Body of European Regulators for Electronic Communications

BEREC

BoR (21) 163

Summary Report: BEREC Workshop on “NRA experiences with 5G”, 23 September 2021

09 December 2021

Contents

1. Introduction

BEREC has undertaken various activities related to 5G topics in the past two years. For example, BEREC issued its Feasibility study on the development of coverage information for 5G deployments[1], published Guidelines detailing Quality of Service Parameters[2], as well as a Handbook of BEREC Guidelines on Geographical surveys of network deployments with relevant consideration for mobile service mapping and fixed infrastructure mapping[3]. In addition, BEREC consulted and finalised the 5G Radar and Guide to the 5G radar[4].

Given this context and observing that BEREC's Common Position on Information to Consumers on Mobile Coverage[5] may address 5G in the future, BEREC sought to conduct an expert workshop to explore this point. BEREC's desk research underscored how connectivity for consumers consists of different inputs which may complicate how to present 5G information to consumers. For example, connectivity is influenced by the usage patterns, perceptions, and experiences of the mobile phone users in the market. Connectivity is also impacted by receiver designs, handsets, building materials, and network types.

BEREC conducted a workshop for experts on 23 Sept to continue to develop an understanding of how service availability in mobile networks using 5G technology can be predicted/calculated. One main objective of the workshop was to build a collective appreciation of how to manage generating information to users on 5G such that there would not be a wide gap between predicted and actual service/experience levels in terms of coverage.

In summary, the workshop was an internal forum for experts to exchange relevant experiences. In total, 72 participants attended the workshop.[6]

[1] https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/9030-feasibility-study-on-development-of-coverage-information-for-5g-deployments
[2] BEREC Guidelines detailing Quality of Service Parameters (europa.eu)
[3] https://berec.europa.eu/eng/document_register/subject_matter/berec/regulatory_best_practices/guidelines/9990-handbook-of-berec-guidelines-on-geographical-surveys-of-network-deployments
[4] Guide to the BEREC 5G Radar and 5G Radar (europa.eu)
[5] BEREC Common Position on information to consumers on mobile coverage (europa.eu)
[6] The participants included 44 experts from 25 NRAs, 6 representatives from the EU Commission, 11 experts from 6 other competent authorities; 4 seconded national experts from the BEREC Office, and 7 industry participants who were invited to speak to experts during dedicated slots (Cisco, Ericsson, ETNO, GSMA, Telefonica and Rohde-Schwartz).

2. Background

Four key background information documents were used to inform the content for the workshop as follows:

- NRA questionnaire / desk research (2021) conducted by experts in the year (questions at Annex 2.0)
- BEREC's feasibility study on development of coverage information for 5G deployments, BoR (20) 33
- the Common Position on information for consumers on mobile coverage BoR (18) 237; and
- Preliminary report in view of a Common Position on monitoring mobile coverage BoR (17) 186.

More information on the NRA questionnaire (2021) is set out in the next section below, see section 2.1.

In relation to Document BoR (20) 33, please see Part 3 of the workshop.

In relation to Document BoR (18) 237, BEREC set out a range of NRA practices to provide highly-accessible independent and reliable information on the state of mobile coverage. In addition, BoR (18) 237 set out four Common Positions (CPs) on informing consumers about mobile coverage:

- CP1 – Technical specifications for providing relevant and comparable information on mobile coverage to European consumers;
- CP2 – The use of signal predictions for mobile coverage estimation;
- CP3 – Ensuring the accuracy of coverage information provided to the public; and
- CP4 – Availability and presentation of mobile coverage information.

In relation to Document BoR (17) 186, BEREC set out how NRAs were addressing mobile coverage measurement and publication in terms of high-level characteristics, which was used to inform the above the Common Positions.

2.1. Summary of NRA questionnaire / desk research (2021)

Annex 2 sets out the questionnaire issued to NRAs. There were 25 responses received and analysed.

Many respondents seem to be thinking of extending their existing approach to incorporate mapping of 5G in the same way they have thought about other generations of mobile technologies (BE, CY, DE, DK, ES, FR, HR, HU, LV, SI). That said, most respondents have also noted the complexity of 5G and therefore, the reality of mapping 5G remains largely unclear.

A key insight then, seems to be managing the 5G mapping journey may entail even more inputs than just signal power thresholds which dominated the previous mapping experiences conducted alongside BoR (18) 237 (with exception of FR where service availability featured more prominently in existing maps). Though we should note that the 2021 survey stops short of really exploring this issue. If NRAs want to manage the accuracy/expectations of 5G maps, it seems that more exploration of this issue would be required.

Another related insight is that there seems to be a potential gap in the standardisation techniques required to measure 5G signals. This seems to be considered important so that NRAs can measure 5G signals in practice with a view to enhancing their toolbox of verifying maps.

In addition, in relation to data rates and other metrics the issue seems to be that there is no indication how the NRA might practically transform these into meaningful coverage maps that could meet expectations of end-users. Potentially, this could lead to gaps between predicted and received service levels in the eyes of the end user.

2.1.1. Selection of other points gathered by the NRA questionnaire / desk research 2021

Other points gathered as part of the 2021 questionnaire are as follows:

- Other than country specific demographic and geographic challenges mentioned (such as by BG, CY, EL, FR, HR, IS, NO, SE, SI, SK, RS) the next most common challenge was on EMF spectrum related issues (BE, CH, CY, DE, ES, NL and RS).
- Another common challenge set out in responses was on measurement issues around massive MIMO and adaptive antennas (CH, DE, NL, NO). This is an important point, because it links back to the main insights summarized at section 2.1 above.
- Individual responses also cited international coordination, 5G security, comparability of information across networks such as for monitoring purposes, enabling verticals to emerge in 5G and providing information to consumers and local authorities are including on NRAs' current thinking around information to map.

3. Part 1. Scene setting presentations

3.1 Case study (Portugal) and the Path to the digital decade (Commission)

A representative of Anacom set out views on mapping of mobile networks coverage. He highlighted that maps can be designed with different approaches. For example, the theoretical coverage of mobile networks is an approach that estimates mobile coverage in the whole country. Different approaches have been adopted in different countries, so coverage maps can include the following information, per pixel:

- Class speed is identified (e.g. 2 to 10 Mbps; 10 to 30 Mbps), but not the operator name;
- Voice service with different quality of service levels;
- Data services mapped on a binary basis (ON/OFF approach), for 3G and 4G networks;
- Number of operators for 2G, 3G and 4G networks.

Next, he presented the Portuguese solution for mapping mobile networks coverage, the tool tem.REDE? (available at https://www.anacom-consumidor.pt/-/-tem-rede-a-sua-aplicacao-para-verificar-a-cobertura-das-redes-moveis). ANACOM's project includes the participation of Portuguese mobile operators MEO, NOS and VODAFONE.

Voice, SMS and MMS services are available using 2G (GSM) and 3G (UMTS) networks:

- Very good;
- Good;
- Acceptable;
- Limited;
- Not available.

Data services are provided using 3G networks (UMTS/HSPA):

- Fast 3G Broadband;
- Basic 3G Broadband;
- Limited access to 3G data;
- Not available.

And 4G networks (LTE)

- Very Fast 4G Broadband;
- Basic 4G Broadband;

- Limited access to 4G data;
- Not available.

In “tem.REDE?” the coverage resolution of mobile networks is 100 by 100 meters, and the coverages provided consider outdoor spaces and ideal conditions. The criteria (theoretical) were previously defined and agreed between operators and ANACOM, namely the technical reception thresholds per service, and the available coverage was calculated using theoretical models validated by mobile operators considering an user at 1.5 meters height. The coverage of mobile networks can vary depending on several factors such as where the users are and the number of simultaneous users.

In the next scene setting presentation, a representative of the Commission set out summary views on the Commission’s proposal for a Decision establishing a policy programme: the path to the digital decade. More information can be found here Proposal for a Decision establishing the 2030 Policy Programme “Path to the Digital Decade” | Shaping Europe’s digital future (europa.eu).

3.2 Transforming into 5G mapping

A representative of Arcep set out introductory remarks about the complexity of meeting the expectations of end-users when it comes to 5G. He stressed out that NRAs face three challenges when mapping 5G:

- Be meaningful for end users
- Be able to generate accurate coverage maps
- Be able to have the maps verified by NRAs

These challenges cannot all be met at once, and compromises have to be made.

Arcep also shared feedback from end users regarding the information they expect from 5G mapping initiatives: maps have, for instance, correlated to the service that end users can reasonably expect. They must also allow them to understand what a 5G-compatible device and plan will bring compared to a “4G-only” situations.

A representative of Rhode-Schwartz set out views on network performance evaluation, from an end-user perspective. She underlined that 5G New Radio (5G NR) does not change the methodology itself, but may affect the thresholds considered in the evaluation, as end users’ expectations may increase. She also stressed out that LTE anchor cell configuration is crucial, and that the device used for testing can have a strong impact on tests. The next steps when it comes to “5G network testing” would be to adapt to 5G Stand Alone (5G SA), for instance with tests linked to ultra Reliable Low Latency Communications (uRLLC) use cases. The methodology to do the measurements is being defined by European Telecommunications Standards Institute (ETSI), and is agnostic to the technologies.

A representative of Ericsson set out views on the difference between 4G and 5G regarding coverage prediction. In 4G, the control channel and user data coverage are provided and simulated with the same approach. However, in 5G, the control channel can rely on wide beam

or beam sweeping. In that case, metrics such as Reference Signal Received Power (RSRP) may then not be relevant as performance may vary widely between one situation and the other with the same RSRP level. Ericsson presented alternatives metrics some of which are under study.[7]: In short, measuring a higher signal level in a beam may not necessarily mean higher data speeds to a user terminal in the beam.

[7] Alternative metrics under study mentioned included: “normalized” RSRP, pathloss, Physical Downlink Shared Channel Signal to Interference plus Noise Ratio (PDSCH SINR) or Channel Quality Indicator (CQI*RANK).

4. Part 2. Closed door session for experts

In light of the foregoing and in particular the findings of the desk research, experts explored three topical issues set out below:

1. Expectations of consumers/verticals
2. Issues surrounding meeting expectations
3. Differences in terms of mapping 5G

4.1. High-level summary

The mode for this part of the workshop was breakout sessions to exchange expert views on the topics and to stress test ideas and observations.

Industry invitees were not included in the breakouts. In addition, chatham house rules applied but some interesting exchanges were shared amongst experts, on the basis that these may not be the formal adopted views of NRAs or competent authorities at this time.

BEREC summarises the topical exchanges as follows:

- Consumers seem to expect more from 5G (this would link to an overall theme to be ambitious when target setting levels of connectivity)
- NRAs should not hype expectations (i.e. NRAs should remain technology and service neutral)
- What's deemed suitable information to map today may likely to differ tomorrow (as this is an evolving project)
- Information should be relevant, accessible and depend on context (mention was made of rural verses urban information requirements as was the impact of software and virtualization / edge computing)[8]
- Better to provide information to the mainstream consumer in a way they are accustomed to (limit making information changes to minimize confusing the main users in the first tranche of 5G use for enhanced Mobile Broadband)
- Latency indicator may be important to and better understood by certain segments of end users presently (e.g. gamers)
- Mapping voice in 5G given the interplay with legacy network may benefit from more expert changes

[8] See also the BEREC Report on the workshop on mobile infrastructure sharing BoR (20) 240 where it was claimed that the distinction between passive/active and rural/urban in sharing models is blurring. In addition during that workshop it was claimed that how operators consider software and virtualisation in the context of 5G should change the way we think about infrastructure-based competition.

- Start-ups / developers may have different information needs as compared to more established players and innovators
- Crowd sourced information may well be a complement to NRA information for some users
- Differences between mapping information for 4G and 5G needs to be looked at from two main perspectives. First, what's the starting place with existing maps for older generations of technology and second, technical issues around frequency band characteristics
- Spectrum assignment policies that are regional/local may factor when mapping information, and may influence comparability between regions and/or countries
- Harmonisation is complex as a result of the foregoing, and therefore that
    - i) BEREC should stay in the conversation with all stakeholders,
    - ii) minimum levels of quality of mapping should be agreed all stakeholders,
    - iii) Quality of Service and Quality of Experience characteristics are functions of the final mobile network configurations deployed
- Collaboration between operators and NRAs is considered important (several experts mention exchange of information between parties, with one idea that where matters need to be resolved guidance from the NRA helps)
- New use cases might accelerate a transition from non-stand along (NSA) to new-radio new-core stand alone 5G
- Efficient use of radio spectrum resources must be maintained in this context, and
- Propagation model of the operators is an essential point – they should inform more how they do their propagation calculations.

5. Part 3. Beyond the eMBB use case

Part 3 of the workshop was dedicated to horizon scanning. BEREC was in listening mode to hear from invited speakers about what they view had changed in the interim since BEREC issued Document BoR (20) 33 on coverage information for 5G deployments and that might warrant BEREC studying this topic again.

In particular, the views of Cisco, ETNO, GSMA and Telefonica SA were set out by representatives, as these were the stakeholders who had engaged with BEREC during BoR(20) 33.

5.1. Introductory remarks: BEREC's Feasibility study, BoR (20) 33

Essentially, BEREC Document BoR (20) 33 set out to consider the feasibility of provisioning coverage information and Quality-of-Service (QoS) aspects of future 5G networks that cater for the needs of verticals. The objective was to provide insights on two key areas:

1. Describe the expected benefits from NRAs' presentation of coverage information and QoS aspects for use by verticals implementing use cases such as automotive, industrial, environmental monitoring, etc.;

2. Attempt to describe the metrics that are of relevance to the verticals.

However, the main conclusions at that time were the lack of findings to progress a specific project on this topic. And as a result, BEREC considered that it would be best to continue to facilitate exploratory discussions with industry, with the objective of keeping BEREC informed of relevant discussions around coverage information and QoS aspects of 5G.

This part of the workshop was dedicated to serving that purpose.

5.2. Invited panel presentations and high level summary

The main observations from the selection of industry presentations referred to above were as follows:

- 5G use cases may be also be supported by a mix / portfolio of radio spectrum (both licensed and unlicensed depending on the case)

- A case-by-case thinking should apply to examine indoor spectrum use environments (i.e. whether / when to apply traditional licensing modes). In addition, indoor will support many use cases so flexible approaches may be best

- Open RAN is at the beginning of its journey c.1/2/3 years from now we will see results; lowers cost of hardware, and it is expected to reduce single ownership and increases scope for innovators and new services

- EU operators are now in a stronger phase of rollout than they were even a year or two ago (though there are some assignment delays)

- Exclusive licensing regimes are preferable (in the view of one association);
- Policy initiatives can and do make differences (e.g. connectivity toolbox and the Commission's work on emf with NRAs, as well as the review of the BCRD was mentioned);
- The extent to which verticals should have a 'call' on access to spectrum should be left to business to business (B2B) arrangements (in the view of one association). Revenues and business cases are coming from internal B2B discussions
- BEREC and NRAs should also consider the demands other transparency and data collection obligations have on operators before settling on requiring 'new' 5G coverage indicators (also given Art 22 of EECC obligations). BEREC and NRAs also have a duty to not replicate other policy initiatives e.g. any future digital decade metric gathering exercises (in the view of one association)
- Industry is proactive and successful in shaping awareness of 5G for businesses with connectivity needs (e.g. verticals) and also industry successfully tackles mis-information such as on EMF
- From the network operators point of view (Telefónica, ETNO association), it is considered a challenge to provide harmonised coverage and QoS information. These stakeholders highlight the incentives of MNOs to provide accurate information to verticals on a case-by-case negotiation through bespoke contracts with specific customer demands, and
- Developers and innovators can access information on coverage (QoS) today using other means such as crowd source apps, and so a BEREC initiative to steer the market on vertical information needs would not be needed.

6. Next steps and recommendation for further work

The workshop achieved the main objective; to build a collective appreciation of how to manage generating information to users on 5G that do not have a wide gap between predicted and actual service/experience levels in terms of coverage.

The reality of mapping 5G, however, remains largely unclear. BEREC intends to continue to monitor developments and to facilitate information sharing between NRAs, which may result in defining a suitable project on this topic in the coming years.

7. Annexes

Annex 1 – Workshop Agenda

Workshop on NRA experiences with 5G

Location:	Videoconference
Date & Time:	23 September 2021, 10.30-14.30 CEST

10.30	**Workshop starts**
10.30 – 10.40	**Opening remarks** *Co-chairs of Wireless Network Evolution Working Group* *Dr. Bo Andersson, Chief Economist, PTS, Mr. Joe Lynch, International unit analyst, ComReg*
10.40 – 11:10	**Scene setting** **"Mapping of mobile networks coverage: tem.REDE?"** *Mr. Miguel Capela, Anacom,* **Monitoring the 5G "Path to the Digital Decade"** *Mr. Philippe Lefebvre , DG Connect*
11.10 – 11.40	**Transforming into 5G mapping** **Arcep "Regulated' coverage maps that mean something for end users: the impossible triangle?"** *Mr. Guillaume Decorzent Head of Unit – mobile coverage and Investments* **Ericsson** *Mr. Pablo Rodriguez Ramiro, Network Engineer* **Rohde & Schwarz "Experience of mobile network testing using the ETSI Method"** *Ms. Maja Mitic, Director Managed Services, Mobile Network Testing*

Breakout for experts (industry presenters excluded)

11.40 – 12.15 **Breakout sessions**

[Experts will be assigned short breakout groups – on topics (circulated in advance)

1. *Expectations of consumers/verticals*
2. *Issues surrounding meeting expectations*
3. *Differences in terms of mapping 5G*
4. *[NRAs have fears about steering the market]*

In this regard, breakout groups of maximum 7 experts will be asked to talk about the topics and reflect their views to the full group. The object is to build a collective appreciation of how to manage generating 5G maps that do not have a wide gap between predicted and actual service levels in terms of coverage.]

12:15 – 12.55 **Rapporteurs from breakouts**

15 min **Break**

13.10 – 13.50 **"Beyond eMBB: Coverage information for other users/verticals"**

Co-chairs will introduce the BoR 20 (33) to set the scene

Invited Industry presentation(s)

Cisco "Unlocking the growth potential of 5G in Europe"

Ms. Diane Mievis - Head of EU Telecoms, Sustainability and Trade Policy; CISCO

ETNO

Ms. Maarit Palovirta - Director of Regulatory Affairs; ETNO

GSMA

Dr. Gary Healy, Director of Public Policy; GSMA Europe

Telefonica SA

Ms. Ana Forcada, Manager for Regulatory Strategy; Telefonica SA

13.50 –14.00 **Open mic with experts closing remarks and workshop wrap**

14.30 **Meeting room closes**

Annex 2 – NRA Survey

- Survey -

BEREC considers that it is timely to start internal discussions, and in cooperation with RSPG, on practises that would allow NRAs and other competent authorities to monitor the roll-out of 5G networks and eventually to inform end-users about the availability of 5G networks and services. To that end, BEREC plans to host a workshop where NRAs and other competent authorities can benefit from experience sharing related to the subject of monitoring 5G, with the aim to establish common indicators and metrics used.

The preparation of this workshop, carried out by the Wireless Network Evolution (WNE) group, may *inter alia* rely on the answers to the following survey.

Therefore, experts are asked to answer the following questions.

A. Preliminary question: State of 5G rollout

Have mobile operators commercially launched 5G in your country?

I. If yes, when and using which frequency bands (700 MHz, 3.6GHz, 26 GHz)? Others (e.g. 800 MHz, 1800MHz, 2.1 GHz)?

II. If yes, do the operator(s) have rollout obligations to provide coverage?

III. If yes, do the operator(s) have other obligations (e.g. to provide QoS, install a specific number of base stations)?

IV. If yes, do the operators advertise providing 5G mobile coverage? If operators publish coverage maps, do they include 5G technology? By specific place or in general?

V. If no, are you able to provide an estimated timeline for 5G commercial launch and other elements related with the previous questions?

B. 5G mobile coverage

What national challenges exist in your country in the specific context of 5G mobile coverage[9]? For example geographic or demographic challenges, coverage obligations, etc.

Please provide views on any other challenges stakeholders such as consumers, verticals, local authorities may have raised with regard to 5G mobile coverage information?

Does the NRA monitor 5G coverage (or does another competent authority in your country) or will it do so / intend to do so in the future? If so:

VI. how: field measurements, simulated 5G coverage, publication of maps, other? (please only give an overview here, as more detailed

[9] Are these challenges different than those arising for mobile coverage as a whole

questions follow). Please include if additional information related to 5G is also monitored, such as speed.

VII. is your approach different for 5G than for other mobile technologies (or will it be)?

VIII. Are you planning to do more for 5G than what you are currently doing for older mobile generations (e.g. 4G) coverage monitoring? If yes, what actions are you considering?

IX. What metrics would you consider relevant to monitor 5G coverage?

C. Field measurement of 5G mobile coverage information

Does the NRA measure 5G coverage in the field? If so, for what purpose (to calculate the mobile coverage, to verify the reliability of a coverage map, licence compliance, other…)?

What parameters are measured?

X. What were the reasons to select these parameters?

XI. Have you identified any challenges regarding these parameters? Please specify?

Is the approach different for 5G than for other mobile technologies (or will it be)?

D. Calculation of 5G mobile coverage information

Does the NRA use coverage calculation software to estimate, simulate or predict 5G coverage information? If so, continue to Question 10.

If not, do mobile operators/licensees? If possible, please attempt Question 10.

Regarding the use of coverage calculation software:

XII. For what purpose does your organisation use (or intend to use) coverage calculation software (to calculate the mobile coverage, to verify the reliability of a coverage map, other…)?

XIII. What types of data does your calculation software use? Network data, data from field measurements, others? How is this data used in the calculation software (types of models and parameters used for example)? How is this data provided to your organisation?

E. Qualification of 5G coverage information

Has the NRA defined (or does it intend to define) specific thresholds to determine whether an area is or is not covered in 5G? If so, which parameters and what thresholds are used (proposed to be used)?

Has your organisation defined specific data rates to consider whether an area is covered in 5G or not (e.g. data rates of at least xx Mbit/s)? If so, what is the threshold of performance?

F. Availability and presentation of 5G coverage information on maps

[this section is intended to be specific to 5G coverage maps – but in the initial phase, until there is 5G standalone, we recognize that there may be a connection to existing coverage maps (i.e. linked to 2G/3G/4G), which were considered during the 2018 survey]

Are there 5G coverage maps (area coverage, road coverage, train coverage, other) available in your country? If so please provide URLs for the maps and other relevant information.

Is there any 5G coverage map including coverage information from all mobile operators? Is the information only displayed in an aggregated way or is it possible to compare the coverage information of each mobile operator?

If 5G coverage maps are available for your country, please answer the following questions in this section:

Do 5G coverage maps made available in your country differ from other mobile coverage maps? In particular regarding:

XIV. who provides and/or publishes these maps (public entities and/or private entities)

XV. the legal obligation (or not) to publish 5G coverage maps (in licences or other legal documents)

XVI. how often the maps are updated (monthly, quarterly, annually, …)

XVII. the target audience identified for the maps, other than the general public (verticals interested in 5G capabilities and specialised services). If so, do you believe the maps adequately serve the target audience?

How are 5G coverage maps presented?

XVIII. Do the maps distinguish different aspects of coverage, for instance by frequency band (e.g. 700 MHz band, 3.6 GHz band, others)? Is 5G treated separately from 3G and 4G (e.g. one map per technology) or together (e.g. as part of a theoretical DL speed aggregating 3G, 4G and 5G)?

XIX. How many coverage levels are presented on the maps (e.g. two layers: covered / not covered, or more)? For each service/technology, please provide if possible the parameters and the corresponding thresholds used to distinguish the different levels. If these parameters and thresholds are defined by you or another organisation, please specify it.

XX. Do you think these maps (information provided, granularity, legend, etc.) are appropriate to provide consumers with adequate information? Same question for verticals?

Are any other sources of information (besides maps) available in your country to inform consumers on 5G? Location of 5G base stations, 5G coverage metrics, others? If they are published, please provide URLs.

If 5G coverage maps are not available for your country, please answer if it is expected to make them available or if there are some reason for not providing this kind of information.

G. Verification of 5G coverage maps and metrics

Does the NRA (or any other competent authority) verify operators' 5G coverage maps? What are the reasons to (not) verify the maps? If you verify the maps, is the verification process different from the approach taken with other mobile coverage maps? Please specify.

Annex 3 – Summary table of web URLs of coverage information and transmitter location maps

Table 1.0 Website addresses of coverage information and transmitter location maps.

Country	NRA	URL of transmitter location map / database (In some cases another competent authority (or other private entity) publishes this info. Asterix (*) denotes this)	URL of mobile coverage information map ((i) in some cases another competent authority (or private entity, we exclude MNOs here who seem to all publish their own 5G maps) publishes this info. Asterix (*) denotes this (ii) in other cases information is available in a searchable address or location database in addition to, or instead of, a map. Asterix (**) denotes this
AT	RTR	https://www.senderkataster.at (*)	https://www.netztest.at/en/Karte which is also available open data https://www.netztest.at/en/Opendata https://breitbandatlas.gv.at/ (*)(**) https://www.data.gv.at/katalog/dataset/ (open data)
BE	BIPT	Flanders: https://zendantenneskaart.omgeving.vlaanderen.be/ (*) Bruxelles: https://geodata.environnement.brussels/client/view/3a33e35f-6b64-4b28-bb50-5b4c6b7cb29c (*) Wallonie: http://geoportail.wallonie.be/catalogue/3de9790e-529f-431f-ac4f-e86d827bde8e.html (*)	https://www.bipt-data.be/en/projects/atlas/mobile
CH	BAKOM	https://www.bakom.admin.ch/bakom/en/homepage/frequencies-and-antennas/location-of-radio-transmitters.html https://map.geo.admin.ch/ (*)	www.breitbandatlas.ch (*)
CY	OCECPR	http://www.emf.mcw.gov.cy/emf/ (*)	
CZ	CTU		http://lte.ctu.cz/
DE	BNetzA	www.bundesnetzagentur.de/lokalesbreitband	www.breitbandatlas.de (*) https://www.nperf.com/de/map/DE/-/-/signal/ (*)
DK	DBA		www.tjekditnet.dk (*) (**)
EL	EETT	https://keraies.eett.gr/	
ES	CNMC	https://geoportal.minetur.gob.es/VCTEL/vcne.do (*)	
FI	TRAFICOM	https://www.cellmapper.net/ (*)	https://eservices.traficom.fi/monitori/area https://www.nperf.com/en/map/FI/-/-/signal (*)
FR	ARCEP	https://www.arcep.fr/cartes-et-donnees/nos-cartes/deploiement-5g.html	www.monreseaumobile.fr
HR	HAKOM	http://mapiranje.hakom.hr/en-US/RadijskePostaje	

HU	NMHH		http://szelessav.net/hu/aggregalt_sebesseg/mobil (**)
IE	COMREG	https://siteviewer.comreg.ie/#explore	https://coveragemap.comreg.ie/map
IS	PFS		
IT	AGCOM		www.agcom.it/broadbandmap https://misurainternetmobile.it/risultaticomparativi (*)
LT	RRT		http://matavimai.rrt.lt https://www.rrt.lt/judriojo-rysio-tinklu-tiketinos-aprepties-zonos/
NL	ACM	https://www.antennebureau.nl/onderwerpen/algemeen/antenneregister (*) https://antenneregister.nl/Html5Viewer/Index.html?viewer=Antenneregister_extern (*)	
NO	NKOM	https://finnsenderen.no	
PT	ANACOM		https://anacom.maps.arcgis.com/apps
RO	ANCOM		www.aisemnal.ro
SI	AKOS	https://gis.akos-rs.si	https://www.svetidej.com/sl/projekti/mobilna-telefonija/zemljevidi/brskalnik.html (*)
RS	RATEL		http://benchmark.ratel.rs/en/portal https://mapepokrivenosti.ratel.rs/eng