Body of European Regulators for Electronic Communications

BEREC

BoR (17) 187

BEREC Report on the convergence of fixed and mobile networks

6 October 2017

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Executive Summary

Fixed-mobile convergence is nowadays a reality that takes place at a number of levels, including the device, the service and the infrastructure level. At the infrastructure level, fixed-mobile convergence translates into the use of fixed network infrastructures to transit mobile data streams, as part of the mobile backhaul service.

While fixed-mobile convergence is a far reaching phenomenon that encompasses many technological, market and regulatory issues, in this report we will restrict our attention to the infrastructure level and, in particular, on mobile backhaul. In doing so, we will provide an overview of the industry's present and future mobile backhaul requirements and the role of regulation in the provision of mobile backhaul services.

An integrated fixed-mobile strategy, encompassing the usage of core and backhaul network infrastructure to provide both fixed and mobile services, has been increasingly adopted by operators because of the synergies that can lead to improvements of efficiency and competitiveness in the context of a highly dynamic electronic communications market. Especially the considerable growth in data traffic on mobile networks fosters mobile operators to access very high capacity quality backhaul connectivity to connect their mobile sites to their core networks. The need of very high capacity and quality backhaul to connect mobile sites to core network starts to emerge already with 4G technologies and will further increase with the advent of 5G technologies.

Regulation of mobile backhaul is not explicitly covered by any of the markets susceptible to ex ante regulation of the European Commission's Market Recommendation (Recommendation 2014/710/EU)[1], but with fixed *access* and mobile *backhaul* infrastructures partly overlapping, fixed access regulation might indirectly impact on mobile backhaul issues. The increasing use of fixed infrastructures for mobile purposes might also imply some adjustments in fixed regulation in response to this new usage.

This report aims to analyse operators' needs in terms of backhaul services and to provide an up-to-date factual report on NRAs' regulation in the context of fixed-mobile convergence. More specifically, this work wants to examine to what extent regulation of fixed services is currently adapted or modified in order to take into account competition issues related to mobile backhaul and how regulation might change in the near future, in order to guarantee a competitive environment at the infrastructure level that is functional to the development of future, advanced, mobile services.

This report is descriptive and not normative – it does not aim to make any recommendations. Instead, it highlights the regulatory challenges that arise as a consequence of fixed-mobile convergence. In particular, the report studies how operators respond to their connectivity needs and compares NRAs' regulation in this context.

The report draws upon the results of two surveys, which were completed in Q2 2017, one among NRAs and one among the biggest MNOs (Mobile Network Operators) of each country. All information provided by the operators has been aggregated, in order to preserve confidentiality.

[1] In the Explanatory Note to the Commission Recommendation in relation to the market 4 (Wholesale high-quality access provided at a fixed location), the Commission leaves NRAs the option to identify specific competitive problems which require a separate national market for passive access to backhaul infrastructure.

Key findings

In response to increasing speed and availability requirements MNOs are in the process of switching from legacy solutions to higher capacity fibre-based backhaul links. While collected data shows that wireless technologies are still the predominant technology for the mobile backhaul, data also confirms a tendency towards fixed technologies (in particular fibre links).[2]

Currently backhauling solutions implemented by MNOs are a mix of own and leased infrastructures. Convergent operators, which emerged from the incumbent, typically show very high shares of self-owned infrastructure since they commonly have the highest fixed and mobile networks coverage. However, in terms of data volume transferred, up to now MNOs' reliance on infrastructure of third parties is generally relatively low in comparison to self-owned provision. A key factor for this seems to be the growing need of the MNOs to control the technical conditions of mobile backhaul.

While some fixed (and mobile-fixed) operators are successively rolling out fibre infrastructures, mobile-only operators generally prefer to get access to fixed operators' infrastructures, when wireless solutions are not economically/technically suitable. Some MNOs are calling for regulated wholesale products to cater for their needs to connect mobile base stations, including options such as active leased lines access, dark fibre and duct access. Within the transition from legacy to fibre technologies, most operators hence will foreseeably need to keep on relying on a mix of owned and leased infrastructure.

In most countries, NRAs adopt regulatory solutions for fixed services that can be used also by mobile operators for mobile backhaul. In particular, in these countries, obligations imposed in the context of the analyses of markets 3a and/or 4, consisting in options including access to dark fibre, leased lines or ducts, are not restricted to fixed network deployment, but can be also used in a mobile context.

In some other countries, obligations imposed on fixed markets are limited to not produce any impact on mobile backhaul. This does not necessarily mean that NRAs have not taken into account issues stemming from fixed-mobile convergence within their market analysis. Indeed, in some cases other regulatory (or legislative) measures, like symmetric obligations, are in place in order to ensure access to the fixed infrastructures functional to mobile data traffic backhauling. In other cases, the market for such infrastructures has been considered sufficiently competitive.

In any case, all NRAs closely monitor the evolution of the market and the mobile backhaul needs of the operators.

Future development

A general consensus was seen in the responses to the MNO questionnaire regarding the concept that current products are not designed to satisfy the future needs of mobile backhaul – in particular for 5G technologies – and that fibre links will be necessary in order to match the requirements in terms of latency, bandwidth and throughput of future mobile services. However, some respondents highlighted that the exact requirements of 5G networks are not

[2] Data collected merely suggests that this is the case, since collected data may not reflect the comprehensive situation in Europe. The answers received from the operators are patchy and do not allow a comprehensive analysis at EU level.

yet clear, since the discussion about the split of the processing between base station site and operator's network and on the capacity requirements of small cells is still ongoing.

Some operators also expressed concerns on the sustainability of current pricing practices of backhaul services, given the expected growth in mobile data per mast site, the growth in the number of mast sites required and the declining revenue environment for mobile services.

In this context, some NRAs plan to impose on the incumbent the obligation to give access to dark fibre to collect mobile data streams. Some other NRAs, and most of them, stated that their regulation is sufficient at this time and that they do not anticipate an evolution of their medium-term regulation.

1 Introduction and background

This section of the document aims to provide an overview of the current structure of national markets for mobile backhaul and of the technological and market trends that are characterising those markets in order to better understand and define the driving forces behind fixed-mobile convergence.

1.1 Structure of mobile and fixed networks

The diagram depicted in Figure 1 was sent to all the NRAs and operators who participated in the survey,[3] so that all respondents would use the same definitions for the different parts of the network.

Mobile and fixed networks can both be subdivided into an access and a core part. Figure 1 shows that mobile backhaul overlaps with both fixed access and backhaul, creating the potential for synergies between mobile and fixed backhaul implementation. In fixed networks, the demarcation point between access and core is the metropolitan point of presence (MPoP),[4] that is the equivalent of the main distribution frame (MDF) in copper networks and of the optical distribution frame (ODF) in fibre networks. Fixed access hence covers infrastructure from the network terminating point on the end user side up to the MPoP; fixed backhaul, in turn, covers the infrastructure from the MPoP upstream to the core nodes (in Figure 1, demarked by the point of presences (PoP) at a higher hierarchical level) of the network operator. In mobile networks, access identifies the wireless link connecting the end user device to the base station (so called radio access networks). Any infrastructure (fixed or wireless) connecting those base stations to the base station controllers and continuously further upstream to the core nodes (i.e. the PoP) is termed mobile backhaul infrastructure in the context of this document. Base station controllers and mobile network nodes are typically located in MDF/ODF sites. Traffic in these sites is further aggregated in PoPs. The radio access network could rely on macro cells, i.e. the traditional base stations, or small cells. Small cells are access nodes to radio spectrum that cover a range lower than macro cells, typically from about ten of meters to two kilometres. As data traffic rises, they represent an effective way to provide coverage and indoor/outdoor capacity and allow a more efficient use of the spectrum.

[3] The questionnaire aimed at collecting information from operators was sent to the four biggest mobile operators in each country.

[4] Cf. Commission Recommendation on regulated access to Next Generation Access Networks (NGA) 2010/575/EU, no. 11.

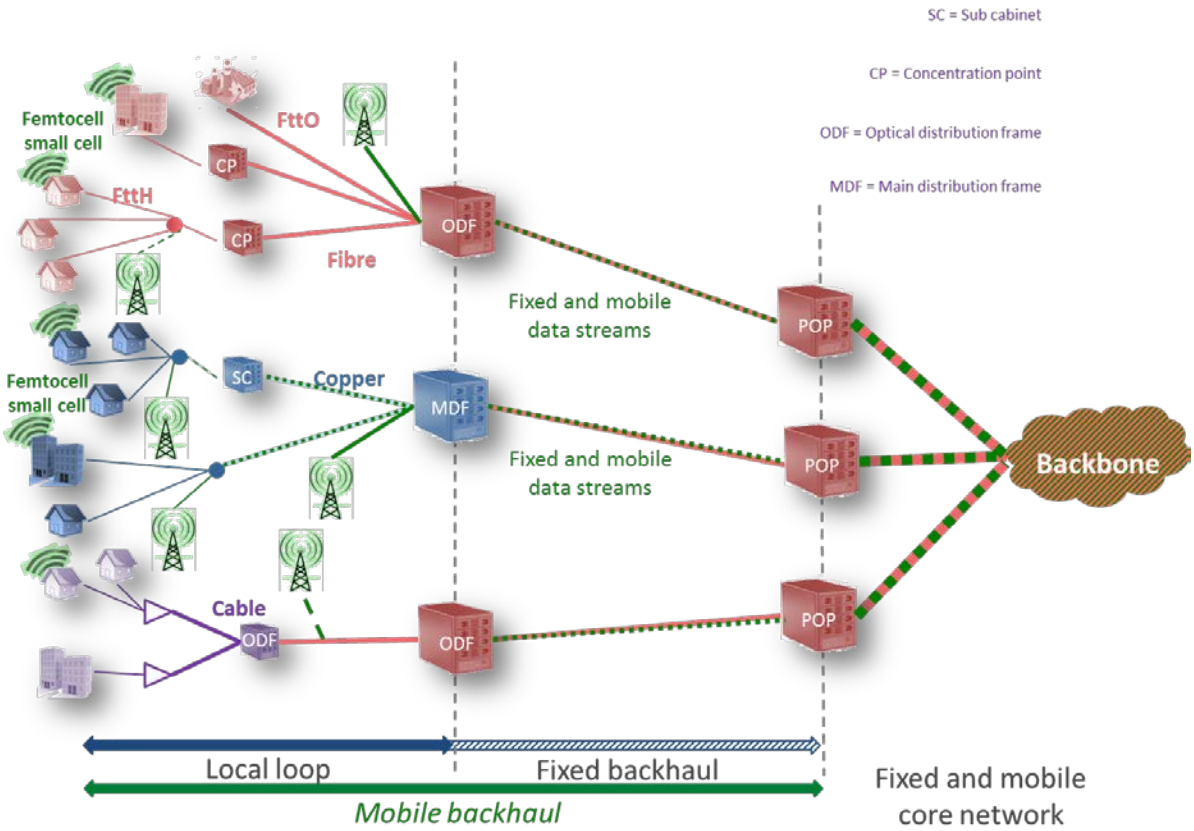

Figure 1: Architecture of fixed and mobile networks.

1.2 Technological and market trends

In most countries, the incumbent, whilst initially offering only fixed services, has moved into mobile services as well. Additionally, in most countries there is at least one mobile operator who owns a proprietary network infrastructure and one mobile operator without its own infrastructure, often being a mixture of wireless and fixed backhaul.[5]

For backhauling purposes, the vast majority of mobile operators use wireless technologies (e.g. point to point radio relay systems and microwave links), in conjunction with fibre based fixed links.

MNOs can rely on both fixed and mobile solutions when backhauling mobile traffic from the cells to their core nodes (PoPs). With increasing demand, e.g. with the development of 4G/ 4G+ and the introduction of 5G, it is expected that operators will rely increasingly on fibre links, especially in order to connect macro cells. Such an outcome is supported by the response of some NRAs, based on information from their national operators. Data collected suggest that wireless technologies are still predominant in 2016, connecting more than half of the Base Transceiver Stations (BTSs). However, collected data do not allow for the differentiation between fixed-mobile operators and mobile only operators; we may assume that fixed-mobile operators use more intensely fixed infrastructures for their mobile backhaul needs whereas

[5] Among the latter, it is possible to observe cases that show a growth pattern that leads from (light or heavy) MVNO (Mobile Virtual Network Operator) towards MNO, where the new MNO will initially be dependent on rented backhaul, often combined with site sharing. A classic light MVNO is based on pure resale of the service offerings of another MNO. A medium MVNO has no own infrastructure like a light MVNO but owns number resources. A full MVNO owns in addition to the medium MVNO also part of the terminating and originating network infrastructure.

mobile only operators mostly rely on their legacy infrastructures. In this respect our analysis is only able to provide a general trend and may not precisely reflect the situation in Europe.

2 Analysis of needs and solutions for mobile backhaul

This section of the report aims to analyse the current needs in terms of mobile backhaul on the part of operators (section 2.1.1) and the technical implementations already in place (section 2.1.2). Moreover, this section provides an overview on how the introduction of fifth generation technologies (5G) could affect both needs and technical implementations (Section 2.2). In order to be able to answer to these questions, an *ad hoc* questionnaire was submitted to mobile network operators of the European Union and the European Economic Area. This section is mainly based on the answers to the mobile network operators' questionnaire.[6]

2.1 Current mobile backhaul needs and solutions

The purpose of section 3.1 is to show the current mobile backhaul requirements of MNOs (section 2.1.1) and the current solutions adopted across the EU (section 2.1.2).

2.1.1 Mobile backhaul needs

2.1.1.1 Mobile backhauling needs – structural differentiation

MNOs can, as has been outlined in section 1, rely on both fixed and wireless solutions when backhauling mobile traffic from the cells to their core nodes (PoPs).

If the demand in terms of capacity is very high, which typically occurs in the areas served by LTE and successive technologies,[7] operators rely mostly on fibre links (which adopt both point-to-point and point-to-multipoint topologies) and, in some cases, on high bandwidth radio systems.

Fibre links are usually the preferred choice of the operators thanks to their higher capacity, their flexibility to different technical solutions and their universal applicability. Operators generally tend to rely on fibre links in urban and touristic areas, where traffic density is usually high.

Where the radio access network is based on 2G and/or 3G technologies, operators can rely also on **copper links**, since the capacity requirements are less stringent.

Mobile backhaul solutions based on **microwave links** are often adopted for access sites in rural areas, because, on the one hand, deploying fibre links in rural areas is more costly and, on the other side, required bandwidth is often lower than in urban areas.

[6] Operators did not answer to all questions. This implies that the number of respondents to the questions changes across tables/pictures.

[7] LTE (Long Term Evolution) is the fourth generation of mobile technology.

2.1.1.2 Mobile backhauling needs - type of final services

Mobile backhaul technical implementation can depend upon various key factors, such as final services provided (e.g. IoT,[8] M2M,[9] retail services), different access network choices (e.g., femtocells, base stations) or different radio access technologies (2G, 3G or 4G).

The survey has revealed that operators usually adopt the same technical implementation for mobile backhaul services, without any differentiation based on the final services, with the exception, as mentioned above, of those depending from the radio access technologies (2G, 3G vs LTE), since they generally do not affect the transmission method. Final services could at most suggest a differentiation in the requirements of the access network in terms, for example, of specific base stations.

2.1.2 Mobile backhaul solutions

Mobile backhaul solutions generally consist in a mix of fixed and wireless self-provided or rented infrastructures. Operators stated that fixed infrastructures are based on both copper and fibre links and wireless infrastructures are generally based on microwave links.

The choice of fixed or wireless infrastructures depends on many factors, including the total cost of deployment (capex and opex), required bandwidth, radio access technology, topography, proximity of dark fibre and landholder permissions (rights of way). Many respondents have also highlighted that the technical implementation of mobile backhaul could depend on the availability of fixed infrastructure.

Due to confidentiality reasons and to the diversified nature of the answers received, the data collected across the European Union (EU) and the European Economic Area (EEA) Member States did not allow a full EU view on this question. However, it can be observed that, amongst the respondents, wireless technologies remain the predominant solution for connecting base stations, even if with its share is decreasing.

As it is explained in the following (see section 2.2), even if data collected are not able to provide an EU wide perspective, we can hypothesise that one reason for the decreasing share of mobile solutions and, in turn, the increasing share of fixed technologies is that the latest mobile standards, with their higher capacity needs, are increasingly reliant on fixed (fibre) backhauling.

In the following section 2.1.2.1, it is first evaluated how operators fulfil their backhauling needs through *both fixed and mobile* solutions, relying either on own or leased infrastructure. The report then focuses on mobile backhauling solutions realized via *fixed* infrastructures (sections 2.1.2.2 et seq.).

2.1.2.1 Mobile backhaul solutions – own vs leased infrastructure

Operators were requested to indicate the proportion of mobile backhaul traffic, in terms of volumes,[10] which is self-provided on their own fixed and/or mobile infrastructures, and the proportion of mobile backhaul traffic that is bought from other network infrastructure operators.

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[8] Internet of Things (IoT) refers to devices and sensors (in general, to objects) connected to Internet.

[9] Machine to machine (M2M) refers to technologies and services allowing automatic transfer of information between devices without (or with very limited) human interaction.

[10] Some operators provided the information in terms of access sites instead of traffic. However, we have elaborated these values together with the percentages in terms of volumes. As first approximation, it could be supposed that the traffic is distributed uniformly among all the access sites; thus, the percentages in terms of sites and in terms

In total, sixty-one operators providing services in 26 countries of the EU and the EEA answered this question.[11] The majority of these operators, forty-one, declared that they are able to satisfy most of their mobile backhaul service needs – more than 75% of the traffic – by means of self-supply on their own fixed and/or mobile infrastructures. In particular, seventeen operators declared to rely exclusively on their own infrastructures. Only two operators among the sixty-one respondents declared not to self-supply mobile backhaul services at all, either through fixed or wireless infrastructures. Thus, forty-two operators rely on a mix of own and other infrastructures. The graph below (Figure 2) shows the distribution of operators, which self-supply and/or buy (regulated and unregulated) mobile backhaul services (from both Electronic Communication Service (ECS) operators and non-ECS operators), over five classes of traffic.[12]

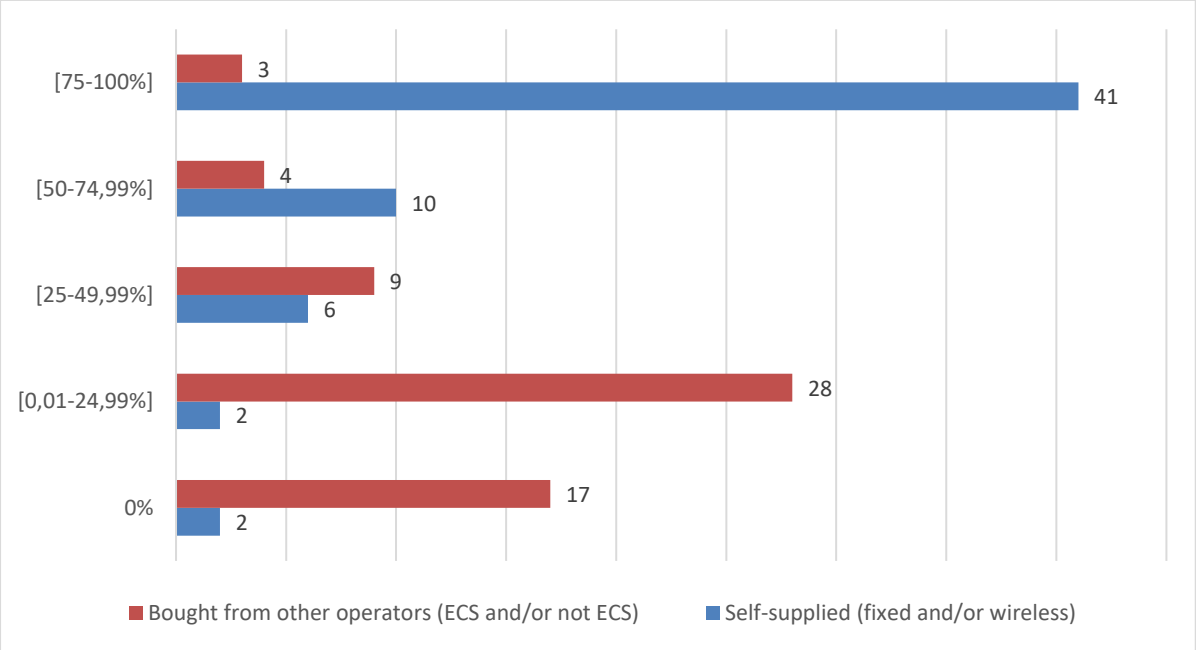

Figure 2: Self-supply and purchase of mobile backhaul services per class of percentages

Among the **fifty-nine operators that self-supply mobile backhaul services** (at least partly),[13] fifty-seven declared to use wireless infrastructures and forty-eight to use fixed network infrastructures (consequently, most respondents used a combination of both wireless and fixed infrastructures).

of volumes correspond. Of course, this hypothesis does not consider that mobile traffic (especially mobile data traffic) is probably higher in the urban areas than in the rural areas, therefore the distribution of traffic among access sites is not uniform. However, for the scope of this report the uniformity hypothesis does not affect the results.

[11]The number of respondents is higher than 61; however, some operators have not been able to provide the required percentages of mobile backhaul traffic. In order to compare the results, we did not include these operators in the analysis of this question

[12] There is a separate class for each 25% increment of traffic, plus one exclusively dedicated to 0%. For each of the five different classes of traffic, two bars are depicted: one which represents the number of operators that do not self-supply backhaul traffic, hence relying on backhauling solutions from other operators (red bar), and one which represents the number of operators that self-supply backhaul traffic (blue bar). This representation makes it feasible to observe the distribution of operators over classes from both the perspective of those who self-supply (in blue) and those who buy mobile backhaul on the market (in red).

[13] Only two (n.2) operators among the sixty one (n. 61) respondents do not rely on own infrastructures for mobile backhaul services.

Figure 3 shows the number of operators that self-supply over their own wireless infrastructures (in red) and the number of operators that self-supply over their own fixed infrastructures (in blue) for each of the same five dimensional classes of Figure 2.[14] As can be seen from Figure 3, the number of operators that use wireless infrastructures and the number of operators that use fixed infrastructures does not considerably deviate per traffic class, suggesting that there is no clear relationship between the percentage of traffic that is self-supplied and the choice of fixed or wireless infrastructures. The introduction of 5G technologies could have a higher impact on operators currently relying on wireless infrastructures. The increase of capacity requirements could drive operators to rely mostly on fibre links and encourage them to replace wireless with fixed infrastructures, if wireless technologies do not provide the needed capacity.

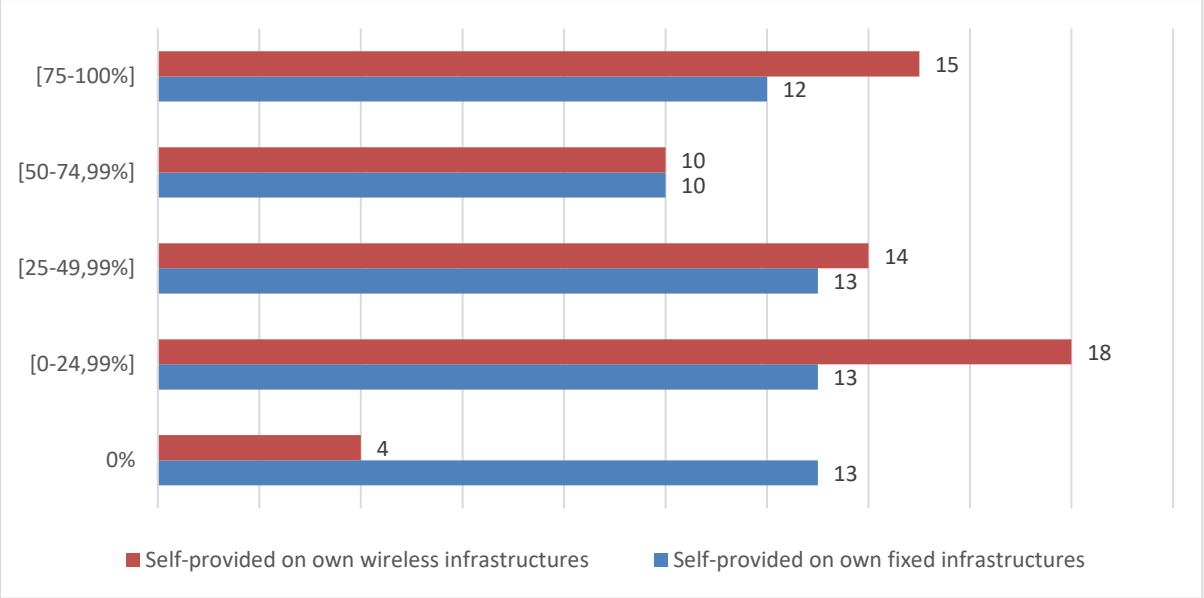

Figure 3: Operators relying on their own infrastructures per class of mobile backhaul traffic percentages.

2.1.2.2 Fixed mobile backhaul solutions – own vs leased infrastructure

Operators that used fixed technologies were asked whether they used their own infrastructure in mobile backhaul, or whether they leased circuits or capacity from third parties.

Sixty-three operators responded to this question, over half of them indicating that they use both their own fixed infrastructure and leased fixed infrastructure. Table 1 below gives more details about the operators' answer.

Question: Which fixed infrastructure do you use for mobile backhauling?	Number of operators
Solely own fixed infrastructure	16 (across 13 countries)

[14] We should bear in mind that operators were asked to specify separately the percentage of backhaul traffic conveyed over their own fixed and mobile infrastructures and that the sum of these two percentages was used to allocate operators to one of the dimensional classes of Figure 2. This means that, for each class of the distribution, the number of operators who self-supply in Figure 2 differs from the sum of the numbers of operators in the same class in Figure 3. For instance, one of the four operators which do not rely on their own wireless infrastructures (shown by the red bar in the lowest class in Figure 3) could convey on its own fixed infrastructure even 100% of mobile backhaul traffic; thus, this operator would be one of the forty one operators which rely on their own infrastructures (in blue) in the highest class (75%-100%) of mobile traffic in Figure 2.

Solely leased fixed infrastructure	14 (across 11 countries)
Both own and leased fixed infrastructure	31 (across 19 countries)
No use of fixed infrastructure	2 (across 2 countries)

Table 1: Own vs leased infrastructure for mobile backhauling.

Of the MNOs that used both third parties' fixed infrastructure and their own, there was a wide diversity in the percentage split of self-owned use, from very high self-owned utilisation (up to 95% self-owned usage), to relatively low (35% self-owned).

The preference indicated from respondents was for the use of self-owned networks, with third party infrastructure used when self-build was deemed uneconomical.

Operators that leased fixed capacity were asked to specify whether they purchased it on commercially negotiated terms, or whether they purchased regulated products from the incumbent fixed operator.

Sixty-three MNOs responded to this question. Seventeen MNOs stated that this question was not applicable to them. Nearly half of the operators purchased solely on commercially negotiated terms. Answers given are summarised in Table 2 below.

Question: If you lease capacity, on which terms do you purchase it?	Number of operators
Solely on commercially negotiated terms	27 (across 16 countries)
Solely on regulated terms	2 (both in the same country)
Both on commercially negotiated and regulated terms	18 (across 14 countries)
Not applicable	16

Table 2: Commercially negotiated vs. regulated leased capacity.

Concerning leased fixed backhaul products, both passive products (dark fibre - via long term lease), and active leased lines were used, as well as – in a very small minority of cases - xDSL (digital subscriber lines).

2.1.2.3 Fixed mobile backhaul solutions – unregulated vs regulated products

Forty-four operators do rely (at least partly) on backhaul infrastructure bought from third (Electronic Communication Service - and non-Electronic Communication Service) operators. While a significant part of backhauling agreements falls into the category of commercial agreements with other ECS-operators, it is interesting to note that a relatively high number of respondents also declared to buy services on commercial terms from operators other than ECS (like, for instance, energy companies). Only relatively few operators rely on regulated products.

Operators that bought mobile backhaul services from the significant market power (SMP) operator through a regulated product were asked to specify which markets the regulated offers belong to.

The following table shows that nine operators purchase regulated products in Market 3a, four operators in Market 3b and thirteen operators in Market 4.

	Market 3a	Market 3b	Market 4
Number of operators	9 (across 8 countries)	4 (across 4 countries)	13 (across 9 countries)

Table 3: Number of operators that buy regulated products for mobile backhauling purposes in market 3a, 3b or 4

Operators were also asked to provide – where applicable – a brief description of the regulated product used. Where available, regulated services included dense wavelength division multiplex (DWDM) over fibre, and real-time Ethernet, with some limited use of xDSL (including unbundled copper lines), and time division multiplexing (TDM) over copper. Table 4 shows the regulated products referred by the operators and the markets they are allocated to.[15]

Regulated products used for mobile backhauling named by operators	
Market 3a: Wholesale local access provided at a fixed location	- FTTH[16] Unbundling - FTTO[17] Unbundling - xWDM channel 10Gbit/s transmission - SHDSL,[18] ADSL,[19] ADSL2, VDSL2[20] - Civil infrastructure access
Market 3b: Wholesale central access provided at a fixed location for mass-Market products	- Fibre, xWDM. - ADSL, ADSL2, VDSL2
Market 4: Wholesale high-quality access provided at a fixed location	- Ethernet (speeds ranging from 5Mbit/s to 10Gbit/s) - TDM copper lines.

Table 4: Regulated products used for mobile backhauling and respective markets.

Operators were asked whether they considered the existence of a regulated "reference offer" would allow them to negotiate better commercial terms when they bought an unregulated product.

There was a divergence of viewpoint across operators in whether the existence of a regulated "reference offer" allowed negotiation of better commercial terms when purchasing unregulated products.

[15] One operator stated that the mobile backhaul regulated product available was not sufficient for requirements.

[16] Fibre To The Home.

[17] Fibre To The Office.

[18] Single-Pair High-speed digital subscriber line.

[19] Asymmetric Digital Subscriber Line.

[20] Very High-speed Digital Subscriber Line.

Question: Does the existence of a regulated reference offer enable better commercial negotiation on unregulated products?	Number of operators
Yes, clearly	18 (across 11 countries)
Yes, partly	6 (across 6 countries)
No	10 (across 10 countries)

Table 5: Impact of regulated reference offer on commercial negotiations.

Eighteen operators across eleven countries claimed that the existence of a regulated offer did enable better commercial negotiation on unregulated products.

Reasons stated for this included that in cases where multiple infrastructure operators are present – among which many are local or regional providers – a regulated offer could provide a reference point for negotiations on unregulated products, and could act as a safety net in case negotiations fail. Similarly, it was stated that a regulated product at the national level from the incumbent could enable better commercial negotiations for MNOs seeking to purchase services from smaller regional providers.

For their offers to be attractive, competitors need to provide better products than the regulated offers, both technically and economically. It was stated that this overall results in more attractive competitive offers, seen in factors such as capacity offering, service level agreements (SLAs), or other technical aspects.

One operator claimed that availability of a reference offer 'changed the tone' of commercial negotiations from *whether or not* access will be provided, to *how* the offering could be improved.

An operator in another country reported that it created a model of a hypothetical network using only regulated products, which grants them a technical and commercial baseline. They then use this baseline for contractual negotiations on managed service products to assess the value that another network operator can provide on top of the baseline network.

Six operators held mixed views on the question. One of those MNOs stated that regulated offers were a preferred choice for *unitary* circuit requests in terms of tariff, whereas in situations of *multiple* links, commercial offers typically were cheaper. Another operator expressed that those regulated products that existed were not technically sufficient for the requirements of mobile backhaul.

Ten operators across ten countries stated that the existence of regulated products in their markets were not sufficient to lead to better commercial negotiation on unregulated products.[21] One MNO stated that the regulated products were too technically comparable to commercially negotiated offers, which resulted in the commercial negotiation failing as the price of the regulated offer acted as a price floor.

In one country, an operator claimed that dark fibre operators maintained prices at similar levels with little competition on price, which was resulting in high prices. It was argued that as there

[21] For example, in the UK unregulated products are BT's MEAS, i.e. managed services combining regulated terminating segments with long-haul unregulated circuits.

was a lack of overlapping networks, there were little incentives for network owners to compete on price.

An operator in another country claimed that the remedies imposed by the national regulator were not seeing price reductions flowing through to operators that purchased the regulated offers. This was because the ability for the wholesale customer to access the regulated offer depended on additionally imposed factors such as volume commitment, or network presence at certain points of interconnect and/or other conditions of an equitable value.[22]

2.1.3 Conclusions on current mobile backhaul needs and solutions

Against the background of the mobile backhaul needs identified, MNOs were asked whether – in case they do not rely on own infrastructure – the existing (regulated and unregulated) products offered do satisfy mobile backhaul needs and whether they are specifically defined for mobile services from a technical and economic point of view.

From a **technical point of view**, some respondents consider the services currently offered, and mostly not specifically designed for mobile backhaul, as not perfectly tailored at satisfying operators' needs. In this context, some respondents mentioned the lack of scalability of the mobile backhaul capacity, intending for "scalability" the ability to easily increase capacity of existing circuits as a function of mobile backhaul needs.[23] The survey, however, also shows that existing products can – at least to a certain degree – be modified to satisfy the specific requirements of the operators.

Concerning **economic conditions**, the wholesale price can be a decisive factor (particularly in case more than one wholesale solution fits the technical requirements). Many operators consider current prices too high, while others state that current prices are cost-oriented and therefore not excessive. Some operators put forward that, usually, the same conditions apply, independent of the usage of the wholesale service. However, some operators provide mobile backhaul services on the basis of some specific commercial contracts, whose main components, such as prices, SLAs and key performance indicators (KPIs), are specifically defined to fit the mobile backhaul needs of operators.

A number of respondents lament a general lack of regulated services specifically defined for mobile backhaul, asking for dark fibre access products instead. They refer to leased lines as well as to wholesale access market products as being not sufficiently tailored for the deployment of mobile backhauling. Some of these operators in general consider active access products as technically inferior to access to passive infrastructures.

Yet, some respondents, especially incumbents, consider that regulatory interventions are not necessary since the market is already competitive. According to these respondents, the decision of some companies not to invest for the deployment of their own mobile backhaul solutions is related to commercial (economic) reasons. Reflecting this point, different points of view arose also with regard to the costs attached to the deployment of proprietary backhaul solutions; while according to some respondents building proprietary infrastructure is not economically feasible, according to other, it is. This divergence in views very likely reflects the different opinions of fixed/mobile operators and pure MNOs.

[22] Three countries had only one operator responding to this question. One stated that a regulated product did not exist in the country. One stated it was not applicable as it did not purchase the available regulated product. The last one also stated that it was not applicable.

[23] Scalability problems are less relevant for passive products.

A key factor obtained from the survey is the growing need of operators to have full control over technical conditions; this could explain why the operators rely mostly on self-provided mobile backhaul solutions. As a general rule, operators however at least partly rely on services provided by other companies when the deployment of a proprietary network results to be too expensive.

Moreover, since the amount of traffic (especially data) is growing and it is expected to considerably grow further, capacity requirements are also expected to rise. Indeed, according to many operators, mobile backhaul capacity requirements for access sites in 4G/5G technologies will exceed 1 Gbit/s.

2.2 Evolution of mobile backhaul needs and solutions

This section intends to provide an overview of how MNOs' mobile backhaul requirements and solutions are evolving.

Many respondents believe that current products are not designed to satisfy the future needs of mobile backhaul, in particular with regard to 5G technologies.

According to most operators, fibre links will be necessary in order to meet the increasing data traffic over mobile networks and to meet the requirements in terms of latency, bandwidth and throughput in a 5G context. 5G technologies – even more than 4G technologies - will ask for an increasing number of local access points [i.e. base stations or small cells]. Particularly small cell deployment is considered to rise in importance, where mobile backhaul solutions might differ from those for macro cell deployments. To link small cells (like femtocells) and backhaul them to the core, cells could be [inter]connected by dual band microwave solutions, this would however on term require more frequencies. Against this background, the fibre optical solution is currently considered the most compelling as well as promising one.

According to some operators, small cell sites could also be installed in the customers' premises and be connected via the customer's broadband fixed access connection, which could be self-provided by the operator or bought from third parties (in particular via regulated services included in Market 3a). According to other operators, connecting small cells via residential internet services will be unlikely for 5G radio access technology, since capacity requirements of 5G small cells are much higher than what residential internet access currently offers (although one might notice that the increasing availability of very high capacity networks should progressively remove this restriction). According to some other respondents, small cells will be backhauled taking into account the specific needs of the site and relying on the most apt solution given the identified needs available at customer's premises.

However, some respondents highlighted that the exact requirements of 5G radio access networks are not yet clear, since the discussion about the split of the processing between base station site and operator's network is still ongoing. Particularly, small cell deployment is at a very early stage and best practices in mobile backhaul backhauling in terms of costs, feasibility and availability are still to be developed. Traffic shaping and other policies that can be applied at the logical layer within the backhaul domain may be used to ensure prioritisation of certain types of traffic, allowing overall service quality requirements to be met.

Concerning implementation of backhauling solutions, many operators claim that future needs could be best met if the owners of passive infrastructures give access to others in order to allow for implementation of fibre based mobile backhaul. As pointed out above, some operators have also highlighted the lack of specific regulated products in this context. While answers from fixed-mobile operators indicate that most of them are – in addition to using

infrastructure provided by third parties – willing to increase the share of self-provided (fibre backhaul) solutions, answers from mobile-only operators indicate that they generally do not intend to increase their share in self-provided backhaul solutions, they therefore call for regulated wholesale products to fill in that need.

3 National regulatory experiences and practices

Within the context of the 2014/710/EU Recommendation on relevant product and service markets within the electronic communications sector susceptible to *ex ante* regulation (from now on, the Recommendation),[24] the Explanatory Note addresses the question whether an ex ante regulatory intervention is warranted in a separate market for access to backhaul in the Note's analysis of market 4 (Wholesale high-quality access provided at a fixed location):

> *"An issue related to the definition of the wholesale high-quality access market is whether ex ante regulatory intervention is required in a market for access to backhaul (distinct from the market for access to fixed networks) in order to facilitate or enhance the competitive provision of services. For instance mobile operators increasingly need access to fixed passive infrastructures (i.e. civil engineering including ducts and dark fiber) to develop mobile backhaul solutions in order to offload increasingly data-intensive services from their respective mobile networks."*[25]

The Commission concludes that there is not enough evidence justifying the inclusion of a separately defined market in the list of relevant markets of the Recommendation. It however advises NRAs to analyse whether other market 4 products could provide for mobile backhauling. In case wholesale access to terminating segments of leased lines does not address the competition problem effectively, the Commission also points to the possibility to *"mandating ancillary services such as dark fibre or duct access in the backhaul segment in order to promote effective competition"*[26]. As a third possibility, the Commission also leaves NRAs with the option to identify specific competitive problems, which require a separate national market for passive access to backhaul infrastructure.

In this context, NRAs were asked for their experience in mobile backhaul and their answers are analysed in the following section.

This section also gives an overview of whether NRAs have been approached by operators asking specifically for products for mobile backhaul access. This section also deals with the question whether there had been any dispute settlements concerning mobile backhaul. It will then discuss the prospects of evolution of regulation according to the NRAs' feedback.

3.1 NRAs' experience in mobile backhaul regulation

NRAs were asked if they regulate mobile backhaul services directly or if they have imposed any regulatory obligations concerning fixed services that have or could have an impact on

[24] COMMISSION RECOMMENDATION of 9 October 2014 on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services (2014/710/EU), available at http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014H0710.

[25] Commission Staff Working Document, Explanatory Note accompanying the Commission Recommendation on relevant product and service markets, p. 51.

[26] Commission Staff Working Document, Explanatory Note accompanying the Commission Recommendation on relevant product and service markets, p. 51, footnote 63.

mobile backhaul. In case of an affirmative answer, they were required to provide details concerning the parts of the network subject to regulation, the relevant markets and the associated remedies. Associated remedies can concern passive or active products.

Based on the responses to the NRA's questionnaire, it emerged that none of the NRAs provides for regulated access to mobile backhaul *specifically*, i.e. through definition of and regulation in a separate market.

However, in the context of fixed-mobile convergence, an *indirect* regulation exists on mobile backhaul operated by the use of fixed infrastructures, which are regulated in one of the markets of the Recommendation. Indeed, in most countries whose NRAs replied to the questionnaire, it is indicated that next to regulation of market 4, regulation of market 3a (Wholesale local access provided at a fixed location) could have some impact on mobile backhaul, with some variations between the countries, as result of their national particularities.

The following section gives an overview of the regulation in countries where mobile backhaul access is available to operators on a regulated basis. More specifically, information is provided on the parts of the network that are subject to regulation and the relevant markets where regulation is therefore applied. Furthermore, information is provided regarding the remedies applicable including their inherency to each relevant market.

3.1.1 Parts of the fixed network subjected to regulation that could impact on mobile backhaul

NRAs were asked whether they have imposed any regulatory obligations concerning fixed services that have or could impact on mobile backhaul. Twenty-three NRAs answered.[27]

From the responses received, in eighteen countries (AT, HR, DE, BG, EE, EL, ES, FR, FI, IT, LV, LU, PL, PT, RS, SI, TR, UK), regulation in fixed markets can impact on mobile backhaul. In four countries (CZ, CH, DK, LT), fixed regulation does not, directly or indirectly, impact on mobile backhaul.

The Table of Annex 1 provides an overview of the regulatory measures adopted across the eighteen European countries where regulation has been imposed; clarifying which parts of the and which services are subject to regulation.

Concerning those countries in which mobile backhaul is directly or indirectly regulated, we find that in four countries (BG, EE, IT, LV), NRAs have imposed at least one of the following obligations in market 3a: duct access as an ancillary remedy to local loop unbundling, dark fibre access as an ancillary remedy to local loop unbundling or duct access as a self-standing remedy. In eight countries (DE, HR, EL, FI, PL, SI, TR, UK), NRAs have imposed at least one of the following obligations in market 4: access to terminating segments of leased lines, backhaul access as an ancillary remedy or backhaul access as a self-standing remedy) that have an impact on mobile backhaul. In six countries (AT, FR, LU, PT, ES, RS), NRAs have imposed obligations that impact on mobile backhaul in both market 3a and 4.

[27]NRAs of Austria, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Italy, Latvia, Lithuania, Luxembourg, Malta, Poland, Portugal, Serbia, Slovenia, Spain, Switzerland, Turkey and United Kingdom.

3.1.2 NRAs' considerations of fixed-mobile convergence in the regulation of fixed networks

NRAs were asked whether they impose some obligations that take account of fixed-mobile convergence. From the responses received, NRAs in eight countries (DE, HR, FR, FI, IT, LV, MT, UK), stated that they have already imposed obligations on fixed services that have or could have an impact on mobile backhaul or that they are considering imposing remedies.

In Croatia, mobile backhaul is considered to be terminating segment of leased line and as such is part of market 4. Furthermore, a duct access obligation enables mobile data streams to be collected.

In France, the NRA has imposed the SMP operator to provide dark fibre for fixed backhaul as an ancillary remedy to LLU. The SMP operator also provides dark fibre to collect mobile data streams originating from fibre local loops on commercial terms. The NRA plans to impose the requirement for the SMP operator to provide dark fibre at the same price "regardless of the origin of the data streams provided those streams are coming from local loop and collected at the MDF".

Finland is studying the need to impose the obligation to collect data streams via dark fibre.

In Latvia, fixed infrastructures can be used to collect either fixed or mobile data streams (the so-called obligation of neutrality of usages imposed on ducts of all owners). Duct sharing is imposed in the SMP framework and in the symmetrical context and mobile operators make use of ducts sharing to collect mobile data streams.

The NRA of Malta considers that with the development of 5G technology, it may review its current position to ensure that access to the network may be utilised to support mobile backhaul.

In some countries, the NRA does not take into account fixed-mobile convergence in the SMP analysis. For example, Lithuania has a symmetrical regulation for sharing of the electronic communications infrastructure and/or suitable purpose physical infrastructure to all infrastructure owners, according to the national law on electronic communications of the Republic of Lithuania. The NRA stated that common use of infrastructure can be used to deploy mobile backhaul. Therefore, the NRA does not have to take into consideration fixed-mobile convergence in the asymmetric analysis.

3.2 Demand by operators to NRAs to regulate mobile backhaul

The following section gives an overview whether NRAs have been approached by operators asking specifically for products for mobile backhaul access in case that mobile backhaul services are not currently regulated in their country. Some examples of operators' approaches during public consultations for market analysis or dispute settlements are presented below. In case the above mentioned demand has been received, NRAs were asked to specify in which circumstances this happened and to state the main arguments presented for requesting access. Furthermore, this section also gives an overview whether NRAs have been confronted with any disputes in the past involving mobile backhaul. In case that such dispute had to be settled, NRAs were asked to provide further information for each dispute regarding involved parties, key disputed matters, timing, which institution the dispute was raised with, the outcomes if it has been resolved, appeal if relevant and possible next steps if it is an on-going case.

3.2.1 Demand for mobile backhaul regulation by operators

In countries lacking regulatory tools at this stage, some NRAs have been approached by operators, who asked for regulation of products for mobile backhaul access.

In Germany, shortly after conducting the review of the analysis of Market 4 some key competitors of the incumbent approached the NRA calling for regulated access to dark fibre. The reasoning was, *inter alia*, that, without access to dark fibre, backhaul capacities needed for the future 5G infrastructure could not be built up. Operators in Germany further reasoned that neither (terminating segments of) leased lines nor microwave links would be sufficient in future 5G environments.

In Spain, an operator has recently asked the NRA to relax the usage conditions to contract the ancillary dark fibre service to transport the signal from CO to PoP. The Reference Unbundling Offer (RUO), Ducts Offer and the Leased Lines Offer can benefit from this ancillary service but it has several usage restrictions.

In Finland, regulated mobile backhaul services fall within the market for wholesale high-quality access provided at a fixed location market (M4/2014). However, only (active) capacity products belong to market 4, but not dark fibre or ducts. In Finland, one operator asked whether dark fibre to base stations could possibly be regulated. No further information is available regarding circumstances and reasoning of that specific operator.

In the Czech Republic, the NRA has been approached by one MNO during the public consultation on the national list of relevant markets held in January 2015. That specific MNO brought forward that they consider the mobile access network sharing between the two strongest competitors could possibly distort competition. Furthermore, that MNO drew attention to the growing demand of data and increasing importance of fibre backhaul. A subsequent preliminary assessment of the mobile backhaul market by the NRA led to the conclusion that the wholesale market does not present risks that could lead to distortions of competition and that would have justified the inclusion of the market into the (national) list of relevant markets in the electronic communications sector. However, the NRA is currently going to review its previous conclusions during 2017 based on new data and additional comments received from one MNO. Also in 2017, during the public consultation to the analysis of market 4 the same MNO commented the market definition demanding that mobile backbone services (mobile backhaul) should be included into the relevant market. The NRA did not comply with the request but started a new round of study of the situation on mobile backhaul market focusing on fibre wholesale leased lines used for mobile backhaul (as a separate market). However, the NRA finally refrained from including mobile backhaul into the definition of Market 4 as that service was regarded as not meeting the relevant product market definition.

3.2.2 Experiences with dispute settlements

From the responses received, NRAs, in 19 countries (AT, BG, CH, CZ, DE, DK, EE, EL, ES, FI, IT, LV, LU, MT, PL, PT, UK, RS, TR), stated that there has been no dispute regarding mobile backhaul in that specific country so far. In one country (FR) there has been one dispute to be handled by the NRA involving the incumbent operator and an alternative operator, both are present in the fixed and mobile markets.

In France, the NRA has imposed on the incumbent operator, Orange, the obligation to provide access to alternative fixed operators to its fixed backhaul via a passive dark fibre offer called

"LFO."[28] This offer is regulated as an ancillary service to provision of local access at a fixed location in the market analysis 3a. In the context of market 3a of 2014, the NRA decided that Orange's copper local loop should also be used for mobile backhaul, and by transitivity LFO. The incumbent then allowed the collection of mobile data streams via LFO when the operator was using fibre local loop to connect its antennas.

In 2015, a dispute settlement was brought before the French NRA by Free, a mobile operator also present in the fixed market. Orange asked Free for a higher tariff to use LFO to collect mobile data streams than the tariff used to collect fixed data streams. The NRA, in its decision n° 2015-0971-RDPI[29], prohibited Orange from charging an additional tariff to use LFO for mobile data streams compared to the tariff for fixed data streams. Meanwhile, the NRA took into account this decision in its pending market analysis 3a by imposing to Orange to provide LFO to collect data streams regardless of their origin at the same tariff. The dispute settlement was subject to an appeal procedure. On the 29th of June 2017, the Paris Court of Appeal confirmed the NRA's decision.

3.3 Possible evolution of regulation

Lastly, NRAs were asked about their anticipation of the evolution of the regulation in the fixed-mobile convergence context. In 16 countries (AT, CZ, EE, ES, FI, FR, IT, LV, LT, LU, MT, PT, RS, SI, TR, UK), NRAs answered this question and gave their point of view on the possible evolution of their regulation.

From the responses received, ten NRAs do not think that regulation on mobile backhaul needs to evolve in the medium term.[30] However, the NRAs of Finland, Slovenia and UK[31] are studying if regulation to access dark fibre to base stations is needed. In particular, neutrality of usage of dark fibre seems necessary with the arrival of 5G that require very high-capacity connection between access points.

For Austria, the increase in bandwidth demand is leading the NRA to consider to modify the regulation of dark fibre and Ethernet services currently in place on market 4. The goal is to allow wholesale customers to increase their bandwidth in certain intervals without significant increases in costs.

The NRA in the Czech Republic expects that the importance of mobile backhaul will increase with growing consumers' data consumption and new development of mobile network. The Czech NRA has considered that it is not possible to impose obligations on mobile backhaul under markets analysis 3a, 3b and 4 (see section 4.2.1 above) because mobile services are not included into the definition of these relevant market and is now studying the possibility of defining and analyzing a separate market for mobile backhaul. Next to the general question whether dark fibre /duct access for mobile purposes is needed, the German NRA also considers the question where to actually impose such access a difficult one since the product

[28] LFO: Lien Fibre Optique.

[29] https://www.arcep.fr/uploads/tx_gsavis/15-0971-RDPI.pdf.

[30] NRAs of France, Greece, Italy, Latvia, Lithuania, Luxembourg, Portugal, Serbia, Spain and Turkey.

[31] In the UK, Ofcom imposed dark fibre in April 2016 as part of their business connectivity market review (market 4). In July 2017 the Competition Appeal Tribunal (CAT) ruled that that Ofcom had erred in its market definition decisions in that market review. However, the CAT has not yet provided its full judgment nor made an order setting out the terms on which the issue will be remitted to Ofcom, so the implications for Ofcom's remedies are not yet clear.

is not clearly addressed in one of the markets recommended for ex ante regulation by the Commission.

Overall, based on their answers to the questionnaire, NRAs indicated that they have not identified any regulatory obstacle with regards to fixed-mobile convergence in the current regulatory framework. However, some NRAs have stated that they remain attentive to market developments,[32] given the increase in mobile data usage.

3.4 Fixed-mobile substitutability

This section summarizes the considerations of NRAs on the substitutability of fixed-mobile services. It also deals with the existence of obligations other than market remedies applicable to all ECS and non-ECS infrastructure that are suitable for provision or deployment of mobile backhaul.

NRAs were asked if and how they take into account fixed-mobile convergence in fixed regulation.

Most NRAs stated that generally, fixed-mobile convergence is increasing. Yet, a number of NRAs said that they are still not including fixed and mobile services in the same retail market since different preferences and user patterns, diverging prices, mobility and usage limitations as well as a fairly stable number of active fixed lines indicated a currently relatively low substitutability (DE, BG, EL, IT, LT). LV considered fixed and mobile voice services to be in the same retail market, however no substitutability between mobile and fixed broadband services was found. Similarly, NRA in CZ in its market analyses considered fixed and mobile voice services to be in the same retail market. Among other things this led to deregulation (in 2016) of former relevant market 1 and 2 (2007 Markets) in the Czech Republic. Czech NRA also took into account mobile services when analysing relevant markets 3a, 3b and 4 (assessed their substitutability) even if it did not impose any specific regulatory obligations that have impact on mobile backhaul.

Other NRAs pointed out that they investigate and take into account mobile services when analysing the fixed markets 3a, 3b and 4 (EE). NRAs in PT and UK stated to take account of the increasing fixed-mobile substitution by including mobile backhaul in the (fixed) market 4. NRA in ES considers its regulation of duct access (Market 3a) to take account of fixed-mobile convergence: mobile and fixed operators do have access to the SMP operator's civil infrastructure, provided that their rollout is aimed at mobile or fixed retail broadband provision to end customers.

Most NRAs declared that they intend to carefully monitor the future evolution of the fixed-mobile relationship, especially in the course of the coming market analyses.

3.5 Obligations to undertakings other than ECS operators

When asked whether companies other than ECS operators are obliged to grant access suitable for mobile backhaul, most NRAs referred to the Directive 2014/61/EU of the European Parliament and of the Council of 15 May 2014 on measures to reduce the cost of deploying high-speed electronic communications networks. NRAs highlighted that the cost reduction Directive provides a very general entitlement for access to physical infrastructures usable for (mobile and fixed) broadband deployment (excluding access to dark fibre), without it being specifically meant for mobile backhauling purposes. While many of the respondents have

[32] Austria, Czech Republic, France, Germany.

already transposed the Directive into national law (CZ, DE, DK, EE, EL, ES, FI, FR, IT, LU, MT, PL, PT and UK), a number of countries (e.g. BG, RS) are still in the process of transposition.

Latvia and Portugal have obligations (dating back to pre-BRCD times) for all infrastructure operators (ECS and non-ECS) to provide access to physical infrastructure suitable for ECS deployment.

PL, CH and TR specified to have no such regulation. CZ and RS both stated that access so far is only possible on a commercial basis; both NRAs however expect some implications from the transposition of BCRD.

4 Implications

This section presents the conclusion of the report, based on the considerations of sections 1, 2, and 3. The report shows that – as mobile data demand is growing considerably – backhauling of mobile traffic is a topic of increasing importance and great interest.

Section 1 shows that in response to increasing requirements in terms of speed and availability (in particular in a 5G context with a considerably higher number of BTS to be connected) MNOs are in the process of switching gradually from legacy solutions to higher capacity fibre-based backhaul links. While the collected data show that wireless technologies (microwave links) are still the predominant technology (connecting more than half of the BTSs in 2016) for the mobile backhaul segment up to the base stations, the data also confirms a tendency towards fixed technologies (in particular fibre links).[33]

Section 2, dealing mainly with MNOs' responses to the questionnaires, revealed that regarding network ownership, the backhauling solutions implemented by MNOs are generally a mix of own and leased infrastructure. A majority of MNOs indicated that the existence of regulated offers is important; allowing them also to negotiate better commercial terms when they bought unregulated products. Fixed-mobile operators, which have emerged from the incumbent operator, typically show very high shares of self-owned infrastructure since they commonly have the highest coverage by fixed and mobile networks. However, in terms of data volume transferred, up to now MNOs' reliance on infrastructure of third parties (whether on regulated or commercial terms) is generally relatively low in comparison with self-owned provision. A key factor for this behaviour seems to be the growing need of the MNOs to control completely the technical conditions of mobile backhaul. There is no general opinion between MNOs, and especially between those that do not provide fixed services, on whether they will change the share of mobile backhaul self-supplied, bought commercially, or bought from regulated offers. For this point, some MNOs without a fixed branch say that it will depend on the technical and economic conditions of the available products.

MNOs agree that backhaul solutions based on optical fibre are needed, this need being driven by increasing traffic on the end users' side and by the evolution towards 5G technologies, asking for low latency as well as an increasing number of local access points. While some fixed (and mobile-fixed) operators are successively rolling out such fibre infrastructures, mobile-only operators prefer to get access to fixed operators' infrastructures. Some MNOs are calling for regulated wholesale products to fill in their needs to connect mobile base stations, reaching from active leased lines access to dark fibre and duct access. Within the transition

[33] We should, however, bear in mind the words of caution expressed at the end of section 1.

from legacy to fibre technologies, most operators hence will foreseeably need to keep on relying on a mix of owned and leased infrastructure. The level at which infrastructure is leased (ranging from active to deep passive) might however differ, depending on the business model.

Section 3 deals with NRAs experiences and practices in the context of fixed mobile convergence. According to NRAs, the scope of the current regulatory solutions possibly impacting on mobile backhauling includes leased lines, access to ducts, dark fibre, LLU access and fixed backhaul. The correspondence between the regulatory products (or remedies) and the implementing market varies across European countries.

None of the NRAs stated to have defined a specific national market for mobile backhauling. Instead, where mobile backhaul access is addressed, it is generally implemented by extending (fixed market) remedies to an enlarged market scope (namely leased lines rent and duct access) and/or by enlarging the scope of network usages such remedies can be put to (i.e. to mobile backhauling purposes). For instance, some NRAs decided to impose access to civil infrastructure (in particular to ducts) as an SMP-obligation when reviewing market 3a, allowing for using such access also for the realization of mobile backhaul. Some NRAs have also decided that duct access can be used to reach the BTS as well. For example, one reason given is that there should be no limitation in the type of use as long as the final goal – namely providing end users with broadband access – is realized, independently of whether this is done via fixed or mobile technologies. Other countries chose to ensure mobile backhauling by including it as an equivalent in the leased lines market 4.

Bringing both MNOs' needs and NRAs' current regulatory approaches together, some MNOs – especially in those countries where dark fibre for backhauling purposes has not been regulated – consider that current regulated offers are not technically sufficient for their needs. This could become a bigger regulatory issue, as the deployment of 5G implies even higher performance requirements. At the same time, most NRAs are aware of the importance of fixed-mobile convergence and plan to adapt their regulation to the arrival of 5G when necessary. For example, some NRAs indicated that they would consider the possibility of imposing dark fibre access in their next market review as a response to operators' need for backhauling purposes.

Based on their response to the questionnaire, within the current regulatory framework, most NRAs seemed not to encounter regulatory obstacles in imposing access obligations for mobile backhaul services via fixed network infrastructures. From the findings of this report, it can be concluded that, at this stage, NRAs can take into account fixed-mobile convergence into their fixed market analysis, and in particular, can adapt their fixed regulation to encompass mobile backhaul services via various remedies depending on the infrastructures available and the preference of national operators. Therefore, the need for the creation of a separate regulated mobile backhaul market has not been clearly identified yet. Nevertheless, given the advent of 5G networks and increasing demand for capacity by mobile operators, it is important for NRAs to continue monitoring the needs of mobile backhaul transmission and fine-tune their regulatory toolbox accordingly. As of now, if necessary, NRAs can always refer to the Explanatory Note to the Recommendation, in which the Commission leaves the NRAs with the option to identify specific competitive problems which require a separate national market for passive access to backhaul infrastructure.

Annex 1

	Market 3a – duct access as an **ancillary remedy** to LLU	Market 3a – dark fibre access as an **ancillary remedy** to LLU	Market 3a – duct access as a **self-standing remedy**	Market 3a – dark fibre access as a **self-standing remedy**	Market 4 – access to terminating segments of leased lines
AT	X • Can be used for mobile purposes • No restriction, can be used to connect BTS to core	X • Can be used for mobile purposes • No restriction, can be used to connect BTS to core			X • Terminating segments Etherlink and dark fibre (but dark fibre is not available everywhere) • No restriction, can be used to connect BTS to core
HR					X
DE	• Cannot be used for mobile purposes • restricted to route between MDF and street cabinet	• Subsidiary to duct access (see above) • Cannot be used for mobile purposes • restricted to route between MDF and street cabinet			X restricted to bandwidths ≥ 2 Mbit/s and ≤ 10 Mbit/s and > 10Mbit/s and ≤ 155Mbit/s
BG			X Duct access in access as well as backhaul part		
EE			X Duct access in access as well as backhaul part		
EL					X

	Market 3a – duct access as an **ancillary remedy** to LLU	Market 3a – dark fibre access as an **ancillary remedy** to LLU	Market 3a – duct access as a **self-standing remedy**	Market 3a – dark fibre access as a **self-standing remedy**	Market 4 – access to terminating segments of leased lines
ES	X[34] • Can transport mobile traffic • Only as an ancillary remedy to Leased Lines, Ducts and LLU Access Offers • Only for the fixed backhaul segment (from CO to PoP) • It has usage restrictions	X • Can transport mobile traffic • Only as an ancillary remedy to Leased Lines, Ducts and LLU Access Offers • Only for the fixed backhaul segment (from CO to PoP) • It has usage restrictions	X Duct access in access as well as backhaul part		X • Terminating segments traditional interfaces at 2, 34 and 155 Mbit/s • Terminating segments Ethernet based at 10, 100 Mbit/s and 1 Gbit/s
FR		X Restricted to route from MDF to premises	X		X
FI					X
IT		X Restricted to route from MDF to premises			
LV			X Duct access in access as well as backhaul part		
LU	X				X Based on Ethernet point to point products with quality of service

[34] In Spain, duct access is declared as ancillary service to the access services of leased lines and LLU markets. In these cases ducts can only be used for the FIXED backhaul segment (from CO to PoP). It can nonetheless be used to carry mobile traffic within the CO-PoP segment. On the other side duct access is also a self-standing remedy in market 3a. This market includes access down to the BTSs through ducts.

	Market 3a – duct access as an **ancillary remedy** to LLU	Market 3a – dark fibre access as an **ancillary remedy** to LLU	Market 3a – duct access as a **self-standing remedy**	Market 3a – dark fibre access as a **self-standing remedy**	Market 4 – access to terminating segments of leased lines
PL					X
PT			X	X Access to dark fibre when there is no duct or pole availability	X
RS			X Duct access in access as well as backhaul part		X
SI					X
TR					X
UK					X

DETAILED COUNTRY EXAMPLES

*In **Austria**, regarding regulation in fixed markets that can have an impact on mobile backhaul, Market 4 obligations (i.e. wholesale high-quality access provided at a fixed location) are considered most relevant by the NRA. Relevant remedies for mobile backhaul are access to terminating segments of Etherlink services and access to terminating segments of dark fibre in certain areas according to geographically segmented market definition[35]. Regarding tariff obligations, cost-oriented prices are mandated.[36] Moreover, duct and dark fibre access is imposed as an ancillary remedy to market 3a LLU access; both remedies can principally be used to connect base stations to PoP locations. Prices for Ethernet Services and traditional leased lines are differentiated by bandwidth while prices for dark fibre are per meter. According to the NRA, prices are considered too high by alternative operators. In addition, the reference offer for dark fibre has only been taken up to a very limited extent. Furthermore, operators (in particular mobile operators) are pointing out that they need pricing schemes where bandwidth increase does not lead to significant price increases since bandwidth demand is growing but retail revenues are not.*

*In **Spain**, regarding regulation in fixed markets that can have an impact on mobile backhaul, Market 3a (covering also duct access for local loop and fixed backhaul) and Market 4 (covering terminal segment of leased lines for fixed and mobile backhaul) obligations are considered relevant. Thus there are a number of standard offers in Spain which cover services (possibly) relevant for mobile backhaul, namely ORLA for leased lines, RUO for LLU access and MARCo for duct access.*

ORLA, the leased lines reference offer provides for active access to wholesale terminating segments of leased lines, ensuring a fixed capacity between two points. It can be used to connect BTS to the PoP of the operator requesting the wholesale leased line service. The reference offer currently includes leased lines based on traditional interfaces at 2, 35 and 155 Mbit/s as well as Ethernet[37] based at 10, 100 Mbit/s and 1 Gbit/s. Tariffs for traditional leased lines cost oriented; prices for Ethernet-based leased lines follow a retail minus approach.

MARCo is the duct access reference offer, initially implemented for FTTH deployment purposes. The terms of the MARCo apply equally to duct access for mobile backhaul purposes. In order to promote investment in NGA, duct access can only be used for deployment of NGA technologies (both fibre and coaxial cable) but not for copper. Tariffs for duct access are cost oriented.

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[35] The NRA has defined two submarkets: Market 1 covers Ethernet-based terminating segments of bandwidths > 2 Mbit/s and dark fibre terminating segments *within* 359 municipalities; this Market 1 is deregulated. Market 2 is regulated and covers, on the one hand, Ethernet-based terminating segments of bandwidths ≤ 2 Mbit/s *within* those 359 municipalities and, on the other hand, Ethernet-based terminating segments of any bandwidth as well as dark fiber terminating segments *outside* of those 359 municipalities. See standard offers of A1 Telekom Austria for terminating segments of Etherlink services (https://cdn3.a1.net/final/de/media/pdf/Vertrag_betreffend_terminierende_Segmente_von_A1_Ether_Link_Services_mit_garantierter_Bandbreite.pdf) and terminating segments of dark fibre (https://cdn1.a1.net/final/de/media/pdf/Standardangebot_Terminierende_Segmente_von_unbeschalteten_Glasfasern.pdf).

[36] In the access segment, prices for dark fibre leased lines are 17 cent per month and meter. Outside the access segment, prices are either 28 cent per month and meter (in areas with buildings) or 13 cent per month and meter (in areas without buildings). The NRA explained that costs for civil engineering are considerably lower in areas where no buildings are present than in urban, densely populated areas.

[37] There is a list of central offices where Ethernet leased lines can be requested, but covers majority of the territory. Regulated Leased lines have a maximum length of 70 km but can be even higher only if they connect two points located within the same province.

Ducts Offer may be used for the deployment of FTTH to final subscribers but also to allow MNOs to transport the signal from BTSs to the Central Office. RUO is also available for mobile backhaul, although it has a very residual use for this purpose.

Finally, Leased Lines, Ducts and RUO Offers *can benefit from ancillary services, such as 'backhaul circuits' or dark fibre, to address the fixed backhaul segment (from the Central Office to the PoP).* They have usage restrictions. *For instance, the usage restrictions for the ancillary CO-PoP dark fibre service are the following: the incumbent operator shall provide dark fibre up to 20 km, only in central offices with less than 7.000 pairs, and only if there is spare fibre. This has to be done under reasonable non-discriminatory conditions.*

*In **Finland**, regarding regulation in fixed markets that can have an impact on mobile backhaul, Market 4 (capacity based products) is seen as most relevant by the NRA. Relevant remedies for mobile backhaul in Finland are access to capacity based leased lines (SDH/PDH/Ethernet), the obligation to publish terms and prices and the non-discrimination obligation.*

*In **France**, fixed backhaul, via dark fibre offer, is considered as an ancillary remedy to LLU access in market 3a. Thus, fixed backhaul is subject to regulation and the NRA imposed mobile data streams collection from dark fibre. France has experienced a dispute settlement in 2015 (which will be developed in section 4.2.2) which has resulted in the prohibition of pricing differentiation according to the type of data streams. Given that the pricing of the incumbent's dark fibre offer for fixed data streams is regulated, the pricing of mobile backhaul when used alongside fixed backhaul is regulated too.*

*In **Bulgaria, Estonia, Latvia and Serbia**, the NRAs imposed access to the incumbent's ducts in the regulation of market 3a for mobile data streams. The incumbent's ducts can be accessed at the level of the local loop and/or the fixed backhaul.*

*In **Turkey**, regarding regulation in fixed markets that can have an impact on mobile backhaul, Market 4 is seen as most relevant by the NRA. Relevant remedies for mobile backhaul in Turkey are access obligation, non-discrimination, transparency including publication of key performance indicators for each quarter, preparation and publication of reference offer including quality of service commitment, tariff control (cost-oriented prices), accounting separation and cost accounting as well as co-location and facility sharing. Legal bases in Turkey are the "Electronic Communications Law numbered 5809" and the "By-law on Market Analysis". No disputes had to be settled in Turkey with regard to fixed backhaul.*

Annex 2

Austria	AT
Bulgaria	BG
Croatia	HR
Czech Republic	CZ
Denmark	DK
Estonia	EE
Finland	FI
France	FR
Germany	DE
Greece	EL
Italy	IT
Latvia	LV
Luxembourg	LU
Lithuania	LT
Malta	MT
Netherlands	NL
Poland	PL
Portugal	PT
Serbia	RS
Slovenia	SI
Spain	ES
Sweden	SE
Switzerland	CH
Turkey	TR
United Kingdom	UK