, is useful to a wide range of stakeholders, including the Government and those responsible for public safety. To support these uses, an appropriate level of access to the coverage results should be made public.

Recommendation 11

Public access should be provided to the outputs of coverage submissions through online maps, service checkers and data downloads. The maps should be interactive and allow the public to view coverage by operator and service level at any given location, identifying the availability of each service level proposed.

The map should also allow the public to provide feedback on the coverage claims where the predictions do not match their real-world experience. This will allow the CRTC to pursue further, where appropriate, and raise concerns or issues with the operators to investigate.

Data should also be published for download showing coverage at each of the agreed service levels by operator at a suitable granularity, ideally at the agreed pixel resolution.

2. Introduction

2.1. Background

Given the now well understood economic and social importance of mobile communication services, there is consensus among regulatory bodies and policymakers internationally that clear and consistent reporting of the coverage of these services is necessary. This reporting ensures that any gaps in coverage are identified and allows the monitoring of interventions to address them. It also allows regulators to understand the extent to which mobile operators are meeting consumer expectations and to ensure that consumers can make informed choices about the appropriate services to meet their needs.

There is, however, divergence in the approaches taken to measuring and reporting on coverage. This is in part due to discrepancies between operators' predictions of coverage and consumers' real-world experience. Consequently, careful analysis needs to be undertaken to ensure any approach adopted is, as far as possible, informed by the consumer experience and that any predictive modelling is consistent between operators and calibrated against real-world service delivery.

Coverage modelling will always be required, but using a standardized approach based on best practice for modelling parameters and terrain data will provide more consistent and meaningful results. To validate these models against the actual consumer experience, modelled data can be augmented with drive surveys, crowdsourced data, and in some cases, direct feedback from consumers to ensure confidence in the modelling predictions.

The Canadian Radio-television and Telecommunications Commission (CRTC) appointed FarrPoint, an independent connectivity consultancy, to provide recommendations on improving mobile coverage reporting from the industry in order to provide more consistent and representative data for consumers. The CRTC wishes to establish a comprehensive and consistent approach to collecting and reporting on service coverage that better aligns with, if not based on, actual consumer experience.

The recommendations made in this study will provide the CRTC with well-reasoned and evidenced options based on technical analysis and international experience for further consideration.

2.2. Existing Predictive Model-Based Approaches

Traditionally, coverage reporting has relied on the use of predictive computer-based tools that combine radio propagation models with operator data on base station locations and characteristics, including the spectrum deployed, with topographic information about the area being reported on to provide an estimate of radio signal strength across it. These models have developed over time, delivering "better" results because of improvements in the propagation models and the topographic/clutter inputs.

This model-based approach offers the obvious advantage that it obviates the need for extensive and expensive direct measurement programmes to collect signal strength data across the entire

target area. It can also be repeated on a regular cadence so that, as networks develop, both in terms of numbers of physical and logical network assets and in terms of the deployment of new technologies, stakeholders have an up-to-date understanding of coverage. It does, however, need some level of output assurance by cross-checking against a more limited set of actual field measurements. Typically, the operators and national regulatory or other agencies tasked with coverage reporting duties undertake such assurance programmes using their own resources or commissioning specialist third parties to undertake the work on their behalf.

Equally, if not more importantly, these models need "calibration" to determine the signal strength that provides acceptable service to the end user. Whilst there is a large body of theoretical work underpinning the relationship between the signal and service, most regulators have concluded that they need to demonstrate this more directly, using typical end-user devices to run tests in different locations and correlating performance with actual measured signal strength. Several regulatory bodies have used this approach to set appropriate thresholds for services delivered over successive generations of mobile network technology based on the quality of benchmark voice and data service sessions tuned to the capability of the technology in question.

The application of this approach continues to evolve, setting different thresholds for specific spectrum bands in each technology and expanding the range of benchmarking use cases, particularly as the industry moves to 5G. The approach also seeks to make the coverage mapping more granular and provide higher levels of confidence. Again, this is partly driven by concerns about the gap between predicted coverage and actual user experience.

2.3. Directly Assessing the User Experience

Information should be assessed against its correlation with the real-world user experience. This is particularly important in setting signal strength thresholds but also serves as an important ongoing assurance tool to identify increasing systemic or localised divergence between predictions and experience.

To date, this validation has been undertaken via operator, regulator or third-party "drive testing" using devices running apps to set up voice and data sessions and record their success/performance. This approach continues to be used, although innovative use of vehicles already making regular journeys through the reporting area, such as those used for public transport, waste collection, etc., is growing as they improve the economics, and the scope of the data set collected.

Alternatively, some regulators are investigating the use of datasets from third-party performance monitoring/test apps. Organisations such as Ookla and Opensignal collect and analyse data from their proprietary apps running on consumer devices in many countries, and this crowdsourcing approach has obvious appeal in terms of test result volumes and, potentially, widespread distribution of test locations. Unfortunately, this approach also has several weaknesses, particularly due to differing handset performance and a lack of understanding of the environment a test result was obtained in

(indoor, outdoor, etc.). This means it can be difficult to draw conclusions on the factors influencing the end-user experience recorded.

Some regulators are also making use of their own crowdsourced data, obtained directly from consumers, as opposed to purchasing from a third party. This has the potential for the regulator to control more elements of the testing; for instance, by developing their own app to use. This may provide more specific evidence on which to confirm or challenge the accuracy of the coverage predictions.

It is clearly feasible to focus regulatory coverage mapping solely on direct Quality of Service metrics, potentially giving a better understanding of the consumer experience. However, the success of this approach needs a robust legislative and regulatory framework that provides effective incentives for operators to comply. It also requires extensive confirmation assurance programmes to ensure that the service quality data from operators is accurate.

This approach would be challenging to scale to several operators and a large coverage area. Both these factors are clearly relevant to the CRTC, making the adoption of such an approach as the primary methodology for Canada challenging in both economic and logistical terms. Nevertheless, we suggest that the feasibility of adopting some elements of this approach is explored to complement the adoption of signal strength threshold methodologies.

2.4. Approach

The approach taken to complete this study was as follows:

Methodology:

- Initiation:
    - Project initiation
    - Background info
    - Communications
    - Timescales
    - Admin
- Coverage Reporting:
    - Review existing process
    - Meetings with MNOs
    - Short report
- Improvement Options:
    - Benchmark
    - Identify information gaps
    - Identify additional measures
    - Validation methods
- Data Requirements:
    - Data threshold
    - Reporting process
    - Coverage presentation
    - Additional data sources

- Reporting:
    - Draft report
    - CRTC review
    - Final report

Following project initiation, the study examined the current process used for reporting coverage data through interviews with CRTC staff and the primary operators involved. FarrPoint then spoke with a number of other international regulators to understand their approach. Analysis of this feedback was used to identify gaps in the current CRTC process and to consider how the modelling and associated thresholds can be improved. The final stage is the reporting presented in this document.

The study was undertaken over the period of December 2024 to March 2025.

3. Current Process

3.1. CRTC Requirements

Scope

The CRTC currently gathers data on mobile coverage through the Annual Facilities Survey, capturing data as of December 31st each year.

Approximately 20 mobile operators submit data through this process.

The CRTC collects and validates the operator data before providing it to Innovation, Science and Economic Development (ISED) for further processing and to create a combined view of mobile coverage for Canada across all operators.

Format

Operators are required to submit spatial data representing coverage by mobile technology via the CRTC's Data Collection System.

Coverage data must be provided for:

- All coverage (by any technology);
- GSM Coverage;
- HSPA+ Coverage;
- 4G/LTE Coverage;
- LTE-A Coverage;
- 5G Coverage.

The preferred format to receive these files is MapInfo (TAB). Most operators already submit data in MapInfo format, with a few submitting in KML/KMZ format. The CRTC converts responses into MapInfo format to provide to ISED.

The CRTC specifies that only coverage within Canada should be submitted.

Modelling & Thresholds

The Facilities Survey does not specify how the operators should derive their coverage maps or if a specific threshold or service level should be used.

The operators are not required to submit details on how their coverage maps have been derived.

Frequency

Coverage data is obtained by the CRTC annually through the Facilities Survey.

Validation

Responses first undergo data validation by the CRTC to ensure valid spatial data has been submitted. Responses are then validated by comparison with previous submissions to identify the scale of change, any 'shrinkage' in coverage by technology, and to confirm each technology is a subset of the total coverage footprint. The coverage footprint is also validated against public maps on operators' websites.

Clarification questions are handled via email exchange with the relevant operators, with any supporting images of any unexpected 'shrinkage' shared via secure sharing platform (Kiteworks).

Publication

The CRTC publishes the resultant coverage information through its regular Communications Market Reports, including information on Mobile wireless coverage and trends. This includes:

- Percentage coverage of homes and major transportation routes by province and territory;
- Spatial data available for download and an interactive map showing LTE coverage on the national highway system;

Spatial data available for download and an interactive map of overall LTE coverage between 2014-2023, and overall 5G coverage from 2020-2023.

Developments

During FarrPoint's discussions with the CRTC, several issues and suggestions were raised, including:

- Data submissions are provided in a variety of formats without consistency in naming, schema or coordinate system. This increases the time required to analyse, clarify and validate data. The CRTC has recently tightened instructions around file naming conventions and how to handle decommissioned technologies to improve this.
- Recent investments have been made in platforms and tools to automate checks and processes, which can only be fully utilised if there is more standardization in the data received.
- It is difficult to validate responses other than by comparing them to the previous response. Little or no supporting information is provided to describe or explain changes in coverage. An example of this is if an older technology or band is decommissioned, it triggers additional scrutiny as it is interpreted by the CRTC as a reduction or abandonment of service.
- There are some challenges in receiving data submissions from small mobile operators who may need more support or guidance on how to submit data.

- There is inconsistency in how coverage around the coastline is handled by operators, although the CRTC states that operators should not crop coverage predictions to the shoreline.
- There is concern about ensuring like-for-like comparisons between submissions and that any gaps in coverage are correctly identified if operators have different definitions of their mobile coverage footprints. More consistency would also better support the targeting of investment programmes and new infrastructure.
- The current information gathering and combined outputs are difficult to reconcile to the end user service/experience. This has been highlighted through feedback from the public that published maps don't match their experience.
- There is increased interest in the use of dashboards and insights by the CRTC, as opposed to the production of static outputs, which rely on the data obtained through the facilities survey.

Communications Research Centre (CRC) Proposal

To standardize reporting, staff at the CRTC and ISED engaged the CRC for a report proposing mobile coverage standards, given their applied research expertise on telecommunications and wireless technologies.

This work proposes a unified approach to generating coverage data for Canada and better linking this to the mobile services experienced by Canadian consumers (CRC Technical Report 031034-TR-01).

This report proposed measuring mobile coverage at three increasing service levels:

- **Emergency Service:**
  A 95% probability of making a 90-second emergency voice call without interruption and with adequate audio quality and a 100% probability of receiving Public Warning System messages; the data rate requirement for this service is at least 250 kbps for both the uplink and the downlink.
- **Basic Service:**
  A 95% probability of a data service with a downlink data rate of at least 3 Mbps and an uplink data rate of at least 1 Mbps.
- **Advanced Service:**
  A 95% probability of data service with a consistent downlink data rate of at least 10 Mbps and an uplink data rate of at least 2 Mbps.

3.2. Operator Feedback

Introduction

A range of operators were contacted by FarrPoint, with the CRTC assisting and providing appropriate introductions.

Discussions were held with TELUS, Bell, Rogers, Sasktel, IrisTel and Quebecor (Videotron). Questions were posed on the following topics:

How is coverage data for the CRTC generated at present?
How is the coverage data validated?
How do you view the proposed changes from the CRC?
What is your view on the sharing of data?

A consolidated view of feedback from these discussions is as follows.

Generation

Coverage predictions are commonly generated at 30m resolution, with the larger operators using radio planning software from Infovista (Planet) or Forsk (Atoll).

The operators prefer signal strength mapping and would welcome dialogue on suitable thresholds that may be used for the service levels in the ISED proposal. This is preferred to an attempt to relate service levels to signal strength as it is recognized that service performance is dependent on many other factors.

Operator predictions use different propagation models dependent on geography and population density, and these models change.

The generation process can be resource intensive and is regarded as particularly significant for smaller operators who also cite issues with software licensing costs and access to the required skills.

Some operators produce predictions at a less granular level (>30m), noting the time and complexity to produce more detailed predictions and the cost of underlying data (digital terrain model and clutter) as barriers.

Annual reporting was felt to be sufficient due to the relative stability of the networks, which would not justify more frequent reporting. However, there was some acknowledgement that there can be periods of significant change due to 5G deployments, changes in equipment manufacturer, and newer bands being implemented at certain times. Smaller operators may not have such significant network changes. The current format of submissions is reported as being generally the same as used for the operators' own coverage maps and matches their internal view of coverage levels.

Validation

The use of crowdsourced data to validate coverage predictions has been investigated by some operators but is not considered to be of great benefit in directly validating coverage submissions due to the varying environments that can affect the data generated. The cost of the data is also an issue.

Drive surveys are used by operators to validate new sites and for any changes made to the network. In some cases, when deploying a new technology or a new band, a third party is contracted to develop a custom propagation model for use by the operator. A statistical tolerance of 8dB between the modelled and measured results is a common measure. Some operators also carry out drive surveys annually, whilst others noted the difficulty in performing direct validation of coverage

due to the rurality of sites, for instance, in areas not accessible by road. A mix of in-house and outsourced arrangements are in place to conduct these surveys.

Future Changes

Potential changes to the modelling and reporting of coverage data are met with caution by operators. This would be expected for any process change, given the potential for this to introduce additional effort and cost.

However, in general, the approach of signal thresholds as opposed to service availability is preferred, and an increased frequency above annually (say 6-monthly) could be accommodated. Any such changes would be expected to go through a more formal process with the chance to consult. Once changes were agreed, a 6-month implementation period was suggested.

There was concern over the use of the term 'Emergency Service' as the base service level in the CRC proposal, as this might be interpreted as a guarantee that an emergency voice call could be made in all covered areas. If this is the intention, operators may be required to use a very stringent threshold to achieve a high service probability, meaning the coverage footprint would shrink beyond their view of normal voice call coverage. Their view is that this would have a disproportionate effect on coverage predictions in a geography that was predominantly rural.

The term 'Emergency Service' was also questioned in some First Nation communities and remote and northern areas where no 911 / Public Safety Answering Point (PSAP) service is available.

Separately, it was suggested that the voice thresholds proposed could potentially be lowered as the levels suggested may be too stringent.

It was highlighted that operators may have a challenge if the reporting thresholds are different from their own view of their network and capabilities. This may potentially lead to public confusion if different maps are published by the operators and the CRTC. Similarly, there may be differences in coverage mapping when roaming is considered, as networks are configured for a seamless handover to a roaming partner (where available) rather than holding on to a device to the cell edge.

There was also feedback that the data sources for the CRC proposal were predominantly European in focus, and there could be an argument for further work to confirm the thresholds and assumptions used are appropriate in the context of Canadian geography. This was considered especially for rural, remote and northern areas where less radio interference may be expected.

Data Sharing

Concern was raised by all operators around the confidentiality of data, particularly its release to the public. This was related to the way data may be presented and how it is then interpreted, noting that different messaging is often required when presenting information to consumers.

Concerns were also raised that network roaming and infrastructure sharing agreements may mean some operators are able to use published data to identify competitors' coverage.

3.3. Summary of Current Position

CRTC staff highlighted several issues with the current approach. These focused on consistency of reporting, difficulties with validation and comparisons, and the recognition that better tools could be deployed to improve the outcomes.

Operators are open to changes to the existing coverage reporting arrangements but want more formal input to the specific thresholds and process through consultation. There is no backing for service level reporting from operators, instead the use of agreed signal thresholds is favoured. The definition of an Emergency Service and the associated thresholds were highlighted as particular areas they would like to discuss further.

Generating coverage data is more of an onerous challenge for smaller operators. Although their number of sites is lower, the skills, resources and costs associated with reporting are a more significant barrier. This feeds into the view of the frequency of reporting, which the operators believe is sufficient as annual.

There was concern over the use of the term 'Emergency Service' as the base service level in the CRC proposal, as this might be interpreted as a guarantee that an emergency voice call could be made in, resources and costs associated with reporting are a more significant barrier. This feeds into the view of the frequency of reporting, which the operators believe is sufficient as annual.

Most operators undertake significant work to validate their propagation models, especially for network changes and new sites, and ensure these are within industry standard tolerances. Crowdsourced data is not used, but drive tests are carried out either by internal or outsourced teams.

4. Regulator Review

4.1. Introduction

A selection of telecom regulators was contacted, and discussions were held to understand their approach to coverage reporting. The results are represented across common headings.

4.2. Overview of Current Work by Regulatory Agencies

In the UK, Ofcom is currently reviewing how it reports on mobile coverage, given the request from the previous UK Government in its 2023 Wireless Infrastructure Strategy and a more recent exchange of letters between the relevant UK Government Minister and the Ofcom CEO.

Ofcom is reviewing how it presents the results of the operators' predictive modelling in light of growing consumer and policymaker disquiet that actual experience at a local level does not align with predictions.

Whilst at an aggregate level, the models are seen as being reasonably accurate, some locations, particularly in more marginal coverage areas, may have a consumer experience that is worse than that predicted. Amongst other things, Ofcom is considering a change to the thresholds used on its public coverage checker website to show, at the boundary, where a reliable connection at a 90% confidence level can be expected.

This may involve a significant change in the threshold used, to be agreed based on directly measured errors in the operators' predictions versus real-world measurements, and input from the OpenSignal crowdsourced dataset Ofcom has negotiated access to that provides another view of the relationship between signal strength and successful connection.

To some extent, this would reflect positions being adopted by the pan-European regulatory coordinating body BEREC in its own recommendations and regulators such as ComReg, who have concluded that such higher confidence levels may better inform consumers in some circumstances. It is worth noting that, whilst Ofcom was a pioneer in this area, these other regulatory bodies have undertaken focused work more recently and have already adopted more onerous signal thresholds.

Ofcom is also considering how to put incentives on operators to provide better prediction data. Ofcom intends to confirm its proposed approach and progressively implement it from Summer 2025 onwards. The approach adopted by ComReg is interesting in another respect - rather than allowing each operator to use its own model, ComReg has developed its own model, calibrated for the Irish radio environment, which it applies to data on base station locations and characteristics it collects from operators. Whilst this approach has the advantage of increasing the likelihood of consistent outputs, it may not reflect differences in technology deployment strategies between operators. It also becomes an increasingly onerous task as the scale of the territory and the number of operators increases, which would clearly be an issue in Canada.

There is a more general challenge in ensuring the engagement and cooperation of operators. In the comparator countries examined, the regulatory body has a clear mandate to report. This generally places a legal obligation on them to do so, coupled with complementary powers to require operators to provide data and enforcement powers if they provide inaccurate information. We consider this to be a vital aspect of any scheme as reliance on voluntary cooperation can lead to conflict and a reduction in scheme effectiveness. We also think it is important that there is a clear duty and right to make the results of the coverage analysis public to aid policy making and to properly inform consumers.

4.3. Ofcom

Scope

Mobile Network Operators (MNOs) are required to submit coverage data for the UK to Ofcom under a Statutory obligation introduced via primary legislation in 2011.

Operators submit data representing the predicted signal strength by technology.

Format

Data is submitted against a 100x100m grid covering Great Britain, produced by the national mapping agency (Ordnance Survey). This grid is clipped to the coastline.

Operators submit this as a non-spatial tabular file (e.g. csv) using a managed file transfer service.

Ofcom is reviewing the 100m grid resolution for coverage submissions and whether this should be made more granular (e.g. 50m) and if this would improve confidence in the results.

Modelling & Thresholds

Ofcom apply a set of signal strength thresholds by technology to estimate the service, or probability of achieving a service, from an operator's modelled signal strength data.

Operators supply predictions based on a 50% confidence level across the 100x100m pixel.

Ofcom does not prescribe specific modelling attributes but requests operators to outline their approach.

Ofcom has defined thresholds for a voice service on 2G, 3G and 4G, and a data service on 3G and 4G[1].

5G is represented as a confidence of a service availability: 'high confidence' and 'very high confidence'.

Ofcom's view is that signal strength for 2G, 3G, and 4G is relatively well understood and more predictable to relate to potential service levels and performance. For 5G, this is currently less clear, and it is more difficult to equate measured signal strength with the expected performance, especially for higher frequency bands.

Thresholds for 5G are currently set based on the confidence of accessing a 5G service rather than any specific performance/quality of service metrics. There are a number of other related factors that affect 5G performance, including beam forming and massive MIMO, which are also more difficult to model.

Ofcom continues to review the thresholds used, especially for 5G. This also relates to the probability of achieving a service – i.e. a more stringent threshold will shrink coverage but increase the likelihood of a service.

Frequency

Coverage data is submitted by operators monthly.

This is used to support Ofcom's online Mobile Availability checker and regular reporting, although these are not updated at the same frequency as data submissions.

Validation

Validation is based on a statistical analysis of the data received. Ofcom does not typically validate specific/individual locations.

Ofcom performs its own drive surveys to validate the coverage submitted, primarily aimed at 4G and 5G. The data is typically captured by 'spectrum assurance vehicles' in their day-to-day business investigating spectrum compliance cases.

Ofcom has also collected data on trains and undertaken more focused outdoor and indoor measurement campaigns, including walk testing.

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1 Ofcom Connected Nations 2024 Methodology Annex

The results of the measurement data exercises are published on the Ofcom website.[2]

Ofcom is using crowdsourced data to understand end-user performance and experience. They do not think it is useful in validating signal strength due to the inherent unknowns of the location, context and device under which it was captured.

Publication

Ofcom provides an online Mobile Availability checker[3] for the public, which provides estimated service availability (Voice/Data/5G Data) by operator for indoor and outdoor coverage.

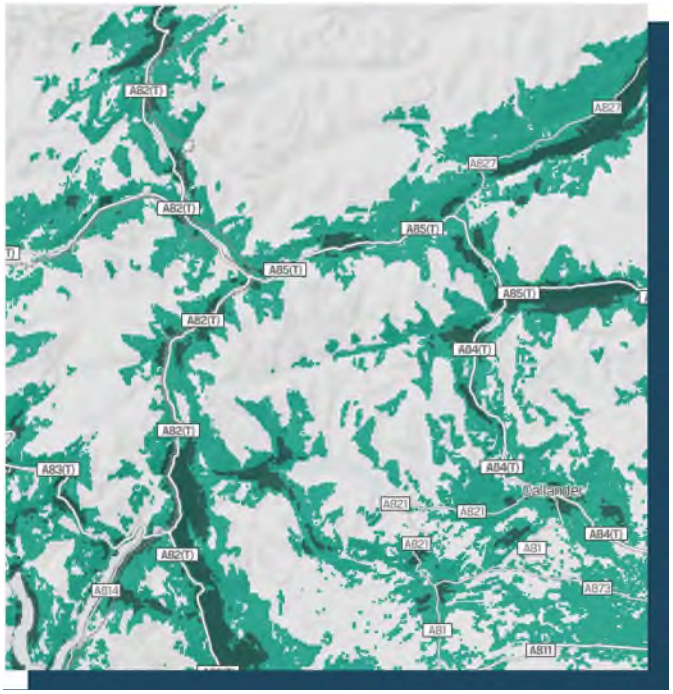
Ofcom publishes a Connected Nations report annually, plus two interim updates during the year, although this is likely to be reduced to a single interim update in the future. These reports include mobile coverage data at an aggregated level (National, Local Authority and Constituencies).

Government bodies and policy makers can access an aggregated view of the 100x100m grid coverage data. This provides a count of the number of mobile operators offering 2G, 3G, 4G and 5G services at an outdoor level. Access requests are on a named basis for a defined purpose and must be approved by all operators prior to release.

Ofcom also offers a REST API to provide property-level data on mobile availability to developers. Usage of the API is subject to a limit on the scale/number of calls.

Ofcom is considering how it presents the data, especially the public online checker. It believes that presentation for the public needs to be different from formal reporting, with clearer messaging and explanations. Ofcom is interested in how it can augment MNO data to give a richer picture – for instance, performance/quality of service data or other metrics. Ofcom is also interested in giving consumers a clearer feedback mechanism if the availability map differs from their experience.

2 Mobile signal strength measurement data from our spectrum assurance vehicles - Ofcom
3 Broadband and mobile coverage checker - Ofcom



Alt text: Screenshot from the Ofcom Mobile and Broadband checker map.

Figure 1 - Example of Ofcom Mobile and Broadband checker map.

Long description: Ofcom's mobile checker displaying 4G/5G coverage and streaming performance for each network in a given area, based on postal code.

4.4. ARCEP (France)

Scope

Operators are obliged to submit data by legislation and through conditions attached to spectrum licence allocations.

ARCEP collects data for metropolitan (European) France as well as overseas territories.

Format

Coverage data is submitted by operators in ESRI Shapefile format, separately by technology and service (voice and data).

ARCEP specifies the projection to use and attributes that need to be populated. The data collected includes:

- Coverage maps;
- Base station lists;
- Percentage of population and geography covered;
- Stations under maintenance or temporarily unavailable;
- Planned sites and coverage up to 2 years in advance.

ARCEP are considering introducing a central channel for operators to upload and submit data, as is currently available for fixed network operators.

Modelling & Thresholds

Coverage data is submitted by operators primarily based on service levels (i.e. being able to make a call or achieve a certain throughput) rather than by providing signal strength. Maps are collected for 2G, 3G, 4G and 5G.

ARCEP are monitoring developments on the reporting of 5G coverage as undertaken by BEREC[4].

Frequency

New data is collected every 3 months.

ARCEP takes around 1 month to process new responses from operators.

Validation

ARCEP undertakes its own drive survey tests to perform quality of service measurements. These tests include throughput measurement, video streaming and making phone calls. The results of the drive surveys are published by ARCEP on its coverage maps[5].

ARCEP also commissions 3rd parties to do drive tests to its required specifications.

The operators pay for the validation surveys, with costs allocated to them proportionally based on their size.

Validation of coverage submissions is completed occasionally and typically targets specific areas. Results are reported as a ratio of successful tests vs. coverage submissions. There is a target compliance of 98% for these validation checks.

Validation of 5G coverage submissions is still at an early stage, and ARCEP is interested in the results of pan-European work on how best to do this. ARCEP does track 5G deployments in terms of sites and frequency bands deployed.

Agreements with crowdsourced data providers are also in place with data being used and published on ARCEP's maps. This data is not currently used to validate coverage maps but instead to provide metrics on the Quality of Service and to provide data in areas that cannot or have not been surveyed. ARCEP also finds this a good tool for engagement with the public, allowing them to contribute by making their own submissions.

Members of the public can provide feedback on the coverage maps and report a problem. Currently, there are around 4,000 such reports a year. These are not currently published (like in the 2 map), but some are investigated further or incorporated into validation drive surveys, if possible.

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4 https://www.berec.europa.eu/sites/default/files/files/document_register_store/2020/3/BoR_%2820%29_33_Feasibility_ study_5G.pdf

5 https://monreseaumobile.arcep.fr/ (English option at bottom of webpage)

Publication

All the coverage information submitted by operators is published by ARCEP as Open Data in Geopackage format.

ARCEP publishes maps with detail on:

- The mobile coverage predictions by service and technology;
- Site information including location and technology;
- Coverage obligations (rail, priority roads).

ARCEP also publishes the coverage results in its regular reporting. Users can generate their own maps/documents for specific geographies, for instance, showing aggregated coverage and changes over time.

4.5. FCC (USA)

Scope

The *Broadband DATA Act* (S.1822) requires mobile coverage data to be reported alongside fixed broadband coverage. This includes improved coverage mapping by signal strength and quality of service down to address level. The act also addresses potential over-reporting through verification processes and the publication of data to the public through interactive maps.

The FCC maintains a national broadband map showing cell and fixed broadband services available to Fabric locations (addresses), as reported by service providers to the FCC as part of their ongoing Broadband Data Collection (BDC)[6].

The FCC has defined a Broadband Serviceable Location (BSL) Fabric[7] », ; a reference dataset of all locations (structures) in the United States where a broadband service could be installed. This is used to collect and present coverage data.

Cell providers who have any end-user connections in service must submit a response. Other agencies may file if they want to, such as federal agencies.

Consumers, state, local and Tribal Government entities, and other stakeholders can help verify the accuracy of the cell coverage shown on the map by filing challenges to service provider coverage claims.

Format

The FCC publishes a detailed specification for filers submitting responses. Spatial (GIS) data is submitted as polygon data in one of the following formats:

- ESRI Shapefile;
- ESRI File Geodatabase;

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6 https://www.fcc.gov/BroadbandData
7 https://help.bdc.fcc.gov/hc/en-us/articles/16842264428059-About-the-Fabric-What-a-Broadband-Serviceable-Location-BSL-Is-and-Is-Not

- GeoJSON;
- Geopackage.

The attributes attached to the polygon data are strictly detailed in terms of attribute names and data types. This includes:

- Technology;
- Download and upload speeds;
- Signal strength;
- Environment (outdoor / in-vehicle).

Files must be submitted in the common (global) EPSG: 4326 / WGS84 coordinate system.

In addition to the spatial coverage data, Service Providers must submit a significant amount of supporting information on how the coverage data was produced. This includes detailed information and rationale on:

- The modelling tools used;
- Terrain and clutter data used, date and resolution;
- Propagation model calibration process and date;
- Link budget parameters;
- Clutter types and attenuation.

The FCC states that these propagation parameters must be based on those specified in the *Broadband DATA Act*, which is adopted by the commission. The resolution used for their mobile propagation model must not be greater than 100m.

Data submissions are made through the BDC system, with logins made available to allow Service Providers and other entities/agencies to file a response.

Modelling & Thresholds

The FCC requires service providers to submit Mobile Broadband and Mobile Voice Coverage maps[8].

Service providers must provide spatial data representing the extent of coverage for specific service levels for 3G, 4G and 5G. These service levels are defined by upload and download speeds based on a given cell edge probability and cell loading.

Data must be provided for both outdoor and in-vehicle service availability.

Service providers must also provide signal strength (heat maps) showing the predicted signal strength within the coverage area.

8 bdc-availability-data-specifications.pdf

Frequency

Data is collected twice a year.

Challenges to the Mobile Availability[9] are accepted on an ongoing basis and successful challenges are reflected in updates to the National Broadband Map and Fabric locations.

Validation

At the point of data submission using the BDC system, several automated data checks are undertaken before the submission is accepted. This includes geometry validation and repair.

Identified errors will prevent a submission from being accepted, whilst warnings can be accepted alongside justification text for why this can be ignored.

From the information published online, the FCC continues to improve the validation of Service Provider submissions. As of May 2023, it states that[10] :

"The FCC has built automated checks into the new system to validate submissions from internet providers. FCC staff have also begun to use the verification and enforcement tools available to ensure accurate availability filings, initiating over 800 verification inquiries thus far. More stringent verification resulted in updates to over 600 submissions from providers and a clearer picture of broadband availability in every state and territory."

The FCC also rely on public or third-party challenges to the published data to improve the mapping and to correctly identify unserved locations. Individual and bulk challenges to the mobile broadband service data are accepted, with Service Providers required to respond or concede to each challenge.

To assist challenge, the FCC has released its own Mobile Speed Test App[11]. This will also support the evaluation of mobile network performance. Three types of tests are supported: challenge speed tests, crowdsource speed tests and 'QuickCheck' speed tests.

Challenge Speed Tests are submitted to the FCC and are used to challenge coverage data submitted to the National Broadband Map. A challenge will be created once sufficient 'failed' data points are created between 6am – 10pm.

Crowdsource Speed Tests allow the public to test the speed of their cell connection.

The results are sent to the FCC and used to evaluate coverage and performance and check the accuracy of the National Broadband Map.

A 'QuickCheck' speed test lets the public test the speed of a connection without submitting the data to the FCC.

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9 https://help.bdc.fcc.gov/hc/en-us/sections/19845302880027-Submit-a-Mobile-Availability-Challenge
10 https://www.fcc.gov/national-broadband-map-it-keeps-getting-better
11 https://www.fcc.gov/BroadbandData/speed-test-app

The FCC states the app can determine whether users are inside or connected to Wi-Fi, in which case a challenge will not be created.

Recent updates to the app allow for repeated testing over a period of up to 4 hours.

Publication

The FCC publishes the results of its data collection in the National Broadband map[12] which is updated twice a year. This provides coverage data at an address location ('Fabric locations'), and the percentage of area served for Outdoor Stationary and In-Vehicle Mobile services.

The providers who claim coverage are individually listed, along with the service levels offered. This information is provided alongside fixed broadband availability (including satellite providers).

4.6. ComReg (Ireland)

Scope

Mobile operators are required to submit coverage information under a Section 13D information request. They provide ComReg with data representing the network configuration for all their transmitters across the country.

This data is used by ComReg to produce coverage predictions for each of the operators for 2G, 3G, 4G and 5G.

Format

All the operators in Ireland and ComReg use the same RF modelling software - ATOLL by Forsk[13]. The operators provide submissions in a proprietary .ATL file that can be used directly by ComReg.

ComReg must ensure it has a matching version of software to operators, as new files are not backward compatible.

As ComReg produces the coverage predictions, if there are any changes to the methodology or approach, it can re-process without needing new data to be submitted by the mobile operators.

Modelling & Thresholds

ComReg sources its own DTM/Clutter/Building Height data for the modelling in ATOLL, at a 10m resolution.

The Crosswave universal propagation model (developed by Orange Labs) is used to make the coverage predictions, which has been tuned for the local geography. This includes different propagation models for Urban, Rural and suburban settings.

12 https://broadbandmap.fcc.gov/home
13 Atoll Radio Frequency Planning & Optimisation Software | Forsk

The thresholds used are primarily based on cross-European work undertaken by BEREC[14]. ComReg has commissioned its own study on how it should set 5G thresholds[15], as BEREC has not yet published equivalent 5G standards [16]. ComReg will monitor any new publications closely.

Frequency

Data is submitted by operators 3 times a year.

Processing by ComReg is resource intensive and takes around 10-12 weeks to complete.

Validation

ComReg has previously commissioned mobile coverage drive tests. These are used to assess compliance with licence coverage obligations, focused on Ireland's National Primary and Secondary road network. The survey includes measuring the signal strength and the ability to make a call or access services[17].

ComReg has recently commissioned a supplier (ranlytics) to complete drive surveys on a wider scale over a 12-month period. This uses equipment mounted on delivery vehicles. The survey equipment will be rotated around different areas, and the results compared to the coverage predictions. The survey results are commercially sensitive and so will not be made publicly available.

ComReg currently does not use crowdsourced data for coverage validation, given the uncertainty in the measurement conditions.

Publication

Coverage results are published on a public online map [18], showing signal quality/ strength by mobile technology, graded from 'No Coverage' to 'Very Good'.

The coverage outputs are considered commercially sensitive and aren't used for any other purposes other than to produce the public-facing coverage map.

4.7. Summary Position

The review of regulators' approach to cell coverage measurement and reporting shows different approaches being taken to the common issue of needing to provide clear and consistent reporting. The approach taken varies in how data is requested, how the data is verified and published to consumers, and the opportunity to challenge.

- In terms of **Scope**, in all cases, operators are required to submit coverage data through a form of legislation. This can be quite specific about coverage data or as part of a more general telecom regulation on service standards and consumer protection.

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14 BEREC - Common Position on monitoring mobile coverage
15 Coverage thresholds for 5G services – A study by Plum Consulting | Commission for Communications Regulation
16 BEREC – Feasibility study on development of coverage information for 5G deployments
17 ComReg-2282.pdf
18 Service Coverage - Commission for Communications Regulation

- The **Format** of responses varies with Ofcom using a 100m x 100m grid, and others requesting specific attributes with tabular files or shapefiles. ComReg stands out with a different approach, producing its own coverage predictions from the site data submitted by operators.
- The approach to **Modelling & Thresholds** also varies with the use of signal strength thresholds by technology or based on service levels. There is no mandating of modelling specification, other than with ComReg, who do their own modelling. 5G thresholds remain a work in progress and are influenced by cross-European work.
- The **Frequency** of submissions ranges from monthly to twice per year.
- All regulators undertake some form of **Validation** through drive surveys to varying levels, with crowdsourced data being sourced but not considered appropriate for validating signal strength. Validation is also addressed through a challenge process, which is available from some regulators, with the FCC notable in their developments, including the release of its own app for the public to use to challenge coverage data.
- For **Publication**, all regulators provide online checkers and coverage data to limited sets of users or more openly in some cases. This data may be aggregated to some level, but continued pressure on 'better data' means this is an area for further development.

If the current approach used by the CRTC for collecting operator coverage data is benchmarked against that used by comparator countries, weaknesses are apparent in both the approach to ensuring consistency between the models used by the operators and for establishing correlation with real world experience.

5. Recommendations

5.1. Scope

From our review of other regulators, it is clear that all data-gathering exercises need to be underpinned with appropriate legislation requiring operators to provide the information requested. The CRTC already gathers coverage information under section 37 of the *Telecommunications Act*, where the Commission has the authority to collect information that it considers necessary for the administration of the Act.

5.2. Format

It is important to establish that coverage submissions from operators are generated on a like-for-like basis so they can be meaningfully compared and overlaid with each other. This means the extent of coverage, predicted service level and any gaps can be accurately identified.

There is currently no strict definition or common standard for operators to use. This leads to uncertainty over what kind of coverage is represented and how it compares to the mobile service experienced by citizens. Feedback from the public suggests that the current CRTC mapping is optimistic and doesn't correctly identify coverage gaps.

The other regulators engaged in this study all mandate that mobile operators provide their coverage at a suitable granularity. For Ofcom and the FCC, this includes submitting signal strength predictions by technology. Arcep and the FCC require the coverage to be broken down into the anticipated service levels (i.e. in terms of speeds experienced).

ComReg takes a different approach, requesting the underlying network parameters to make predictions on behalf of the operators. This provides confidence that all predictions have been made in the same way and enables ComReg to map the varying quality of coverage from each operator. However, this is a specialized and resource-intensive activity, which would be a particular issue for a geography the size of Canada.

The engagement with operators shows that they perform coverage mapping on a signal strength basis, typically at a resolution of around 30 metres. When discussing the potential requirement for more granular coverage submissions for the CRTC, concern was raised about resource implications, especially by smaller operators given the skills, software and reference data required to provide this data.

The choice of submission format should consider what the data represents (either the signal strength or a defined end-user service level) and how detailed the predictions are required to be. Generating radio coverage predictions is a computationally intensive exercise, intrinsically linked to the scale (number of transmitters) and resolution of the outputs. More granular predictions also require matching input data in the form of digital terrain and clutter data, which can be expensive to source.

It should be noted that all predictions rely on a range of assumptions and input data. Increasing the resolution (granularity) of the maps will not resolve all concerns about how well predictions reflect the real-world experience at all times and locations.

Given this, a balance must be found between achieving sufficient accuracy for the CRTC (and residents) and the burden on operators to generate more detailed submissions. This is especially true for smaller operators, where skills and resources can be challenging.

Recommendation 1

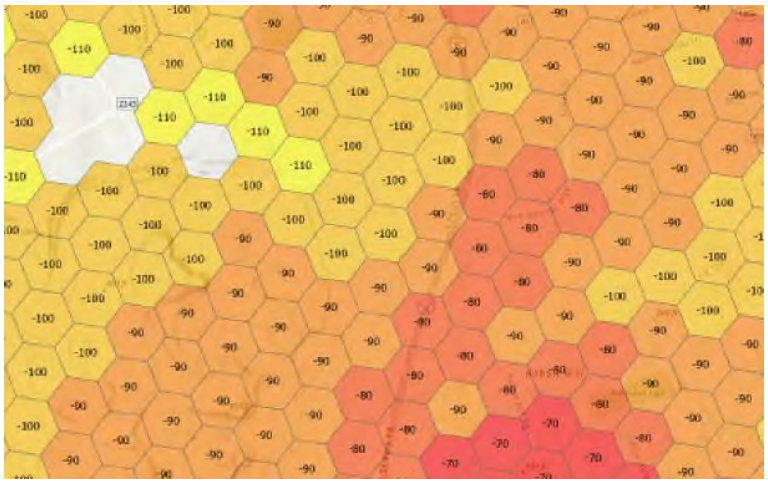
Considering deficiencies in the current data collected and noting common practice from other regulators, we recommend that a data submission format be adopted that captures predicted signal strength by technology for each pixel at a defined resolution.

Service level mappings can then be applied to the data collected, based on the thresholds proposed in Section 5.3.

The technology parameters captured for each pixel should be:

- 2G GSM: Received Signal Strength (RxLev);
- 3G UMTS: received Signal Code Power (RSCP);
- 4G LTE: Reference Signal Received Power (RSRP);
- 5G: Synchronization Signal Reference Signal Received Power (SS-RSRP).

An example image of signal strength reporting by pixel is shown in Figure 2 on the next page.



Alt text: A screenshot of a signal strength report.

Figure 2 - Example of Signal Strength Mapping by Pixel (Hexagon)

Long description: The screenshot contains hexagons overlayed onto a map. Each hexagon is coloured according to the signal strength. The colours range from a light yellow representing -110 to a red, representing -80.

The view from other regulators on pixel resolution is mixed: ComReg utilize a 10 meter resolution, while Ofcom is proposing a move from 100 to 50 meter mapping to improve reporting accuracy. The FCC requires operators to state the accuracy of their propagation model, which must have a resolution of less than or equal to 100m.

Recommendation 2

Balancing the scale of Canada's geography, the footprint of national operators, and the impact of very detailed coverage predictions on the need to transmit and process very large files, we believe a resolution of no less than 50m should be specified for operators to use when generating coverage predictions.

The operator feedback identified that most already produce coverage predictions at or above this resolution, meaning this requirement should not place a significant burden or barrier to adopting the standard.

Recommendation 3

To further standardize responses and simplify the data submissions, we recommend considering the specification of a standard grid for operators to respond against. Operators would overlay their coverage predictions onto this grid to report the predicted signal strength for each pixel.

A grid could be produced at the required resolution (e.g. based on the CSRS) or the H3 hexagonal indexing system[19] could be used, which the FCC coverage reporting has adopted. This open-source

19 Home | H3

library provides a global hexagonal grid at a range of resolutions and, due to its hierarchical nature, supports statistical and spatial analysis.

Recommendation 4

To support operators in moving to and adopting the new standard, detailed guidance should be published and communicated to operators on the required data format and schema for submissions. This guidance should include:

- A list of accepted spatial formats, suggested to be MapInfo TAB (version 6.5 or above), ESRI Shapefile or FileGeodatabase, or GeoPackage;
- The schema to be adopted, detailing the layers, attribute names, types and permitted values;
- A list of accepted geographic or projected coordinate systems (e.g. Canadian Spatial Reference System (CSRS) and EPSG: 4326);
- Template files showing example submissions.

Given the change in submission format, we recommend engaging with mobile operators to ensure they understand the new submission format and how and where to access the guidance. Feedback should be gathered to tailor further the guidance (for instance, to a particular software package or data format).

Operators submitting responses should be required to provide supporting information that includes:

- An explanation or rationale for any known changes in coverage. For instance, relevant equipment, technology or spectrum changes;
- An explanation of how the coverage predictions have been produced. For instance, describing the software and tools used, the input data utilised, and how the assumptions and propagation models used are appropriate and calibrated to the technologies deployed, and geographies served.

5.3. Modelling & Thresholds

The proposed data format will provide signal strength predictions, which will need to be mapped to service levels so the coverage can be suitably classified.

The CRC Mobile Coverage Metrics report reviews the two primary ways in which mobile coverage data is collected - by signal strength or a defined end-user service level. As highlighted in this report, there is variation between international regulators on the use of these two methods.

Producing coverage plots by signal strength is the most common method used by operators and regulators. These are created using technical parameters such as the equipment, antenna, frequency and power to estimate the electrical field strength at a given location. They do this by attempting to simulate path (signal) loss using spatial information like the terrain, obstacles, and types of ‘clutter’ that affect radio signals, such as water, trees, foliage and buildings.

Propagation models are also tuned to specific technologies, frequencies, and types of geographies, such as dense urban, suburban and rural settings. Another key parameter is the

confidence level used in the models, defining the likelihood of achieving the predicted threshold across the pixel.

Mobile operators are familiar with producing these kinds of coverage predictions as a core part of their operations.

From the regulators contacted, Ofcom and the FCC request that operators provide the outputs of these predictions for their data collection.

The other data collection approach is to model the performance a typical end user might experience, normally taking the form of the throughput (download and upload speeds) experienced. These calculations can be built on the signal strength predictions with a broad range of further assumptions like cell loading (contention), the type of end-user device, and the backhaul capacity.

Arcep and the FCC request that operators submit coverage information that equates to specific service levels.

Research has been completed on equating signal strength measurements with the likely end-user experience, and suitable approaches are reasonably well established for 2G, 3G and 4G. However, 5G brings additional complexity, and there is currently less clarity on how to predict the performance an end user can expect. For instance, in the UK, Ofcom only provides information about the probability of accessing a 5G service rather than any specific service level.

The CRC Mobile Coverage Metrics report investigates these two data collection methods and benchmarks the thresholds currently used by other regulators when equating signal strength with performance level. The CRC report recommends that signal strength thresholds should be collected from operators and mapped to three service levels (voice, basic and advanced) using defined thresholds for each mobile technology.

FarrPoint does not expect operators to have significant issues with this recommended route.

Recommendation 5

We endorse the CRC approach and agree that the proposed threshold levels should be used as the basis for discussion and agreement with the operators. However, we make this recommendation with two caveats.

Firstly, we recommend that the term ‘emergency’ be dropped from the entry-level service. Whilst this is aimed at ensuring a very high confidence of being able to make a voice call, text message, or receive a Public Warning, concerns were voiced by operators that this term could be construed as a service ‘guarantee’, with the potential to expose them to legal challenge.

Operators also felt that the high service confidence was to a more stringent threshold than they would typically assume and that coverage claims would significantly shrink as a result.

The operators engaged during the study were keen to have an opportunity to comment on these thresholds and the emergency/voice service in particular. Similar concerns were not raised on the thresholds for the basic or advanced service.

Secondly, whilst we suggest that the CRC proposed threshold for 5G is adopted, we recommend this is regularly reviewed in light of the ongoing work being completed internationally and by other regulators to ensure this continues to reflect the associated service levels.

Recommendation 6

Each operator's modelled coverage will vary slightly, given the large number of assumptions used and differences in each operator's network. To allow the CRTC to understand these differences, we recommend that operators are required to provide sufficient supporting information with their coverage data to understand how they have undertaken their coverage predictions, and the internal processes and validation used to ensure the models are sufficiently accurate.

This information can be utilized to better understand how different operators approach their coverage predictions and assist in understanding any variation between submissions. The information will also highlight any changes in methodology that have impacted the modelled coverage between submissions.

We recommend this approach instead of mandating the parameters operators must use in their modelling, given the complexity and detail this alternative approach would require the CRTC to provide. It would also prevent operators from reflecting differences in the way they configure and deploy their networks.

Recommendation 7

We expect very small operators may face challenges in undertaking coverage modelling in the format recommended due to the cost of the required software, and the skills and resourcing necessary. For this reason, we recommend that support is provided to small operators where possible in making their data submissions.

For instance, the CRC already support ISED in analysing information on fixed wireless networks using information tower locations, antennas and the technology used to better characterize the services delivered[20].

A similar kind of support could be provided to very small operators for generating coverage predictions to the required standard.

5.4. Frequency

Mobile networks, and the resulting coverage, experience regular change for a variety of reasons.

Operators provided examples of network changes, such as the rollout of 5G, sunset of older technologies (e.g. 2G or 3G), equipment manufacturer changes, and changes in spectrum usage. There will also be changes to infrastructure over time, including new sites, decommissioning and relocations.

In order for the information used by the CRTC for coverage reporting, decision making, and consumer guidance to be sufficiently accurate, new data needs to be obtained from operators at

20 Broadband network feedback from Internet service providers

an appropriate frequency. Regular data updates also enable any changes or corrections in predictions to be highlighted sooner.

The CRTC currently collects mobile coverage information on an annual basis, as of the 31st of December each year.

The regulators consulted for this report all obtain data on a more frequent basis than the CRTC. The European regulators receive new data at a frequency of between 1 and 4 months, and the FCC gathers submissions every 6 months.

The view from operators was that they support the current annual frequency of submissions, believing that the pace of network change will decrease after current 5G rollouts are completed. Some operators stated that it takes them two months to generate national coverage predictions, and so had a strong objection to moving to a much shorter reporting frequency, for instance, every 1-2 months.

Recommendation 8

Considering these positions, we recommend that revised data is requested from operators every 6 months.

This will allow the CRTC to better track changes in coverage and ensure that information communicated to citizens is more up to date than the current annual reporting.

5.5. Validation

Mobile coverage predictions are built on models which inherently have a certain amount of variation and are dependent on the accuracy of the input data and assumptions. A degree of variation is expected, but there is a need to confirm they are sufficiently accurate for the CRTC to have confidence in the results. It is also important to confirm consistency in coverage reporting standards between operators.

These two checks require a comparison of responses against real-world measurements.

The operators engaged during the study typically demonstrated a robust approach to developing their coverage predictions, including processes to validate the predictions through drive testing and bespoke tuning of models for their network in different geographies. However, there is no information on potential variation in coverage mapping when comparing operators.

All the regulators contacted perform some form of validation of the coverage data. Ofcom, Arcep and ComReg use drive surveys, whilst the FCC utilises the challenge process for residents.

Ofcom performs its own drive surveys to validate the coverage submitted and performs statistical analysis to confirm that the predictions are within an acceptable tolerance. Arcep undertakes its own drive surveys and commissions third-party tests to perform quality of service measurements - throughput testing, video streaming and calls. Operators fund these drive surveys and are assessed for compliance with their coverage predictions, which must be within an agreed tolerance. ComReg recently commissioned a third party to complete drive survey testing using equipment on parcel delivery vehicles covering different parts of the country.

The FCC takes a different approach and relies on public or third-party challenges to the published data to improve the mapping and to correctly identify unserved locations. Individual and bulk challenges to the mobile broadband service data are accepted, with operators required to respond or concede to each challenge. To assist with challenges, the FCC has released its own Mobile Speed Test App, which allows citizens to test their connection and submit challenges on the back of their results.

This model is more aligned with the use of crowdsourced data (for instance, Ookla or Opensignal), which most of the regulators contacted also use in some capacity. This is most frequently used to better understand the end-user experience and investigate issues in specific areas. Due to the nature of crowdsourced data, with varying environments and devices leading to uncertainty in the measurements, it is not typically used to directly validate coverage submissions - such as the signal strength reporting recommended - and is more commonly used when looking at Quality-of-service measurements.

Recommendation 9

We recommend that an approach is developed to validate coverage submissions, and work is undertaken with operators to agree on an appropriate model accuracy validation process.

Survey work should be commissioned to validate submissions from operators, providing the ability to independently confirm the accuracy of each operator's signal strength prediction, and quantify any variation between operators. Ideally, surveys should be performed across varying geographies (urban to rural) that represent the wider Canadian topography and include areas where specific concerns have been raised as appropriate.

We recommend a small sample be taken across operators and geographies annually, noting that the size and rurality of the geography will limit the scale of testing that can be reasonably undertaken. It is noted that whilst traditional drive surveys have been expensive, more recent developments can lower these costs and provide more flexible options to cover more geography at lower costs.

A process should also be developed to feed back the results of the validation work to operators so that adjustments and improvements in their coverage mapping can be made.

The results from this validation work will help to strengthen discussions with operators, track improvements, and enable the CRTC to have a higher level of confidence in the mapping.

Recommendation 10

In addition to the work to directly validate coverage submissions on a signal strength basis, quality of service metrics should be incorporated into the reporting of mobile coverage. This would provide a basis to confirm the linking of the thresholds to service levels proposed in the CRC proposal and better report on the end-user experience of Canadian citizens.

Quality-of-service measurements could be gathered in several ways, including through performance drive testing (at the same time as capturing signal strength data), by utilising and analysing crowdsourced data, or by collecting data directly from citizens (for instance, using an App similar to that produced by the FCC).

5.6. Publication

A key aspect of the CRTC's mobile coverage reporting is to make appropriate information available to Canadian citizens to better inform them on the availability of connectivity at both a national and local level.

Coverage information, particularly gaps in coverage, is useful to a wide range of stakeholders, including the Government and those responsible for public safety.

To support these uses, an appropriate level of access to the coverage results should be made public.

Our review of other regulators showed that they publish different levels of data. Arcep openly publishes all data submitted by operators and the results of their real-world performance testing. ComReg and Ofcom publish interactive online maps of mobile coverage by operator and technology that allow the public to view the services available at any given location. Ofcom also provides API access to this data and publishes aggregated coverage information at a higher level.

The FCC publishes data on mobile coverage along with fixed broadband on their National Broadband Map. This shows availability by technology per hexagonal tile and Fabric location (address/structure), identifying each operator, the technologies and predicted speeds. The FCC also openly publish 'raw' spatial coverage footprints by operator and technology and signal strength data by operator by hexagon (based on the H3 library).

The CRTC currently publishes less information than the other regulators reviewed, identifying only the overall footprint of each technology, not linked to the operators present or the predicted service level.

The greatest area of concern raised by operators about providing more detailed coverage data to the CRTC related to its commercial sensitivity if made public. However, from our review of other examples, it is clear that detailed coverage information by operator is commonly published by other regulators in maps and data downloads, supporting a range of uses from Government policy, intervention/infill projects, and consumer guidance.

In addition, ISED already publishes information identifying all site locations and configurations from its Spectrum Management Portal, so a level of site data is already in the public domain.

Recommendation 11

Public access should be provided to the outputs of coverage submissions through online maps, service checkers and data downloads.

The maps should be interactive and allow the public to view coverage by operator and service level at any given location, identifying the availability of each service level proposed in Section 5.3.

The map should also allow the public to provide feedback on the coverage claims where the predictions do not match their real-world experience. This will allow the CRTC to pursue further, where appropriate, and raise concerns or issues with the operators to investigate.

Data should also be published for download showing coverage at each of the agreed service levels by operator at a suitable granularity, ideally at the pixel resolution proposed in Section 5.2.

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