Fixed and Mobile Convergence in Europe
Quality Measurements for 5G and Network Densification

EXECUTIVE SUMMARY
A study prepared for the European Commission
DG Communications Networks, Content & Technology by:

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Executive Summary

This study was commissioned by DG Connect, Unit F4, Digital Economy and Skills, and Unit B4, Radio Spectrum Policy Unit, and was conducted during 2017, analysing material from surveys with national regulatory authorities (NRAs), technical standards and relevant literature. The objectives of the study were to:

1. Analyse fixed-mobile convergence (at service, infrastructure and market level) in Europe over time and to detect future trends that can improve connectivity in Europe;
2. Complement the EU Integrated Platform Mapping of Broadband Services in Europe;
3. Provide a clear understanding of differences in coverage measurement among Member States and elsewhere; and,
4. Assess the technical, political and economic obstacles that prevent the definition of common coverage measurements.

To address these objectives, the study was divided into six tasks:

1. Investigating the issues of fixed-mobile convergence (FMC) and fixed-mobile substitution (FMC);
2. The possible role of fixed networks in the densification of 4G and 5G mobile networks;
3. The impacts of coverage obligations in cellular licences on connectivity;
4. EU Member States’ use of quality of service (QoS) indicators;
5. The possibility of moving toward a common set of QoS indicators; and,
6. How that might be accomplished.

The subject matter is detailed, fairly technical and so quite dense, hence the Final Report provides a Summary Report as well as a more detailed Methodological Section, supported by separate appendixes. We were also asked to comment on the European Electronic Communications Code (EECC) where it pertains to the study, and the Code’s relevant Articles and areas for possible amendment are included in a table at the end of the Summary Report. This Executive Summary presents the key findings and recommendations.

Key Findings

The key findings from the study that may impact future EU policies are summarized below:

- The greatest challenges for the Digital Single Market (DSM) will not just be politico-economic but increasingly technical, as we become more dependent on networks, especially radio networks. As our dependence rises, so the more reliable and ubiquitous our networks will have to become. In general, the study presents a pragmatic, but quite ambitious, approach to making decisions on quality standards for networks.
- The main policy aim should be to make the next, and far more advanced, generation of networks into a viable and dependable reality for the DSM. That requires ensuring appropriate levels of operational quality, reliability and affordability that match technology challenges to social needs, to guarantee that the promised advances work in practice every minute of every day, everywhere.
- This ambitious approach is essential because we are now at a key point in planning delivery of the digital infrastructure that consumers and business will
This study provides the evidence necessary to take decisions on making implementation of the DSM a reality.

- Moreover, the possibility of agreement on this topic among the Member States, which is essential to its success, is at a critical, positive moment. It could be possible to reach agreement with the key stakeholders, the NRAs, essentially through their consultative bodies, such as BEREC, on the quality measures necessary, in terms of indicators, metrics methods and benchmark values.
- A further major EU policy initiative is the European Electronic Communications Code (EECC) which we have been asked to take into account, in detailed terms, of where it is relevant to our findings and recommendations and where it may need to be strengthened. Its potential impacts are widespread through the study. Thus, to pinpoint these impacts, a table is given at the end of Summary Report outlining its major proposals (in the September 2016 version) and their effects on the future of FMC for novel generations of networks.

**Fixed-mobile convergence will impact the forms of network densification**

- Convergence of fixed and mobile communications is, and will be, an important trend in the development of EU communications over the long term. The complementarity of the two technology families is likely to be essential to progress further with 5G. The existing fixed infrastructure could supply backhaul for mobile infrastructures in some locations to save investment and speed up deployment of an integrated or converged infrastructure. But there are geographic, economic, technical and regulatory limits on how much the existing fixed infrastructure can be repurposed.
- FMC should be understood as affecting much more than the physical network level. Its impact is layered, affecting the whole constellation of market, services, base stations and access points, down to the level of terminal devices. Whether fixed and mobile technologies are complementary, or substitutes, is determined by the combination of market pricing, service bundles offered, and by the human interfaces. Over-the-top (OTT) services have recently joined the fixed-mobile substitution process, particularly with Voice over IP (VoIP), a close substitute for traditional telephony (e.g. Skype for home use) or a managed business service such as Vonage.
- The integration of Wi-Fi and mobile cellular is also essential, as Wi-Fi can serve stationary or nomadic users at much lower cost than mobile cellular, while mobile remains necessary at speed, for wide area coverage and for hand-offs during a communication session. But cellular/Wi-Fi integration must not impair the end user’s right – and ability – to choose which local networks to use for data traffic offloads, and when to allocate data traffic to cellular and when to allocate it to local area networks.
- On the fibre backhaul side, some MNOs and ISPs – particularly those that are not subsidiaries of converged network operators – want the incumbent players to be more open on price and availability of “dark fibre” for mobile backhaul and broadband FTTH. They have asked regulators to investigate if the dark fibre owner/operators will have Significant Market Power over this product. Ensuring an open competitive market in wholesale access to mobile and fixed infrastructure – especially for backhaul – will encourage the proliferation of small cells. It could imply the unbundling and sharing of all elements of mobile networks, as well as fixed networks for use by new entrants. It would apply to existing infrastructure, or to novel 5G dense small cell infrastructure support, that
could be shared with other new entrants and so lower the barriers to market entry.
Coverage obligations can be effective for increasing connectivity

- Coverage obligations can be an effective tool to increase coverage. But their design requires careful definition, with constant attention through enforcement by frequent measurements. Field monitoring should fall under the aegis of the NRA, with active verification by the NRA, even if outside bodies are contracted for this.
- Twenty-six of the 28 EU Member States have imposed coverage obligations in one or more mobile frequency bands. These obligations are more common in the lower bands, especially 800 MHz and below. They often concern both voice and data services. Data-only coverage obligations have become more common recently, especially in bands designated for LTE, i.e. 700, 800, 1800, and 2600 MHz. Obligations often specify a minimum population coverage or, less often, minimum area coverage – or some combination of the two. Obligations are often stricter in the bands below 1 GHz, less stringent in the 2.1 and 2.6 MHz bands, as the latter may aim at preventing spectrum hoarding rather than maximising access.
- Confirmation of coverage usually involves two steps: (1) a self-declaration from operators in which they provide evidence of coverage, typically calculations of outdoor signal strength using network planning data; (2) NRAs or subcontractors may then follow up with spot checks to confirm.
- Signal strength, usually received, is the most common metric used to define voice coverage, while for data, it is the minimum downlink data transfer rate. For LTE, threshold data rates typically range from 1 to 30 Mbps. If specified, the obligation usually concerns outdoor coverage. If indoor coverage is included, it often involves some assumptions about wall attenuation (e.g. 10-12 dB attenuation).
- Although there are many similarities between the MS they also differ substantially in terms of how these obligations are specified, e.g. on time limits, whether different spectrum blocks and/or incumbents and new entrants have different obligations, whether several bands can be used, and so on. In several MS, the regulators define a list of areas to be covered to a certain extent by a certain date.
- While mobile connectivity and coverage depend on many factors, most of which vary from one MS to another and over time, evidence suggests that coverage obligations can increase public access to broadband services if the obligations are suitably designed. The obligations should be specified to address policy needs, be specific (yet simple) enough, well timed, and include (legislative and economic) incentives for build-out in targeted areas. Vague obligations with deadlines far in the future and no prospects of operator cost recovery should be avoided to achieve the objective of rapid improvement of coverage.
- From our interviews and surveys with NRAs, many MS are reluctant to consider harmonising their mobile coverage obligations. The diversity and specificity of local conditions (including different population distributions and agreements with neighbouring states, some of them outside the EU) produce different policy objectives and targets, which in turn demand different policy interventions, including different ways to specify coverage obligations. The prevailing opinion among the NRAs is that these matters should be left to the individual MS. Enforcement procedures in cases of non-compliance (fines, revocation of licences, and so on) should also remain national prerogatives.
- However, the value of sharing knowledge and best practice among the Member States is also recognized, and is already taking place to some extent. This should be encouraged and supported by the EU, in particular for the issues regarding
coverage along major transport paths, indoors and in remote and otherwise underserved areas.

- Our research also indicates that European harmonization and standardization of definitions and measurement of coverage and its related indicators could have important benefits. These include economies of scale in the enforcement activities of NRAs, greater certainty in interpretation of policy objectives and improved comparability across Europe. These benefits are generally recognized by the NRAs, although some also point to difficulties and costs of implementing harmonized measurements. Recommendations below examine this further.

**Member States’ use of QoS/QoE indicators is varied but with similar trends**

- The EU Member States realize that the performance of their telecommunications networks and services needs to be monitored using quality indicators. However, today’s quality indicators have accumulated gradually, largely in response to regional initiatives, with little planning or foresight. QoS/QoE measurement obligations, minimum performance levels and reporting requirements are scattered across many types of regulatory instruments, from regional directives and national laws to mobile licences, universal service and interconnection agreements, leased line contracts, etc.

- The 28 MS now require the regular measurement and reporting of at least 858 QoS/QoE indicators, an average of more than 30 per country. But averaging hides the fact that some Member State’s rely extensively on QoS/QoE measurements while others hardly use them. Only about a quarter of the indicators have preset target values, and these are mainly aimed at universal service providers.

- Moreover, our research shows that quality of service (QoS) and quality of experience (QoE) minimum performance levels and targets, service benchmarks, and state-imposed obligations to measure and report are scattered across many types of regulatory instruments. They range from regional directives and national laws to mobile licences, universal service and leased line contracts, etc.

- Although the purpose, and sometimes the indicators’ definitions, may have been established by European Directives, the MS determine how measurements are made, by whom, how often, and with what target values. ETSI standards are often the basis for their decisions. But implementation varies and this diversity has become an impediment to the formation of the DSM. Also, for the DSM, measurement-based indicators are essential, not just theoretical estimates.

- Fundamentally, there is a major disparity today in the standards for quality assurance for future networks, as they are a fairly random selection. Moreover, the draft European Electronic Communication Code (EECC) notes that expanding the availability and speed of broadband had been Europe’s main policy ICT goal. But in the future, improving network reliability and reducing latency will be more important.

- In consequence, modernising the selection of indicators is needed to prepare for more challenging future use cases, as fixed and mobile networks converge in 5G, with stricter performance requirements. And optimistically, the fact that ETSI standards are widely used as guides, and there is growing acceptance of crowd-sourced data speed measurements as being a useful tool, suggest that further convergence in methods and metrics may be possible.

**Flexibility and willingness to change are now apparent for QoS measurement**
The study began with the impression that QoS measurement obligations were more or less static among the NRAs and, therefore, they might be difficult to change. However, that is not the case: there is evidence of widespread flexibility and a strong inclination to improve quality standards across all MS.

Moreover, we also found that this field is more dynamic than is generally recognized, with many NRAs making in-depth reviews every few years and modifying their QoS monitoring agendas. Some benchmarks are updated, while others are retired. Consequently, it would be a mistake to assume that a country’s specific strategy is set in stone and can never change. The EECC, as examined in a table at the end of the Summary Report, might offer a positive initiative to pursue this further if suitable advances in the areas identified for improvement can be made.

Hence the study’s findings suggest NRAs might be able to agree on a common set of quality indicators, definitions and methods of measurement and acceptable ranges of benchmark values. This optimism is based on an analysis of QoS rules in the 28 MS which shows that differences have logical explanations. Many apparent differences among national implementations are superficial – arising mainly from language differences than anything else – although there are some substantive differences that could be harder to overcome: specifically, some countries prefer a “market led” approach while others prefer a “regulator led” approach. The former tend to impose few QoS reporting obligations while the latter tend to impose many (up to ten times as many).

Most Member States adopted and modified their QoS regulations in waves, responding to regional policy initiatives (Directive 98/10/EC, voice telephony and universal service in a competitive environment; the Universal Service Directive 2002/22/EC; and Directive 2009/136/EC, amending the 2002 Directive). They generally accepted regional guidance as long as the harmonization of details could be considered voluntary. The clearest example is in measurements of call-handling by emergency “112” phone-in centres. This is the only group of QoS parameter measurements implemented similarly in every Member State, and the principles are voluntary. In addition, commonality of approaches already has a useful model: minimum QoS standards were required for the universal service obligations in Directive 95/62/EC. Its parameters list is still in use in many MS. This could be a model for further commonality of approach.

The draft EECC code tasks BEREC with devising a plan for harmonising QoS indicators and measurements and we support that solution.

A future approach may be that, while the Commission suggests metrics and methods through BEREC, NRAs may then decide if they are appropriate. In this way, the NRAs would be empowered to propose methods that the Commission could evaluate jointly with the NRA to reach agreement. (Note that the EECC also proposes that NRAs specify QoS parameters taking utmost account of BEREC guidelines). For instance, the growing acceptance of crowdsourced data and link testing by end users is an important area of convergence, even though the websites use different software. Adaptations of M-Lab, Ookla and Austria’s NetzTest are the basis of several websites sponsored by the NRAs. Also in this context, ETSI standards provide much commonality, on measurement methodologies, definitions, descriptions, statistical analysis and sampling.

In summary, all Member States realize that they require their telecommunications networks and services to be monitored regularly and the measured values of these indicators to be reported consistently. They seem willing to accept regional guidance on national implementation as long as the
detailed aspects can be considered voluntary. Many of the differences among Member States in the choice and use of QoS/QoE indicators seem surmountable.

The recommendations below specify the steps necessary to achieve greater regional policy coherence.

**Recommendations**

The way forward is examined, first, in terms of broader policy perspectives and, second, in terms of specific regulatory actions needed to implement the DSM.

**Broad Policy Recommendations**

- An institutional framework is needed to bring together NRAs, standards development organizations, operators, software and equipment suppliers, and user communities. Through such an initiative, the EU with BEREC can collectively organize the current random mix of indicators for QoS, QoE and network performance (NP), removing any that are redundant or obsolete and coherently assemble those that are left to form “key quality indicators” (KQIs) for the DSM.

- To promote this common approach on network quality and coverage, the European Commission is in the best position to trigger the consensual action needed. This process should be guided by a forum of stakeholders, led by the NRAs and BEREC with the aim of seeding a new generation of indicators to support innovative applications based on ubiquitous, affordable, high performance broadband including future 5G networks.

- Sharing of network quality assurance experiences among Member States, with knowledge gained and best practice, is important. It is already taking place to some extent, e.g. via BEREC and through the Mapping of Broadband Services in Europe project. It should be supported by the European Commission.

- Broadly speaking, there is no international example outside the EU that offers a model for the EU to follow in terms of QoS/QoE metrics, coverage obligations, measurement methods or enforcement practices. The most useful example beyond the EU is Canada, which has focused attention on the detail of reliability of QoS and QoE for the consumer. From its history of maintaining high quality services in difficult geographic and climate conditions, its regulation focuses on QoS for fixed line and mobile operators, who often have to share a legacy infrastructure from the competing incumbent. The incumbent and competing operators must publicly report their quality achievements and failures, including the penalties paid for transgressions, on online consumer websites.

**Regulatory Measures and Reforms to Implement the DSM**

These inputs to policy as recommendations are far reaching. Therefore, we first suggest a framework within which they could be organized and implemented. Their basis is collective EU-wide agreements agreed in collaboration with all stakeholders.

1. **A European expert group on quality indicators is needed** to produce collective decisions about which quality indicators to adopt as a common core set. This would also require an implementation plan, which would probably need to be phased. The move towards new levels of quality could not happen at once or in a short period, so a phased introduction, with three phases is probably required. The selected key quality indicators (KQIs) would be based on the QoE/QoS parameters. Such a Europe-wide working group could be based on BEREC’s working groups for its many regulatory initiatives to guide NRAs who would lead the process (underlined in Articles 5 and 22 of the EECC Code on
the tasks for NRAs). The successful COCOM expert groups, such as the successful emergency number 112 group and the new COCOM 5G group demonstrate the probability of success for such a BEREC-led initiative. It should meet frequently (monthly or more as required) and take ownership of three activities: indicator selection, planning of the implementation task, and overseeing the take-up of indicators across the EU in a phased rollout.

It is recommended that, while BEREC with the NRAs lead this process, other key stakeholders are included – the relevant SDOs, network operators, suppliers, user groups for citizens and industry sectors. The principle task would be to examine the key quality indicators and form the KQI selection, with specific methods of measurement proposed, that all MS are encouraged to implement. A set of higher-level composite KQIs, incorporating QoS and NP parameters, needs to be designed to simplify understanding of the performance of complex converged heterogeneous networks for end-users and NRAs alike. It would create a series of composite indicators for KQIs that move towards QoE for the end-user. There would also be a need for standard reporting formats for monitored results for KQIs, identified with numbered clauses from any SDO definitions, to avoid translation divergences in the various MS languages. The final list of key quality indicators (KQIs), and their measurement, could be the subject of EU Regulation for reasons of ensuring the commonality of implementation that endorse BEREC guidelines for a consistent implementation. Our experience of the previous divergences with Directives urges this implementation path.

To build a complete European framework for networking quality, the expert group would also decide on actions to realize the following:

2. **A common platform for measurement** – a quality monitoring system for Europe’s networks via a shared platform for NRAs to observe key quality indicators may become necessary. Facilities for embedded instrumentation of networks might be set up individually, for each NRA. More advantageous would be a shared EU-level measurement platform, used by all NRAs. That would also bring coherence and harmonization to parameters, measurement methods and data formats. It would support the transnational/internetworking aspects of quality monitoring and bring consistency to parameters, measurement methods and data formats. This has already been proposed by BEREC.

3. **Financing the common measurement platform** – in order to monitor network operator quality and performance, NRAs may need their own facilities for measuring quality in the future. That would require additions to NRA budgets. Consequently, the cost to NRAs of the measurement process may become a deciding factor in choices of parameters and methods. A shared platform, with central funding by the Commission, may therefore be necessary to seed the initiatives that will ensure new networking quality levels in all MS with optimal measurement methods to protect the DSM.

4. **A European KQI database of quality measures for consumers** – to provide constantly updated information of the quality from the various operators, a European database could be attached to the measurement platform for KQIs (it could also leverage existing major repositories of QoS/QoE measurements, if there are suitably compatible information types and formats, or low effort extract and transform processes). This should show the results in an easily understood form for consumers. It could also highlight two key measures:
• Which operators and networks are most reliable and where for a given performance.
• The public record of transgressions by operators in terms of quality of operations and services against their commitments and licence obligations.

5. Widen the parameters to meet the DSM economy’s needs – Europe’s current inventory of mandated QoS indicators needs modernization. It is still skewed toward voice telephony and includes standards whose continuing relevance is already questionable. More importantly, it does not recognize certain themes as part of the DSM quality agenda that will be of increasing importance in the years ahead. Action is needed to:

• Modernize the selection of indicators and prepare for more challenging use cases as fixed and mobile networks converge and stricter performance requirements are needed for the array of high value applications envisioned for 5G networks.
• Work towards a higher level of composite indicators, for end-users and NRAs to simplify understanding of the quality and performance of complex converged networks.

A wider comprehensive quality parameter set for the DSM should include:

• Reliability and resilience will become benchmark parameters as networks advance – Bulgaria, Finland and Sweden have benchmarks for network resilience aimed at reducing the possibility of physical disruption from bad weather or the loss of mains power causing loss of service. While reliability appears on our comprehensive list of QoS indicators, it does not appear on the lists of widely mandated indicators because most European countries do not have minimum reliability requirements for public networks. International standards, e.g. from the ITU and ENISA, exist on this topic. Uniform minimum standards for continuity of service throughout Europe will be increasingly important as society’s dependence on network services grows.

• Energy efficiency and pollution reduction – Telecommunications can reduce greenhouse gas emissions from travel and industry, but the industry’s own carbon footprint is steadily expanding. With denser 5G networks, energy density could rise in proportion. Standards for energy consumption should be adopted, as well as for equipment recycling, e.g. with ITU/IEC standards.

• Network security – A review of suitable network security standards for EU-level adoption should be pursued, probably within a framework such as ISO.27001, coordinated with European and national cybersecurity agencies; ETSI is active here.

• Privacy and identity protection – Privacy and identity protection should be recognized as essential parts of network QoS in a web-based society.

• Health and safety rules – the biological effects of radio frequency energy are still poorly understood even after a century of widespread human exposure. As we move to higher frequency bands in the centimetric and millimetric ranges, where the energy content of signals is greater and molecular resonance effects become significant, new safety standards will be necessary. These should be formed into a coherent standards policy, with maximum levels of exposure clearly defined.

Several of these parameters are mentioned in the proposed EECC and so are included in the EECC analysis table at the end of the Summary Report.
6. **A regional model for mobile coverage obligations** – To reach optimum levels of ubiquitous broadband access, a variety of forms of public support and funding may be necessary. NRA intervention in various ways will also be needed. Relevant tools might include coverage obligations, rules for network sharing that protect competition, etc. Some of these are pointed to in the EECC, e.g. Articles 30 (with 18 and 19), 42, 45 and 47, but many require basic changes, especially to 47(3) (see the EECC review table at the end of the Summary Report). Such interventions will only be effective if suitably designed (the obligations should address policy needs, have a suitable level of detail specified, with an appropriate time-frame and include legislative and economic incentives for rollout in targeted areas, etc., see above). We therefore recommend that a *regional model for mobile coverage obligations is produced as an EU guide*, including principles for enforcement. Its design guidelines should be based on best practice for quality indicators, offering definition of metrics and acceptable parameter levels with measurement methods, as well as what to consider for the design of coverage obligations. However, obligations and enforcement procedures for broadband coverage obligations could be designed and implemented nationally by NRAs as they see fit, brought together by BEREC.