BoR (25) 32

Summary Report on the outcome of the public consultation on the draft BEREC Report on the evolution of private and public 5G networks in Europe

13 March 2025

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Executive Summary

BEREC's Board of Regulators adopted the "Draft BEREC Report on the evolution of private and public 5G networks in Europe" (the "draft Report") for public consultation at the 60th BEREC Plenary meeting (3 October 2024).

The draft Report sets out BEREC's preliminary views on the current status, and needs, and regulatory issues concerning the implementation of private 5G networks in Europe, from the perspective of national regulatory authorities ("NRAs"). BEREC's views were predominantly based on an internal survey to NRAs. BEREC set out that there are many configurations and architectures of private mobile networks from the isolated standalone private networks to public network integrated private networks in the form of a private slice of a public 5G network. BEREC's view was that it was very likely that a significant part of private network deployments may not be known to NRAs because of the different classifications and registrations used by NRAs. For instance, this may happen where MNOs deploy private networks without the need to register this as a private network, where other companies deploy standalone private networks using (leased) MNO spectrum, or where there is no obligation to separately register certain types of private networks. As a result, potential difficulties faced by private network actors which regulation might address, may go unnoticed. BEREC set out it was also aware that EU Members States are taking different approaches regarding numbering and spectrum issues and that it is the intent of the European Commission (through the Radio Spectrum Committee) to harmonise dedicated radio frequency ranges for private networks.

From 8 October until 29 November 2024, stakeholders were invited to comment on any of the material presented in the draft report, including answering consultation questions on numbering, drivers and use cases raised in chapters 3 and 4 in the draft report.

BEREC received 20 contributions (including two anonymous contributions) from the following stakeholders:

1. Anonymous contribution (Stakeholder_1);
2. Anonymous contribution (Stakeholder_2);
3. Connect Europe (ETNO) - Association of leading providers of connectivity networks and services in Europe;
4. DECT Forum - International association of the wireless home and enterprise communication industry;
5. European Broadcasting Union - Alliance of Public Service Media;
6. EENA - European Emergency Number Association;
7. GSMA - Association representing the interest of MNOs;
8. HPE Hewlett Packard Enterprise - Multinational IT company;
9. Liberty – Global Multinational telecommunications company;
10. MVNO Europe – Europe Association representing Mobile Virtual Network Operators;
11. Nokia - Finnish multinational communications and information technology company;

12. Obvios - French company that provides software solutions for 5G NPN networks;
13. Radtonics - Global private wireless network provider;
14. Sateliot - LEO Satellite operator to offer IoT connectivity over standard 5G Narrowband IoT;
15. Siemens - German multinational technology conglomerate;
16. Transatel - Global cellular IoT connectivity solutions provider and a leading MVNO Enabler;
17. University of Oulu - University in Finland;
18. Västra Götaland Region - County council governing the territory Västra Götaland in Sweden;
19. Volvo - Autonomous Solutions Research and product development in Sweden;
20. 4iG Group - Service provider in telecommunications which operates in Hungary and Western Balkans.

BEREC is grateful for the responses received, which set out additional and, in some cases, new and interesting information on the topic of the evolution of private 5G networks in Europe. As part of equipping itself with a broad range of inputs, BEREC experts also held invited presentations with some 5G private network users at a working group level meeting on 27 January 2025, and the non-confidential informations from these presentations are published alongside this summary report, the submissions from respondents to the consultation, and the Final Report itself.

This report summarises the consultation responses received and includes BEREC's relevant observations.

Structure of this report

The report is structured as follows:

- **Chapter 1** sets out an overview of stakeholders' general comments & observations.
- **Chapter 2** sets out stakeholders' specific comments, some of which request BEREC to amend or introduce new text in the report.
- **Chapter 3** sets out stakeholders' feedback in response to the consultation questions on numbering at chapter 3 of the draft report, BoR(24) 150.
- **Chapter 4** sets out stakeholders' feedback in response to the consultation questions on drivers and regulatory/technological/other challenges at chapter 4 of the draft report, BoR(24) 150.
- **Chapter 5** refers specifically to use case studies and associated drivers in line with the chapter 4 of the draft report, BoR(24) 150.

Interested readers are encouraged to review the material received from the stakeholders for the definitive version of their responses. BEREC also reminds readers that the purpose of this particular work item was to inform itself about the developments in 5G private networks in Europe (and their interrelations with the evolution of public 5G networks), and as such, BEREC sets out only high level observations when considering the answers to the questions, because it is not appropriate at this time to make any conclusions on them.

In summary, based on the available information and level of understanding by BEREC of the issues, 5G private networks have many diverse users and drivers depending on particular needs. Interrelations with the evolution of 5G networks is also at a relatively early stage, and if there are issues around interconnection, roaming, emergency 112 access these are not yet well defined.

1. Overview of stakeholders' general comments

This chapter provides a short summary of stakeholders' general comments and relevant observations, and concludes with BEREC's response.

In general, all of the stakeholders welcomed the opportunity to provide their view on questions and topics raised in BoR (24) 150, the "consultation".

Stakeholder_1 appreciates that BEREC's report recognizes a variety of deployment models for private 5G networks, which range in a similar vein from an isolated deployment in a standalone private network to ever more integrated variations with the public network. It believes that each one of these solutions has its own added value for its users – in terms of control over data flows and users on the network, local autonomy, and in terms of cost and complexity. From the perspective of the network operator, each of these solutions has its own requirements for spectrum and numbering resources.

Since different technical solutions exist to implement 5G private networks, **Stakeholder_2 and Liberty Global** consider that it is important to favour the ones offering more efficient resource usage to increase opportunity for a real market development.

Stakeholder_2 is not surprised that private network users seek access primarily to resources in the 3400-3800 MHz frequency range (3GPP n78 band), as presented in the report, but such spectrum has been already allocated in most of EU countries for 5G public networks after very expensive auctions for MNOs, both in terms of license acquisition fees and new advanced radio equipment capable to maximize spectrum efficiency. Therefore, **Stakeholder_2** believes that standalone private network (isolated deployment), managed by parties other than authorized mobile telephony operators, and with dedicated radio access is not the right choice to pursue. Spectrum is a scarce, very expensive resource, and MNOs have the expertise and the economy of scale to build and deploy advanced and more efficient 5G networks, both at private and public level. Shared radio access network and control plane or, in some cases, even private network hosted by the public network offer a more maintainable and resource-efficient solution in the long term, addressing most, if not all private network users' requirements.

Stakeholder_2 believes that the frequencies, for which operators currently hold rights of use, will be insufficient to manage the expected evolution of mobile radio traffic (voice and data) on the networks. For this reason, it is considered desirable to continue with the assignment of rights of use for frequencies only for public use.

University of Oulu underlines that the draft report provides important status information and sets the steps for the future work. There can also be other relevant regulatory topics in private 5G and 6G networks such as terminology, security and privacy, access regulation and interconnection, competition and pricing, that are not addressed in the BEREC report. The current draft report presents preliminary information about the status of private 5G networks in Europe, which should be stated in the report. It would be important to continue the European level regulatory work on private 5G and 6G networks. RSPG has taken a role in the spectrum policy domain to address this. Similarly, BEREC could play a role in other regulatory topics for private 5G and 6G networks except the radio spectrum acting as the forum for regulatory discussions on private 5G networks by bringing together regulators from different countries with industry and academia to collect inputs from all relevant stakeholders.

University of Oulu draws attention to the national and EU level research initiatives addressing private 5G and future 6G networks. There is a need to bring the research community of experts to the table and the BEREC could build a bridge between the regulatory domain and the research domain by creating mechanisms for information sharing. Independent research conducted at academic and other organizations plays an important role in the topic, balancing the self-interests of stakeholders towards the common good. There is a need to develop mechanisms that allow the voices from the academic stakeholders to be heard in the process beyond what was done in this study. For example, EU-funded and national level funded research projects address private 5G and 6G network topics and can significantly contribute to regulatory activities, when there are proper mechanisms in place for the information exchange.

Connect Europe and **GSMA** appreciate that the draft report recognizes the role of the Mobile Network Operators (MNOs) as private network solution providers. For most customers interested in having a private network, the communication systems and networks are not their “core business”. Thus, instead of setting-up an in-house team to build and operate this private network, many decide to purchase the private network solution and its operation from MNOs, which have long experience in providing secure and reliable communication solutions.

MVNO Europe considers that NRAs and BEREC could take-on a positive role, in gathering, aggregating and publishing reliable information with regard private wireless network authorisation and related requirements in EU Member States, in all spectrum bands, covering license-exempt spectrum, experimental licensing, and individually licensed spectrum, and covering all technologies. This information would be informative for the community of NRAs themselves, could constitute a BEREC contribution to the work of the Radio Spectrum Policy Group (RSPG), the European Commission, other EU institutions, and the CEPT, and would have clear added value for all stakeholders interested in spectrum policy and telecommunications policy more broadly. For business end-users, as well as for specialised providers (including MVNOs) interested in delivering private wireless networks and/or MVNO-based solutions customised for business end-users, it would be of high interest and relevance to have a centralised and easy to consult source of information on the spectrum available for private wireless networks (any band, any type of licensing, any technology, applicable one-off and recurring fees) in a tabular format, covering all EU Member States.

Liberty Global believes that network slicing and/or hybrid solutions provided by mobile network operators (MNOs) can accommodate the private network needs of enterprise customers most efficiently, including where scarce resources (numbers, spectrum) are concerned. **Liberty Global** commends BEREC for recognizing that the diversity of “*different classifications and registrations*” used by national regulators may be the cause of a lack of awareness or visibility amongst regulators as regards a “*significant part of private network deployments*”. Moreover, BEREC acknowledges in its conclusions of the draft report that this ‘knowledge gap’ may lead to suboptimal regulatory outcomes. **Liberty Global** acknowledges BEREC’s effort to address this knowledge gap, as demonstrated through the consultation of the draft report. Additionally, **Liberty Global** recommends BEREC to continue to pursue this broad, transparent and active approach of stakeholder engagement in the domain of private

5G networks, considering the fast evolution of both market conditions and relevant technologies used in private networks.

As a general observation, **Liberty Global** notes that the implementation of 5G networks is currently still ongoing in the primary and pioneer bands identified for 5G and that roll-out – in some cases – has been hampered significantly by Member States' diverging regulatory practices. Whilst some new solutions for more dynamic and shared use of spectrum have already been introduced with the uptake of 5G, this demand is expected to only increase with 5G's evolution and during the uptake of 6G. At the same time, however, **Liberty Global** expects the extensive infrastructure investments already made by MNOs in 5G and 4G to continue to play an essential role in the uptake of 6G as well.

In terms of private 5G network investment, **Hewlett Packard Enterprise** notes that analysts predict a CAGR of approximately 42% from 2024 to 2027, with contributions from vertical industries such as manufacturing, utilities, and many others. The integration of these networks is expected to generate nearly $9 billion by the end of 2028[1]. **Hewlett Packard Enterprise** believes that in the future, private 5G and Wi-Fi will work jointly, enabling new use cases for customers in which outdoor coverage and latency play a fundamental role; this synergy finds application in contexts such as ports, defence applications, mining activities and sporting events. Historically, the adoption of mobile private networks has been hampered by complexity and high costs. In particular, private 5G has been considered too complex and burdensome in terms of resources to be implemented and maintained over time by companies. This is because the integration and management of the various components of such a network required specialist telecommunications skills that went beyond those possessed by most network IT managers and engineers. Fortunately, recent advances in mobile private network technologies and supplier offerings have simplified the use and adoption of such infrastructure by companies.

1.1. BEREC's response

BEREC thanks the respondents for their general remarks, which broadly seem to support the work done so far. BEREC also understands that different industry participants may have different views on the preferred approach to deploying 5G private networks. One respondent's view about the positive opportunity for BEREC to provide additional value on topics which are not being dealt with by the RSPG is noted. Security and privacy, access regulation, interconnection and pricing, are topics which BEREC agrees form part of functioning markets in electronic communications. BEREC currently believes that given the nascent state of 5G private mobile networks in Europe, potential issues in the domains mentioned, including those which could warrant regulatory intervention and oversight, simply did not emerge in this consultation. Calls for greater stakeholder engagement and awareness raising seem reasonable, and BEREC is pleased to have had engagement with a stakeholder from the

[1] Analysys Mason, Telecoms capex: Worldwide trends and forecasts 2018–2028, 2024

internet of things ("IoT") satellite communications ecosystem as well as from sets of stakeholders that use terrestrial private networks in practice, as well as with several stakeholders who offer to deploy 5G private networks.

2. Specific comments requesting BEREC to amend or introduce new text

This chapter provides a summary of specific comments requesting BEREC to amend or introduce new text at various sections of the report.

4iG Group considers that the draft report well describes basic technical configurations / architectures of the four major scenarios of 5G private networks and sets out that it would be beneficial to gain a more in-depth understanding of the advantages and disadvantages of the various scenarios, particularly in terms of the financial and operational differences. **4iG Group** also notes that the draft report correctly concludes, based on the authorities' experience and examples, that private 5G networks use the 3400-4200 MHz frequency range, however, **4iG Group** feels that it is an exaggeration to say that the 3400-3800 MHz band is predominant or prevailing (page 13), as there are many examples of successful use of the 3800-4200 MHz band for this purpose.

University of Oulu draws attention that Chapter 1 introduces many important terminologies, such as private 5G network, public 5G network, neutral host network (in private settings), connected private network, etc., but does not properly define or explain them. There is a need to properly explain the key concepts to help Europe make use of the new business opportunities arising from the new deployment models, which are particularly targeting different vertical sectors, such as industry, healthcare, transport and logistics, etc.

University of Oulu considers that current terminology in chapter 2 is not clear. The starting point for defining private networks is explained as follows: "*Private networks and in particular private mobile or wireless networks, are networks owned and operated by private entities and organisations such as enterprises, industries, and governments and in most cases primarily intended for specific use by these entities and organisations (footnote: In contrast, public mobile networks offer services to the general public--*." This connects private networks to private entities and organisations through "*owning and operating networks for specific use by these entities and organisations*". There is no discussion on "open" or "closed" user groups, which used to be an important defining factor in service provider discussions and private/public 5G network discussions previously. Public networks, on the other hand, are said to "*offer services to the general public*". It is not clear what these services are, and the only other defining term is the general public. Later in Section 2.1, the definitions from other sources are cited but there is not attempt to establish the notion of private networks in the current BEREC work. Developing a proper definition for private mobile communication network would be an important step, which could be done by BEREC in collaboration with stakeholders. The follow up explanation "*As a result, private mobile networks are typically deployed to serve a private entity's premises, such as a campus or a factory by providing connectivity within a specific geographic area ('plot-related').*" connects private networks to "*a specific geographic area*", which is an important topic. This has been the focus in University of Oulu's research on local 5G and 6G networks, which can be private or public, depending on the end user group which can be closed or open, respectively. To address these issues researchers at the **University of Oulu** have used the terminology of "local 5G and 6G networks" to denote 5G or future 6G networks that cover a geographically restricted area and can be deployed by different stakeholders including mobile network operators (MNOs) and others. Local 5G and 6G networks can be private or public, depending on the end user groups whether they are restricted or not. The terminology about "local" is very important in the context of private 5G networks and the connection between local 5G/6G and private/public 5G/6G network could be further clarified in the draft BEREC report. For example, not all local networks are private networks and not all private networks are local networks but can cover wide areas as well. It would be helpful to provide clear explanations for the introduced terms including private and public networks as well as local mobile communication networks, to guide the community. If this is not possible, it would be important to state that currently the terminology is not defined but future work will address it.

University of Oulu notes the architecture options presented in Chapter 2.2, which consider four different deployment models, which are then mapped to radio spectrum, depending on whether the spectrum band is "MNO spectrum" or "other spectrum". The classification for "other spectrum" in reality covers a wide range of spectrum access options including unlicensed bands, locally licensed bands, and bands shared with incumbent non-MNOs, etc. University of Oulu has done research on spectrum access options for local 5G and 6G networks[2] and their availability varies a great deal between countries. There are developments particularly outside Europe that make spectrum available through different mechanisms to deploy private 5G networks. These different spectrum access options could be mentioned in Chapter 2.2. Regarding the spectrum discussion for private 5G in the draft report, RSPG has done extensive work on the topic in its Opinion on "5G developments and possible implications for 6G spectrum needs and guidance on the rollout of future wireless broadband networks" which was published in October 2023. The RSPG Opinion is an important source to include in the draft BEREC report. Furthermore, there are discrepancies in countries deployments in the main body of the text and the annex in the current BEREC report, which should be crosschecked.

University of Oulu considers that the heading could be adjusted to reflect the contents to be "BEREC Report on the evolution of private 5G networks in Europe". Alternatively, new contents about the evolution of public 5G networks should be added, which is currently not provided. A glossary of the terminology used in the report would be very helpful as an annex, similar to the three previous BEREC Reports on sustainability. Clear explanations for the used terminology would act as guidelines for the entire community to work on the private and public 5G network topics. BEREC could have a role in developing common definitions for private network topics.

According to **Connect Europe and GSMA** it is not always clear whether a specific conclusion, analysis, or question relate to private networks in general, or only to the isolated deployment operated in dedicated spectrum, which the report defines as "stand-alone private network". For example, the report concludes that "*The frequency range 3400-4200 MHz is the most common band for private 5G networks in Europe*". While it may be true, also when considering various private network solutions, this conclusion seems to be based only on "stand-alone private networks" on which regulators are aware of, e.g. to which they have issued licenses. According to **Connect Europe** the report rightfully also concludes that "*it is very likely that a significant part of private network deployments is not known to National Regulatory Authorities*

[2] M. Matinmikko-Blue, S. Yrjölä & P. Ahokangas. (2023). Spectrum Management for Local Mobile Communication Networks. IEEE Communications Magazine, vol. 61, no. 7, pp. 60-66, July 2023.

(NRAs) because of the different classifications and registrations used by NRAs". In addition, the question 1 under section 4.3.1 may be understood to focus on drivers primarily for "stand-alone private networks", not for drivers of private networks in general. **Connect Europe** would support a clarification from BEREC on whether specific conclusions and analysis relate to the private networks in general or only one deployment type. According to **Connect Europe and GSMA** a further clarification would also be needed regarding the reported number of actual private networks in use versus the number of issued licenses. For example, the draft report states under section 2.3 that there are 400 known private networks in Germany. While it is true that the German NRA has issued 400 licenses for private networks, the real number of private networks in operation is only a fraction of it.

MVNO Europe's and **Transatel**'s key comment is that companies which have invested in the technical capabilities needed to be an MVNO/MVNE/MVNA (Mobile Virtual Network Operator/Mobile Virtual Network Enabler/Mobile Virtual Network Aggregator) have relevant capabilities to bring to bear in the context of the deployment and management of private wireless networks (including 5G Stand-Alone networks). **MVNO Europe**'s and **Transatel**'s key request to BEREC in this context is to amend the text on Page 21, para 2 of the draft Report, to include explicit recognition of the capabilities of MVNOs as relevant specialist providers for the deployment/integration/interconnection/interoperability of private (5G) networks. **MVNO Europe**'s and **Transatel**'s simple suggestion is that the text be extended as follows, to reflect the reality that companies (end-users) rely on specialist providers including MVNOs to deploy and manage their private wireless networks: "*BEREC considers that depending on the needs, the cost of the solution, and the level of technical knowledge inside the company using a private network, the deployment of the private network can be led by the company via a standalone solution with owned spectrum, <u>led by, or outsourced to, specialist providers including MVNOs, with spectrum owned by them or their customers for private 5G Networks,</u> or led by the MNO with different configuration possibilities (see section 2.2.4).*"

MVNO Europe considers that BEREC's proposed finding to the effect that: "*As a result of its preliminary analysis, BEREC considers that the case for further harmonisation by it towards private networks is inconclusive at this stage*" (page 2) and, in the preliminary conclusions: "*BEREC considers that the case for further harmonisation by it towards private networks is inconclusive at this stage*" (page 25), seems premature, given that it may result from the lack of information identified by BEREC. There can be no doubt that there is a considerable degree of fragmentation within the EU today regarding spectrum and authorisation and related requirements for private wireless networks. An in-depth analysis, based on a compilation of more extensive information may lead to a finding that fragmentation is not justified by objective national differences, and may be detrimental to achieving outcomes which are positive for Europe's economy and society. One of the largest hurdles facing the deployment of private 5G networks in Europe is a lack of harmonised standards for power and performance regulations. In this regard, **MVNO Europe** urges BEREC to include in the final Report that there is a case for harmonised power and performance regulations for private 5G networks across the European Union.

Similarly to MVNO Europe, **Liberty Global** does not understand BEREC's suggestion that '*the case for further harmonisation by it towards private networks is inconclusive at this stage*". Whilst **Liberty Global** may agree with BEREC's restraint in such circumstances where it recognizes that '*it is the intent of the European Commission (through the Radio Spectrum*

Committee' to pursue harmonizing measures, **Liberty Global** notes that BEREC's role in the pursuit of a harmonized regulatory environment and level playing field should not be underestimated. Harmonization is a key contributor to legal certainty, and thus integral to ensuring continued innovation and investment in the digital sector, and to ensuring the competitiveness of European services and operators. **Liberty Global** therefore encourages BEREC's and the Commission's ambitions to further adopt common European approaches, with due regard for the most efficient use of spectrum and numbering resources by mobile network operators or vertical operators.

GSMA considers that the draft report seems to tend to present the 3400-3800 MHz band as predominant for private network solutions (noted on page 13). However, it is important to recognise that the 2300 MHz, 2600 MHz and 3800-4200 MHz bands are also used in Europe for private networks provided by MNOs. Any mentions in the document could be clarified with other ranges being added (e.g. in page 14) and explanation of the private network nature (with or without reservations of spectrum). Additionally, in general, the draft report appears to combine the cases of frequencies used for commercial offers and for trials. It would be helpful to highlight trials in the final version. As for the 3400-4200 MHz band, presenting this band as a single block where private networks can get licenses anywhere within it, raises some concerns. The technical conditions for 3400-3800 MHz allow the use of high-power transmission and so it can be used solely for this purpose for wide-area coverage by MNOs. As 3800-4200 MHz can technically only be used for low/medium power use then it should be used for local networks (MNO and private). To do anything different would reduce the efficient use of the spectrum in the full range 3400-4200 MHz. In the view of the GSMA, comparing large-scale public 5G networks to smaller private networks would not be accurate. Even in Germany, a leading industrial nation, only 400 licenses have been issued by the NRA, while only a fraction has been implemented in local 5G networks after five years. This also supports the reasoning to guarantee access to at least 3400-3800 MHz by full-power implementations by MNOs.

2.1. BEREC's assessment and response

BEREC welcomes the proposals of the stakeholders to improve the report and in this paragraph responds to the views.

Some stakeholders noted that the four major scenarios of technical configurations/ architectures of 5G private networks are correctly identified and recognise that all four scenarios are used in practice, although some more often than others. Some stakeholders asked for deeper examination of these scenarios, in order to allow a comparison of their traits. BEREC responds that this is not within the goal of this particular report, which aims in providing a factual overview on the extent of the use of private and public 5G networks in Europe, including drivers, requirements and related case studies. However, BEREC will assess the need to continue its work on the matter in future Work programs.

One stakeholder noted that the 3400-3800 MHz band should not be characterized as the predominant or prevailing band for use for private networks. The information that BEREC collected from the NRAs regarding the use of spectrum, clearly leads to this conclusion, as the vast majority of the private networks implemented in the Member States are using this band, according to the knowledge of the NRAs that provided this information. However, BEREC has no objection to replace the word “predominant” in the last paragraph of the introduction of section 2.3.

To the comment of one stakeholder that terminologies introduced in Chapter 1 of the report should be properly defined or explained in order to help Europe make use of the new business opportunities, BEREC would like to note that, as mentioned above, this report is a factual overview and does not set out to introduce new terminologies to describe 5G private networks. BEREC explores terminology already used by other competent bodies and notes other general industry concepts and notions about 5G private networks, particularly the differentiation between isolated deployments or network slice deployments within the architecture of an MNO’s or MVNO’s control. BEREC welcomes the proposal to develop a definition for private mobile communication networks that would be unambiguous. This would, however, have to be taken forward in collaboration with all stakeholders, whilst observing this does not seem to be a barrier to 5G private networks for many stakeholders. Further, as the results of this consultation have shown, and bearing in mind with only twenty responses received, few argue for any fundamental overhaul of definitions. Having greater clarity on the terms and definitions on network type and associated issues seems reasonable, so BEREC avoid using terms that are not an industry norm or might be open to wide interpretation. BEREC will consider this in any future work it conducts on 5G private networks.

As to the comment that there is no discussion on “open” or “closed” user groups in the report, “which used to be an important defining factor in service provider discussions and private/public 5G network discussions previously”, BEREC notes that in section 2.3 and footnote 26 of the report it is explicitly mentioned that, although “there are several implementations of private networks which differ on whether they use components of public networks and what parts of them they use”, “all private networks are restricted to a specific user group/end user organisation and thus not open to the public. A private network enables a connection between a limited group of users, thus the wider public cannot use the private network”. Moreover, in regard to the comment on the geographical aspect of private networks, BEREC would like to note that in its report the mention of “private mobile networks” “typically deployed to serve” “by providing connectivity within a specific geographical area” is not unambiguously connected to the notion of locality. The “specific geographical area” is defined by the area (location of the user group) that the owner of the private network is interested to serve and is not necessarily local, but it is of limited geographical and user coverage.

BEREC agrees with the view expressed that the RSPG opinion “5G developments and possible implications for 6G spectrum needs and guidance on the rollout of future wireless broadband networks” is an important source of information regarding the spectrum discussion for private 5G networks and has included a relevant paragraph in section 2.3. of the report.

To the comment expressed by one stakeholder that the title of the report should change to reflect the contents of the report, BEREC has carefully considered this proposal. Changing the title of a report is not a usual or typical practice in BEREC. In the present matter, there are a number of reasons which seem to support refining the title in this particular case, including that the work focuses on 5G private networks evolution, with the interrelation of 5G public networks being part of that enquiry, than on an assessment of the evolution latter networks. As a result, and bearing in mind that this is a fact finding report largely based on an NRA survey and complemented with information from the consultation, BEREC aligns the title to better fit the expectations of readers.

BEREC would like to respond to the relevant comments from stakeholders, that the analysis and conclusions derived in the report relate to all types of deployment and not only the stand alone type. However, as already stated in the report, the information is illustrative and not intended to be exhaustive because most NRAs have limited engagement with private network actors. Due to this reason it is not possible to provide definite data on the number of actual private networks in use, but only number of issued licenses, where this is applicable.

BEREC agrees with the request of several stakeholders to amend page 21, para 2 of the report and include specific mention of MVNOs, as providers that could also assist in the implementation of private networks.

BEREC notes the request of two stakeholders to acknowledge in the report the fact that there is a case for harmonised power and performance regulations for private 5G networks across the European Union, however, the information gathered by BEREC in the course of this exercise, is not conclusive enough in order to allow such a definite statement. Moreover, issues of spectrum harmonization fall within RSPG's expertise and European Commission's realm. However, BEREC acknowledges the need to further examine the issue and will assess the need to engage in further work on the matter in future Work programs.

3. Stakeholders' feedback in response to the consultation questions on numbering

In addition to inviting comments on any of the issues set out in the draft report, BEREC also asked stakeholders to provide feedback on the consultation questions on numbering, on which questions the stakeholders provided the following views:

***Q1 Did you request any numbering resources for standalone private mobile networks, and if so, please specify**:*

Stakeholder name	Nokia	Siemens
ITU-T E.164 numbers	No	/
ITU-T E.212 MNCs	Yes	Yes
ITU-T E.118 IINs	Yes	/
GSMA EIDs	No (not so far)	/

Stakeholder_2 notes that EID codes may be granted not only to authorized mobile radio operators, but also to entities that exclusively produce eUICC (and not to manufacturers of other equipment) previously authorized and who have in any case previously reached an agreement with an authorized mobile operator in the first application phase. Moreover, Mobile Network Operators (MNO) already authorized should also be automatically guaranteed the assignment of IIN equal to the MNCs assigned. The following codes should be so reserved: 1) eIIN 0xx to already authorized operators with assigned MNCs (mapping a yz MNC to a 0yz eIIN), and 2) the eIIN 9xx to entities that exclusively produce eUICC. The other eIIN codes should be reserved for future needs.

Q1-a) Are you using for private networks the global MCC 999 allocated by ITU TSB for shared use by private mobile networks?

Obvios uses MCC 999. Most of the recent deployments have been done with the self-assigned use of MCC 999. There are some concerns that the self-assigned use of MCC 999 might cause issues in the future. Obvios recommended a coordinated assignment by the regulator to avoid collisions. Collision of network identifiers can cause unexpected attempts to register to a private network. These attempts can create unwanted signaling load and pose a risk to the availability of a private network depending on the generated load. In order to avoid collision on a number level, **Obvios** have implemented a method to reject UEs that are not provisioned in the network, but try to attach. This functionality is standardized to avoid signaling storms. The drawback of this method is that these devices will not connect to the network with the same PLMN-ID until after reboot, and also not to the neighbor/home network.

Nokia uses MCC 999; **Siemens** does not use MCC 999.

Connect Europe considers that in general for private networks it is preferable to use the shared international resources made available by the ITU-T, such as shared MCC 999, and the future shared E.118 resources currently foreseen in the revision of Recommendation

E.118.1 (Allocation, assignment and management of global Issuer Identifier Numbers - IINs), in Annex B (International ITU-T E.118 Issuer Identification Numbers using global E.164 Country Code “999 ” for internal use within a private network). The rationale for using these shared international resources is not to waste scarce national resources, for uses within private networks that do not require uniqueness. In addition to these shared uses, it is also necessary for private networks located in surrounding areas to coordinate among themselves in order to avoid interferences. It is also possible, at the discretion of public mobile operators, to use public resources for private networks, as long as these resources allow for the decoupling and blocking of private users on the public networks. The case of roaming between private and public networks can be allowed in specific cases if requested by the private customers. The essential requirement for the public networks is to be able to distinguish and, if necessary, block private users on the public networks given that this is normally a requirement for the private networks themselves (e.g. for the protection of business activities).

GSMA sets out that the public mobile network operators can often use their existing MNC for private 5G network propositions that require more integration between the private and mobile network configuration – where the RAN and control plane is shared (2.2.2) or when a private network is hosted by a public network (2.2.3). On the other hand, if the private network services have to be restricted to the private environment, such as in the case of strictly stand-alone private networks, the preferred solution could be the use of a shared numbering resource, such as ITU-T MCC 999 or a national shared resource. However, apart from these configurations there are more hybrid models imaginable, not strictly following these descriptions, which may require tailored numbering resources.

Hewlett Packard Enterprise confirms the use of the MCC 999 for demo purposes and commercial deployments in the countries where such MCC (and PLMN) is allowed.

Q1-b) Are you using for private mobile networks specific MNCs allocated under the geographic MCC used in your country for shared use by private mobile networks? Have you noticed any problems that these allocated MNCs are not open in mobile phone operating systems (iOS and/or Android)? Have you noticed any problem in terms of interoperability with public networks (for cases in which private networks could need to interconnect/roam with public networks)?

Obvios uses MNCs allocated under the geographic MCC e.g. 208-90 allocated by ARCEP. 001-01 was used initially due to limited support in handsets. Interoperability with public networks has not been validated.

Västra Götaland Region highlights the necessities of allocation of a unique network identifier (PLMN) to facilitate interoperability with other semi-private networks. It is crucial to ensure that the functionality of **Västra Götaland Region** network is not constrained by limitations imposed by user equipment vendors solely due to our utilization of a private 5G network. Instances such as Apple's lack of VoLTE support for private networks with MCC 999 exemplify the potential challenges. Consequently, it is imperative for an organization of the scale and significance of **Västra Götaland Region** to secure necessary number resources, including PLMN-IDs and telephone numbers, to ensure seamless integration with public mobile network operators (MNOs) and other private networks.

In the context of private network identification, **Nokia** has noticed problems with support of PLMN ID parameter configuration for private networks in different devices available in the market. These are country specific, and in general, this parameter cannot be configured freely. For clarity, these are not related to identifying public network operators with PLMN ID.

With regards to numbering, **Stakeholder_1** believes that shared numbering resources, such as the ITU-T MCC-999 or any nationally available shared codes, can only be deployed in the standalone private network configuration. These standalone private networks can use the shared MCC-999 because some device manufacturers, such as Apple, recognize these numbering resources as valid for private networks and provide generic settings where features are generally enabled or manually configurable. Nevertheless, it is important to note that based on conversations with different device vendors, **Stakeholder_1** understands that not all large device manufacturers are willing to support MCC-999, where there is no clear owner to be contacted in case of problems. Hence, there would be a limitation in device choices which could in turn have business impact. Therefore, **Stakeholder_1** would prefer to use a unique MNC. As long as roaming between the private and the public mobile networks is required, the use of a unique and separate numbering resource is absolutely necessary. This does not need to be a unique MNC for every private network customer, but a unique MNC for every private network provider is needed (where the provider may serve many private networks and customers with the same MNC). Roaming with the public network is needed, for example, where a user of a private standalone network would like to be able to use some applications in exceptional cases, when they leave the geographic location of the private network. In instances where roaming between private and public networks is required, a unique identifier is needed so that the public network can identify which private network the user belongs to and route the respective control and user plane traffic to. This cannot be achieved with a shared MNC (with possible overlap of IMSI ranges) between different private networks. The MNC/IMSI space needs to be unique for each private network, and the MNC itself needs to be unique for each provider of private networks that wants to facilitate roaming on public networks. **Stakeholder_1** considers that the need for numbering resources is different for the other private network configurations: public mobile network operators can often use their existing MNC for private 5G network propositions that require more integration between the private and mobile network configuration – where the RAN and control plane is shared (2.2.2) or when a private network is hosted by a public network (2.2.3). Only when the closed user group of an isolated private 5G network needs to roam and be recognized as a separate group for special treatment, a separate, unique MNC is required (per network provider). The existing MNC for the public network could not be used here due to potential conflicts in case of overlapping coverage between private and public network and due to the need of different MNC dependent device settings. **Stakeholder_1** believes that the need for private network numbering resources is set to grow quickly. Nevertheless, scarcity does not seem likely as any market player active in the private network market would need only one unique MNC to identify their private network customers – even if they come from many different private networks.

Stakeholder_2 considers that both the solution adopting the same or separate MCC-MNC for the public and the private network could be suitable for the full separation of public and private networks, and should therefore be maintained. At the same time, the full separation of private and public network is possible even using the same MCC-MNC for the two networks. Currently such solution allows to avoid waste of numbering resources, and determine minor complexity in both network running both at maintenance and upgrade level.

Liberty Global submits that the allocation of unique MNC under a country's MCC, to enable private networks' end-users to connect to public communications networks, is not appropriate for a multitude of reasons. Firstly, because MNCs are a scarce resource and therefore this solution is not scalable, as the number of private networks is expected to grow rapidly over coming years. Secondly, because post-allocation of the unique MNC, the private network would need to establish roaming relationships with all public networks where its devices are expected to be connected. This vastly increases the administrative burden for all parties involved. Thirdly, because various jurisdictions require identification of the end-users on publicly available networks, private networks could be faced with complex traceability obligations. Therefore, **Liberty Global** submits that enterprise customers desiring a private network solution, which includes the ability for their end-users to connect to public communications networks, are better served by an MNO-operated solution. Such solutions will support this ability by default, since the operator SIMs will be used for both private and public network services.

Hewlett Packard Enterprise did not experience PLMN incompatibility with OS yet. However, when deploying private networks, the combination of allowed i) MNC, ii) 5G frequency and iii) support by mobile terminal equipment should be simultaneously matching. Besides using the PLMN owned by mobile network operators and end customers in EU, **Hewlett Packard Enterprise** uses PLMN 001-01 for testing and demo purposes.

Q1-c) Are you using private mobile networks with any other kind of 3GPP numbering resources (e.g. NID etc.)?

Obvios considered support of NID, but support of handsets and RAN equipment has not been verified yet. The ecosystem implementing NID is questioned.

Nokia and Siemens do not use 3GPP numbering resources.

Q2. Please describe measures to address interference aspects between private mobile networks close to each other if you are using the global MCC 999, or some other national E.212 MNC for shared use.

Obvios notes that no interference between private networks has been experienced on the numbering level. Mostly low-power radio is used, with which overlap in coverage with other networks is not very likely.

Nokia handles issues with numbering / PLMN on case-by-case approach, but according to Nokia this is not a major problem as long as the NPN SIM is considered as nome (by IMSI or EHPLMN list). When shared PLMN-ID such as with MCC 999 is used, in order to avoid possible confusion between neighboring private networks, more networks identifiers are used in order to ensure the uniqueness of each private networks. Such additional identifiers are for example AMF identifier, gNB identifier, Tracking Area Code (TAI) and Mobile Subscriber Identification Number (MSIN).

European Broadcasting Union underlines that it is preferable to use 3-digit MNCs (and not 2-digit MNCs) in order to create 1000 rather than 100 MNCs under the MCC 999 or a geographically defined shared MCC for standalone NPNs. It would be desirable that NRAs establish an assignment procedure and an appropriate coordination mechanism to avoid the use of the same MCC-MNC by multiple NPNs in the same geographical area. Content producers may be able to coordinate directly with other NPN users provided that they have access to the information about these other networks. It would be rather similar to the current on-site frequency coordination for PMSE applications, which is routinely carried out even in complex productions. As some professional production use cases could potentially occur anywhere and at short notice it is essential that interference is prevented rather than addressed once it has occurred.

In order to address interference among NPNs, **Hewlett Packard Enterprise** takes into account techniques, when allowed, for shared RAN and spectrum management, neutral host infrastructures, proper network design and planning, and advanced radio antenna technologies.

3.1. BEREC's assessment and response

BEREC thanks respondents for their views on the numbering issues raised in this chapter. Many stakeholders provided feedback on the most suitable combinations of MCC+MNC (PLMN ID) to be used in mobile private networks.

BEREC observes that the use of self-assigned MNC under the shared MCC 999, provided by ITU-T for internal use within a private network, is the preferred option for most stakeholders, in order to avoid wasting numbering resources. One stakeholder emphasizes that using 3-digit MNCs (rather than 2-digit MNCs) is preferable, as it allows for the creation of 1,000 MNCs instead of just 100 under the MCC 999 or a geographically defined shared MCC for standalone private networks.

It is also recognized that public MNOs can use their existing MNCs for deploying private networks integrated or hosted within their infrastructure, as long as private users are isolated and blocked from the public network. Stakeholder opinions on the use of unique PLMN IDs and numbering resources were mixed—one stakeholder sees the advantage of using a unique PLMN ID, while another believes it is inappropriate to assign unique MNCs. However, BEREC notes that a unique MNC would be necessary for private network use cases that require roaming with the public network. As further analyzed in section 4.4, this could provide a competitive advantage to MNOs in the deployment of private networks, as roaming cannot be supported with a shared MCC/MNC, such as MCC 999, unless a technical solution resolves this issue.

BEREC acknowledges that handset / device support is also needed for some combinations of MCC-MNC, and this device support is not always put in place.

One main observation from the result of the consultation is the extent to which network collisions was raised by respondents. BEREC notes the need to avoid potential network attachment issues related to MNC collision in nearby private networks when using un-coordinated shared PLMN ID, such as with MCC 999. Although there are few practical examples so far due to the limited deployment of 5G private networks, BEREC observes that the risk of network collisions is more likely in high-demand scenarios, and this is an issue that

NRAs should already be aware of. This concern has also been addressed in ECC Recommendation 17(02) amended 28 November 2023 “*Harmonised European Management and Assignment Principles for E.212 Mobile Network Codes (MNCs)*”.

Stakeholders have provided different solutions to address these collisions: (i) coordination mechanism to avoid the use of the same PLMN ID by different private networks in an area, either solved by the parties themselves or with NRA intervention, (ii) low[er] power transmissions to avoid coverage overlapping with other networks, and (iii) more network identifiers to ensure the uniqueness of each private network.

In summary, BEREC carefully considered the respondents views on all numbering issues and believes that further examination by NRAs on a case by case basis may be necessary. For example, the role of coordination between networks may require awareness of relevant points of contact between providers. Furthermore, the potential for combinations of identifiers to serve as a solution remains unclear, as insufficient details were provided for BEREC to analyse the matter further. Specifically, regarding the use of NIDs in 5G networks, BEREC observes that there is no competent authority coordinating the assignment of NIDs, and some stakeholders question the ecosystem support in both handsets and network equipment.

BEREC’s goal at this point is to raise awareness of this potential issue for NRAs. As the deployment of 5G private networks increases, more sharing of practices will help address this potential challenge.

4. Stakeholders' feedback in response to the consultation questions on drivers and regulatory/technological/other challenges

In addition to inviting comments on any of the issues set out in the draft report, BEREC also asked stakeholders to provide feedback on the consultation questions on drivers, regulatory/technological/other challenges on which questions the stakeholders provided the following views.

There are 10 subsections including a summary one in this chapter. Each subsection describes a consultation question(s) set out in BoR(24) 150, and summarizes the stakeholders answers, and concludes with some of BEREC's observations on the issues described.

4.1. Theme and Question(s): Drivers for various private mobile network solutions

Q1. What are the main reasons that drive the implementation and deployment of private mobile networks in your view (e.g. guaranteed QoS parameters, security, lack of awareness of MNO offerings, MNO offerings not fitting requirements, fears of vendor lock-in, other)?

Radtonics identified the following drivers: Mobility, range, stability, predictable performance, security.

According to **Obvios** the main drivers are the following: 1) be owner of dedicated secure 5G infrastructure to enable digitalization and automation of business processes (industrial, agriculture); 2) the availability of a versatile high-quality and dedicated network supporting use cases in various verticals (as opposed to WiFi); 3) lower cost media production; 4) ad-hoc private 5G network for crisis management and public safety.

The primary drivers for implementing private mobile networks in **Västra Götaland Region** appear to be: 1) guaranteed QoS Parameters for critical services and customized network configuration (tailoring network parameters to specific use cases); 2) enhanced security – controlled access and network isolation; 3) flexibility and control - independent network operation and rapid deployment and customization; 4) addressing specific requirements - unique use cases and avoiding vendor lock-in; 5) future-proofing infrastructure and adapting to evolving technologies.

According to **Nokia**'s experience most common triggers for private networks are the wireless limitation of Wi-Fi, and the introduction of new use cases that need much better reliability (e.g. mine autonomous haulage), security (e.g. worker safety, site security, data privacy), innovation and paradigm shift. One key challenge today is the increased diversity of both the demand and supply of services and resources in the mobile communication networks. The local network concept allows different entities like communities, property owners, or local commercial or individual users to roll out their network infrastructure to control connectivity over a well-defined area and provide location-specific services. Private networks can introduce user-centric design with enhanced usability, serviceability and operability, ensuring intuitive interactions and seamless integration with existing systems. Private networks present a new paradigm and the key differentiators of future systems from prior generations of mobile communication networks. The combination of data and connectivity networks to provide tailored localized connectivity, computing, content and context services in multiple locations to scale the service and match differing needs on demand and resources together would be enabled by an envisioned ecosystem openness, with business stakeholder interactions with complementors, developers, customers and partners in a platform-based ecosystem.

Nokia underlines that the private network offers developers APIs that can help enable premium connectivity and enrich the applications for a superior performance and experience. Moreover, the enhanced network automation will facilitate a higher degree of autonomy and flexibility for service agility and enable a tailored service level agreement (SLA). Envisioned ecosystem grounded on open platform architecture with application layer interfaces has the potential to create complementary opportunities for a rich developer community, increasing network value, revenue, and the user experience.

Siemens lists the following main reasons for implementation and deployment of 5G private networks: 1) use of dedicated spectrum, making interference by other wireless devices or technologies unlikely; 2) reliable communication, low latency, guaranteed QoS; 3) network flexibility and tailored functionality; 4) companies have full control over their data; 5) network sovereignty; 6) coverage of large areas and 7) trustworthiness of local, private network deployments.

Sateliot considers that the deployment of private mobile networks is primarily driven by the need to address specific connectivity challenges that public networks cannot fully satisfy. These challenges often evolve around guaranteeing Quality of Service (QoS) parameters, ensuring data security, and meeting specialized industry needs. Many private networks are deployed to achieve tailored performance, such as ultra-low latency or highly deterministic connectivity, which are crucial for certain industrial applications. Another driver for private networks is the need for data security and control.

Stakeholder_2 sets out that customers expressed the need to have a private network in order to have a single infrastructure that enables the use cases needed for their business. These are usually mission critical applications which require on-premise data security, managing large volumes of data, low latency, business continuity thanks to resilient solutions granting high reliability and reduced out of order time. The main characteristics which enable those applications are the dedicated radio coverage and the security of the on-premises core network. The customers can then achieve a better business operation and an increase of the value of their services.

DECT Forum considers that following key factors influence the deployment of private 5G include: 1) technological advancements: the inherent capabilities of 5G, such as ultra-low latency, high data throughput, and support for massive device connectivity; 2) industry requirements: IoT in manufacturing, logistics and healthcare require reliable and high-speed connectivity; 3) regulatory environment: spectrum availability. Regulatory bodies in various countries are allocating specific spectrum bands for private 5G networks, facilitating their deployment; 4) network customization: private 5G networks allow organizations to customize the network to meet their specific needs, including performance optimization and specialized applications; and 5) overall, the deployment of private 5G networks is driven by a combination of technological capabilities, industry-specific requirements, regulatory support, economic considerations, and the growing ecosystem of support and applications tailored to leverage 5G technology.

According to **European Broadcasting Union** the motivation to use 5G NPNs in professional content production stems from their technical characteristics (e.g. IP transport, the ability to provide guaranteed QoS, flexible configuration of uplink/downlink capacity) which enable the increased operational flexibility (e.g. remote production, integration in IP workflows), security, and the potential for increased productivity and reduced production costs. At present, MNOs are not offering comparable services in public mobile networks. Standalone 5G NPNs also ensure a full control over the network resources and bandwidth availability, as opposed to public networks where the resources are shared with other users under control of an MNO. This provides increased reliability which is important in high-value productions.

Volvo Autonomous Solutions draws attention to the following main drivers for deployment of private mobile networks in autonomous applications in the mining and quarry context: 1) many sites are located in areas with no or very poor access to public networks, meaning that it is often not cost efficient to expand the public network to these locations. It is also by definition so that extracting of material from the ground creates an open pit where coverage of public mobile networks is problematic unless new antennas are installed anyway; 2) autonomous systems typically require a stable and predictable network where a glitch in communication or a spike in latency can cause a costly stops of vehicles and transport operations; this may be problematic in public mobile networks, but is often fulfilled by local private network where the QoS parameters like latency, traffic prioritization and network load can be controlled and monitored as well as the possibility to control service windows and upgrades; 3) MNO offerings are often expensive and based on designs made for massive amounts of users and SIM-cards. The interest from traditional MNOs to make tailor-made solutions to enable an application with few users are by experience very limited; 4) the flexibility to tune the network for high uplink applications is crucial for a majority of the industrial use cases. The data is typically generated by machines and sensors on-board the connected devices and needs to be sent to central servers and data centres for processing, instead of the typical consumer use cases where the data is distributed from servers and data centres to the connected devices (e.g., phones, tablets, TVs etc.). In public networks, the downlink capacity is far more important than the uplink capacity, and it is the other way around for industrial use cases such as the operation of autonomous machines and trucks in mines and quarries.

In the view of **Hewlett Packard Enterprise**, the provision of dedicated spectrum for private 5G networks and the isolation from public networks is an important factor as it provides network owners with full control over their network and their data. According to statistics published by the Global mobile Suppliers Association (GSA), nine out of the top ten countries (in terms of number of deployed private mobile networks) provide dedicated spectrum for industry/verticals[3]. Unlike public mobile networks, private 5G networks provide enterprises with full control over their communications infrastructure, its operation, traffic, and performance. In addition, private 5G networks offer a high level of security using encryption

[3] Source: GSA-Private_Mobile_Networks_Feb_24.pdf

and authentication protocols to protect data and ensure network integrity. Private 5G networks ensure business continuity even when public networks are overloaded or down.

4.1.1. BEREC's observations

BEREC welcomes the feedback provided by the different stakeholders on the drivers for private mobile networks deployment, which seem aligned with those pointed out by NRAs views in the report.

In general, stakeholders highlight that 3GPP-based private mobile networks are mostly driven by the need of a highly reliable and predictable dedicated network with guaranteed QoS parameters and tailored configuration to address specific connectivity, security and data privacy requirements that certain use cases demand and public mobile networks or wifi solutions cannot fully address. Particularly for some industrial areas, enhanced coverage, flexibility and control of network parameters, such as network load, traffic prioritization or uplink capacity, can be crucial factors to ensure a stable performance of mobile connectivity and business operation.

BEREC also appreciates the forward-looking insights on the potential of private networks ecosystem built on open platform architecture with APIs that would enable network value opportunities and richer applications. BEREC will keep observing the development of these technical functionalities, as they may potentially enable innovative services and new competitive dynamics.

Q2.What type of private mobile network solution did you select and why (e.g. standalone, public network integrated, implemented by an integrator)?

- ***a) If you have deployed a 3GPP-based broadband private mobile network, what are the main reasons to select this technology vis a vis other wireless technologies (such as Wi-Fi)?***
- ***b) If you have already deployed a private network based on wireless or proprietary technologies, would you foresee a migration in the future towards a 3GPP-based broadband private mobile network? What would be the driver for this migration?***

Radtonics deploys 5G IT/OT/IoT networks on premise, with a local core network, local/remote management etc. In **Radtonics** experience, 90% of such projects are not about 5G but about IT (e.g. segmentation, routing, verifying Ue connectivity end to end, IP configurations, MTU adjustments, MSS clamping and much more).

Västra Götaland Region has opted for a semi standalone 3GPP-based private mobile network. The service provision will be exclusively limited to **Västra Götaland Region** internal operations and designated partner organizations, excluding general public access. The decision to deploy a 3GPP-based network over Wi-Fi is likely influenced by the following factors: 1) wider coverage; 2) higher data rates for demanding applications like video streaming; 3) lower latency which is critical for real-time applications like remote surgery and autonomous systems; 4) enhanced security such as encryption and authentication, to protect sensitive data.

Nokia sees strong demand for standalone networks, with all equipment locally on site in many cases in order to provide high levels of control, performance and data privacy. **Nokia** offers standalone network equipment, its integration and related services directly to enterprises, and also supports MNOs in offering standalone networks based on Nokia equipment. Thus enterprises have a wide choice of operating models from own operation based on pure equipment purchase to fully MNO operated standalone networks, subject to their level of control and expertise. 3GPP networks typically operate in (locally) exclusive spectrum access giving much higher level of control on the spectrum resource than systems based on shared spectrum access requiring e.g. listen before talk functionality. Thus, 3GPP based systems can deliver higher quality of service (QoS) in terms of availability, reliability and performance. Specifically, ultra-low latency requires immediate access to the spectrum. Furthermore, 3GPP systems support handover functionality when moving e.g. within a factory, contributing to QoS in terms of e.g. uninterrupted high-res video transmission in uplink from mobile cameras. 3GPP also supports consistent security and data protection via SIM card authentication and encryption. According to **Nokia,** both 3GPP and Wi-Fi technologies have a role to play in private networks. 3GPP technologies address reliability, low latencies, and mission critical services, and Wi-Fi is a sustainable solution for many use cases that are not mission critical and the ecosystem is very extensive.

Siemens selected 5G-based standalone NPN (SNPN) solutions because of the reasons listed in Q1 and because it is used as complementary network to Wi-Fi.

Most of the trials conducted by **European Broadcasting Union** Members included standalone 5G NPNs. The main reasons were the lack of MNOs' offer that meet the operational requirements and in some cases the lack of public network infrastructure. In some trials the objective was to validate the technology under specific and controlled conditions which required a standalone network configuration. As a technology, 5G has reached the point where devices and services are becoming available, marking the start of a potential transition from the experimental usage to every-day productions. It is expected that in professional content production 5G will be used alongside other wireless production technologies such as the conventional audio and video PMSE. The adoption of 5G in professional content production will primarily depend on its ability to meet the technical and operation requirements. Other conditions include the availability of 5G enabled equipment and spectrum for standalone 5G NPNs. **European Broadcasting Union** notes that conventional audio and video PMSE is widely used in professional content production and this will continue to be the case for the foreseeable future. It is expected that the adoption of 5G will be gradual, where this is technically and commercially justified. The main drivers for the adoption are: 1) 5G-enabled production equipment must be widely available and reasonably priced, and 2) regulatory conditions for standalone 5G NPNs, including access to the spectrum must be suitable for all production cases (See Q3). However, no outright migration from the conventional PMSE to 3GPP-based private mobile networks is foreseen. The main reasons include: 1) such a migration would require significant investments, and 2) 5G technology cannot support some of the most demanding production use cases (e.g. live audio production).

Volvo Autonomous Solutions has experience from both deployment of private networks: hosted by an MNO in a public network (i.e. running a private APN in a public network and having the private data traffic terminated to the enterprise network) and standalone private networks provided by a supplier (not MNO). Running a private APN in a public network is suitable for applications with limited QoS needs, where global or country-wide coverage is needed. Standalone private networks have been proven to be very useful for demanding use cases where a stable and predictable low latency connection is needed. The main reason for selecting standalone private network technology is technical aspects such that a larger geographical area can be covered by 5G base stations compared to Wi-Fi using access points (mainly due to the allowance for 5G to use higher allowed output power but also a lower carrier frequency). Further, the handover between access points in Wi-Fi is slow, this has been implemented for nomadic devices and mass consumer market and not for mission-critical industrial deployment.

Liberty Global has conducted a pilot in Switzerland leveraging network slicing for a private network solution for seamless livestreaming by a TV crew. Such use cases require the deployment of networks, equipment and portable devices across a broad geographical area (French competitor Orange used slicing to deliver dedicated services to media and participants at the 2024 Summer Olympics). The investment required to achieve such coverage and the capabilities required for private networks is achievable for only a handful of enterprise users. Realistically, these kinds of private network use cases will therefore always be dependent on the ability of publicly available 5G networks to create such private networks dynamically, as they cannot be facilitated through standalone 5G enterprise networks.

4.1.2. BEREC’s observations

BEREC thanks the stakeholders for the information provided about the types of private networks they have deployed. Most of the references correspond to standalone networks based on 3GPP, such as 5G, with equipment locally installed on-premise, as customers require higher stability and control over the performance of the network and data privacy.

According to some stakeholders’ contributions, BEREC notes that private networks hosted by a public network (MNO) are more suitable for uses cases that require broad coverage area, but with limited QoS needs because the public network resources are shared with other users. Nevertheless, 5G network slicing feature would overcome this limitation, by dynamically assigning resources to the private network to guarantee a reliable performance in highly demanding data rates capacity scenarios across wide areas, such as livestreaming events.

From the comments gathered, BEREC acknowledges that dedicated spectrum and handover functionality are the key factors that enable 3GPP based private networks to provide the reliable, predictable and higher QoS required to support high data-rate applications with low latency (e.g. advanced surveillance systems, mission-critical services), often combined with mobility in large sectorial areas (factories, ports/airports, campus). The wireless limitations of shared spectrum technologies (Wi-Fi) cannot satisfy the required performance, reliability or wider outdoor coverage demanded in these kinds of scenarios. However, the widespread and scalable ecosystem of Wi-Fi devices and providers makes this technology suitable for other use cases where secure and uninterrupted service are not required. Therefore, both technologies (3GPP, Wi-Fi) may be complementary, depending on the service needs of the private network customer.

4.2. Theme and Question: Administrative and regulatory obstacles for solutions

Q3. What are the main administrative/regulatory obstacles you encountered to deploy the solution?

Obvios identifies the following administrative or regulatory obstacles: 1) lack of temporary (nomadic) licenses for media production; 2) long and complex process for approval of export of software licenses in case of software that is considered as a “dual use” item, due to inclusion of cryptography technologies.

Västra Götaland Region highlights the following obstacles: 1) spectrum allocation and licensing - securing sufficient spectrum for the network especially in densely populated areas, navigating complex licensing processes and coordinating with other spectrum users to avoid interference; 2) network numbering - securing a unique network identifier to enable interoperability with other networks and allocation of appropriate numbering resources; 3) regulatory compliance - adhering to regulatory standards and interoperability requirements; 4) security and privacy - implementing robust security measures and complying with data privacy regulations; 5) procurement and deployment - vendor selection, procurement processes and deployment challenges and 7) human resources and expertise - recruiting and training staff and building partnerships.

Nokia sets out that a major regulatory challenge is timely access to affordable quality spectrum for local networks by different stakeholders, especially those who currently do not hold spectrum access rights. Many countries have not made licensed spectrum available for private networks, leading to a lack of coordination on spectrum availability and challenges for enterprises looking to deploy private networks across different countries. Local spectrum access brings a new challenge to spectrum valuation and pricing. The demand and value of local spectrum licenses can drastically change between the different locations and types of use, influencing the pricing of local licenses.

Siemens highlights the following main administrative/regulatory obstacles: 1) no dedicated spectrum for verticals available in some European countries and 2) if dedicated spectrum for verticals is available, a variety of options exists with regard to the frequency range, technical details for operation, and the process to get the permission.

European Broadcasting Union notes that the following conditions would facilitate the adoption of standalone 5G NPNs in professional content production: 1) obtaining a spectrum licence for a 5G NPN should be no more complicated or lengthy than it is today for a PMSE equipment such as wireless microphones or cordless cameras, and the fees and application times should also be similar; 2) in urgent circumstances (e.g. breaking news) there should be a means to secure permissions to use spectrum immediately; 3) different types of licences should be available, including a long-term licence (e.g. several years) for a network in a given permanent location (e.g. a campus or production facilities), and a short-term licence (e.g. from a few days to several months) for a network on a temporary location for coverage of an event (e.g. festival, sports event, political convention, elections, or other news gathering operations); 4) some events are moving over large geographical areas (e.g. bicycle races) or are repeated at different times in different locations (e.g. touring shows, skiing competitions). For a broadcaster covering such events it would be beneficial to be able to use the same equipment, network configuration, and spectrum in all locations; 5) a spectrum licence should not be tied to the ownership of the premises. Broadcasters often cover events in public places or in different venues that they do not own themselves; 6) there should be no constraints with regard to signal configuration. In particular, it should be possible to freely specify the UL/DL ratio. This is particularly important for production use cases that require much higher UL than DL capacity; 7) the licensing regime should allow different business models. For example, a local 5G NPN might be deployed by broadcasters themselves for their own use or could be outsourced to the third parties (e.g. professional service providers). In some cases (e.g. at a major news event) a broadcaster might deploy a 5G NPN network for their own use and also provide connectivity services to other broadcasters covering the same event. Such an approach not only results in a more efficient use of spectrum but also reduces the need for on-site coordination.

Volvo Autonomous Solutions notes that the application process for getting access to private 5G network spectrum is simple and straightforward. The concerned NRAs have to process the application swiftly. The major problem has up until now been that the spectrum regulation has been unsecure, licenses can be granted for up to 5 years but for industries with perspectives on 20-30 years and beyond cannot invest in infrastructure that tomorrow can no longer be used.

Hewlett Packard Enterprise reports the lack of dedicated spectrum and frequency availability in several countries for enterprises to build their own private networks (besides options offered by mobile network operators). To note also the limitations encountered against data and voice services, due to local regulatory, varying from country to country, and due to limitations of available mobile terminals.

4.2.1. BEREC's observations

The responses in this question brought forward as one of the main obstacles the lack of spectrum availability. It has been pointed out that in many Member States (MSs) no dedicated frequency bands for private networks have been allocated and even if there have, a large variety of options between the different MSs exist with regard to technical or administrative requirements. This adds a level of complexity for stakeholders that implement private networks across M-Ss in the licensing procedure, a lack of coordination on spectrum availability and other challenges like price variation. Depending on the specific characteristics of every stakeholder, other challenges have been acknowledged, like the timely licensing for private networks that will cover urgent circumstances, or the differentiation of the license with regard to its duration.

Although BEREC is not the competent authority regarding spectrum access or licensing conditions, spectrum issues can potentially have indirect consequences for markets and end user rights, and are part of the discussions surrounding private networks. Therefore BEREC included some spectrum related questions in its consultation questions, and reflects on the answers, to raise awareness for NRAs.

4.3. Theme and Question: Technical obstacles for solutions

Q4.What are the main technical obstacles you encountered (network planning and deployment, integration with IT or operational technology used by the company, lack of specialized skills/expertise…)?

Radtonics considers that uplink TDD scheme in private networks (with typical DL/UL being 20/80) must be aligned with MNO networks which come with 80/20 configuration. **Radtonics** is dealing a lot with manufacturers who push out non-verified firmware, who cannot set the correct MTU size etc.

Obvios identifies the following technical obstacles: 1) lack of skills or expertise at end-user and integrators; 2) availability of ecosystem for different features that are important for use cases, like 5G routers that support frame routing, IoT devices supporting RedCap, or precise positioning provided by RAN; 3) understanding that radio planning; 4) availability of EU-produced small cells for a sovereign solution.

Nokia draws attention to interference management and spectrum sharing strategies for managing inter and intra-network interference as the main technical obstacles.

According to the **European Broadcasting Union** at present the deployment of 5G NPNs in professional content production requires significant specialized skills/expertise and integration effort. It is expected that, over time, more user-friendly solutions will become available.

Volvo Autonomous Solutions underlines that 5G network technology is complex. A company cannot just buy a base station, configure it and start deployment using the private network spectrum. Hence, operations who want to use private 5G networks in factories, mining etc. must have a dedicated supplier under contract for providing this service. This is not something that a traditional IT service department at a company can support with. The number of available suppliers for 5G networks to be used in a private network setting is few, and they differ in skills and experience (and service offerings). There is really no economy of scale for providing 5G network equipment to industries who want to enjoy the benefit of access to 'private' spectrum because of the low number of base stations (the equipment is also very expensive compared to other communication technologies). From a 5G network supplier perspective, every new installation of a private 5G network is unique and requires tailoring of the equipment to new mission-critical applications. The allowed output power for antennas mounted on unmanned vehicles (or static installations such as high poles) should be allowed to be higher to enable a better coverage and uplink capacity when operations are in remote areas where there is no coverage by public networks that can be interfered.

The main technical obstacles **Hewlett Packard Enterprise** encounters are the lack of dedicated spectrum, with local limitation against the offered services from country to country, along with a shortage of available IMT equipment.

4.3.1. BEREC's observations

BEREC greatly appreciates the feedback received and observes a consensus among stakeholders regarding the identification of the main technical obstacles faced in their private network deployments:

- Radio spectrum configuration and management: these are considered key technical aspects, crucial for avoiding interferences that could degrade network performance and potentially affect public networks or other private networks in highly concentrated areas (see also Q10). In particular, UL/DL frame scheme in TDD radio networks can be configured in different ways depending on the specific traffic pattern demands of the network. Typically public mobile networks are configured with a greater DL capacity. However, many private networks require higher UL capacity, which makes it more difficult to manage TDD synchronization with public mobile operator networks.
- Availability of an advanced device ecosystem: several stakeholders complain about the lack of devices enabled with important features for private network use cases (e.g. 5G routers with frame routing, RedCap IoT), devices that cannot be adequately configured or have not been tested/verified by the manufacturer.
- Specialized skills or expertise and integration effort: 5G technology is complex and must be integrated with customer's systems. While private network customers may share common needs, they will likely require tailored configurations and skilled integrators to implement the end-to-end solution.

BEREC notes that the deployment of 5G private networks is challenging, particularly for use cases that require guaranteed high data rates and mission-critical applications. However, as with any technology, there is an ongoing learning curve.

Companies are still exploring the value that 5G technology can bring to their businesses, compared to alternative connectivity technologies. As the number of 5G private network deployments increases, stakeholders will contribute their experience to the value chain, allowing the solutions ecosystem to gain scalability and become more sustainable.

Moreover, the growing global deployment of public 5G-SA networks is expected to naturally stimulate the devices ecosystem, enhancing interoperability and supporting advanced features.

In any case, BEREC will assess the need to continue its work on this matter in future work programs.

4.4. Theme and Question(s): Roaming, connectivity, 112 and legal intercept

Q5. Are there roaming, connectivity issues to 112 emergency communications services, or legal intercept issues that you know of, please specify?

EENA underlines that for private 5G networks offering voice services to end-users, connectivity to public networks is typically required to enable inbound and outbound calls to national numbering plans, including access to emergency services through emergency communications on 112 or other relevant national emergency numbers. These private networks often cover large areas, sometimes spanning borders, meaning it is critical that end users can not only contact emergency services, but also be routed to the most appropriate PSAP based on their location. Key issues related to accessing emergency communications on private mobile networks include: 1) prioritization and routing - emergency communications should be prioritized and routed to the most appropriate PSAP; 2) network-based location - location data from the network should reflect the specific area within the private network; 3) device derived location - devices with smartphone functionality should transmit location data via packet headers or HTTPS if a data connection is available; 4) unique Calling Line Identity (CLI) -a unique CLI, i.e. an E.164 number, should be assigned to each device to facilitate callbacks when necessary; 5) limited service state for emergency calls - if the private 5G network has poor coverage, devices must be able to connect to any available public network to facilitate an emergency call; and 6) roaming agreements - agreements between private and public networks are essential to ensure continuous emergency service access when users move between coverage areas.

Västra Götaland Region considers that while private 5G networks offer numerous benefits, they also present unique challenges, particularly when it comes to roaming (interoperability, security concerns, and cost implications) and access to emergency services (ensuring reliable connectivity to emergency services and adhering to national and international interoperability standards for emergency services).

Liberty Global notes that deployment of private network solutions on MNO-operated networks will lower the deployment and operational costs associated with such networks – whilst guaranteeing seamless connectivity and compliance with regulatory requirements. It is key to ensure that the interests of end-users and other societal stakeholders, such as law enforcement and emergency service providers, remain protected.

Hewlett Packard Enterprise notes the lack of experience to share. However, one key point about legal intercept would be the interoperability with Law Enforcement Authorities, which may not have direct control over the private network's infrastructure or may not be aware of the network's presence in a given area, making monitoring or interception more difficult. For what concerns roaming and connectivity issues to emergency services, key points to be addressed are the potential limited interconnection of NPNs to public networks and lack of location information, when location-based services are not present. Roaming agreements are also to be taken into consideration.

4.4.1. BEREC's observations

BEREC notes there is a lack of practical experience on these issues, as standalone private networks deployments are generally tailored only to support the internal communication requirements of the enterprise customer and isolated from other networks for protection of business activities.

BEREC understands that roaming between private and public networks may be required by the enterprise for some situations. However, at first glance, mobile operators would be in a better position to provide roaming and comply with the emergency and lawful interception regulatory requirements that are already applicable in their public networks. This would favour the deployment of MNO-hosted private networks. Therefore, BEREC is of the view that more information would need to be gathered to assess all regulatory implications.

Additionally, BEREC acknowledges that access to emergency services in private networks face many challenges that will need more work on this obligation foreseen in article 109 of the Code: "Member States shall promote the access to emergency services through the single European emergency number '112' from electronic communications networks which are not publicly available but which enable calls to public networks, in particular when the undertaking responsible for that network does not provide an alternative and easy access to an emergency service".

4.5. Theme and Question: Interconnection of private and public networks

Q6. Please provide your views on the role of interconnection with one or more public networks (interconnection, purpose of interconnection)?

According to **Radtonics** the only reason to interconnect with public networks is to facilitate some kind of inter-site connectivity, provide asset tracking capabilities or to facilitate emergency calls. **Radtonics**' 5G networks are used for OT/IoT use cases and there is very little reason to connect back to a macro network.

Obvios sets out that there is a need for interconnection of private networks and public networks, to provide connectivity outside of the perimeter of the private network coverage. Furthermore, **Obvios** sees a need for the interconnection of stand-alone private networks. This use case has been contributed to standardization by **Obvios** (3GPP TR 22.848 rel19) and is related to the interconnection of temporary private networks for example when multiple vessels which each have their own private network act as a group of 5G stand-alone networks.

Västra Götaland Region notes that there is a substantial requirement for their organization to establish connectivity with Mobile Network Operators (MNOs) to extend the network coverage beyond campuses and fully leverage the capabilities of 5G Standalone (SA) technology, including network slicing and edge computing.

European Broadcasting Union considers that interconnection between 5G NPN and a public network would be useful in some use cases to extend the operational range of production equipment beyond the 5G NPN coverage area and as a redundancy solution. In some cases, e.g. (campus NPNs) interconnection would enable the services provided within the public network to be also available within the NPN but without the need for duplicating the network infrastructure.

Liberty Global considers that while some communications on private networks will need to remain within the private domain of the enterprise user (closed user group), it is expected that the increase of private networks will also lead to an increase of communications between the end-users of the private network and the outside world. However, the need for interconnection with public networks will likely be far more widespread than the relatively isolated case of emergency communications. In practice, the enterprises customers' devices will likely use the private network connectivity whilst *on site* but will typically be capable of – and expected to be – connected to public networks whilst *off site*.

4.5.1. BEREC's observations

BEREC welcomes the views of stakeholders, who tend to agree on considering that private network interconnection with public networks is mainly triggered by the need to extend the private network connectivity beyond the local coverage area. This would be for example the case in campus networks deployed in multiple sites where users/devices move across the covered areas.

4.6. Theme and Question: Definition and classification of private mobile networks

Q7. Please provide any views on the variants (A, B, C, D) described in figure 5. What variants exist or could exist in practice? What could be the merits in harmonizing an approach to classification?

Obvios highlights that for stand-alone private networks variant D is most likely and used today. Obvios estimate variant B not very likely, as MNOs are currently not in favor of stand-alone private network deployments.

In practice, **Västra Götaland Region** sees a mix of these variants. Many enterprises are opting for Variant A, leveraging the expertise and infrastructure of MNOs. However, as the demand for customized solutions and increased control grows, Variants B and D are becoming more prevalent. Harmonizing an approach to classifying private networks can bring several benefits: clearer regulatory framework, facilitated interoperability, accelerated deployment and enhanced security.

In **Siemens** view Option D is the preferred option as it provides customers with a straightforward way to implement a 5G SNPN, does not require negotiations with an MNO, minimizes commercial relationships, and does best support the reasons and advantages mentioned under Q1.

Stakeholder_2 believes that only solution A seems to be the most performing one, allowing the most efficient use of needed resources, starting from spectrum, up to numbering codes, installation sites, core network equipment, and so on.

According to **4iG Group** knowledge all the scenarios described in figure 5 are viable but in practice mobile network operators offer services that are provided at least partially hosted by their public mobile networks. It might be said that mostly it is the MNOs who can best offer tailor-made technical solutions. This can result in the creation of a 5G private network that is operated in a cost-efficient manner and provides an efficient use of the frequency band as well.

According to **Connect Europe** and **GSMA** all variants could exist and to Connect Europe's knowledge exist. MNOs provide solutions based on customers' needs. MNOs naturally provide solutions that are provided in conjunction or hosted by public mobile networks (2.2.2 and 2.2.3), i.e. variants A and C. However, Connect Europe notes that MNO may also be involved in providing or supporting solutions described as variants B and D, as MNOs provide also "stand-alone private network" solutions. **Connect Europe** does not see specific merits for harmonizing an approach to classification. As noted above the solutions are provided based on customers' needs and requirements. Classification/harmonization of approach may eventually lead for overregulation of the solutions which are already provided on commercial basis.

GSMA members provide private network solutions to their business customers with different approaches, depending on the customer needs and requirements. While MNOs also provide "stand-alone private network" solutions, the GSMA considers that often the solutions provided "in conjunction with/hosted by public networks" are the best solution also from a customer perspective. Such solutions can be scaled to the needs and do not need to rely only on one spectrum band which may have e.g. capacity or UL/DL limitations. In addition, customers may have communication needs which go beyond one specific location, and MNOs can serve also such demands. Along with 5G-Standalone (SA) expansion, solutions provided “in conjunction with/hosted by public networks” become even more appealing.

The tests and trials conducted by **European Broadcasting Union** Members have confirmed that the variant D allow the deployments suitable for professional content production. Further trials are required for the variants A, B, and C. The attractiveness of these variants will depend on their ability to meet the technical, operational, and commercial requirements in content production. This will require adequate business models to be offered by the MNOs.

So far **Volvo Autonomous Solutions** has practical experience of Options ‘A’ and ‘D’, but ‘B’ and ‘C’ have been considered for deployment for both testing grounds and customer implementations: 1) option ‘A’ has been used in the somewhat simple case of using private APN in public networks operated by the MNO. This has been a standard setup for many years and exists in several variants, with local breakout of traffic or even local core installations; 2) option ‘B’ has been used in niche installations such as testing grounds in early deployment of 5G, in remote areas where the MNO spectrum was not deployed. If possible, it would be very good to regulate the case B in such way that unused spectrum owned by MNOs can be made available in remote locations (preferably with a stipulated price/MHz/sqm or similar); 3) option ‘C’ has been discussed for deployment of local private networks, where the MNO simplifies installation and operation. In this case, it is of great importance that the non-MNO spectrum permit is not owned by the MNO, since this creates a lock-in effect and limited competition; 4) option ‘D’ is today often the most preferred solution for local installations. This is due to the considerations mentioned above, where MNOs (and traditional suppliers) needs to be challenged to lower the price level for smaller installations, where local survivability and a network of full control is crucial etc.

Liberty Global supports BEREC’s adherence to the 3GPP terminology in the classification of private networks in section 2.2. of the draft report. Liberty Global regards a combination of scenarios A and C to be most likely to lead to societally optimal outcomes. The following caveats apply: 1) scenario A may be constrained by the ability of MNOs to allocate licensed spectrum for mobile private network use in areas with high end-user density; 2) scenario C is best placed to meet the challenges in the market if the full potential of 5G is to be realized.

Hewlett Packard Enterprise sets out that challenges with relying on public 5G networks include high cost, low speed of deployment, and lack of flexibility and customization options. For non-private (commercial) 5G networks, network slicing techniques cannot deliver the independence and scalability required by business-critical applications. Private 5G networks should operate as standalone isolated networks (SA-NPN) within geographically delimited areas.

4.6.1. BEREC’s observations

From the responses, it is clear that all variants are used to some extent, but variants A and D are prevalent. Variant A is feasible for users that do not have the resources and know-how so they use MNOs’ expertise and infrastructure in cost efficient manner and efficient use of spectrum. Users that want to manage their own network and have more control, along with their more flexible customized solution use variant D. Most of the stakeholders did not express their opinion on harmonizing the approach to classification (of variants) and those that expressed opinions are contradictory.

4.7. Theme and Question(s): Spectrum harmonization issues for mobile networks

Q8. Please provide views on spectrum harmonization for private mobile networks in the EU?

Radtonics is very supportive to harmonization because most of their potential customers have factories/mines etc. in different countries.

In **Obvios** view the harmonization of the EU spectrum is a mandatory precondition for large uptake of deployments of private networks. At this moment it is difficult to find RAN equipment that supports the right bands, or equipment that can be used in different EU countries. Solutions that require integration with different radio equipment for each country are not economically scalable.

Västra Götaland Region considers that achieving maximum spectrum harmonization is essential for the overall market. Spectrum allocation in both low-band and high-band frequencies is required to facilitate both indoor and outdoor network deployments. The utilization of globally supported spectrum is highly desirable, as the majority of manufactured chipsets are designed with a global market in mind. The capability to procure commercial off-the-shelf user equipment is paramount for cost optimization and a wider range of solution options. A regulatory framework analogous to the US CBRS model would be beneficial for the European Union. The CBRS initiative has been instrumental in fostering the development of tailored solutions for the US market.

Nokia considers that harmonization is the key enabler for the successful scalable, replicable and sustainable business model. Different approaches taken by national regulators on spectrum for private 5G networks have led to a fragmented market and challenges to deployment. The recent technical harmonization of the 3.8 -4.2 GHz band in CEPT, technically addressable by 3GPP band n77, has potential to create and enable novel business opportunities, value and advantage in the EU. **Nokia** encourages administration to seek ways to make spectrum in that range available for private networks.

Siemens underlines that spectrum harmonization in Europe is key to foster the deployment of 5G private networks for verticals because: 1) reduces the barriers for vendors and customers; 2) simplifies the availability of 5G network equipment as well as 5G devices; 3) benefits the economy of scale; 4) allows for blueprints for implementation and deployment in the whole European market; and 5) spectrum harmonization should be accompanied by a harmonized technical framework and spectrum application procedure.

Sateliot underlines that spectrum harmonization for private mobile networks in the EU is essential to fostering a robust and inclusive digital ecosystem that supports diverse connectivity needs. A harmonized spectrum framework offers several key benefits. First, it reduces administrative complexity for enterprises and operators, enabling faster deployment of private networks while ensuring compatibility across EU Member States. Second, spectrum harmonization can drive economies of scale, reducing costs for enterprises deploying private networks. Finally, harmonization should include provisions for flexible spectrum use, allowing enterprises and operators to adapt to evolving technological and operational needs.

Stakeholder_2 also shares GSMA[4] concerns about the departures from the principle of service neutrality if technical restrictive conditions on mid bands, including 3800-4200 MHz, will be imposed by EU spectrum policy makers. Harmonization at EU-level should specifically focus on applying the least restrictive technical conditions that ensure coexistence with MNO spectrum users. It should be made available for all possible 5G technologies (or, more generally, wireless broadband technologies) within those limits. Very low power thresholds would have a particular service implication and push the band towards certain services. Such limits risk being entirely unnecessary from a sharing and co-existence perspective and will impede service neutrality. Less restrictive sharing mechanisms that do not require strict power limits and provide more flexibility can be applied.

4iG Group believes it is important to highlight that private networks are limited in terms of their localisation, geography and technical parameters to a specific user base, while the spectrum used has the potential to be exploited by a much wider user base for the improvement of the quality of 5G services. It is therefore considered a priority for spectrum harmonisation to ensure that private use of spectrum bands that are well suited for public 5G networks with nationwide coverage is only allowed if there is no demand from public MNOs for the specific bands.

DECT Forum is supportive of the EC's actions to harmonize spectrum for private wireless broadband systems providing local-area network connectivity. Any harmonizing Decision should be strictly technology and application neutral in order to promote competition and choice in technology for users.

Connect Europe sets out that the spectrum band 3800-4200 MHz is being harmonized within the EU for local networks with low/medium power deployment, and this has been progressing without publishing any prior analysis on the actual demands of the dedicated spectrum for local or private networks. While **Connect Europe** recognizes that the harmonization plan of the band is not limited to private networks only, it may be understood to be the intention. As also recognized in the BEREC draft report, there are various solutions already in use to serve private network demands, and likely a significant part of the private network deployments is not known to NRAs. In addition, according to the results of the questionnaire, half of the countries have already allocated dedicated spectrum bands or frequency ranges for use by private operators.

The experience **GSMA** members have as suppliers of private networks, both stand-alone (scenario 2.2.1 identified by BEREC) and in conjunction with public networks (scenarios 2.2.2 and 2.2.3.), is that lack of a common harmonized band available across Europe for private networks has not been a barrier to their deployment. A recent empirical study by GSMA[5] confirms that view. Using a dataset covering 51 countries between 2018 and 2022, the study shows that, considering all the relevant factors, there is no clear boost to private network adoption in countries that have set spectrum aside. The GSMA sees that a better

[4] https://www.gsma.com/about-us/regions/europe/wp-content/uploads/2022/06/GSMA-Europe-3.8-4.2-GHz-position-paper.pdf
[5] Impact-of-Spectrum-Set-Asides-on-Private-and-Public-Mobile-Networks.pdf (gsma.com)

understanding of the underlying drivers of private network adoption is required before taking the decision to set aside a very large amount of prime spectrum across all of Europe for local low and medium power uses, depriving other potentially more valuable uses from the possibility to have access to it. The **GSMA** acknowledges that there is a request by the local network community in Europe for access to an EU harmonized band, to facilitate the development of an ecosystem. However, a proper analysis on the spectrum demands for "stand-alone private networks" has not been taken.

Connect Europe and GSMA note that the number of licenses/networks reported in the BEREC report varies from one to a few hundred in countries which have reserved mid-band spectrum for "stand-alone private networks". These are low numbers if comparing to the number of base stations that mobile operators have deployed for public mobile networks in the same spectrum range. This would be fair comparison, noting that the public mobile networks would be alternative use of the spectrum, and that the estimated mid-band spectrum need is 2 GHz by 2030 for mobile operators to be able to meet the society demands efficiently[6]. The EU has harmonized in mid-bands only 950 MHz for WBB ECS (wireless broadband electronic communication services), and typically all the harmonized spectrum is not made available for public mobile networks in each member state.

In light of the above, **Connect Europe** considers harmonizing fully the 3800-4200 MHz band only for the use of local networks (i.e. 400 MHz of valuable mid-band spectrum) would be premature and would not support the efficient use of this band within EU. Thus, Connect Europe requests a proper analysis on the demand before deciding on the harmonization of the 3800-4200 MHz band for local networks (i.e. before preparing the EC decision). **Connect Europe** does realize that there are some demands for "standalone private networks", which may also benefit from harmonized EU spectrum (noting that some MNOs also provide such solutions). However, these demands do not justify harmonization of the full band. **Connect Europe and GSMA** underline that the harmonization of only part of the band, e.g. 4100-4200 MHz range, would be more appropriate. According to the **GSMA** the advantage of this approach, as opposed to setting aside the entire 400 MHz for local low and medium power use, is that it provides the opportunity to see if there is excess demand beyond the initial part of the band, before exposing more of it to irreversible fragmentation. Similarly, **Connect Europe** notes that such more focused range, would also help to ensure that countries focus their private network assignments primarily to this [4100-4200 MHz] part of the band. Otherwise, countries may assign licenses fragmentally in different parts of the band. That may limit the possibilities for future harmonization of part of the band for public macro mobile networks, in case the demand for private networks remains low in this band.

Connect Europe sets out that if the EU harmonization proceeds for the 3800-4200 MHz band before proper analysis on demands, Connect Europe requests that: 1) the EU harmonization of the band is revised within 3-5 years; 2) in national approaches for licensing this band for local networks the spectrum efficiency and competition aspects are taken into account; and 3) the existing national reservations for private/local networks in IMT mid-bands should be migrated to the 3800-4200 MHz range which is harmonized for local/private networks in EU. For more info read the full contribution from Connect Europe.

[6] Coleago report to GSMA, "Estimating the mid-band spectrum needs in the 2025-2030 time-frame", July 2021

European Broadcasting Union underlines that spectrum harmonization across the EU and beyond is highly desirable. From the operational perspective, the production equipment should be able to operate across national borders to facilitate international productions and touring events. Spectrum harmonization also increases the attractiveness of the EU market for equipment manufacturers and services providers. Therefore, it is important that spectrum bands for 5G NPNs are included in 3GPP specifications to ensure the availability of affordable 5G-enabled production equipment. Beyond spectrum harmonization it is also desirable that licensing conditions for 5G NPNs are similar across the EU, in particular those relevant for short-term temporary deployments. This would benefit not only audiovisual content producers such as **European Broadcasting Union** Members but also other sectors such as for example trade shows or touring live performances.

Volvo Autonomous Solutions notes that it is of great importance that the spectrum and legislation is harmonized in order to simplify and accelerate the deployment of disruptive solutions such as electric autonomous transport solutions. As a solution provider, a harmonized setup would make it more cost efficient to deploy solutions, since hardware and software can be reused and deployed with no or very limited adaptions.

According to **Transatel** the key regulatory barriers to the deployment of private 5G networks in Europe is the lack of harmonized: 1) authorization requirements for private 5G networks, including those required for testing; 2) spectrum for private 5G networks; and 3) power and performance standards. **Transatel**, therefore, urges BEREC to fully harmonize the authorization requirements to facilitate the deployment of private 5G networks.

Liberty Global submits that the currently fragmented approach to spectrum allocation within the 3400-4200 MHz band is not conducive to creating conditions that will foster significant take up of private networks. The main issue created by such fragmentation is the inhibition of economies of scale for manufacturers (especially manufacturers of specialist vertical modules) of network equipment and devices. This fragmented landscape forces such parties to create 5G equipment and modules, and to design enterprise solutions, which are compatible with a wide array of variables. This diversification hinders innovation and investment. The pursuit of a harmonized spectrum approach for private network use in the 'industry band' across Europe could help justify the investments in equipment, devices and solution designs, specifically for use in verticals (where such private networks can be most relevant). Unlocking a larger addressable market for equipment and device manufacturers, as well as service providers, will spur innovation and investment. Consequently, such an approach can clear a major hurdle for enterprises seeking to transition from legacy connectivity solutions to leveraging private mobile network connectivity's opportunities. One potential solution in the context of such a harmonized approach, would be to facilitate the allocation of contiguous blocks of spectrum. In case of more fragmented allocation, the network operators in these fragmented blocks are typically prevented from using the entire (theoretically available) spectrum, due to the need to implement ultra-wide band filters over 400 MHz. This lack of local spectrum efficiency can in turn have a negative effect on spectrum efficiency overall, inhibiting the achievement of societally optimal allocations of this scarce resource.

Hewlett Packard Enterprise appreciates the efforts of the European Commission to harmonize the 3.8-4.2 GHz for use by private local mobile networks. Being able to utilize harmonized spectrum, **Hewlett Packard Enterprise** expects private 5G networks to trigger waves of innovation on many different levels, similar to the case of Wi-Fi where the availability of affordable (in this particular case, free) spectrum resources and technology helped create a large ecosystem of innovative suppliers of devices, applications, and services. **Hewlett Packard Enterprise** general recommendation is that Europe adopts a regulatory framework that includes low barriers of entry for private wireless network operators. This framework should include the implementation of a dynamic spectrum access system (SAS) as an element of a dynamic spectrum management system (SMS).

4.7.1. BEREC observations

Spectrum harmonization for private mobile networks is supported by a number of stakeholders. 3800-4200 MHz band is recognized as the possible solution for harmonization for private networks. Recent technical harmonization of the band in CEPT for local networks with low/medium power should facilitate the deployment of terrestrial wireless broadband systems, providing local-area network connectivity for both, private and public networks. Operators and manufacturers suggest caution and deep analysis on the demand side before making decision on 3800-4200 MHz band. They propose a gradual approach – harmonization of only part of the band in order to avoid irreversible fragmentation and revision in 3-5 years in order to ensure spectrum efficiency and competition aspects. Also, existing national reservations for private networks in IMT band should be migrated to 3800-4200 MHz. Frequency band allocation issues for private networks (see also 4.2.1).

Q10. For frequency ranges that are assigned to users of private mobile networks, what are your thoughts on how NRAs may facilitate future demand (see also question 4), particularly in areas with a high concentration/density of potential needs/demand to deploy such networks (such as ports, industrial areas, etc.)?

Since there is no support for NB-IoT or LTE-M on higher bands than 2100 MHz, **Radtonics** believes a harmonized “industry IoT band” where these protocols can be deployed would be very good. **Radionics** has lost customers because it can’t provide body cam connectivity through thick walls in the same way an MNO can on the 700 MHz spectrum.

To promote the global industry adoption of private networks, **Nokia** encourages regulators and other governing bodies to make spectrum available to fit a wide range of use cases, performance, and deployment. By considering the following framework, regulators can stimulate access to and meet the growing need for private networks across industry verticals: 1) lower the barrier to entry of spectrum access by facilitating timely access to affordable quality spectrum to meet the increasing needs and use cases; 2) promote the development and testing of innovative use cases and services by opening access to new spectrum bands by issuing test licenses; 3) Advance regulatory actions that facilitate a level playing field to local network operators with different stakeholder saliences; 4) provide improved flexibility and scalability required by the novel use cases through varying service level parameters and customer value; 5) allow for certain flexibility, e.g. agreements among neighbors on common TDD patterns, to enable best possible use of the spectrum resource; 6) develop and utilize automated authorization and spectrum management processes to deliver timely and equal opportunity access and high efficiency for network deployments; 7) support the creation of automated marketplaces to stimulate the reuse of unused spectrum resources and reduce transaction costs associated with spectrum leasing; 8) encourage researchers to develop technical solutions that address real-life spectrum access challenges in specific bands with incumbent systems by promoting the sharing of knowledge.

Siemens notes that to meet additional future demand, particularly in areas with a high concentration/density of networks/applications, additional local spectrum is required. This should be taken into account when setting the framework for new frequency ranges, e.g. the upper 6 GHz band.

Stakeholder_2 considers that NRAs could facilitate future deployment of private networks, particularly in areas with a high concentration/density of potential needs/demand to deploy such networks, avoiding to pre-assign spectrum to such purpose and, on the opposite, continue to assign spectrum resources to MNO without any predefined use constrain. This is because only an MNO with a large set of spectrum resources can provide dedicated frequencies to a private network (typically with a geographically limited extension) just adding them to the public network infrastructure in that specific area, and reuse the same frequency in a different area at national level.

4iG Group recognizes the importance of national authorities in the designation and proper use of spectrum. However, 4iG Group wonders if they might also have a role in facilitating specific private uses of frequency bands, which is a matter for further discussion. It seems that the demand for private networks from industry is primarily driven by economic and security considerations, as is the demand from mobile operators' own operations or even from users of public networks. It is possible that regulatory intervention which differs from market conditions and has a significant impact could potentially distort market conditions and contribute to the development of long-term anomalies.

In addition to the inputs provided in Question 8 **Connect Europe and GSMA** provide the following: 1) NRA should issue the license, and set the conditions to it (e.g. bandwidth, power/area) based on the actual need of the use case (not based on “nice to have”). Special focus for conditions should be put in “high concentration/density areas”. The conditions should be strict especially on such areas; 2) if considering the TDD spectrum bands, NRA should set requirements for TDD synchronization, in particular in expected “high concentration/density areas”. Many private networks may be UL-heavy, and this should be considered when defining the TDD synchronization requirements. If any private networks are assigned in a spectrum range adjacent to MNO holding (e.g. above 3800 MHz), it will be important to ensure that the private network does not cause interference to public network. This is also one reason why Connect Europe and GSMA prefer private networks to be initially and primarily assigned in the upper range of the band, i.e. 4100-4200 MHz. Many private networks may have need for different TDD frame than public networks, and possibly all private networks may not be configured appropriately (if the configuration and operation is not handled by qualified experts); 3) NRA should require and ensure that the licensee deploys network according to the license conditions. If the network is not deployed and in operation, license is withdrawn. The NRAs should check the status of license and network, for example annually.

Connect Europe and GSMA sets out that private networks in “high concentration/density areas” may be provided with different solutions, including solutions “in conjunction with/hosted by public networks”. Sufficient spectrum resources for public networks are important in such areas. In some “high concentration/demand areas” e.g. in ports there are also a lot of people using public mobile network services.

Volvo Autonomous Solutions sets out that it is of great importance that facilitation of local private spectrum is handled by NRAs and not sold to MNOs, since the MNOs in many cases may use this to prevent deployment of competitive private standalone networks. It is also important to not limit the freedom to tune a network in isolated and remote locations due to the existence of areas with the needs of dense deployments of private networks. In areas where the density of private networks is high, it would be recommended to define a spectrum zone where NRAs or local authorities can be responsible for the spectrum, potential limitations, technical requirements etc. **Volvo Autonomous Solutions** has already faced problems in port applications, where deployment of nearby public networks limits the possibility to get spectrum for deployment of private networks. These kind of networks are often crucial to deploy disruptive solutions like electric and autonomous transport vehicles.

Hewlett Packard Enterprise believes that in the frequency ranges assigned to users of private mobile networks, no artificial restriction of the maximum amount of spectrum available per request and geographical area should be imposed, at least not in the early stages of private 5G networks deployment. At a later stage it may become necessary, particularly in dense deployments, to limit the maximum amount of spectrum. NRAs could make additional capacity available to private networks by authorizing operation of standard power (SP) WAS/RLAN in combination with an Automated Frequency Coordination (AFC) system in the 6 GHz (5945-7125 MHz) band.

4.7.2. BEREC's observations

Regulators should facilitate timely access to affordable quality spectrum, allow test licences and flexibility, and ease and optimize authorizations. Some consider additional spectrum is required. Operators and manufacturers consider that real demand should be taken into account and that most of it can be taken care of in conjunction with/hosted by public networks. On the other hand, some respondents consider that spectrum should not be sold to MNOs. A solution in dense areas is proposed, where NRA would be responsible for the spectrum (not necessary in other areas) and should prescribe technical conditions of spectrum usage. It is also suggested that in early stages of deployment limitations on quantity of spectrum and geographical area should not be imposed (see also 4.2.1).

4.8. Theme and Question: Transnational networks

Q9. Do you see a demand from actors for transnational private networks, using a combination of private networks in multiple Member States and are there issues to be addressed in that regard (for instance with regard to roaming or coordination along specific corridors)?

Obvios has identified a few transnational private networks, like European satellite networks or multinationals with locations in different member states. In these situations, the control plane is centrally deployed, and multiple edge networks are deployed (user-plane/UPF) where the local radio networks are connected.

Västra Götaland Region draws attention to the growing demand for transnational private networks. As businesses and organizations expand their operations across borders, they require reliable, secure, and customizable connectivity solutions.

Nokia provided an example of transnational private networks in the sector of transportation and logistics. According to Nokia, Europe has decent mobile coverage from mobile networks suitable to cover connectivity needs e.g. for tracking goods and their state along transport paths. 5G provides, if needed, by the means of network slicing the possibility to even set up virtual private networks for specific purposes with specific QoS parameters. This could lead to use cases where e.g. smart connected containers roam on public networks during transport between different stations along the supply chain, but roam on local private networks during goods being processed at particular stations of that supply chain.

Sateliot draws attention to the growing demand for transnational private networks, particularly in sectors such as logistics, transportation, energy, and agriculture, where operations span multiple Member States. These sectors require seamless connectivity across borders to enable real-time data sharing, coordination, and monitoring. The demand for transnational private networks often stems from the need for consistent service quality, ubiquitous coverage, and interoperability across various jurisdictions. However, significant challenges must be addressed to meet this demand effectively. A key issue is the lack of harmonized regulatory frameworks and spectrum policies across Member States, which creates administrative burdens and technical barriers for deploying networks that operate seamlessly across borders. These inconsistencies can lead to fragmented solutions that undermine the efficiency and scalability of transnational networks. Additionally, numbering resources and interoperability standards pose challenges for transnational operations. Ensuring that devices can roam between private networks in different countries without interruption or additional administrative overhead requires a coordinated effort among regulators and industry stakeholders. **Sateliot** advocates for a harmonized approach to regulatory and technical frameworks that supports transnational private networks. This includes addressing spectrum harmonization, simplifying administrative processes, and promoting open standards for interoperability.

DECT Forum is of the view that the majority of use cases for private networks is for local area connectivity. There are scenarios such as smart grid and smart cities where coverage requirements may extend over a large area, but DECT Forum is of the view that this does not indicate a substantive need for private transnational connectivity, and therefore this scenario should not set the overarching policy on private wireless broadband.

Connect Europe and **GSMA** draw attention that some industries e.g. factories in different Member States may have requirements for harmonized and integrated approach for their private networks solutions. Demands however are different and industries may also have demands beyond the locations of the factories. MNOs provide various private network solutions and have roaming agreements in place.

4.8.1. BEREC's observations

According to the contributions, there are certain specific areas where transnational private networks are needed – logistics, transportation, energy and agriculture. Harmonized regulatory approach and technical frameworks should be addressed in order to facilitate this type of networks. Some respondents do not see the substantial need for private transnational connectivity. MNOs already provide some solutions like this, with roaming agreements in place. Implementation of 5G SA networks allows the possibility to set up virtual private networks for specific purposes with specific QoS parameters.

BEREC and NRAs are open to gathering more information on the future development of such networks

4.9. Potential impact of cloudification on private networks

Q11. How would you describe the (actual or potential) impact of networks' cloudification on the interest in the deployment of private mobile networks?

Radionics replied that in pretty much all of their existing customer cases, this is not a viable approach. Most of **Radionics**' customers require traffic and network management to be on premise for many reasons (segmentation, security, autonomy and much more).

Obvios notes that network cloudification can allow lower-cost deployments of private networks, for example with a control plane deployed in a central cloud. This central cloud can be either a private, public, or hybrid cloud. With a public cloud, this could lead to new business models like "5G-network-as-a-service". **Obvios** sees this as an opportunity for the uptake of private network deployments.

Västra Götaland Region notes the following positive impacts with network cloudification: rapid deployment, greater scalability allowing enterprises to easer adapt to changing needs, and reduced operational costs by leveraging economies of scale and automation. However, there are some potential negative impacts of cloud-based private mobile networks: 1) latency (distance between devices and cloud data centres can introduce latency); 2) security risks; 3) vendor lock-in (relying on a single cloud service provider can lead to vendor lock-in); 4) costs (while cloud-based solutions can offer cost savings in the long run, there may be significant upfront costs and ongoing operational expenses); 5) complexity (managing cloud-based networks can be more complex than traditional networks); 6) compliance (complying with data privacy and security regulations can be challenging when data is stored in the cloud, especially across different jurisdictions); and 7) availability (while cloud services typically offer high availability, planned or unplanned outages can disrupt operations).

Nokia considers that cloud native design, open source, and standardized interfaces drive openness in the network and operation architecture. The integration of enabling technologies (AI/ML, O-RAN) will be a critical driver of innovation and efficiency. An intent-based balance between edge and cloud computing capabilities enables the local network to utilize efficiently their resources, avoiding unnecessary data transmission as resources that are needed at the edge are managed locally in coordination with the resources managed in the cloud. From this sense, an intent-based deployment acts as a sustainability enabler.

Siemens notes that cloudification expands the range of choices for implementing a 5G private network and increases the flexibility to easily scale solutions as needed.

Sateliot considers that the cloudification of networks has a significant impact on the interest in deploying private mobile networks by enabling enhanced scalability, flexibility, and cost efficiency. Cloud-based network architectures reduce the need for costly on-premises infrastructure and allow enterprises to deploy and manage private networks more effectively. This trend is particularly relevant for sectors with dynamic connectivity requirements, as cloudification supports rapid scaling of network resources and enables advanced capabilities such as real-time analytics and remote management. One of the key drivers of interest in cloudified private networks is the ability to centralize and virtualize core network functions, which improves operational efficiency and reduces costs. Enterprises can deploy private networks with lower capital expenditure while benefiting from the agility to adapt to changing business needs. Additionally, cloudification facilitates edge computing, allowing data processing and decision-making to occur closer to end users and devices. Furthermore, the shift toward cloud-based architectures underscores the importance of interoperability and open standards. Cloudification enables enterprises to adopt hybrid models that combine private and public network resources. In conclusion, network cloudification increases the attractiveness of private mobile networks by lowering costs, improving flexibility, and enabling advanced features.

Stakeholder_2 sets out that private networks rely on the concept of full control of data infrastructures running the private network, mainly for security and reliability reasons. Such features hardly match with the performance of a cloud infrastructure, relying on an internet access.

Volvo Autonomous Solutions notes that if the cloudification of networks would disrupt the cost level and complexity of configuring a private 5G network it would probably be positive and accelerate the deployment. At the same time, it is very important to keep in mind that many mission-critical applications will need local survivability and stability that is not realistic with a cloud based solution due to lack of (redundant) fiber infrastructure.

4.9.1. BEREC's observations

BEREC appreciates the feedback received from stakeholders regarding the impact of network cloudification on the deployment of private mobile networks. Many stakeholders emphasize the benefits of cloudification, including scalability, flexibility, and cost efficiency, which could potentially enable lower-cost private network deployments with advanced capabilities. However, significant challenges remain in terms of security, reliability, and the complexity of cloud-based infrastructures, which may not meet the more stringent requirements of enterprise customers for stability, predictable performance, and full control over their private networks.

4.10. Summary of key observations & relevant additional insights

BEREC has carefully considered all of the respondents' views and makes a new chapter in the final report to highlight a selection of its observations on the above topics (enumerated 4.1-4.9). As NRAs develop and adapt frameworks for 5G private networks BEREC is ready to assist by promoting additional exchanges between all stakeholders, including where appropriate by inviting experts in the field of private networks to meet at working group level if relevant.

5. Case studies and their drivers for private networks

Case studies have been provided by the following stakeholders: Obvios, Västra Götaland Region, University of Oulu (https://www.oulu.fi/en/projects/hola-5g), DECT Forum, European Broadcasting Union, Volvo Autonomous Solutions, Hewlett Packard Enterprise and Nokia (https://www.dac.nokia.com/).

In line with BoR (24) 150, BEREC sets out information on two selected two case studies in the final report; one from the European Broadcasting Union and one from Volvo Autonomous Solutions. Once again, BEREC reminds readers that the aim was not to write a report about case studies but that referring to some more detailed examples in the final report would complement the perspectives from the NRA survey.

BEREC thanks the respondents for their views and encourages readers to consult all the case studies by reviewing stakeholders' full contributions, which are published alongside this report on the BEREC website.