Call for Input on

Potential spectrum bands to support utilities sector transformation

Nokia’s response to Ofcom’s CFI

Executive Summary

Purpose

Nokia welcomes the opportunity to respond to Ofcom's Call for Input on the "Potential spectrum bands to support utilities sector transformation". We understand this CFI as a first formal step towards identifying suitable spectrums for serving dedicated utility networks, ideally harmonized across the Great Britain and Northen Ireland. Nokia is welcoming this initiative to engage with stakeholders and provide pragmatic views based on our expertise at national and international level in both CSP and enterprise domains.

We understand that at this stage Ofcom is collecting inputs on the potential use of spectrum to sustain the future operational communications in the utilities sector and that spectrum bands under discussion are subject to further consultations. While each frequency under consideration in this document has its own advantages, based on our expertise, Nokia recommend further consideration of frequencies or combination of frequencies that have the potential of the largest harmonization footprint that would benefit the industry. Harmonisation of radio frequency increases the robustness of an end-to-end ecosystem bringing down the cost of the equipment and reducing the potential interferences and coordination requirements. These aspects are of high importance for enabling solutions in the utility/ energy sector.

Our experience in consulting with the UK Energy Network licensees[1] would suggest this is certainly a major juncture in supporting the UK's smart grid and Utility services. We recognise the plurality of spectrum choice.

Our input can be summarised as:

- Access to harmonized spectrum is of interest for short- and long-term benefits: early availability of the ecosystem (including hardware), economies of scale, coordination, etc.
- Technology and service neutral licences that encourage the use of the most spectrum-efficient technologies should be considered.
- Use of standardised (3GPP) broadband solutions and upgradeable technologies for vendor interoperability.
- Ideally, critical infrastructure mobile networks require a minimum of 2x5 MHz FDD sub-GHz spectrum to equally allow for initial utility grid service evolution and support the increasing data traffic. Bandwidths of 2x3 MHz is a starting minimum to assure initial stage of utilities services digital transformation.
- Low frequencies in the sub-GHz range are preferred for coverage purpose. The lower the frequency, the better the propagation.
    - Allocation of spectrum in the higher range of the sub-GHz cannot be compensated with increases in transmit equipment power (UL is a limitation factor for cell density).

[1] https://www.nationalgrid.co.uk/downloads-view-reciteme/597187#:~:text=The%20'LTE%20Connecting%20Futures'%20NIA,Management%20and%20Smart%20Grid%20functionality

    - Combining spectrum in different low bands can assure service centric coverage (e.g., standards in IOT for NB1 and Cat M service, use of private voice services)
- The combination of low and medium bands can provide the required mix of coverage and capacity in designated areas where enhancements are required. Bands above 1 GHz can provide the additional capacity in designated locations but are not suitable for large national footprint for the utilities' purposes.
- Spectrum is a key element that impacts network planning, cell density, energy consumption and associated civil works. Cost-benefit analysis is an important element taken into account by utilities.
- To achieve the ambitious targets of digitally enabling a smarter and sovereign UK utility / energy grid, timely access to adequate spectrum is required to enable the requirements of increasing security in grid supply and the lowering of carbon emissions by 78% before 2035[2]. This can only be achieved by greater digitalisation of the grid, which needs to start in the RIIO-ED2 / RIIO-T2 /AMP7 industry control periods by way of formalised spectrum.
- Proliferation of industrial services over 5G public mobile networks and /or 5GSA private networks are viable options for most non-safety critical or generalised metering / smart grid utility services. Mission-critical aspects of energy/utility services seek separation and privacy from public and more generic services, to meet stringent service level agreements compared with general mobile services. This is a major anchor point for using private networks administered by the CNI organisations across Europe (for/by utilities by e.g., ESB in Ireland, 450connect in Germany, Utility Connect in the Netherlands, and PGE in Poland).

As a critical industry communications provider, Nokia supports solutions based on international standards such as 3GPP, this guarantees hardware and solution interop and ecosystem development with adequate support for the extended operating life of such solutions. Proprietary solutions are not encouraged as they prove difficult to scale and fulfil both from a supply diversity and financial perspective in manufacture.

Nokia has participated and supported numerous European and global trials, in which fostering the right ecosystem is vital for building a smart grid system and solutions based on standards like 3GPP[3].

[2] https://www.bbc.co.uk/news/uk-politics-58792261 and https://www.gov.uk/government/publications/net-zero-strategy

[3] https://www.nationalgrid.co.uk/projects/lte-connecting-futures

Nokia Response

Your response

Question	Your response
Question 1: Have we correctly identified the key changes in the utilities sector that could lead to additional spectrum requirements?	Confidential? – N Nokia agrees that Ofcom rightly identified the trends in the utilities sector and their growing aspirations to leverage digital services. This is a global trend and UK utilities make no exception to it and the desire to achieve a high level of digitization of their networks and processes. We agree with Ofcom's assessment and the expressed view that several sectors within the utilities field have growing communication needs. We equally agree that the electricity sector is predominant and given its nation-wide expanding/consolidating footprint, other utilities may choose to rely on the electricity's communication infrastructure in partition for their individual needs. Nokia sees the LTE systems and their evolution to 5G and further to 6G to offer a supplemental level of efficiency via service convergence. Currently many communication services in utilities are served via narrowband UHF scanning telemetry. Those can be accommodated into a multi-utility services private network operating in a harmonised 3GPP band (e.g., a host services with multi-tenant services for power, gas, water, and renewable grid services leveraging common infrastructure and spectrum bands) by using LTE to deliver extensible and multiple efficiency (as opposed to the way narrowband service individual requirements). Resilience and control – such as under a grid restart or partial distributed restart – require increased communication resources such as voice and video which are ideally offered via private wireless spectrum to reach the increased spread of generation sources which are part of vital power systems[4]. We agree and set some context with thoughts towards global trends where systems employing LTE in similar sub-GHz bands have set multi-service precedence. Nokia look forwards to support further consultation and to engage with stakeholders for developing understandings and future proof points. Strengthening the Grid Operational Telecoms (OT) demands have increased along with the density of assets used in new grid supply points. These typically need to be met via

[4] https://www.nationalgrideso.com/document/156221/download Appendix 1 highlights why a communication fabric such as wireless is essential to a modern resilient and functional grid

	increased use of SCADA and field area monitoring systems to leverage grid capacity with efficiency. Growing complexity in balancing supply and demand Additional spectrum can address the needs of balancing the grid as well as offer the necessary capacity for monitoring and sensing to support EVs and demands in electrification of heating. New spectrum would also enable additional communications capability of the Advanced Distribution Management systems that utilities will use to administer the new local grids. Additional spectrum is therefore essential for energy orchestration - supply, balancing and consumption demand cycles. Outage management and restorative services Nokia agrees that utilities need private spectrum for communications such as 3GPP voice (VoLTE & MCPTT/V) to) to enable to coordinate field crews and to help with fault management. Of particular importance is the availability of spectrum for enabling the use of critical networks during storms when/where the energy and utility providers might have to use common and interoperable communications standards and for efficient joint cooperation of interventions. Private systems would be maintained by utility backup power (e.g., substation batteries) and thus not suffer outages which would be typical in conventional cellular services. This is an important use case for where dedicated spectrum play an essential role. Offshore and Onshore Services In our view, demand for available spectrum in the UK offshore environment is leading to challenges in the coordination. Provision of increased harmonisation of spectrum for a wider UK Energy footprint might be prudent. We acknowledge that Ofcom offers possibilities for offshore spectrum license applications[5], however developments in the Crown estates and in particular licensing of new grid supply points (e.g., Celtic Sea Wind areas[6]) bring home the need for consideration for additional harmonised spectrum, especially when proximities to onshore systems need to be considered.
Question 2: What alternative communication solutions might play a role in meeting the future	Confidential? – N Specific applications of the utilities sector require critical networks capable to deliver security, low latency, reliability, and capacity matching their concrete needs. Such stringent requirements can be provided on daily basis by private networks relying on dedicated spectrum resources. For critical situations –

[5] https://www.ofcom.org.uk/__data/assets/pdf_file/0021/81327/of552_spectrum_access_offshore_mobile_application.pdf

[6] https://www.thecrownestate.co.uk/en-gb/what-we-do/on-the-seabed/floating-offshore-wind/ and https://www.thecrownestate.co.uk/media/4269/gis_2022_0552_flow_refinedareasofsearch_fullextent.pdf

operational communication needs of the utilities sector, alongside or instead of additional spectrum for a private network?	when/where loss of communications or disruptions occur (e.g., storm damage) – transportable Cell on Wheels systems can offer strategic alternatives to maintain services between utilities and provide the connectivity in extreme situations[7]. This may be essential during storm times for power restoration and outage management[8]. While alternatives may equally consider the use of complementary satellite solutions, the high availability sought by the power sector – essential during storm times for power restoration and outage management – cannot be replicated via such systems. For less critical communication needs, several alternatives include use of public networks (mobile and fixed) and in some cases the use of satellite connectivity. The complementary role of satellite can be considered for hard-to-reach, remote areas where delivering capability for rural energy grids. As an equipment developer and supplier, Nokia is involved in the non-terrestrial systems (NTN) discussions[9]. However, we understand the regulatory framework to be under evaluation, and while development of such technology seems to increase, its use remains, at large, complementary to the terrestrial infrastructure for emergency situations and coverage of hard to cover, unpopulated areas. Equally, the use of solutions based on license-exempt spectrum may be of interest for best-effort applications that do not require guaranteed quality of service. Lastly, the shutdown of PSTN systems are likely to see increased use of last mile alternates especially after 2026. These could be PON Passive optical fibre and be considered as necessary infrastructure for the WLR wholesale Line Retal sunset. Many devices will require power solutions for sensors, and this is especially true in Water telemetry systems. Consequently, providing the required communications needs via own networks is the preferred alternative for utilities. Planning for additional spectrum availability to satisfy the growing utilities needs is welcome, considering not only the increasing data traffic growth of the networks but also the technological upgrades of the communication infrastructure (e.g., from narrow band to broadband, from non-3GPP and proprietary solution to 3GPP-based technology, upgrades to latest technology evolution LTE-5G-6G, etc.). Harmonisation at larger scale of such approach can ensure a consolidated end-to-end ecosystem with economies of scale and early availability of equipment and devices.

[7] https://www.nist.gov/image/dscn0014jpg

[8] https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/interesting/2021/2021_07_storm_arwen.pdf

[9] https://ast-science.com/

Question 3: Are there any other spectrum bands we should consider for use by utilities?	Confidential? – N Nokia is of view that frequency bands in the Table 3.1 have potential for utilities network roll-out. However, consistent with our response to the consultation on the 1900 MHz band[10], we reiterate the preference for low UHF bands, below 1 GHz, for such deployments due to better propagation characteristics of the sub-GHz band and the economies associated with the overall network cost. Above 1 GHz spectrum can be considered as an enhancement to the UHF spectrum where/when additional capacity is needed and in specific locations. (e.g., for specific localised capacity) - With this in mind, Nokia is supportive to privilege the use of the FDD 410MHz and 450 MHz bands. As rightly mentioned by Ofcom, harmonization of the bands within the country, aligned with other European countries will have a positive impact both on the equipment ecosystem (availability, prices) and cross border coordination. - Coexistence constraints also should be considered, and restrictions should not be applied exclusively to newcomers. We encourage Ofcom to analyse actual status of the proposed bands and the measures that can be adopted. In the event that moving of existing users in other bands is not or partially possible, retuning of historic frequencies, as well as other measures to reduce interference they may create is welcome. Ideally, access to a clear band is the preferred option. - In line with the concerns regarding the costs associated with deployment of a private network for utilities, we agree with the Ofcom's assessment. However, costs associated with potential clearing of the band should be carefully assessed as utilities cannot take a high burden from these costs that will reduce their capacity to invest in the network. Nokia consider the use of 410-430MHz frequency range for deployment of suitable network for utilities, as propagation characteristics allow for large coverage area. FDD channels of 2x3 MHz in the short-term, and ideally 2x5 MHz in the long-term. Its consultation goal should be as a contender for GB (recognizing that proposal in this consultation concerns portion of the band for NI only). We would like to suggest Ofcom to consider the potential use of the 410 MHz band across the entire country, both NI and GB. With several trials currently underway we understand that a lot of concerns for the low band interference to national systems can be pragmatically resolved by further study. The use of 700 MHz would clearly abstract such problems in

[10] https://www.ofcom.org.uk/__data/assets/pdf_file/0025/262807/nokia.pdf

	sensitive locations to make such concerns from spectrum adjacency negligible or zero. Furthermore, the launch by the Electricity Supply Board (Republic of Ireland) of its 410 MHz Band 87 LTE service, along with recent ongoing considerations ongoing in other European countries (France, the Netherlands), indicate a growing potential for consolidation of deployments in the band. Further consideration should be also given to potential channels of least 2x4 MHz FDD in the 410-414 MHz paired with 420-424 MHz range, to allow future migration/upgrade of existing UK hilltop narrowband services. Any additional 3GPP standardised UHF frequencies are also ideally suited, due to penetration characteristics. Equally, larger bandwidths (up to 2x10 MHz) would benefit the utilities landscape, where aligned with ecosystems. Expansion options within the 700 MHz bands 28/68 are under consideration/implementation in Europe and Middle East allowing for a total of 2x3 MHz + 2x5 MHz to be used for critical communications. Lastly, we would like to highlight the growing interest for definition of new 3GPP 4G/5G bands in the 380-400 MHz range. While discussions are in early stage, we encourage Ofcom to monitor developments and assess in due time the potential of spectrum in this range for further use by utilities.
Question 4: Do you have any comments on the three bandwidths we have considered that might be necessary to support a private network for utilities? Please reference our capacity analysis in annex 7 where relevant.	Confidential? – N Nokia agree with the capacity analysis which have been constructed with the empirical sources from the active field trials. We consider that for immediate provision of effective industrial LTE services, utilities would need a bandwidth of minimum 2x3 MHz to provide the required capacity per cell, including multiple voice channels, multi-service, and for potential of multi-tenancy services for gas and water utilities. This point is important in terms of the continuous use of radio resource blocks independently of the symbols and capacity bitrates per Hz that has been studied for services. Engineering design will need to factor in the number of resources available to serve endpoints (devices and CPE equipment) in a given cell / zone as to maintain certain latency and throughputs. As an example of this point, video CCTV could easily sustain 50-100 ms of delay but activating a re-closer or switchgear over LTE would need to have dedicated resources or spectrum for near real time performance. As the grid becomes more dynamic and adaptive due to renewables, this last point is important when considering resource / spectrum constraints and the potential for the radio cell (ENode) to buffer services if the channel is too constrained by quantity of endpoints.

In real terms, the use of Primary Resource Blocks (PRBs), in an LTE system is an important consideration that should be viewed differently to the spectral bandwidth employed.

Service mix consideration: 2x1.4 MHz bandwidth would be ideally suited to dedicated IoT and sensing environments which have less need of low latency factors. IoT systems like NB-IoT / Cat M1 services could be fulfilled in the 400 MHz spectrum areas however complemented (essentially) by a 2x3 MHz allocation in the 700 MHz range for general utility services. These two complements would enable grid services such as voice, data and the transport of SCADA telemetry, which are important for Grid supply and new administrations of energy systems.

2x5 MHz channels would allow for growth and multi-tenant services and the future evolution from industrial LTE to industrial 5G and 6G in longer term.

In addition, 5 MHz channels would allow partition into a number of multi-tenant fabrics (for DSO, TSO, gas services, water services), that means future allocation of spectrum would be somewhat offset for the sector as a whole and differing from the way business radio has employed spectrum in 1:1 narrowband assignments.

We therefore invite Ofcom, when defining its future strategy for spectrum for utilities, to consider not only the actual situation but also LTE systems in medium and long-term evolution of the utilities' private networks and the spectrum requirements to allow an evolutive path towards 5G and 6G.

The use of 1.4 MHz channels would be ideal foundations for utility IoT/NB-IoT/Cat – M services (e.g., 100s Kbps) although this would not be enough spectrum resources to serve the needs of UK energy grid administrations as noted in the capacity studies.

It could be that multiple bands are used to create a situation similar to that in Germany[11] with the allocation of the spectrum in the 450-470 MHz Band 72 LTE space. For 2x4.74 MHz channel assignment for national use and partitioning (offering almost 2x5 MHz channels).

In summary, PRBs are a fundamental building block of LTE networks, providing a fixed-size channel that can be allocated as a shared system (this is important that the net result is a multi service fabric).

The number of PRBs allocated to an LTE user determines the data transmission rate and the quality of service. By dynamically allocating PRBs based on QoS requirements and network conditions, the network can maximize its resource utilization and efficiently serve a larger number of users,

[11] https://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/DE/2021/20210309_450mhz.html and https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Sachgebiete/Telekommunikation/Unternehmen_Institutionen/Frequenzen/OffentlicheNetze/450mhz/Praesidentenkammerentscheidung450mhz.pdf?__blob=publicationFile&v=2

	which would be the case for a shared fabric in the UK and thus support the gas and water company aspirations alike, all using a single spectrum deployment. Other factors here include "slim carrier" techniques which can allow wider channel assignments to be employed outside of the normal 3GPP channel designations but with masking of the radio such that licensing can be met (i.e., blocking of certain PRBs). Carrier aggregation can be used to combine multiple channels on different carriers, but this is subject to limited eco system support across the designated frequencies.
Question 5: Do you have any comments on our approach to examining each potential candidate spectrum band, including the factors relevant to assessing suitability, and the capacity and coverage analysis provided in annexes 7 and 8?	Confidential? – N Nokia agrees in the most part with the findings, which present useful variables in achieving the coverage modelling. - We would agree that the most universal band is the 700 MHz range due to its coverage potential and availability for the existing eco system or devices (readily available today) - We do see some divergence in the uplink EIRP and modelling from a UE perspective, where commercial CPE UE devices are limited to 23dBM (~200 mWs of output power). Usually, the higher power base station transmit EIRP is of sufficient reach for the high percentages indicated. However, the pre amp technology (used to hear back from the extended cell reach in the case of raising cell power) may be constraining, Meaning that the device or UE ability to talk back is always the constraint. Therefore, some regulatory consideration to CPEs uplink EIRP power may be warranted to improve the footprint in bidirectional capacity. This may create opportunity for high gain CPE and or antenna per se.
Question 6: Do you have any comments on our overview of the 400 MHz band in NI? Please consider the specific factors we have discussed in your response.	Confidential? – N Nokia is of the view that spectrum in the 400 MHz band is of great potential for critical energy services within the entire UK territory. We see improvements to the MOD systems in GB and the nature of LTE channel adjacency (out of band emissions) to making coexistence possible (i.e., modern LTE filters have sharp decay, therefore it is not expected these would generate anticipated interference with other systems). This can easily be demonstrated to mitigate concerns and also noted is the use of proprietary wireless[12] (non-LTE) in the 412-422 MHz paired areas presently allocated which, also have never knowingly impacted such systems. The conclusion is that harmonisation of this band

[12] https://arqiva.com/Smart%20water%20insight%20guide%20-%20ARQIVA.pdf?language_id=1, see page 6

	across NI and GB for 3GPP LTE mission-critical utility services should be given clear consideration by Ofcom. This will reduce interference from 3gPP / GSA[13] approved UE devices and base stations that align with continental Europe and in particular Republic of Ireland. The characteristics of the 410 MHz band make it ideal for providing the most cost-effective option for network deployment (in terms of cellular sites density) to deliver advanced connectivity for utilities. Nokia see the potential for using the band to serve NI (using the upper 2x3 MHz FDD – that according to Ofcom are not in use) whilst avoiding the lower 2x2 MHz in the PSNI regions. In GB we also note potential of harmonisation similar to use in NI for the band over the potential ranges 410-415 MHz paired with 420-425 MHz. Therefore, it follows that for NI and GB could harmonise this band with its neighbours over time.
Question 7: Do you have any comments on our overview of the 450 MHz band in GB and NI? Please consider the specific factors we have discussed (including the coexistence analysis in annex 9) in your response.	Confidential? – N The 450 MHz band presents an interesting challenge requiring moving existing licensees into another portion of spectrum to create the necessary space for co-existence. If the LTE spectrum masks applied are as specified in ECC Dec (19)02 Annex 3[14], only limited guard bands are required to support the required adjacent service with the narrow band incumbents. 1.4 MHz, 3 MHz and 5 MHz LTE FDD channel arrangements could be implemented in the paired frequency of 451-456 MHz and 461-466 MHz or in 452.5-457.5 MHz paired with 462.5-467.5 MHz, but this will need the appropriate masking and migration to be in effect to avoid mutual interference. These bands being typical for Germany and Poland Utility provisions. The spectrum masks are based on extensive compatibility studies performed as per ECC Report 283[15]. A 200 kHz guard band could be considered for protection of existing narrow band (NB) BS receivers in the near proximity of an LTE BS transmitter. The issue is compounded not by co-existence but one of base station transmit (DL) frequency for LTE system, which is high power compared to the

[13] https://gsacom.com/paper/lte-ecosystem-august-2023/

[14] https://docdb.cept.org/download/1455

15 https://docdb.cept.org/download/1355

	legacy narrow band systems device TX (UL). This is also the discussion of much interference from European systems which adopt the 3GPP standards for base station transmit (Tx)and can propagate high noise floor levels which disrupt existing utility systems.
Question 8: Do you consider that changes in the spectrum environment for the 450 MHz band mean that there is a case for re-examining whether this band should be reconfigured in the UK to align with the harmonised band plan?	Confidential? – N Nokia welcome the discussion to look at harmonisation of both UHF Band 1 and Band 2 - 410 to 470 MHz region especially given that many European countries are following the 3GPP spectrum allocation for FDD systems in which base station transmit is in the higher duplex. As part of longer-term horizon this is an important consideration in which many of the existing frequency users would benefit from the potential in LTE / 3GPP band harmonisation where legacy narrow band services could evolve into such harmonised areas.
Question 9: Do you have any comments on our overview of the 700 MHz band in GB and NI? Please consider the specific factors we have discussed in your response.	Confidential? – N The frequency highlighted benefits from a rich and mature ecosystem of device and chipsets supporting the 3GPP band 28/n28. Many module chipsets exist for this band with Cat 6 3GPP capability which drives higher aggregation and throughput (spectrum efficiency). Examples from Sierra Wireless and other module manufacturers for form factors using the PCI Express M.2 module[16] can support a wide range of eco system devices with LTE Band 28 703–748 MHz 758–803 MHz The 2x3 MHz (733-736/788-791 MHz) band can represent a useful starting spectrum block for utility services, which could easily co-exist within SDL and current public networks operations in the band28/n28. 3GPP is extremely clean for out of band emission compared to other equivalent systems (the reason is significant manufacturing investment in filtering) , and this can be easily proven by equipment trials to make efficient use of the 700 MHz clearance being suggested. Furthermore, analysis of the somewhat proprietary nature of SDL shows this is not heavy utilised by current device manufacturers. Thus, potential for edge band disruption is considered to be minimal if not negligible. Evidence for

16 https://www.4gltemall.com/sierra-wireless-airprime-em7430.html

	similar UHF neighbouring is cited within footnote[17]. This indicates that with suitable guarding, out of block emissions can be suitably abstracted.
Question 10: Do you have any comments on our overview of the 800/900 MHz band in NI? Please consider the specific factors we have discussed in your response.	Confidential? – N At present we understand there is no direct correlation with Utility ecosystems or devices, and lacks a 3GPP index or spectrum index, which make employment of this band use difficult to predict. We understand that GSM-R as anchor would need to be re harmonised for such possibilities to exist in GB. Given the lack of device support in market terms we would be unable to commit in manufacture for such niche allocations.
Question 11: Do you have any comments on our overview of the 1900 MHz band in GB and NI? Please consider the specific factors we have discussed in your response.	Confidential? – N Whilst this spectrum is designated at European level for railways for FRMCS, we understand that Ofcom seeks to potentially improve its usage in the future by opening it for utilities. For additional details on our Nokia position please consider our response to the consultation "Exploring future use of the unpaired 2100 MHz (1900 - 1920 MHz) spectrum".
Question 12: Which band(s) do you consider we should examine further with a view to developing consultation proposals to enable their use in a private network, if this were needed? Please reference the factors we have considered where	Confidential? – N We would suggest two horizons in summary of our response. Near term horizon consultation • Providing spectrum that facilities an ecosystem • UHF designation for improved business case of cellular density • CPE / supplier choice across voice and data services. • Offers useable spectrum in at least 2x3 MHz FDD designation, and subject to interference mitigation can be administered in short term. The frequency that services this typically is the B28 Bravo for 733-736 MHz paired with 788-791 MHz. Medium term horizon

[17] ECC Report 283 provides results of compatibility and sharing studies related to the introduction of broadband land mobile systems as well as systems based on NB-IoT and LPWAN technologies in the bands 410-430 MHz and 450-470 MHz. No conclusion on the intermodulation effect from broadband interferers into narrow band victims could be reached in ECC Report 283 and additional investigations will be conducted within ECC.

appropriate and provide separate answers for GB and NI if relevant.	• We would suggest that 410-430 MHz is the ideal spectrum already employed in GB trials and provisioned in continental Europe. • Use of FDD spectrum in this area <u>would be a complement</u> to the near term horizon. • Will offer diversity in spectrum choice across the UK as a whole. it is recognised further administration is needed, specifically to align bands in 410-430 MHz and 450-470 MHz domains. Hence, we identify a combination and a two-phase approach.

Addendum

A7 Capacity Discussions

Nokia agree with the general capacity statements within appendix 7 but highlight that spectrum capacity should not be viewed as a real time finite resource. In other words a capacity of x Mbps sliced amongst Data Voice and Video granularity would be accurate if each service continuously needed real time data link over the air. Consideration should be given to <u>multiservice time scheduling</u> where devices (CPE) and LTE systems can also time slice services with the available channel (resource blocks allocated).

3GPP represents a departure from existing narrow band and single point services models which look at capacity as a function of dedicated 12.5Khz channel building blocks and bps. Here with 3GPP we employ PRB and subchannel sharing techniques, which means that applications are subject to a fabric sharing and at the general cost of latency. (Thus , more channel equates to more service efficiency overall)

QCI and Qos mapping can ensure that the system is not overloaded for such multiservice aspiration and indeed the table below highlights a typical Utility service environment.

Low = 100Kbps   Med = 1-5 Mbps   High - > 6 Mbps

Utility Use Case		UE type	Service Type	Interface	Bandwidth	Latency
Utility	*Distribution Automation*	CPE / UE	L3 VPRN, raw socket IP Transport	Ethernet, RS-232	Low	100-300 ms
	AMI Backhaul	*CPE / UE*	*L3 VPRN*	*Ethernet*	*Medium*	*100-300 ms*
	Fallen Powerline Protection	*CPE / UE*	*L3 VPRN,* *L2 VPLS/VPWS*	*Ethernet*	*High*	*50 ms*
	Physical Security	*CPE / UE*	*L3 VPRN*	*Ethernet,* *RS-232*	*High*	*100-300 ms*
	CCTV	*CPE / UE*		*Ethernet*	*High*	*175 ms*
	IT/Office	CPE / UE		Ethernet	High	100-300 ms
Utility Voice	*MCPTT/ MCPTV**	Mobile UE	Data Channel UE	Voice/Video	Low	<100 ms
	MS / VoLTE	Mobile UE	APN Voice	Voice/Video	Low	<75 ms

*Push to talk / push to video

Theoretical capacity using Uplink with 3 MHz from an FDD duplex (3GPP standards/Specifications)

Bandwidth	1.4 MHz	3 MHz	5 MHz
PRB	6	15	25
Sub Carrier	72	180	300

Typical LTE resource blocks and subcarrier (15Khz) totals

The data rate always depends on the channel bandwidth and modulation . For example, in case of 3 MHz channel bandwidth, 180 subcarriers are used.

Case 1 (typically downlink) = For a perfect idle condition 64 QAM is typical, and each symbol is 6 bits of data. (000000-111111)

Total bits are then 180 X 6 = 1080 bits.

1 symbol is of 71.4 microseconds (7 OFDM symbols per slot) = 0.5mS for LTE.

So, the data rate is 1080bits / 71.4uS = 15,126,050 bps (15Mbps) for 64QAM

Case 2 (typically uplink) = 16 QAM and each symbol is 4 bits of data. 0000-1111

Data rate is (180x4) / 71.4uS = 10 Mbps for 16 QAM

Conclusion on Spectrum Capacity and Services

1) The formula for calculating maximum data rate at physical layer at 64QAM is:
   (Number of subcarriers X 6) / 71.4 microseconds , subcarriers is function of channel BW size
2) Ceteris parabis modulation rates are key to symbol rates and bits / Hz.
3) LTE and 3GPP evolution is a multi service system where small amounts of latency increase the yield of Radio / Spectrum services supported and this is shown in the table of Utility Use cases previously where some tolerance in latency allow for multi service environments. In other words the capacity of connections is a function of scheduling and latency beyond physical bits / Hz.

<End >