3GPP RAN TSG Meeting #90e RP-20xxxxx

Electronic meeting, December 7 – 11th, 2020

Agenda item: 9.11

Source: Apple Inc.

Title: [33][DSS\_TDD]

Document for: Discussion & Decision

# 1 Introduction and background

Dynamic spectrum sharing is an important feature that allows for sharing existing spectrum between the LTE and NR carriers, thus enabling smoother transition from LTE and faster adoption of NR. Among prerequisites for running LTE and NR within the same frequency channel, either FDD or TDD, an operator has to ensure that both LTE and NR sub-carrier grids are aligned. And for that, the corresponding "UL channel raster shift" higher layer parameter was introduced already in Rel-15. However, while a UE has to act upon that parameter signalled for the FDD and SUL bands, its support is not mandatory by default for the TDD bands.

The aforementioned issue with DSS and NR TDD bands was realised when DSS for band 41/n41 frequency range was instantiated [1], outcome of which was introduction of a new band n90 to enable UL shift. That time the issue with DSS and NR TDD bands was raised [2], in which it was elaborated further on consequences of having UL channel raster shift as an optional parameter for the TDD bands. It was suggested making it mandatory, but the proposal was not agreed. The n41 band was followed by WIs enabling DSS for other TDD bands: n48 [3], n38 [4], and n40 [5]. However, as discussed during the RAN4#96 meeting, it is not entirely clear how 3GPP should proceed with enforcing mandatory UL shift for earlier releases of those bands. In [6] submitted to RAN#90 meeting, it is elaborated further on a common way of handling UL channel shift for NR TDD bands and how to introduce this functionality to earlier releases.

As mentioned earlier, according to the outcome of the 41/n41 LTE/NR spectrum sharing WI [1] RAN WG4 agreed to introduce a new band to circumvent around the fact that the UL channel raster shift is not a mandatory parameter for the NR TDD band n41. As the outcome of that discussion, a new band n90 was introduced which is effectively the same band as n41, but the network deploying LTE and NR on the same carrier will use band n90 to prevent legacy terminals from camping on that carrier. In turn, a UE supporting band n90 has to support UL shift.

Observation 1: To enable UL shift for the **Rel-15** NR band n41, a new band n90 was introduced.

After RAN#84 meeting, another re-farmed LTE TDD band 48 was added to NR, which was followed by the corresponding WI to enable DSS in that frequency range. However, since band n48 is a Rel-16 band, it was concluded that the corresponding changes can be introduced for that band because no commercial devices were anticipated that time, i.e. a new band was not created.

Observation 2: To enable UL shift for the **Rel-16** NR band n48, the corresponding changes are introduced into the band n48 because no commercial devices were anticipated when the WI was agreed.

After the RAN#88 meeting, two more WIs were approved that aim at enabling the DSS functionality for Rel-15 NR TDD bands n38 and n40. Even though both bands are Rel-15 bands, different approaches were taken on how to enable UL shift. While band n38 has UL shift as mandatory parameter starting from Rel-15 (with a special NOTE for Rel-15 indicating that some UEs will not support it), band n40 has mandatory UL shift only starting from Rel-17 with a release independent statement.

Observation 3: To enable UL shift for the **Rel-15** NR band n38, the corresponding changes are introduced starting from Rel-15 (with a special NOTE in the Rel-15 specification).

Observation 4: To enable UL shift for the **Rel-15** NR band n40, the corresponding changes are introduced starting from Rel-17 with a release independent statement.

Observation 5: There are four NT TDD bands where DSS was enabled – n41, n48, n38, n40 – and all of them follow a different approach on UL shift functionality was mandated.

As a summary, there are the following approaches on how it is possible to mandate UL shift for a particular TDD band:

a) *Introduce a new band*. This approach was taken for the Rel-15 band n41/n90 and can be regarded as the "safest" approach because legacy UEs, not supporting UL shift, will not camp on a new band. However, as discussed previous in RAN WG4, this approach should be avoided because every time DSS is needed in a particular TDD band, a new band will have to be instantiated.

b) *Mandate UL shift starting from the release when the band was introduced.* This approach was proposed by several proponents during the RAN4#96 discussion and was referred to as the "cleanest" in terms of the specification clarity. Indeed, by making the corresponding changes straight to the release when the corresponding band was added, we could ensure that the UL shift functionality will not be missed by UE implementations; however, this is true if we assume that there are no UEs in the market or in the development process. This approach can be applied only in those case when a particular band is added in the open release. Otherwise, the main drawback of this solution is that by mandating UL shift functionality for the closed release, we will introduce a non-backward compatible change for the UEs that have entered the market or been already entering it. These UEs are compliant with the existing versions of specifications that do not mandate UL shift support, but they will become non-compliant if specifications are revised to mandate UL shift.

c) *Mandate UL shift starting from Rel-X and enable UL shift in earlier releases only to new UEs*. This solution is somewhat similar to the previous one, with the only difference that UL shift is mandated starting from the open or the next release. As for the earlier releases, the corresponding NOTE or a clarification is added to the specifications indicating UL shift applicability. And even though the difference between approaches b) and c) can be viewed as rather marginal, this approach can be viewed as the most "compliant" one because we will not taint existing UEs with the mandatory functionality that they will not support. At the same time, new UEs will support UL shift.

## 2 Discussion

## 2.1 Initial discussion

### 2.1.1 Input for the initial discussion

Based on the presented considerations in section 1, we ask companies feedback for the following open points with an intention to formulate common principles on how DSS will or can be enabled for FR1 TDD bands.

**Q1: If UL shift is enabled for a particular TDD band, starting from which release UL shift should become mandatory?**

As an example, if there is an FR1 TDD band X introduced in Rel-15 into 38.101-1 specifications, but the operator request to enable UL shift is submitted in Rel-17, then the question is whether we should try to enable UL shift also in earlier releases.

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| Company | Feedback |
| Huawei | So far the work on the operators’ interested band was completed. For some mainstream band, there will be severe NBC issue such that UL shift cannot be supported in a release independent manner, while from some band there would be possibility to enable UL shift in a release independent way. Since UL shift is related to initial access, it should be mandated from Rel-15, if needed. Otherwise, even if some UEs are able to support it, network cannot use it.  But for Q1 we prefer to discuss it based on the concrete band proposed by operators. Maybe we do not need have a general agreement. |
| Ericsson | We do not believe it is needed or useful to make a generic agreement for as yet unknown future TDD DSS bands. We should discuss which release should be considered on a case by case basis if and when bands/WI are identified. |
| ZTE | As a generic comment, in RAN4’s practice to enable DSS operation for an NR TDD band, different approaches were applied. The reason is that solving UL shift alone is not enough to enable DSS for these TDD bands with SCS based channel raster, e.g., n41. A solution resolving SCS based channel raster issue may resolve UL shift at the same time. So we don’t think a generic agreement on UL shift would be necessary. |
| Vodafone | Agree there is probably not a one-fits-all solution for additional TDD bands. Hopefully we have had enough practice now to know what options we have for future DSS specified TDD bands. |
| Qualcomm | First of all, we do no understand why we keep coming back to this discussion, it seems a single company has some issues. This document makes some misleading statements, for example this part from the 1st paragraph of the introduction “an operator has to ensure that both LTE and NR sub-carrier grids are aligned” is not true, DSS is possible even if sub-carrier grids are not aligned. It is arguable that efficiency can be improved if the sub-carriers are aligned.  We do think there should be any generic agreement, we should treat bands one by one. By now most likely the TDD bands in which DSS would be needed had already been handled.  The main issue will be whether there are any legacy devices in the field or not. |
| CMCC | The TDD DSS bands request normally based on operator input. So far the four main TDD refarming bands for DSS have already been specified in dedicated WI. In the summary part, all these three options are well known in RAN4, and which option to apply need to be discussed case by case. We don’t think a generic approach or rules can be applied for all TDD DSS bands.  Regarding the question, the main issue is whether there is any legacy UE supported on this TDD bands or not. If no, it is of course desirable to enable UL shift from earlier releases. |
| Intel | Every spectrum has its own special situation and we cannot simply assume a general situation. RAN4 should discuss case-by-case basis. |
| Nokia | We agree with the general view that we need to consider bands case-by-case. |

**Q2: If UL shift is enabled in earlier releases, what is the way to reflect it in the specifications?**

As an example, if there is an FR1 TDD band X introduced in Rel-15 into 38.101-1 specifications and there is an agreement to enable UL shift in all releases starting from Rel-15 when the band is added, then there are two potential ways how it can be accomplished. One way is to follow the way it was done for band 38/n38 DSS: introduce the corresponding CRs starting from the release where the band was introduced adding, if needed, a special NOTE acknowledging the fact that legacy UEs may not support it. Another approach could be similar to what has been done for band 40/n40 DSS: introduce the release-independent statement only in a later release.

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| Company | Feedback |
| Huawei | We prefer to discuss it based on the concrete band proposed by operators. Not sure if we need to reach a general agreement. |
| Ericsson | Similar to Q1 and Huawei, we think that the release and specification mechanism should be handled on a case by case basis. |
| ZTE | Similar views. We are not convinced there is a generic way which can solve the issues for DSS operation at an NR TDD band, thus no generic way to reflect it in the specs. |
| Vodafone | Would need to consider the specifics of that band and discuss with the relevant operator stakeholders the market situation and characteristics with respect to devices in that band. |
| Qualcomm | WE agree with the comments above, we should treat this case by case. This generic discussion of “what if” is counterproductive. |
| CMCC | Same comments as Q1. We don’t think a generic approach and rule can be applied to all TDD bands. It should be discussed case by case. |
| Intel | Same view in Q1 where every spectrum has its own special situation and we cannot simply assume a general situation. RAN4 should discuss case-by-case basis. |
| Nokia | We agree with the general view that we need to consider bands case-by-case. |

**Q3: What is the company view/preference on mandating UL shift for \_all\_ FR1 TDD bands starting from e.g. Rel-17?**

To minimise potential issues with enabling DSS for TDD bands in the future, one approach could be to mandate UL shift for \_all\_ FR1 TDD bands starting from e.g. Rel-17. That will also eliminate a need to instantiate a new WI every time UL shift is needed for a particular FR1 TDD band.

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| Company | Feedback |
| Huawei | As we commented for Q1, mandating UL shift from Rel-17 seems less useful, since it is related to initial access and network won’t use it if some UE cannot support it. |
| Ericsson | We also take the view this could cause issues with initial access if a network tried to use the shift. |
| ZTE | As comment in Q1, mandating UL shift for all FR1 TDD bands does not resolve the issues for DSS operation at an NR TDD band. |
| Vodafone | Tend to agree with Huawei – something else may be required to motivate devices to support as early as possible – but depends on the market characteristics for operating in that band. |
| Qualcomm | We would oppose to mandate generic support of UL shift. Furthermore, mandating this feature from Rel.17 seems pointless. |
| CMCC | Same comments as Q1. We should not make the decision for all TDD bands ahead of time. |
| Intel | Same view in Q1 where every spectrum has its own special situation and we cannot simply assume a general situation. RAN4 should discuss case-by-case basis. |
| Nokia | We agree with the general view that we need to consider bands case-by-case. |

### 2.1.2 Summary of the initial discussion

Summary of key points expressed by companies:

- The DSS functionality for FR1 TDD bands are usually requested based on operator input;

- There is no need make a generic agreement because it is not clear which TDD band might need the DSS functionality in the future;

- We should discuss which release should be considered on a case-by-case basis if and when a need for DSS in a particular TDD band is identified;

- Release and specification mechanism should be handled on a case-by-case basis considering the specifics of that band, operator stakeholders, the market situation and characteristics with respect to devices in that band.

## 2.2 Intermediate discussion (round 1)

Based on the outcome of the initial discussion, the moderator suggests capturing the following key points in how DSS will be handled for NR FR1 TDD bands:

- DSS for NR FR1 TDD bands will be enabled based on the operator request;

- If enabling DSS for a particular TDD band requires further changes (e.g. UL shift), then the corresponding spectrum WI should be submitted (i.e. following the same principle we have at the moment);

- The objectives of the corresponding WI should clearly specify the following points:

- Whether changes are going to be applicable to earlier releases and, if so, starting from which release;

- If changes to earlier releases are needed, it should be reflected in the WI objectives how changes to earlier releases are captured to the RAN4 specifications;

### 2.2.1 Input for the intermediate discussion

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| Company | Feedback |
| CMCC | We are OK with the 1st and 2nd bullets. But regarding the 3rd bullet, we believe all operators proposing the DSS TDD bands would like to apply the changes from earlier releases, otherwise, it will cause accessibility issue for the legacy UE. And regarding the last sub-bullet “how changes to earlier releases are captured to the RAN4 specification”, we think this belongs to the WI phase work, not necessary to reflect in the WI objectivies. |
| Apple | @**CMCC**: Our general understanding is that it would be indeed better for the overall ecosystem to follow the approach that if DSS is enabled for a particular band, then the corresponding changes would become applicable to earlier releases. However, as commented by a number of companies, it is not likely that we can formulate it as a general principle so it will be case-by-case discussion. The 3rd bullet just reflects the fact that the corresponding WI objective should ideally clearly indicate that. As for the last bullet, the intention is to capture the point that since we do not have a common framework on how DSS will be enabled for potential TDD bands, it should be discussed unless the WI objective already indicates an agreed way on how to do it. |
| Huawei | Thanks for summary. If operators have request for a certain band to support DSS, we are open to discuss and if needed approve a WI. Reading the first bullet, it seems a bit strong. As we commented previously, for some band support of DSS would be OK since it may not be widely deployed, while for others it would be challenging. Maybe we can say that   * 3GPP can discuss the support of DSS for NR FR1 TDD bands based on operator requests. * The corresponding spectrum WI can be approved based on the outcome of discussion. |
| Ericsson | The first two bullets; i.e. if operators identify a need to support DSS in a band then a WI will be proposed make sense. Isn’t this anyhow how any operator request for supporting a particular feature in a particular band is handled though ?  For the third bullet; supporting from an earlier release is generally better but the decision will depend on the practicalities for the band in question so will need to be debated on a case by case basis. Agreeing the release at RAN may help to spare some RAN4 time, however it is not clear whether it is prudent to agree in advance that the release will be decided in RAN for hypothetical new WI. |
| ZTE | DSS for NR FR TDD bands are requested by operators, and 3GPP can discuss how to satisfy the demands on a case-by-case basis from standardization perspective, and consider to approve a spectrum related WI if a consensus is reached.  Regarding bullet-3, one more point is that in the objective of the WI, it needs to clearly state whether or not the DSS operation on the band is intended to be transparent to the legacy UEs which are already in the market. This would have important on the technical solutions eventually. |

### 2.2.2 Summary of the intermediate discussion

Summary of key points expressed by companies:

- Several companies expressed the view that proposing DSS for a particular TDD bands would likely apply to earlier releases, otherwise, it will cause accessibility issue for the legacy UE;

- Supporting DSS from an earlier release is generally better but the decision will depend on the practicalities for the band in question so will need to be debated on a case-by-case basis;

- While defining DSS operation for a particular band, it would be preferrable to state whether it is intended to be transparent to the legacy UEs which are already in the market.

## 2.3 Intermediate discussion (round 2)

Based on the outcome of the further discussion, the moderator suggests capturing the following key points in how DSS will be handled for NR FR1 TDD bands:

- 3GPP can discuss the support of DSS for a particular NR FR1 TDD band based on operator requests.

- The corresponding spectrum WI will be approved based on the outcome of discussion (i.e. following the same principle we have at the moment);

- The objectives of the corresponding WI should clearly reflect the following points:

- Whether changes are going to be applicable to earlier releases and, if so, starting from which release (depending on the practicalities for the band in question such as transparency to legacy UEs and/or UEs which are already in the market);

- If changes to earlier releases are needed, it should be captured in the WI objectives or discussed further how changes to earlier releases are captured to the RAN4 specifications;

### 2.3.1 Input for the intermediate discussion

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| Company | Feedback |
| Qualcomm | The 2nd bullet is not needed, it just creates some confusion. Approval of such item is business as usual, no need to mention here |
| Ericsson | The first two bullets are all OK in principle, but it is not clear what needs to be agreed here ? It is usual for operators to bring spectrum WIDs and discuss the objectives and in this case clearly backward compatibility impacts would be an issue to consider during such a discussion. For the third bullet, probably RAN could agree on the applicable release but we do not see a need to mandate that (as compared to RAN4). |
| ZTE | We are ok with Moderator’s proposal with slightly changes on the last two sub-bullets:  - Whether changes are going to be applicable to earlier releases and, if so,  - Starting from which release (depending on the practicalities for the band in question such as transparency to legacy UEs and/or UEs which are already in the market);  - ~~If changes to earlier releases are needed, i~~It should be captured in the WI objectives or discussed further how changes to earlier releases are captured to the RAN4 specifications; |

# 3 Conclusions

# 4 References

1. RP-182883, "New WI proposal: LTE/NR spectrum sharing in Band 41/n41", KDDI Corporation
2. RP-191848, "Channel raster shift for NR TDD bands", Apple Inc.
3. RP-192427, "New WID: LTE/NR spectrum sharing in band 48/n48 frequency range", Apple Inc.
4. RP-201314, "New WI proposal: LTE/NR spectrum sharing in Band 38/n38", Vodafone
5. RP-201362, " New WID proposal: LTE/NR spectrum sharing in Band 40/n40", Reliance Jio
6. RP-202585, "DSS and UL shift for NR TDD bands", Apple Inc.