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| 3GPP TR 38.893 V18.0.0 (2023-03) | |
| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Radio Access Network;  Study on UE support of regionally-defined subsets of an NR band (Release 18) | |
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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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x the first digit:

1 presented to TSG for information;

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# Introduction

3GPP defines specifications that are applicable worldwide including the definition of NR frequency bands across both FR-1 and FR-2 frequency ranges. In general, 3GPP seeks to enable economies of scale and commonality of bands across multiple countries and regions around the globe. This can lead to bands with very wide bandwidth to be able to capture the frequency ranges within this band that might be available within different countries. Hence, the band definitions are not necessarily tailored to the frequency ranges available in any one country but may be broad enough to enable applicability across many countries. In addition, mechanisms such as NS signaling have been introduced in RAN4 specifications to enable the network to indicate additional or unique country or deployment-specific requirements on top of the general requirements associated with the band.

In order for a UE to declare support of a band, it must support the entire band including all of the general requirements as well as all NS requirements specified for this band. Consequently, the UE is able to operate on the band in any country where this band or portion thereof is deployed while also meeting any country specific requirements or regulations that may be applicable. However, it has been observed recently that there are situations where the UE can only operate on one or more subsets of the band within a particular country. This was reported for Band n77 first in the US and then again in Canada. In both of these cases, Band n77 was defined as a very wide band with global applicability, but the regulators in the US and in Canada only made available portions of the band for mobile usage. Moreover, different portions of the band were made available at different times, so there was the possibility that UE’s might support one or more-than-one subset of the band depending on when the UE was designed, manufactured, and/or certified with respect to the timing of spectrum release and regulations in the country. To be clear, to meet 3GPP requirements, the UE must support the entire band. However, the situation describe above pertains to regulatory compliance rather than compliance to 3GPP requirements. If the UE is not certified by a country’s regulator to operate on a certain part of the band, irrespective of what is specified in 3GPP, the UE is not allowed to operate on that part of the band in the country.

Specific solutions were identified and specified for Band n77 to resolve the issues related to spectrum subsets in the US and Canada. However, it is anticipated that issues such as this may become more commonplace and therefore a RAN level study item to consider a more generalized solution was agreed. This technical report captures the contents of the study item.

# 1 Scope

The present document captures the study on UE support of regionally-defined subsets of an NR band. In accordance with 3GPP specifications, a UE is required to support the entire frequency range of a band as defined by [2], [3], or [4]. However, it was found that for some bands, there may be regional regulatory restrictions to this frequency range in some countries. The scope of this study is to investigate the root causes that may require 3GPP specification changes to accommodate as well as to consider possible general solutions if needed.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 38.101-1: "User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".

[3] 3GPP TS 38.101-2: "User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone".

[4] 3GPP TS 38.101-5: "User Equipment (UE) radio transmission and reception; Part 5: Satellite access Radio Frequency (RF) and performance requirements".

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

**example:** text used to clarify abstract rules by applying them literally.

## 3.2 Symbols

For the purposes of the present document, the following symbols apply:

<symbol> <Explanation>

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

DOD Department Of Defense

MPR Maximum Power Reduction

NS Network Signalling

# 4 Root cause

The first step of this study item is to identify root causes using Band n77 in the US and Canada as an example.

The regulatory bodies of some countries limit device certification to the designated spectrum and limit operation of certified devices to that designated spectrum. This has not created issues for 3GPP because usually there were regulations for an entire band when spectrum was licensed and because regional spectrum allocations seldom change. The introduction of very wide bands, e.g., 900 MHz wide NR band n77, created a situation where regulations existed for only part of the band in some countries. For example, in the United States, initially 3700-3980 MHz was available for mobile services, auctioned in December 2020, but other parts of n77 were not available at that time. In order to be able to certify devices, Note 12 was added to 38.101-1 Table 5.2-1, which read:

"NOTE 12: In the USA this band is restricted to 3700 – 3980 MHz".

The problem with this solution was that there was no plan to handle the situation where additional spectrum in n77 would become available for licensing. Later, when 3450-3550 MHz became available to be auctioned in October 2021, assignment of a new 3GPP band for the 3450-3550 MHz frequency range was considered, but it was decided in 3GPP that re-use of n77 was a more expedient course for incorporating the additional US allocation. The note was therefore modified as follows:

"NOTE 12: In the USA this band is restricted to 3450 – 3550 MHz and 3700 – 3980 MHz."

But this led to a situation where early US FCC certified devices would only operate on 3700-3980 MHz and not on 3450-3550 MHz. Roaming UEs not certified for 3450-3550 MHz in the US might attempt to access that part of the band, but such UE behaviour was not specified so concerns were raised that the gNBs needed to know if the UE was allowed to operate in that part of the band for handovers and CA configuration. To inform the gNB if the UE supported 3450-3550 MHz in the US, a new UE capability was introduced: extendedBand-n77-r16. However, concerns were also raised that a roaming UE that did not indicate extendedBand-n77-r16 might attempt to access 3450-3550 MHz, causing confusion and potentially negative consequences. To prevent a UE that does not indicate extendedBand-n77-r16 from accessing 3450-3550 MHz in the US, a new NS value (NS\_55) was created. Where normally NS values indicate additional emissions requirements for a band, in this case NS\_55 is used to bar UEs that do not support extendedBand-n77-r16 from accessing 3450-3550 MHz in the US.

There is a similar situation in Canada, where the initial licensed spectrum was 3450-3650 MHz was auctioned in June 2021 and then 3650-3980 MHz is expected to be auctioned in Early 2023.

It should be noted that while the UE only supports a part of the band in certain countries, e.g., the US and Canada in the above examples, the UE still shall support the entire band when roaming to other countries to be compliant with 3GPP requirements.

The root cause of the issue requiring UE band subset support is summarized by the combination of the factors listed below

1. A regional regulator makes an initial frequency allocation of portions/subsets of the 3GPP band, i.e., not including the entire band

2. The region requires UE certification for all UEs operating within the borders of the region.

3. The regional certification only applies to the frequency allocation at the time of certification.

4. The UE must confine its operation to the frequency band for which it was certified.

5. The regional regulator subsequently allocates other portions/subsets of the band [and/or regulations change within the existing sub-bands].

6. Newer UEs are certified for both the original allocation and subsequent allocations.

This combination of factors leads to different UEs supporting different subsets of the band. The network needs to be able to distinguish between these different UEs to enable efficient handover and SCell/PsCell activation.

# 5 Other Issues

## 5.1 Roaming UEs

In some countries it is neither the operator nor the base station that takes responsibility for the UE meeting regulations. In the USA UE vendors can only allow their devices to operate in parts of the band where there are FCC regulations at the time of device certification.

UE vendors may choose to pursue certification for some countries but not others. In view of the regional regulatory differences described above, we recognize that there may be ambiguity with regards to exactly which regulatory requirements are supported in any given UE implementation. It is important to understand how this ambiguity could affect regulatory compliance when UEs roam in countries in which they are not certified. Two scenarios are identified for clarification for feasibility of roaming:

- The first scenario is if a UE is certified to operate only in part of a band (e.g. band n77 cases UE in Canada/US). In this scenario, the UE is only allowed to operate within the subset of the band for which it is certified in the country where this certification is necessary. Because the UE in addition to the above regulatory certification is also compliant to 3GPP requirements (e.g., for Band n77), it is required that the UE can support the entire band. Therefore, this UE when roaming to a country which does not have any regional regulatory requirements shall be able to operate on the entirety of the band. If this country does have regional requirements, the UE shall abide by them to operate in this country.

- The second scenario is if a UE can support the frequency range of a band based on the 3GPP requirements but not certified for additional regional requirements in a subset of the band in a certain foreign country. This aspect has to be evaluated for each country based on prevailing regulation. Whether the roaming UE is allowed to operate without certification from the country’s regulator is subject to each country’s laws.

# 6 Possible solutions

## 6.1 General

The solutions in clause 6 should be at least capable of solving the issues indicated in clauses 4 and 5. Moreover, solutions should be applicable for handling existing UEs which were already deployed in the market before the introduction of new regionally-defined subsets of an NR band or new released regulation.

Regarding all solutions, considering accommodations for cases where the UE subset support precludes the possibility to test some MSD exceptions: If the UE supported subset precludes the possibility to test some MSD exceptions, just like with Note 12 for n77 either the MSD configuration can be changed so the MSD is testable in the country that uses the sub-band or a note can be added to waive the MSD.

## 6.2 Solution A: New Band introduction for sub-band

Introducing a new band is a well-known technique for RAN4, which has been used to differentiate between different (sub-)bands or portions thereof in 3GPP specifications. For instance, Band 26/n26 are supersets of Band 5/n5, and Band 25/n25 are supersets of Band 2/n2. Also, Band 19/n19 are regional subsets of Band 5/n5. These new bands have separate band combinations and separate RF requirements, including different refsens and MSD. However, in the case of Band 26 and 25, the superset bands were introduced in 3GPP after the smaller B5 and B2 were in the specification, so it is not quite the same situation as with Band n77, where there is an existing wider band, but a need for a regional sub-band.

One downside of introducing a new band for a regional sub-band is that new band combinations are required for the new bands. This can create significant workload for RAN4 because of the redundant effort. Also, RAN4 would need to specify all of the requirements for the sub-band including RF and performance requirements.

The use of new bands for regional sub-bands would provide a means to limit access to spectrum in a region that only has regulations for the sub-band, but it could lead market fragmentation if vendors introduce UEs that only support the new regional band, and not the wider full band.

## 6.3 Solution B: New Band Number

Another potential solution is to introduce a new band number, which is not a new band. The difference between solution A (a new band) and solution B (a new band number) is that all the same RF and performance requirements of the original band (i.e. parent band) should apply to the new band-number without generating new requirements with respect to existing system, RF, RRM and demodulation requirements (i.e., "parent" bands requirements), but the new band number would allow for differentiation of which part of the spectrum a UE is certified to operate in the region. All the band combinations that apply to the parent band would also apply to the new band number. One example of a new band number is n90, which is identical to n41 and applies the same requirements except that n90 also supports the 100 kHz raster and the 7.5 kHz uplink shift. There are no band combinations defined for n90 because all the n41 combinations apply to n90 also. In the case of n90, the new band number was more of a capability signalling mechanism to allow the network to identify UEs that support the 100 kHz raster and 7.5 kHz shift, and bar n41 only Ues that don’t support those features.

For regional sub-bands, the new band number can be thought of more as a signalling mechanism used to allow or bar devices based on support for a particular part of the band. It is similar to the extendedBand-n77-r16 / NS\_55 solution, except that it uses existing UE capability signalling and barring and does not require any new network signalling.

An example of how this would work is that at some point in time 3300-3450 MHz might become available in the USA for Mobile use. If this spectrum does become available, then a new band number could be allocated to indicate that a UE supports 3300-3450 MHz, as well as 3450-3550 and 3700-3980 MHz, in the US. Only the new band number would be signalled from cells in the new frequency range in the US so that only Ues that support the new band number would attempt to access 3300-3450 MHz in the US. Also, when the gNB examines the UE capabilities, it would know if the UE supports 3300-3450 MHz in the US based on if it reports support for the new band number or not in its UE capabilities.

The benefits of the new band number approach are:

- No new RAN2 signalling needed as new parts of the band become available.

- No new NS values required for barring UEs

- Only to change the semantics of 3GPP frequency bands and need 3GPP clarification

There are many available band numbers (i.e. 107 out of 1024 have been used so far for NR), so there is no concern on the band numbers shortage.

3GPP would pro-forma select a new band number based on regional frequency allocations within an existing 3GPP band, the existing band being referred to as the parent band.

If the network wants to avoid that a legacy device supporting only the parent band (but not indicating support for the new band number) will camp on a cell in the new sub-band, the network can indicate only the new band number on cells in the new sub-band. In this manner the technique of a new band number should prevent UEs which are not compliant to the requirements of the new sub-band from camping on or accessing the cell in such a sub-band. And the gNB sees from UE capabilities the bands and band numbers that the UE supports and hence the gNB knows if the UE can be handed over to a cell in the new sub-band.

The new band number would apply the RF requirements from the parent band. It assumes that there is no dedicated sub-band hardware for the UE such as RF filters to be utilized for the new band number. Whether the sub-band corresponding to a new band number may include previously (chronologically) introduced sub-bands of the same parent band. This is to be considered case by case and depending on different factors (e.g., whether sub-bands are defined within the same geographical region. To avoid market fragmentation and to support UE roaming, it should be mandated that the new band number can only be supported by a UE which also supports the associated parent band. If a UE including, roaming UEs, is not certified to operate in new band number based on regional regulatory certification, the UE shall not advertise the new band number in its capabilities nor shall it attempt to connect to a cell broadcasting this new band number.

In current practice, adding a new band triggers introduction of new band combinations, which would add many new band combinations to the specification and UE capability signalling. By contrast, adding a new band number, such as when n90 was added, does not require new band combinations, but rather text stating that combinations for the parent band apply to the new band number. Furthermore, inter-band or intra-band CA is determined with consideration of the parent band and not the sub-band(s).To ensure that UE capability signalling is not adversely impacted by the number of supported band combinations, this technique requires that the new band number corresponding to the new sub-band has a reference to the parent band for signalling carrier aggregation (CA) and dual-connectivity (DC) band combinations.

NOTE 1: It should be studied further whether a UE shall report band combinations for the parent and sub-bands, and if not, which specification impact it will have.

NOTE 2: The introduction of a new band number should not have impact on the parent band.

NOTE 3: Any other optimizations based on new band number approach are not precluded.

This technique should require no new signalling and can work for any release UEs, but it does change the semantics of 3GPP frequency bands and 3GPP should clarify the association between a new band number and their parent band in signalling requirements. If the new band number approach is applied, 3GPP RAN4 should:

- Ensure that the number of new band number definitions does not exhaust the range of possible band numbers: Rel-17 signaling supports 1024 NR band numbers, or which 104 are assigned in Rel-17. Exhaustion of the range of band numbers is not anticipated to be an issue.

## 6.4 Solution C: Reuse existing NR band number, new signalling

With this solution, the existing NR band is re-used, but there is also explicit signalling for different regions– either from the UE to the network, from the network to the UE, or both – providing further information to the communicating entities regarding which sub-bands are supported. Hence for the sake of clarity we will focus separately on potential options for signalling for both communication sides.

The premise for introduction of signalling from the network to the UE can prevent legacy UEs from camping on particular sub-bands which they do not support. The easiest way to accomplish this is to define new NS value associated with the corresponding band. With this approach the network broadcasting new NS value can be always sure that a legacy UE will not camp on a particular sub-band. It does not matter how many sub-bands are added and in which release – as long as every sub-band is associated with a particular NS value, the network remains in controls of permissible cells for camping destinations.

As for the UE to the network signalling, one of the main reasons to have it is to provide the network with additional information regarding which sub-bands a UE supports to facilitate network sub-band selection for re-direction and handover procedures. This information on supported sub-bands can be implemented in at least the following ways (not precluding other options):

- **Option A:**The UE capability is implemented as an explicit capability in the UE capability container, whereupon it can be as simple as one bit or something more versatile. Since such a generic UE capability does not exist, RAN WG4 will need to contact RAN WG2 every time such a capability is needed (as it already happened with the DOD-band). To reduce such issues, a generic approach (as illustrated by the next alternative) could be preferable

- **Option B (via e.g., *modifiedMPR-Behaviour* field bitmap or a new bitmap)**: This approach is logically identical to the previous alternative, with the difference being that instead of the asking RAN WG2 to define a new capability for each new sub-band, a more generic signalling is used, which can be defined as per-band signalling and whose content can be defined by RAN WG4. Two options below are examples of how it can be accomplished.

a) One option is that the existing capability *modifiedMPR-Behaviour* can be leveraged for this purpose. The *modifiedMPR-Behaviour* can already be signalled for every band not requiring any RAN WG2 changes. Since it is up to RAN WG4 to define the purpose and meaning of every value of that field, UE can use this capability to indicate supported sub-bands based on meaning defined in RAN4. However, this would be changing the original intent of this capability since it relates to MPR, not to sub-bands, and Repurposing the existing capability may create unforeseen issues.

b) Another option is to include a new band subset indication to UE capabilities. In this proposal, the parent 3GPP band designation may be followed by an indicator which identifies which sub-allocation of the band applies to the region in question. From the signalling perspective this approach is similar to *modifiedMPR-Behaviour* described above, but a new dedicated capability would be defined by RAN2 WG2, content of which will be further specified by RAN WG4. This proposal avoids the issue of parent-band association, but at the cost of defining new signalling.

As an example, the solution adopted for band n77 was a combination of the following elements:

- UE-to-NW signalling: defining the explicit UE capability indications (extendedBand-n77-r16 and extendedBand-n77-2-r17); and

- NW-to-UE signalling: defining new value NS\_55 and NS\_57 for barring UE access to the sub-bands.

# 7 Conclusions and recommendations

The study item has reviewed possible responses to situations in which regional regulatory bodies may allocate subbands of the existing 3GPP bands in a phased fashion. In these cases, UEs may be certified for different subsets of the 3GPP band(s) and must therefore operate only within the subbands for which certification has been received. Further, networks should not attempt to redirect these UEs to frequencies not in the subbands for which certification has been received. Different proposals for ensuring these behaviours are documented herein.

For band standardization issues which arise from cases where regionally-defined subbands do not occupy an entire 3GPP band, we offer the following conclusions.

Solutions A, B or C are valid approaches which could be used to solve the problem with the regional sub-bands. Solution B is expected to have a lower standardization workload and hence, should be adopted over Solution A if no issues are identified. However due to related workload, it is recommended that solution B with applying the same requirements (i.e., "parent" band requirements), is preferred over solution C if this approach is confirmed by the working groups. Which method (e.g., new band number, new NS flag, new band, etc.) is chosen for a particular band can be decided on a case by case basis under a dedicated work item.

RAN2 and RAN4 should fully evaluate the specification, implementation, and test impacts of the new band number approach during the first work item associated with a regionally-defined subband and adopt an appropriate solution based on their evaluation.

Finally, it is recommended that care should be taken to ensure that the UE behaviour is predictable when operating within the regionally-defined subband and when the UE is operating in the parent band when it in a location where the regionally-defined subband is not applicable.

Annex A (informative):  
Change history

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| --- | --- | --- | --- | --- | --- | --- | --- |
| Change history | | | | | | | |
| Date | Meeting | TDoc | CR | Rev | Cat | Subject/Comment | New version |
| 2022-09 | RP-97e | RP-222221 | - | - | - | Skeleton TR for 38.893 | 0.0.1 |
| 2022-09 | RP-97e | RP-222681 | - | - | - | Add content on root cause and other issues | 0.1.0 |
| 2023-03 | RP-99 | RP-230339 | - | - | -- | TR 38.893 as submitted to RAN #99 for 1-step approval | 1.0.0 |
| 2023-03 | RP-99 | RP-230815 | - | - | - | TR 38.893 as submitted to RAN #99 for 1-step approval | 1.0.1 |
| 2023-03 | RP-99 | - | - | - | - | TR 38.893 as approved by RAN #99 (incl. alignments with 3GPP drafting rules) | 18.0.0 |