**3GPP TSG RAN WG1#106bis-e R1-21nnnnn**

**e-Meeting, October 11th – 19th, 2021**

**Agenda Item: 8.2.2**

**Source: Moderator (Lenovo)**

**Title: Draft discussion [106bis-e-NR-52-71GHz-02] on PDCCH monitoring enhancements**

**Document for: Discussion, Decision**

# Introduction

Among other items, the WID "Extending current NR operation to 71 GHz" includes the following RAN1 objective:

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| Support enhancement to PDCCH monitoring, including blind detection/CCE budget, and multi-slot span monitoring, potential limitation to UE PDCCH configuration and capability related to PDCCH monitoring. |

As stated by the chairman:

[106bis-e-NR-52-71GHz-02] Email discussion/approval on PDCCH monitoring enhancements with checkpoints for agreements on October 14 and 19 – Alex (Lenovo)

Depending on the progress, new questions or proposal may be added after the defined checkpoints.

# Discussion

FL NOTE: Excerpts from submitted documents are listed in Section 3.

## Topic A1: Blind Decoding Capability, Multi-slot monitoring

### Issue A1-1:

### Multi-slot PDCCH monitoring capability definition

After RAN1#106-e, the following alternatives are the basis for discussion and final down-selection:

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| * Alt. 1: Use a fixed pattern of slot groups as the baseline to define the new capability.   + Each slot group consists of X slots   + Slot groups are consecutive and non-overlapping   + The capability indicates the BD/CCE budget within Y consecutive slots in each slot group     - The location of the Y slots within the X slots is maintained across different slot groups   + Further discuss down-selection of Y within 1<=Y<=X/2 (both in units of slot) when X>1   + FFS: Further definition of capabilities * FFS: The following issues for the search space configuration discussion   + Whether a slot group is aligned with a slot boundary   + Restrictions on location of the Y slots within a slot group, e.g. whether to restrict the location of a SS to be within the first Y slots within a slot group * FFS: What the UE capability defines for monitoring within the Y slots * Alt 2: Use an (X, Y) span as the baseline to define the new capability   + X is the minimum time separation between the start of two consecutive spans   + The capability indicates the BD/CCE budget within a span of at most Y consecutive [symbols or slots]   + Y <= X   + FFS: Exact values of X and Y and units in which they are defined (e.g., symbols, slots), including cases where a span is longer than one slot or crosses a slot boundary.   + FFS: What is a span pattern, how it is defined and whether it is supported. If it is supported, whether number of slots within which the span pattern is repeated is needed, and if needed, the value of the number of slots.   + FFS: Further definition of capabilities * Alt 3: Use a sliding window of X slots as the baseline to define the new capability.   + The capability indicates the BD/CCE budget within the sliding window   + The sliding unit of the sliding window is [1] slot.   + FFS: Further definition of capabilities |

#### First round discussion

**FL Summary:**

The benefits and drawbacks have been discussed for several rounds of contributions and in GTW sessions, which should provide sufficient mutual understanding. Many companies express a preference for Alt 1, with the understanding that several points have been identified as needing further decisions in the course of the work item, e.g. regarding SS restrictions on the Y slots locations within a slot group. In order not to spend even more time with this general aspect and allow suffiicent time for other open items, it is highly desirable to agree on an alternative in this meeting.

**FL Suggestion:**

Select Alt 1 (including applicable FFS) for defining the multi-slot PDCCH monitoring capability. Can proponents of Alt 2 accept this for the sake of progress and work on addressing their concerns when defining the more detailed aspects?

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| **Company** | **Comment** |
| Ericsson | We support Alt-1.  We think this a pragmatic way forward due to its simplicity and that it avoids changes to the CSS monitoring procedures defined in Rel-15/16 (see comments in Issue A1-2a below). |
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### Issue A1-2: Definition of monitoring capability

#### Issue A1-2a: General definition

##### First round discussion

**Please provide your comments on the following proposal:**

**R1-2108935 (ZTE):  
The capability indicates the BD/CCE budget within each slot group and at least Type 1(with dedicated RRC configuration)/3 CSS and USS locate within Y consecutive slots**

**R1-2109434 (Ericsson):  
The BD/CCE budget per X-slot window is the default PDCCH monitoring budget per X=4 slots for a UE operating with 480 kHz SCS and per X=8 slots for a UE operating with 960 kHz SCS. That is, the PDCCH monitoring budget per X slots is the shared resource for monitoring both (1) type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS; and (2) type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS.**

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| **Company** | **Comment** |
| Ericsson | As proponent, we agree that a distinction should be made between the following two types of SS:   1. Type 1 CSS (with dedicated RRC configuration), Type3 CSS, and USS 2. Type 1 (without dedicated RRC configuration) and Type 0/0A/2 CSS   We think that the bullet in Alt-1 that says "*The capability indicates the BD/CCE budget within Y consecutive slots in each slot group*" naturally applies to (1). Regarding (2), we think that the monitoring procedures defined in Rel-15 can be reused, and that analogous to Rel-15, an overall BD/CCE budget per X-slot group is defined and this "pooled" budget is shared between (1) and (2). This is analogous to FG 3-1 in Rel-15, hence this per-X slot BD/CCE budget should be the default for 480/960 kHz SCS. |
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#### Issue A1-2b: Multi-slot monitoring restriction applicability.

##### First round discussion

**Please provide your comments on the following proposals:**

**R1-2109434 (Ericsson):  
For operation with 480/960 kHz SCS, the restriction of monitoring occasions within Y slots/symbols per X-slot window is applicable to type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS.**

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| **Company** | **Comment** |
| Ericsson | As proponent, we agree (see comment in Issue A1-2a). |
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**R1-2109434 (Ericsson):  
For operation with 480/960 kHz SCS, the restriction of monitoring occasions within Y slots/symbols per X-slot window is not applicable to type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS. That is, for type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS, the monitoring occasion can be within any single span of three consecutive OFDM symbols within any slot (same as Rel-15 FG 3-1).**

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| **Company** | **Comment** |
| Ericsson | As proponent, we agree (see comment in Issue A1-2a). |
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### Issue A1-3: Supported PDCCH multi-slot monitoring durations for reporting capability 480/960 kHz (i.e. additional supported values for X)

**FL Suggestions: Considering discussion during RAN1#106e, it is suggested to deprioritize the issue for the time being.**

## Topic A2: Search Space Configuration/Enhancement

### Issue A2-1: Slot group alignment

**FL Suggestions: To be discussed after progress on Topic A1.**

### Issue A2-2: Location of Y slots within a slot group (e.g. floating within a slot group, fixed to start of slot group)

**FL Suggestions: To be discussed after progress on Topic A1.**

### Issue A2-3: CSS enhancements/modifications

**FL Summary:**

Companies point out that the current Type0 PDCCH CSS requires the UE to monitor PDCCH over two *consecutive* slots, which is not compliant with the multi-slot PDCCH monitoring capability. Another potential issue is pointed out for Type 0/0A/1/2 PDCCH CSS.

**FL Suggestions: Considering discussion during RAN1#106e, it is suggested to come back to this issue after progress on Topic A1.**

### Issue A2-4: SS set group switching

**FL Summary:**

Many companies support SSSG switching for 480/960 kHz, which seems to be a natural extension of the Rel-16 functionality, so it may not need explicit agreement. However, without agreeing corresponding minimum switching times the switching feature would not be available for SCS greater than 60 kHz kHz.

An open item is whether SSSG switching can support switching between PDCCH multi-slot monitoring periodicities (and per-slot monitoing, if supported).

**FL Suggestions: To be discussed after progress on Topic A1 and N1 timeline.**

## Topic A3: BD Budget/Dropping

### Issue A3-1: PDCCH candidates and non-overlapped CCEs for 480/960 kHz

#### First round discussion

Many companies suggest to take the numbers for 120 kHz as the reference for multi-slot monitoring.

FL Suggestion:

* **The maximum number of monitored PDCCH candidates per X=4 slots for a DL BWP with 480 kHz SCS configuration for a single serving cell is 20.**
* **The maximum number of monitored PDCCH candidates per X=8 slots for a DL BWP with 960 kHz SCS configuration for a single serving cell is 20.**
* **The maximum number of of non-overlapped CCEs per X=4 slots for a DL BWP with 480 kHz SCS configuration for a single serving cell is 32.**
* **The maximum number of of non-overlapped CCEs per X=8 slots for a DL BWP with 960 kHz SCS configuration for a single serving cell is 32.**

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| **Company** | **Comment** |
| Ericsson | Support the FL suggestion for issue A3-1. |
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### Issue A3-2: PDCCH candidate dropping for 480/960 kHz

#### First round discussion

FL Suggestion: Please comment on the following proposals:

R1-2108768 (Huawei, HiSilicon):  
All PDCCH candidates for UE-SS k with k>=j across the Y slots will be dropped if the number of monitored PDCCH candidates and non-overlapped CCE exceeding the maximum numbers per X-slot after SS j is added.

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| **Company** | **Comment** |
| Ericsson | We agree with the above proposal in principle, but we want to clarify two points:   * Shouldn't it be k > j (instead of k >= j)?   + We assume that the BD/CCE budget is checked in order of increasing SS index (as in in Rel-15) and that the budget is not exceeded for SS's up to (and including) SS index j. Is this correct understanding? * Is the wording "after SS j is added" meant to convey the idea that SS j is configured? |
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R1-2108935 (ZTE, Sanechips):

**For multi-slot PDCCH monitoring capability, the similar dropping rule as Rel-15 can be used.**

* **The SS set dropping rule is only allowed for PCell or PSCell**
* **The gNB should guarantee that the configured CSS sets do not exceed a UE’s capability**
* **The whole USS set in multiple slots with higher SS set index is dropped when overbooking happens.**

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| **Company** | **Comment** |
| Ericsson | Agree in principle, but the wording can probably be a bit more precise. Our understanding is that the 3rd bullet is equivalent to Huawei's proposal above.  We think "The whole USS set in multiple slots" should be changed to say "The USS in X-slots" |
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R1-2109599 (Intel):

* To handling USS dropping in PDCCH overbooking
  + A USS set with largest SS set index is dropped
  + If the PDCCH MOs of a USS set are configured in multiple slots in the X slots, the USS set in the multiple slots is dropped slot by slot.

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| **Company** | **Comment** |
| Ericsson | We think the dropping should be for the whole X-slots to as proposed by Huawei and ZTE above. Also it is not just the USS with the largest index that may need to be dropped; it could be other SS's too. Generally the checking should be done in order of increasing SS index. |
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R1-2109666 (NTT DOCOMO):

***Proposal 4:*** *The SS set overbooking can be allowed with multi-slot PDCCH monitoring capability same as the current specification, i.e., SS set overbooking is allowed for USS in PCell and PSCell and UE expects no overbooking for CSS and CSS/USS in SCell.*

***Proposal 5:*** *The dropping rule for multi-slot PDCCH monitoring capability can be the same as the current specification, i.e., a UE drops UE specific search space set(s) with higher index when SS sets are overbooked and expects there is no overbooking for CSS sets. In addition, if USS set is configured across multiple slots in a slot group, USS set should be checked and dropped as a whole.*

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| **Company** | **Comment** |
| Ericsson | Agree with these proposals |
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## Topic A4: PDCCH Extensions

### Issue A4-1: CORESET duration longer than 3 symbols

**FL Suggestions: To be discussed after progress on Topic A1**

## Topic B: Multiple PDSCH/PUSCH by a single DCI

### Issue B-1: DCI format monitoring restrictions

R1-2109898 (Lenovo, Motorola Mobility):  
For supporting NR between 52.6 GHz and 71 GHz with high subcarrier spacing values including 480kHz and 960kHz, if a new DCI is agreed to schedule multiple PDSCH/PUSCH, then restrictions on monitoring of other DCI formats (such as DCI format 0\_1/1\_1) should be supported i.e., search space set configuration with restricted combination of DCI formats should be supported to not increase the number of blind decodes

**FL Suggestion: Do not discuss this proposal in RAN1#106bis-e**

## Topic C: Multi-Beam Aspects

### Issue C-1: Beam-specific indication in DCI format 2\_0

**FL Summary: Contributions and discussion in earlier meetings show the following proposal has support by many companies; however several companies prefer to decide on the proposal after progress on directional LBT in channel access AI is achieved.**

Proposal: In DCI format 2\_0, the following parameters can be indicated in a beam-specific manner

* Remaining CO duration
* Available RB set
* Search space group switching

**FL Suggestion: Potentially come back to this issue in RAN1#106bis-e, pending progress on directional LBT**

## Topic D: Multi-Cell Operation, Cross-carrier scheduling

### Issue D-1: *Npdsch* and *Ncsirs*

**FL Suggestion: Few companies provided input to this issue; it is suggested to discuss this issue under AI 8.2.5.**

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| **Company** | **Comment** |
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### Issue D-2: Cross-carrier scheduling and multi-cell operation limitations

**FL Suggestion: Discussion in RAN1#106e seemed to show some support for a limitation along the following line:**

Cross-carrier scheduling of a cell within 52.6-71 GHz from/to a cell outside 52.6-71 GHz is supported, at least for |*μPDCCH* − *μPDSCH* | ≤ k.

#### First round discussion

**Please provide your comments on the following proposal:**

* Cross-carrier scheduling of a cell within 52.6-71 GHz from/to a cell outside 52.6-71 GHz is supported, at least for |*μPDCCH* − *μPDSCH* | ≤ k, value of k to be determined from
  + Alt 1: k=3
  + Alt 2: k=4

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| **Company** | **Comment** |
| Ericsson | In the most recent RAN plenary (RAN#93-e), the WID was updated with the following FR1 + FR2-2 band combinations:   * + Specify gNB and UE RF core requirements for the band(s) in the above frequency range, including a limited set of example band combinations (see Note 1).     - For the case of FR2-2 DC or CA with an anchor in FR1 the following three example band combinations shall be considered:       * n79 + Nx       * n77 + Nx       * n41 + Nx     - where Nx is the 57-71 GHz band for unlicensed operation and the [66-71] GHz for licensed operation.     - RAN4 to further discuss the need for single or multiple bands relevant for FR2-2 licensed/unlicensed operation.   Given that bands n41, n78, and n79 in FR1 are defined in 38.101-1 for both 15 and 30 kHz, it seems that for cross-carrier scheduling from FR1 to FR2-2, |*μPDCCH* − *μPDSCH* | can take values as large as 5/6 for 480/960 kHz SCS, respectively. Hence, limiting to k = 4 would mean that cross-carrier scheduling would at least be supported from FR1 with 30 kHz SCS to FR2-2 with 480 kHz. If k is limited to 3, then cross carrier scheduling from FR1 to FR2-2 would not be supported at all, which seems contrary to the sprirt of the WID. Hence we think that k should be no less than 4, and that we should also discuss k = 5. |
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### Issue D-3: Cross-carrier scheduling capability

#### First round discussion

FL Suggestion: Please comment on the following proposal:

R1-211022 (Apple):  
For cross-carrier scheduling, the max number of CCs that can be scheduled from a single CC is reported as UE capability.

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| **Company** | **Comment** |
| Ericsson | This can be discussed in the UE capability email thread. |
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# Contribution Details

The following sections show extracted discussion and proposals from the contributions submitted to this AI, by a pure subjective decision by the FL.

## Topic A1: Blind Decoding Capability, Multi-slot monitoring

List of issues, proposals, and suggestions for handling in the email discussion phase.

### R1-2108768 (Huawei, HiSilicon)

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| 1. ***For 480 kHz SCS and 960 kHz SCS, Alt 1 is preferred for multi-slot PDCCH monitoring.***   It is to be specified that whether a slot group is aligned with a slot boundary for Alt 1. Furthermore, although it is agreed that, for Alt 1, the location of the Y slots within the X slots is maintained across different slot groups, the location of the Y consecutive slots within the slot group is to be clarified. There are two alternatives:  • Alt 1-1: The Y slots always start at the first slot within a slot group;  • Alt 1-2: The Y slots can start at the any symbol within a slot group.  If a slot group is aligned with a slot boundary, then, when X=4 for a 480 kHz SCS cell or X=8 for a 960 kHz SCS cell, the multi-slot PDCCH processing capability windows for Alt 1-1 are aligned with the slots of a 120 kHz SCS cell while otherwise is not. Hence, Alt 1-2 seems more flexible but at the cost of more complex gNB configuration. The main issue of Alt 1-1 is the configuration of CSS, which can be alleviated if Y>1 is supported. Therefore, we prefer to restrict fixed pattern to align with slot boundary and Y slots to start from the beginning of X slot.   1. ***Support fixed pattern aligned with slot boundary and Y slots always to start from beginning of X slot.***   It is clear that a larger time duration of Y implies more flexibility but higher UE complexity due to the more frequency blind PDCCH detection. Thus, it is beneficial to determine the value of Y according to the actual UE capability. To this end, a corresponding UE capability feedback needs to be supported.   1. ***Support capability report on the value of Y (1<=Y<=X/2, both in units of slot).***  * **Type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS**   In Rel-15 [3], it is mandatory without capability signaling to support the feature group 3-1 of DL control channel. In FG 3-1, the monitoring occasion for type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS is within the first 3 OFDM symbols of a slot. Considering multi-slot PDCCH monitoring capability will also supported as conditional mandatory for 480 kHz and 960 kHz SCS, FG3-1 could be directly extended that the monitoring occasion should be restricted within the first 3OS in each of Y slots in the X-slots group. It could be regarded as the basic feature for 480 kHz or 960 kHz SCS especially for UE with limited capability.   1. ***Corresponding to FG3-1 in Rel-15, PDCCH monitoring occasion restricted in the first 3 OS of each of the Y slots in the X-slot group should be supported as a basic feature for type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS.***   For UE with higher capability, always restricting monitoring occasion only in the first 3 OS in each of Y slots in an X-slots group is not efficient to multiplex searching spaces across different UE, because gNB need to configure all CSS and UE-SS in the first 3 OS in each of Y slot per X-slots group in such case. In Rel-15, there are 3 feature groups allowing UE to monitoring PDCCH in any OS in a slot, i.e. FG3-5, FG3-5a and FG3-5b. For FG3-5, monitoring occasion can be any OFDM symbol(s) of a slot without gap, which results too frequent PDCCH monitoring in Y slots. Both FG3-5a and FG3-5b can achieve the balance between complexity and flexibility by modified the separation between two consecutive monitoring occasions or spans. However, considering the limited time in the meeting and standard effort, we prefer to work based on FG3-5a if Alt 1 in section 2.1.1 is adopted.  According to FG3-5a, monitoring occasion can be any OFDM symbol(s) of a slot with minimum time separation of 14 OFDM symbols for 120kHz between two consecutive transmissions of PDCCH scrambled with C-RNTI, MCS-C-RNTI, or CS-RNTI for Type 1-PDCCH common search space configured by dedicated RRC signaling, for a Type 3-PDCCH common search space, or for a UE-specific search space, with the capability of supporting at least 20 blind decodes in a slot for 120 kHz SCS. By scaling the time separation between two consecutive transmissions of PDCCH according to SCS and allowing monitoring occasion in any of Y slots in an X-slots group, we had following proposal for multi-slot PDCCH monitoring capability.   1. ***Corresponding to FG3-5a in Rel-15, PDCCH monitoring occasion in any OFDM symbols of a slot with***  * ***location of monitoring occasion maintained in the same symbols across different slots within a slot group, and*** * ***a minimum time separation of 56 OS for 480 kHz SCS or 112 OS for 960 kHz SCS between the first monitoring occasions of two consecutive slot groups,***   ***should be supported as an optional feature for type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS.*** |

### R1-2108783 (Futurewei)

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| During RAN1#106 discussions, most companies showed either direct support or ready to compromise for the Alt 1 [4, R1-2108559].  The main reason for the support of Alt 1 is its simplicity, while the support of Alt 2 was mainly justified by its flexibility on the SS configuration. The argument against Alt 1 was the possible back-to-back configuration of SS, which would require Y <<X, which would limit the scheduling flexibility. However, it was noted that when Y length is about X/2 length the benefit of Alt 2 is marginal. Moreover, Alt 2 would require additional discussions for multi-cell BD/CCE calculation for aligned and non-align span. Another drawback of Alt 2 was that would require PDCCH processing load checking according to several different delineations of monitoring occasion groups, which practically lead to a sliding window approach as in Alt 3. The discussions around Alt-1 led to the multiple updates to Alt 1 as presented in the agreement above.  Given the pros and cons presented and the latest updates of Alt 1 and the fact the vast majority supports it, we propose that this alternative is selected, and group moves to solving the remaining dependent open issues.  **Proposal 1: For PDCCH monitoring enhancement adopt Alt-1.**  One remaining issue to be decided is if the X slot group is aligned or not at the slot boundary. We think that a natural extension of the existing slot based PDCCH monitoring is that the X group of slots is aligned with the slot boundary.  **Proposal 2: The X slot group for monitoring PDCCH is aligned with slot boundary.**  If the Alt 1 is considered as an extension of slot-based monitoring it is preferred that slot-based monitoring (X=1 slot and Y = 3 symbols) be a particular case of Alt 1, and Alt 1 be just a scaled-up version of the slot based PDCCH monitoring. Therefore, we propose that Y span to be always at the beginning of X slot group.  **Proposal 3: The Y span slots always start at the first slot within a X slot group.**  During RAN1 discussions, it was proposed that UE should support multiple values for X such as for 480kHz SCS X = {1,2,4} slots, for 960kHz SCS X = {1,2,4,8} slots. However, the consensus was not reached. One of the main objections was against the support of X=1 (per slot monitoring). We see the value X=1 just as another option for UE capability monitoring, which can be reported by UE and may or may not be used by gNB for configuration of PDCCH monitoring. Thus, it should be allowed. If X=1 slot, based on the Alt 1, Y =X and the SS location are not restricted and there is no power saving provided by this scheme. Therefore, in our opinion, if X=1 is supported, Y length less than one slot should be supported.  **Proposal 4: For UE reporting the multi-slot PDCCH monitoring capability the following values are supported:**   * **For SCS 480 kHz, X= {1,2,4} slots** * **For SCS 960 kHz, X = {1,2,4,8} slots** |

### R1-2108887 (Transsion Holdings)

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| In the revised WID, in addition to the 120kHz SCS, 480kHz and 960kHz SCS are also introduced for control and data channels. If UE is required to monitor PDCCH in every slot, then it is quite challenge for UE implementation to maintain the same BD/CCE budget as Rel-15 NR, because for 480kHz SCS and 960kHz SCS, the TTI of one slot is reduced to 31.25/15.625 us, which is 1/4 or 1/8 of the TTI for 120kHz SCS. Therefore, in order to relax the per-slot PDCCH monitoring capability, multi-slot PDCCH monitoring capability has been proposed. So far, three alternatives have been agreed, and down-selection will be done among these alternatives at a future RAN1 meeting.  For Alt 1, a multi-slot PDCCH monitoring capability is defined as the BD/CCE budget per Y consecutive slots within a fixed pattern of X slots, where 1<=Y<=X/2. It had been agreed that at least X=4 for 480kHz SCS and X=8 for 960kHz SCS in RAN1#106-e meeting [2]. With these values, the duration of one slot group for 480kHz SCS and 960kHz SCS is equal to that of one slot for 120kHz SCS. In this case, the PDCCH processing overhead is maintained on the UE side. In addition, when the the value Y equals to X/2, the flexibility of PDCCH monitoring is consistent with that of 120kHz SCS.  For Alt 2, a multi-slot PDCCH monitoring capability is defined based on Rel-16 PDCCH monitoring span with some extension. Although, Alt 2 provides more flexibility in PDCCH monitoring compared to Alt 1, considering that only three combinations (X,Y) for15kHz SCS and 30kHz SCS have been specified, considerable standardization efforts may be required to extend the combinations (X, Y) to accommodate the multi-slot PDCCH monitoring.  For Alt 3, a sliding window of X slots is introduced to avoid a back-to-back issue [3]. However, it had been identified that the back-to back issues can be resolved by a fixed monitoring pattern for Alt 1 or restricting the (X, Y) values for Alt 2. Furthermore, Alt 3 may increase UE complexity due to iterative calculate the total number of PDCCH candidates within the sliding window.  Given that Alt 1 is the most straightforward and simple of these three alternatives, it is better to adopt Alt 1 as the definition of multi-slot PDCCH monitoring capability.  ***Proposal 1: Adopt Alt1 as the definition of multi-slot PDCCH monitoring capability.*** |

### R1-2108935 (ZTE, Sanechips)

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| **Proposal 1: Alt 1 using a fixed pattern of slot groups is preferred as the baseline to define the new capability for PDCCH monitoring with the new SCSs 480/960 kHz:**   * **Each slot group consists of X slots** * **X={1, 2, 4} slots for 480 kHz SCS** * **X= {1, 2, 4, 8} slots for 960 kHz SCS** * **Slot groups are consecutive and non-overlapping** * **A slot group should be aligned with a slot boundary** * **The capability indicates the BD/CCE budget within each slot group** **and at least Type 1(with dedicated RRC configuration)/3 CSS and USS locate within Y consecutive slots** * **For multi-slot PDCCH monitoring, 1≦Y≦X/2 when X>1 and Y=X when X=1 (X and Y both in units of slot)** * **Y is always the first Y slot(s) within each slot group** * **The locations of the PDCCH monitoring symbols should not be restricted** * **To solve the initial access related CSS sets monitoring issues, consider changing default CSS configuration or differentiating PDCCH monitoring capability** |

### R1-2108960 (vivo)

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| In RAN#90e [1], it is agreed that (120, 480, 960) KHz SCS are all supported for data/control. When PDCCH is configured in one DL BWP with 480/960KHz SCS, UE needs to monitor PDCCH every slot (i.e. ~15/30 us) if following the mandatory capability defined in existing NR operation as described in Section 2.1.1. This is quite challenging for UE implementation especially in such high frequency band. So, the mandatory capability on PDCCH monitoring in NR FR1&FR2 should be relaxed for NR operation from 52.6-71GHz, e.g. UE only needs to monitor in certain slot group instead of each slot within one subframe.  **Proposal 1: For NR operation from 52.6-71GHz, PDCCH monitoring capability in FR1&FR2 should be relaxed from slot level to multi-slot level granularity.**  For the purpose of down-selection, Alt. 1 and Alt. 2 are compared from the following aspect:   * In terms of network simplicity, gNB has full flexibility to configure SS as a fixed pattern for simplicity even Alt .2 is adopted. As mentioned before, Alt. 1 is a subset of Alt. 2. So from network perspective, Alt. 2 indeed provide more network flexibility; * In terms of UE simplicity, both Alt. 1 and Alt. 2 can achieve monitoring Y slots and rest X-Y slots, which has the same UE complexity for PDCCH monitoring; * In terms of spec simplicity, Alt. 2 is a simple extension of symbol-based span defined in Rel-16 where the unit is changed from symbol to slot. All definition there could be simply reused including CA case. In this sense, Alt. 2 has less spec effort than Alt. 1.   Besides, CSS configuration is an important issue to be considered for the definition of multi-slot-based capability. In NR Rel-15&16, different PDCCH monitoring occasions in one CSS is always associated with different SSBs. In this sense, different UEs under different SSBs may have different PDCCH monitoring occasions that may be located in different slots. The following alternatives could be considered as candidate for handling CSS issue:   * Alt. A: Alt. 1.1 together with separate capability for CSS and USS * Al.t B: Alt. 1.2 together with CSS configuration-based location of Y slots * Alt. C: Alt. 2 without any enhancement   It is obviously that Alt. 2 could solve CSS issue without any enhancement while Alt. 1 needs further design such as separate capability for CSS and USS, CSS configuration-based location of Y slots and etc.  **Proposal 2: Support Alt. 2 to define multi-slot based PDCCH monitoring capability, i.e. use (X, Y) span as baseline to define the capability.** |

### R1-2109071 (OPPO)

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| **Observation 1: if Alt-1 is adopted, RAN1 should further discuss the followings:**   * **Whether slot group is UE-specific or cell-specific** * **If slot group is cell-specific, how to flexibly allow Y location within slot group** * **Y length choices**   **Observation 2: if Alt-2 is adopted, RAN1 can reuse the R16 span framework and RAN1 does not need to further discuss the location of Y restriction.**  **Observation 3: Both Alt-1 and Alt-2 are workable alternatives. But it seems that Alt-2 can save quite a lot of further discussions as it reuses R16 framework. Given the limited remaining time before R17 frozen deadline, we suggest that RAN1 can go with Alt-2.**  **Proposal 1: Adopt Alt-2 span framework to define multi-slot PDCCH monitoring capability.** |

### R1-2109117 (NEC)

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| For 480 kHz and 960 kHz SCS adopted beyond 52.6GHz, In the WID [3], PDCCH monitoring enhancement with multi-slot span is supported, it can maintain scheduling framework same as for smaller SCS (e.g. 120 kHz) when UE is configured to monitor the PDCCH every multiple slots. There are 3 alternatives for defining the multi-slot PDCCH monitoring capability. In previous meeting [1], there were many discussions on Alt1 (fixed pattern) due to its simplicity, but with fixed X and Y location, there may be some issues when monitoring Type 0/0A/1(without dedicated RRC configuration)/2 PDCCH CSS, how they could fit within the framework of Alt1? In our view, with fixed X and Y location, for example, Y slots always start at the first slot within a slot group, UE need to monitor the above CSS in extra slots other than Y if they don’t fall into Y slots, and in order to avoid the back-to-back overload issue, an extra window can be considered to calculate the PDCCH monitoring burden. In this extra window with size equivalent to X, the monitoring capability indicates the BD/CCE budget within the whole window.    Figure 1  **Proposal 1: For Alt1 with fixed Y location, an extra window can be considered to calculate the PDCCH monitoring burden if Type 0/0A/1(without dedicated RRC configuration)/2 PDCCH CSS don’t fall into Y monitoring slots.**  In previous meeting [1], it was agreed that at least the following values are supported: 4 slots for 480 kHz SCS and 8 slots for 960 kHz SCS, and other specific number of the multiple slots is in discussion. For some use cases such as low-latency services which require more frequent PDCCH monitoring, the flexibility will be reduced with the multi-slot based monitoring. To handle those use cases with low-latency, denser PDCCH monitoring occasion should be considered to support, such as per-slot, per 2-slots based monitoring for 480 kHz SCS and per 2-slots, per 4-slots based monitoring for 960 kHz SCS, and accordingly the associated BD/CCEs limit number needs to further study.  Proposal 2: Additional PDCCH monitoring group sizes should be supported: 1 or 2 for 480 kHz SCS, 2 or 4 for 960 kHz SCS, and further study the associated BD/CCEs limit number. |

### R1-2109209 (CATT)

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| **Alt 1: Use a fixed pattern of slot groups as the baseline to define the new capability.**  For Alt 1, a fixed pattern of slot groups consists of X slots where the PDCCH monitoring occasions can be configured within Y consecutive slots/symbols of slot groups. The capability can provide the maximum number of BD/CCE within a fixed pattern of slot groups for a UE for operation with a single serving cell. During the previous discussion, it has been observed that Y=X may cause the number of back-to-back MOs in adjacent slot groups exceeds maximum number of BD/CCE budget, and then it can’t be checked by UE. Thus, it is reasonable to assume the value of Y is less than X. Furthermore, the relationship between slot group, slot boundary and the location of the Y consecutive slots within the slot group should be further clarified.    Figure 1: The relationship between the start of slot group and the slot boundary  The slot group is used to define a PDCCH monitor capability that is the maximum of BD/CCE budget supported by the UE within a period of time. In our opinion, the starting point of the slot group doesn’t need to be restricted to start from the slot boundary. For example, as is shown in Figure 1, the slot group can start from a certain symbol within the slot when the search space is configured at this symbol that may be not in the slot boundary. When the start of slot group can start from any symbols within the slot, it enables more flexible symbol level configuration, which is aligned with that of the span definition of monitoring at least.  ***Proposal 1：For the fixed pattern of slot group definition, the starting point of the slot group doesn’t need to be restricted to the slot boundary.***  For the location of Y consecutive slots within the slot group, there are two alternatives as follows.   * Alt 1-1: The Y [slots] always start from the first symbol within a slot group * Alt 1-2: The Y [slots] can start from any symbol within a slot group     Figure 2：The location of the Y within the slot group  It has been known that each slot groups are consecutive and non-overlapping. If Alt 1-1 is supported, the Y always starts from the first symbol of the slot group. If Alt 1-2 is supported, the Y can start from a certain symbol that may be not the first symbol of the slot group. For example, Y can start from the third symbol of the slot group, as is shown in Figure **2**(Alt 1-2). However, Alt 1-2 may bring more complexity to the definition of the multi-slot PDCCH monitoring capability. Besides, if the starting point of the slot group does not need to be restricted to the slot boundary, the flexibility comes with the moving Y slots shall be take advantage anyway. Then extra benefit of Alt 1-2 is not clear. Therefore, it is recommended that the location of the Y should always start from the first symbol within a slot group.  ***Proposal 2: For the fixed pattern of slot group definition, the location of the Y should always start from the first symbol within a slot group.***  When Y [slots] start at the first symbol within a slot group, as long as the valued of Y is no more than half of the value of X, the issue about back-to-back MOs in adjacent slot groups can be avoided. On the other hand, if Y can be configured with larger value, the network will have more scheduling flexibility. Thus, it is recommended that Y can be equal to half of the X to achieve the tradeoff between scheduling flexibility and back-to-back MOs issue.  ***Proposal 3: For the fixed pattern of slot group definition, it is recommended to at least include Y= ½ X as one configuration for (X,Y) pair for both 480KHz and 960KHz.***  In the last meeting, the additional value of the X other than X=4 slots for SCS 480 kHz and X=8 slots for SCS 960 kHz has been discussed. For the X=1 slot for SCS 480 kHz/ SCS 960 kHz, the number of supported BD/CCE will be too small and the performance of PDCCH will be affected. In additional, the duration of X=4 slots for 480 kHz or X=8 slots for 960 kHz is equal to one slot of 120 kHz, which is small enough to meet the delay requirement of most use cases. In our view, the motivation to support X=1 slot for SCS 480 kHz/ SCS 960 kHz is not strong, and it may introduce extra complexity for the PDCCH monitoring capability of UE. Similar to X=1 slot for SCS 480 kHz/ SCS 960 kHz, the benefit of supporting X= 2 slot for SCS 480 kHz and X= {2, 4} slot for SCS 960 kHz is not clear. Therefore, it is recommended that the additional value of the X other than X=4 slots for SCS 480 kHz and X=8 slots for SCS 960 kHz should not be down prioritized in the Rel-17.  ***Proposal 4：For the fixed pattern of slot group definition, the additional value of the X other than X=4 slots for SCS 480 kHz and X=8 slots for SCS 960 kHz should be down prioritized in the Rel-17.*** |

### R1-2109402 (Xiaomi)

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| In a general case, with Alt1, fixed pattern of slot groups (X/Y), UE can only support search space configurations with periodicity of X\*M slots. But this restriction can be released if Y>X/2. For example, with (X/Y)=(8,5), search space periodicity of 8 or 4 slots are both supported.  Alt 2 does has some more flexibility on aspects of search space periodicity, with a PDCCH monitoring span (X/Y), UE can support any periodicities >=X slots, but this flexibility is limited. To illustrate this, assuming UE with Alt 2 PDCCH monitoring capability (8/3), and configured a SS with periodicity of 9 slots, if the UE needs to be configured with another SS, the new added SS has to be with periodicity of 9\*M slots, otherwise the new added SS may not be able to fall into the Y slots of the (X/Y) span.  ***Proposal 1: PDCCH monitoring capability Alt 2 has limited flexibility over Alt 1 on search space periodicity configuration.***  In a multi-cell scenario, with Alt1, fixed pattern of slot group (X/Y), the time unit of calculation of PDCCH monitoring on multiple cells are easy to align. For example, if a UE is configured with 2 cells, both the cells are with Alt 1 PDCCH monitoring capability (8/5), the time unit for calculating PDCCH monitoring is simply the first 5 slots of every 8 slots group. But for Alt 2, the situation may be complicated. An example shown in Fig.1, if a UE is configured with 2 cells, both the cells are with Alt 2 PDCCH monitoring capability (8/5), and cell1 is configured with SS of periodicity 8, and cell2 is configured with SS of periodicity 12, the monitoring occasion of cell 1 and cell 2 are overlapped or partially overlapped in a unaligned manner. For the time duration in red block, since UE has to process PDCCH in three spans, UE may exceed its PDCCH monitoring capability, then how to coordinate multi-cell PDCCH monitoring capability will need a lot of specification effort.  ***Proposal 2: PDCCH monitoring capability Alt 2 needs more specification effort to coordinate multi-cell PDCCH monitoring capability while Alt 1 doesn’t.***    Fig 2 Multi-cell PDCCH monitoring capability issue for Alt 2  Compared with defining PDCCH monitoring capability per single slot, defining PDCCH monitoring capability per multi-slot span would allow gNB scheduling DCI in a busty way, for example when X=8,Y=1. And it may cause the UE to spend more time on decoding all the DCIs scheduled in a DCIs burst, which will increase the total processing time for the scheduled PDSCH/PUSCH since UE has to decoding the DCI first. For example, with maximum number of B1/C1 of BDs/CCEs for PDCCH monitoring per single slot, UE is able to decode the all the DCIs in PDCCH in 1 symbol from the end of the PDCCH. But with maximum number of 4\*B1/4\*C1 of BDs/CCEs for PDCCH monitoring per multi-slot span (4/1) and gNB scheduling DCI in a busty way, UE may need extra 2 symbols to guarantee to decode the all the DCIs in PDCCH, thus cause the decoding time of PDSCH(N1) and preparation time of PUSCH(N2) may need to be extended as well.  ***Proposal 8: Impacts on PDSCH/PUSCH processing time (N1/N2) may need be considered for multi-slot PDCCH monitoring capability.*** |

### R1-2109434 (Ericsson)

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| 1. For Rel-15 slot-based PDCCH monitoring, the BD/CCE budget for a slot is allocated for monitoring CSS located within the slot, with the remaining budget utilized for monitoring USS according to ascending USS index.  The presence of type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS within a slot, regardless of where such a CSS locates within the slot, has no impact on the BD/CCE budget for the next slot.   In the Rel-15 slot-based PDCCH monitoring capability, the BD/CCE budget is shared between (1) type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS; and (2) type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS as discussed in the above. To address the processing capability challenges of Rel-17 support for 480/960 kHz SCS, we agree that the pooled BD/CCE budget per X-slot window is the default PDCCH monitoring budget per X slots for UE operating with 480/960 kHz SCS to monitor both types of SS.   1. The BD/CCE budget per X-slot window is the default PDCCH monitoring budget per X=4 slots for a UE operating with 480 kHz SCS and per X=8 slots for a UE operating with 960 kHz SCS. That is, the PDCCH monitoring budget per X slots is the shared resource for monitoring both (1) type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS; and (2) type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS.   For UEs operating in CONNECTED mode on a serving cell with 480/960 kHz SCS, multi-slot PDCCH monitoring has been discussed in Rel-17 for reducing UE processing complexity and power efficiency. It is proposed   1. For operation with 480/960 kHz SCS, the restriction of monitoring occasions within Y slots/symbols per X-slot window is applicable to type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS.   For Rel-17 operation in the FR2-2 range, maintaining the same initial access procedures and IDLE mode operations is beneficial to reducing implementation complexity and shortening time to market. Hence, the same NR system design principle that the Rel-15 UEs are required to support more flexible monitoring occasions in initial access and in the IDLE mode should be followed for a more streamlined Rel-17 specs. Therefore, we propose   1. For operation with 480/960 kHz SCS, the restriction of monitoring occasions within Y slots/symbols per X-slot window is not applicable to type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS. That is, for type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS, the monitoring occasion can be within any single span of three consecutive OFDM symbols within any slot (same as Rel-15 FG 3-1).   This Rel-15 system operation approach can easily be integrated with multi-slot PDCCH monitoring Alt 1 with fixed windows. Note that, as discussed Section 2.2, the windows are aligned with radio frames and hence fixed even during initial access.   * With fixed X-slot windows, the BD/CCE budget for an X-slot window is appropriated for monitoring CSS located within the X-slots, with the remaining budget utilized for monitoring USS according to ascending USS index. The presence of type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS within an X-slot window, regardless of where such a CSS locates within the X-slot window, has no impact on the BD/CCE budget for the next X-slot window   Therefore, we propose   1. For the fixed window multi-slot PDCCH monitoring Alt 1 with 480/960 kHz SCS, the BD/CCE budget for an X-slot window is allocated for monitoring CSS located within the X slots, with the remaining budget utilized for monitoring USS according to ascending USS index.  The presence of type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS within an X-slot window, regardless of where such a CSS locates within the X-slot window, has no impact on the BD/CCE budget for the next X-slot window.   In addition to the support of X=4 for 480 kHz SCS and X=8 for 960 kHz SCS, several companies proposed the support of per-slot PDCCH monitoring as well as multi-slot PDCCH monitoring other than these two cases as optional UE capabilities. In our view, this distracts and slows down RAN1 from finalizing the core multi-slot PDCCH monitoring designs. Therefore, we propose   1. For operation with 480/960 kHz SCS, multi-slot PDCCH monitoring other than X=4 for 480 kHz SCS and X=8 for 960 kHz SCS is deferred until RAN1 completes the details of multi-slot PDCCH monitoring with X=4 for 480 kHz SCS and X=8 for 960 kHz SCS including at least (1) A decision on Alt-1 vs. Alt-2 multi-slot PDCCH monitoring? (2) The minimum supported values of Y for the respective X values? (3) What symbols within the Y slots for PDCCH monitoring? (4) The BD/CCE budget requirement for the X-slot window?   The central issue for per-slot PDCCH monitoring is hence the BD/CCE budget for a slot, which as we pointed out in the above has not seen any progress in RAN1. Therefore, we propose that if per-slot PDCCH monitoring is discussed the discussion must start with the BD/CCE budget. Furthermore, we observe that in Rel-15, the CCE budget is 32 for 120 kHz, which is enough to cover (with a small margin) the requirements for monitoring Type0-PDCCH CSS (7 BDs / 28 CCEs). Hence, if optional per-slot monitoring is supported for 480/960 kHz, the BD/CCE budget can be no less than the 120 kHz value. Note further that companies motivated the introduction of the optional per-slot PDCCH monitoring on the basis of URLLC applications requiring very low latency. UEs supporting such URLCC applications should be expected to be equipped with enhanced and accelerated processing capabilities.   1. For operation with 480/960 kHz SCS, if the optional per-slot PDCCH monitoring is discussed, the discussion in RAN1 should start with defining the BD/CCE budget for a slot while ensuring that Rel-15 Type0-PDCCH monitoring requirements can be met.   In our view, the following three PDCCH monitoring cases are sufficient for operation with 480/960 kHz SCS:   * X=4 for 480 kHz SCS * X=8 for 960 kHz SCS * Optional per-slot monitoring for 480/960 kHz SCS   The same scheduling frequency and granularity as a 120 kHz SCS cell can be achieved with X>1 multi-slot PDCCH monitoring for 480/960 kHz SCS. For applications with low latency requirements, per-slot PDCCH monitoring with 480/960 kHz SCS can meet the same low latency achievable with mini-slots on a 120 kHz SCS cell. Furthermore, RAN1 has only agreed processing latency requirements on N1/N2/N3/Z1/Z2/Z3 for 480/960 kHz SCS that are multiples of the processing latency requirements for 120 kHz SCS. There has been no evidence or evaluation results to indicate the additional benefits of introducing other window sizes other than the above three PDCCH monitoring cases for 480/960 kHz SCS. Therefore, we propose   1. Multi-slot PDCCH monitoring window sizes X>1 other than X=4 for 480 kHz SCS and X=8 for 960 kHz SCS are not supported for Rel-17.   In the TDD UL/DL configuration, if only one pattern is configured, the periodicity of pattern1 shall divide 20 ms evenly. If two patterns are configured, the sum of the periodicities of both patterns shall divide 20 ms evenly. As a result, the first symbol of every period when only one pattern is configured or every period when two patterns are configured is a first symbol in an even frame.  Therefore, this first symbol in an even frame can be used as the start of the first PDCCH processing capability window. All subsequent monitoring windows are defined with the specific window advancing offsets in the three respective UE multi-slot PDCCH processing capability definitions. For Alt 1, the window advancing offset is fixed for a cell. If X=4 for a 480 kHz SCS cell or if X=8 for a 960 kHz SCS cell, the multi-slot PDCCH processing capability windows for Alt 1 are aligned with the slots of a 120 kHz SCS cell.   1. The PDCCH processing capability window for Alt 1 starts from the first symbol in an even frame to align with the TDD UL/DL configuration. 2. For X=4 with 480 kHz SCS and X=8 with 960 kHz SCS, the multi-slot PDCCH processing capability windows for Alt 1 are aligned with the slots of a 120 kHz SCS cell.   Based on the analysis and discussion presented in Section 2.1.1, we propose to further clarify the following bullet regarding the operation of multi-slot PDCCH monitoring Alt 1:   * + The capability indicates the BD/CCE budget within Y consecutive slots in each slot group     - The location of the Y slots within the X slots is maintained across different slot groups   That is, we proposed the following clarification for multi-slot PDCCH monitoring Alt 1:   1. For multi-slot PDCCH monitoring Alt 1 with 480/960 kHz SCS, the BD/CCE budget for slot group is clarified as follows:    1. The capability indicates the BD/CCE budget within ~~Y consecutive slots in~~ each X-slot group for monitoring       1. Type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS within Y consecutive slots          1. The location of the Y slots within the X slots is maintained across different slot groups       2. Type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS in any 3 consecutive symbols of a slot (as in Rel-15 FG 3-1)   Incorporating the above proposed clarification, the Alt 1 operation is described as follows:   * Alt 1: Use a fixed pattern of slot groups as the baseline to define the new capability.   + Each slot group consists of X slots   + Slot groups are consecutive and non-overlapping   + The capability indicates the BD/CCE budget within ~~Y consecutive slots in~~ each X-slot group for monitoring     - Type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS within Y consecutive slots       * The location of the Y slots within the X slots is maintained across different slot groups     - Type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS in any 3 consecutive symbols of a slot (as in Rel-15 FG 3-1)   + Further discuss down-selection of Y within 1<=Y<=X/2 (both in units of slot) when X>1   + FFS: Further definition of capabilities   + FFS: The following issues for the search space configuration discussion     - Whether a slot group is aligned with a slot boundary     - Restrictions on location of the Y slots within a slot group, e.g. whether to restrict the location of a SS to be within the first Y slots within a slot group   + FFS: What the UE capability defines for monitoring within the Y slots   In the last RAN1 meeting, the operation of multi-slot PDCCH monitoring Alt 1 has been clarified that the location of the Y slots within the X slots is maintained across different slot groups. Several companies provided views during the RAN1 #106e email discussion regarding the following FFS:   * Restrictions on location of the Y slots within a slot group, e.g., whether to restrict the location of a SS to be within the first Y slots within a slot group   Note that, as long as Y≤X/2 is fixed within the X-slot windows, back-to-back PDCCH processing overloading is avoided. Hence, several companies expressed the view that, as long as the Y-slot location within each X-slot window is maintained, there is no particular necessary conditions favoring, e.g., the first Y slots within each X-slot window vs the last Y slots. We agree with this analysis in general.  However, the equivalence between the possible locations of Y slots may further offer system configuration and operation complexity reduction benefits. That is, e.g., fixing the Y slots to be always at the beginning of each X-slot windows may allow simpler configuration parameters and protocols. In our view, restricting Y to be the first slots of the X-slot group and be the same for all UEs is no worse in terms of network flexibility than for the mandatory monitoring capability defined in Rel-15/16 for 120 kHz SCS. Observing that RAN1 has only agreed to processing latency requirements (in terms of μs) for 480/960 kHz SCS on the same level as for 120 kHz SCS, there is no evidence or evaluation result to indicate the necessity or utility of much more SS configuration flexibility alone.   1. For multi-slot PDCCH monitoring Alt 1 with 480/960 kHz SCS, RAN1 to consider restricting Y slots to be at the beginning of each X-slot windows for type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS as an approach to simplify multi-slot PDCCH monitoring configuration parameters and protocols as well as to reduce implementation complexity.   Observation 7 Compared to Alt 1, the float monitoring capability spans of Alt 2 introduce additional monitoring capability misalignment/overburden issues when multiple serving cells are active. As a result, additional PDCCH processing load restriction/checking will need to be defined for Alt 2 to handles these cases. |

### R1-2109443 (Nokia, Nokia Shanghai Bell)

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| Smaller values of X can provide e.g. better multiplexing capabilities (i.e. better scheduling flexibility) and improved latency. It can also offer a better processing time budget for gNB with the UE processing times agreed in RAN1 #106 [3]. We also think that that specification impact for supporting smaller values of X is quite minor, mainly definition of a few additional BD/CCE cap values as a function of X. Based on that, we make the following proposal:  ***Proposal 1*:** *Multi-slot PDCCH monitoring is not the only supported configuration for 480 kHz and 960 kHz SCSs. In addition to X=4 slots for 480 kHz SCS and X=8 for 960 kHz SCS, support the following additional values for X:*   * *X=[1, 2] for 480 kHz SCS* * *X=[1, 2, 4] for 960 kHz SCS* * *UE capability for supporting the additional values for X is FFS.*   The FL summary (R1-2108559) captures the company positions in the following way:   * Alt 1 supported by Huawei, HiSilicon, Interdigital, Sony, ZTE, Sanechips, Nokia, Nokia Shanghai Bell, Charter (2nd choice), LG, MediaTek, Apple, Sharp, Xiaomi * Alt 2 supported by vivo, Lenovo, Motorola Mobility, Samsung, Futurewei, Qualcomm, Panasonic, Apple, NTT DOCOMO, Convida Wireless * Alt 2 in addition to Alt 1 if necessary: Interdigital, Mediatek * Alt 3 supported by Ericsson, Charter (1st choice)   We think that technical differences among different alternatives have been discussed already with sufficient level of details, and are well understood. It is time to make the decision. For the sake of simplicity, and considering the majority views, we make the following proposal:  ***Proposal 2*:** *Select Alt 1 as the baseline to define the new multi-slot PDCCH monitroing capability*  In order to support operation according to Alt 1, there is a need to configure slot group(s). Starting position of the slot group can be alinged with a known time reference, e.g. pre-defined subframe or slot boundary.  ***Proposal 3*:** *Slot group (X) starts from the first symbol of a predefined slot, subframe and frame.*  The following options are available for supporting CSS on top of Alt1:   * SSB Pattern is designed in a way that all SSB slots are within Y slots. This is not preferred due to the large specification impact. * Support Y=X. This is not preferred since it basically maintains the problem of blind detection (UE needs to be prepared to the worst case where BDs in the adjacent slot groups are next to each other). * Allow floating, UE specific location for Y slots (within X slots). gNB should be able ensure that Y slots follow the location of the active TCI state of the UE. In other words, the location of Y slots within X should vary according to the active TCI state of the UE. This would ensure that UE’s PDCCH monitoring (i.e. Y consecutive slots) is also aligned with the strongest SSB beam including CORESET#0. One benefit of this approach is that it allows grouping of the UEs that are served by a same beam so that they would be able to monitor PDCCH at a same time. * Support search space- specific configuration for (X,Y), e.g. such that USS operates according to one (X,Y) definition and CSS according to another (X,Y) definitition. Example:   + slot groups containing CSS could operate according to Y=X   + slot groups without CSS would operate according to Y=X/2   + when defining BD/CCE limits for certain slot group (X), UE would operate according to the lowest BD/CCE limit involved for the slot group X (à if CSS is involved, the UE would operate according BD/CCE limits defined for the case of Y=X) * BD/CCE limits are defined only for USS while CSS is always monitored according to gNB configuration.   ***Proposal 4:*** *Consider one or more of the following solutions for supporting CSS on top of Alt1:*   * *Allow floating, UE specific location for Y slots (within X slots).* * *Support search space- specific configuration for (X,Y) or for (Y)* * *BD/CCE limits are defined only for USS.* |

### R1-2109477 (Samsung)

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| **Observation 3**: Both Alt 1 and Alt 2 support multi-slot span based PDCCH monitoring according to a combination of (X, Y) and a predetermined span pattern repeated over time.  **Observation 4:** There is no need to support fixed span pattern, such as fixed repetition cycle of span pattern and fixed location within the repetition cycle.  The minimum PDCCH monitoring gap X should be more than one slot so that a UE can distribute PDCCH processing/monitoring requirements over multiple slots. For a maximum PDCCH monitoring span duration, Y, applicable values for Y can be same as Rel-15 slot-based PDCCH monitoring (i.e. one slot). Alternatively, Y can also be multiple slots to provide more PDCCH monitoring occasions and higher scheduling flexibility to the NW. As a UE may expect much narrower beam direction from 52.6 GHz to 71 GHz compared to FR1 or FR2, the additional occasions when Y is larger than one slot can be used to for PDCCH receptions associated with different beam directions.  **Proposal 2: Support multi-slot span based PDCCH monitoring capability according to combination (X, Y), where**   * **X > 1 slots (e.g. X = 4 for 480 KHz and X = 8 for 960 KHz)** * **Y>= 1 slots (e.g. 1<=Y<=X/2)**   **Proposal 3: Support flexible span pattern for multi-slot span based PDCCH monitoring, where the repetition cycle of a span pattern and span location within the repetition cycle can be flexible and predetermined according to configured search space sets.**  In practice, a UE can support multiple applicable values for combination (X, Y). The larger the X value is, the larger the reduction in PDCCH monitoring requirements for a UE. To provide full flexibility for configuration of search space sets to a NW, multiple combinations of (X, Y) can be supported for multi-slot span based PDCCH monitoring at high SCS, such as 480 KHz and 960 KHz, similar to span-based PDCCH monitoring in Rel-16. The combination (X, Y) can either be determined based on UE capability or predetermined for applicable SCS configurations, such as, .  An extended span gap increases latency. A scheduling delay of (X - Y) slots can be large for some cases, such as when X is much larger than Y, or when Y is small, e.g. 1. In addition, there may be some loss in data rate if only single PDSCH/PUSCH scheduling per slot is supported. To overcome those issues, adaptation on combination (X, Y) can be considered when a UE is capable of supporting multiple combinations (X, Y). For example, when a UE reports a capability of multiple combinations (X, Y), the UE can be indicated by the NW a selected combination (X, Y) from the multiple combinations based on L1 signaling. The UE can deactivate or activate some PDCCH monitoring occasions according to the PDCCH configuration limitations for the selected combination (X, Y). The UE can also use a maximum number of PDCCH candidates/non-overlapping CCEs based on the indicated (X, Y).  A UE can report its preferred minimum multi-slot span gap, X, and/or maximum multi-slot span Y, according to UE requirements on power savings, latency, and data rate.  **Proposal 4: Support UE reporting of multiple combinations (X, Y), and support adaptation among combinations and UE assistance information on the selection of combination.** |

### R1-2109560 (MediaTek)

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| Proposal 1: For multi-slot PDCCH monitoring capability, remove Alt3 from the discussion.  The remaining discussion is whether the location of the Y slots within the X slots is the same for all the UEs. Based on the discussion in RAN1 #106e meeting, to resolve the Type-0 CSS monitoring issue, two alternatives can be considered under the assumption that all UEs supporting same (X,Y) adopt the same fixed pattern of slot groups: Alternative 1) The location of the Y slots within the X slots is fixed for all the UEs and Type-0 CSS configuration needs be revised accordingly.  Alternative 2) The location of the Y slots within the X slots can be configured.  From single UE perspective, both alternatives are similar. From gNB perspective, the selection of Alt1 and Alt2 depends on the tradeoff between scheduling configuration simplicity and scheduling flexibility. That is, fixed monitoring slots locations for all the UE are restricted for scheduling but it can achieve scheduling configuration simplicity at gNB side compared with having the monitoring slots location within the X slots be configurable.  The other discussion of Alt1 is whether the fixed pattern of slot groups and the location of the Y slots within the X slots are the same across CCs with (X,Y) multi-slot PDCCH monitoring configuration when multi-cell operation is considered. In our view, all the CCs with (X,Y) multi-slot PDCCH monitoring configuration should share the same pattern of slot groups to simplify the design. As for the location of the Y slots within a slot group of X slots, compared with the fixed location of the Y slots across CCs, non-aligned locations of Y slots can provide potential scheduling flexibility with the cost of complicating the BD/CCE limit distribution when multi-cell operation is considered. For example, it is possible that the monitoring slots in a cell with (X,Y) multi-slot PDCCH monitoring configuration might be close to the monitoring slots in another cell with the same (X,Y) multi-slot PDCCH monitoring configuration, which is illustrated in Figure 1. In this example, both CCs follow (X=4,Y=1) multi-slot PDCCH monitoring configuration and the BD/CCE limit assigned to monitoring slots M1\_2 in CC#1 and M2\_1 in CC#2 need to acknowledge UE monitoring capability on monitoring the back to back slots. Therefore, to complete the design, the multi-cell monitoring capability need to be carefully discussed. On the other hand, the fixed location of the Y slots across CCs have benefit on BD/CCE limit determination for CA operation, which expedites BD/CCE budge assignment from gNB perspective and facilitates PDCCH candidate dropping determination at UE side. Furthermore, the aligned PDCCH monitoring pattern across CCs can further improve PDCCH monitoring power consumption compared with the non-aligned PDCCH monitoring pattern. The same observation applies to Alt2 where PDCCH monitoring configuration can be flexible under the constraints of (X,Y).  Proposal 2: Adopt Alt1 as the multi-slot PDCCH capability with the following aspects.   * Alt. 1: Use a fixed pattern of slot groups as the baseline to define the new capability.   + Each slot group consists of X slots   + Slot groups are consecutive and non-overlapping   + The capability indicates the BD/CCE budget within Y consecutive slots in each slot group     - The location of the Y slots within the X slots is maintained across different slot groups   + The fixed pattern of slot groups associated with (X,Y) is the same for all UEs   + For CA, the location of the Y slots within a slot group of X slots is maintained across CCs associated with (X,Y) configuration   + For restrictions on location of the Y slots within a slot group, adopt one of the following alternatives     - Alternative1:Restrict the location of the Y slots to be the first Y slots within a slot group       * FFS: Type-0 CSS configuration adaptation     - Alternative2:The location of the Y slots within the X slots can be configured   + Further discuss down-selection of Y within 1<=Y<=X/2 (both in units of slot) when X>1   + FFS: Further definition of capabilities   + FFS: The following issues for the search space configuration discussion     - Whether a slot group is aligned with a slot boundary   + FFS: What the UE capability defines for monitoring within the Y slots   Regarding the candidate values of (X,Y) in Alt1 and Alt2, at least X=4 slots and X=8 are agreed to be supported for multi-slot PDCCH monitoring in 480 kHz and 960kHz, respectively. To facilitate the discussion, we suggest to prioritize the discussion of Y values for the cases of X=4 slots for 480kHz and X=8 for 960kHz and we suggest at least Y=1 should be supported to achieve UE power saving. For other values of (X,Y), if needed, we prefer to have an UE capability to address the trade-off between UE implementation complexity and gNB scheduling flexibility.  Proposal 3: To achieve UE power saving in multi-slot monitoring, at least (X=4 slots, Y=1 slot) and (X=8 slots, Y=1 slot) should be supported for multi-slot PDCCH monitoring in 480 kHz and 960kHz, respectively, in Alt1. For other pairs of (X,Y), if needed, optional UE capability should be introduced. |

### R1-2109599 (Intel)

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| Alt 1 adopts a fixed pattern of slot groups, i.e., the Y consecutive slots repeat every X slots periodically. On the other hand, the distance between adjacent spans of up to Y consecutive slots is variable, i.e., larger than or equal to X in Alt 2. Alt 2 is essentially a superset of Alt 1. However, it is questionable what additional flexibility can be provided by Alt 2 considering that the PDCCH MOs of a USS/CSS set is allocated periodically. For example, assuming X=4, it is impossible to configure a USS set with periodicity of 4 slots and another USS set with periodicity of 5 slots by Alt 2. Since Alt 1 is quite simple solution and already achieves the key design of multi-slot PDCCH monitoring which mitigates the problem of maximum number of BDs/CCEs for per-slot PDCCH monitoring. Hence, we prefer to support Alt 1 for the multi-slot PDCCH monitoring capability.  On the other hand, Alt 2 does allow some more patterns for PDCCH monitoring than Alt 1. Alt 2 allows a flexible gap (>= X) between adjacent spans. A special case is that the gap is fixed but it can be larger than X between adjacent spans. For example, if multi-slot PDCCH monitoring capability is defined with X=4, Alt 2 allows the configuration periodicity of a USS/CSS set of 5 slots. Effectively, the actual configured pattern of PDCCH MOs is a fixed pattern of 5-slot groups. Therefore, if there is a strong interest to support certain designs from Alt 2, as a compromise, Alt 1 can be extended so that the actual configured PDCCH MOs follows a fixed slot group pattern with group size >= X slots. Note that since the UE has the capability to decode PDCCHs in every X slots, UE can support PDCCH decoding with a periodicity larger than X slots.  Regarding the open issues of Alt 1, since gNB can control the periodicity and offset configured for a USS/CSS set, it is sufficient to define the fixed slot group pattern from a frame boundary and configure the Y slots to the beginning of Y consecutive slots in each slot group.  **Proposal 1:**   * Adopt Alt 1 to define multi-slot PDCCH monitoring capability. * The fixed slot group pattern is defined referring to a frame boundary, with Y slots being at the beginning of Y consecutive slots in each slot group.   Regarding value X for Alt 1, it was agreed to support at least 4 for SCS 480kHz and 8 for SCS 960kHz. Further, additional smaller values are not excluded. Having smaller X value allows gNB to configure PDCCH monitoring more frequently, which can enable quick response of certain indication. For example, if LBT is used for the channel access, the frequency PDCCH monitoring enables gNB to start effective DL transmission right after the successful of DL LBT. Therefore, it is beneficial to support X equals to 2 for SCS 480kHz. Further, X can be 2 or 4 for SCS 960kHz.  One open issue is whether per-slot PDCCH monitoring capability can be supported for SCS 480/960kHz. It is expected that the number of BDs/CCEs per slot that can be monitored by a UE is reduced for the high SCSs. As a result, a UE may not support the PDCCH monitoring of high aggregation level, e.g., 16 or 8. Otherwise, if the number of BDs/CCEs per slot is increased, the overall complexity for PDCCH monitoring of a UE becomes substantially high. Therefore, we prefer that per-slot PDCCH monitoring capability is not supported for SCS 480/960kHz.  From the past discussions, it was agreed that a maximum value of Y is X/2, which avoids back-to-back configuration of PDCCH monitoring occasions. Regarding the minimum value of Y, the candidates include one slot or more than one slots. For the flexibility to configure the USS sets and CSS sets, it is preferred to restrict a minimum Y of two slots, which allows gNB to configure USS sets and CSS sets in same or different symbols in same or different slots. As an exception, if X equals to two slots, Y can be just one slot. In this case, it only supports the gNB to configure USS sets and CSS sets in same or different symbols in the same slot.  **Proposal 2:**   * Additional X value, i.e., 2 for SCS 480kHz, 2 and 4 for SCS 960kHz can be supported   + Per-slot PDCCH monitoring capability is not supported for SCS 480/960kHz * The minimum value of Y is 2, except the case that X equals to 2 and Y equals to 1. * FFS other Y values larger than the minimum value and smaller than X/2. |

### R1-2109666 (NTT DOCOMO)

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| As described above, RAN1 now focuses on down-selection between Alt.1 and Alt.2. In our view, given the discussions so far, the possible approaches for multi-slot PDCCH monitoring capability definition can be described as follows:   * Alt.1 based multi-slot PDCCH monitoring capability definition   + Alt.1-1: Alt. 1 with flexible X or Y with Y>1 * The location of either X or Y is flexible among different UEs. * All types of SSs are configured within Y slots. * Y is larger than one slot for scheduling flexibility and it can also address the current specification that two consecutive slots are monitored for type0-PDCCH CSS.     Fig.1: An example for Alt.1-1 multi-slot PDCCH monitoring capability definition   * Alt.1-2: Alt. 1 with fixed X and Y with Y=1 with enhancement of type0-PDCCH CSS configuration * The location of both X and Y are fixed among different UEs. * All types of SSs are configured within Y slots. * Y is one slot and any symbols in Y slot can be the monitoring occasion. The monitored slots for type0-PDCCH CSS with SSB and CORESET multiplexing pattern 1 should be enhanced, e.g., n0 slot and n0 + X slot.     Fig.2: An example for Alt.1-2 multi-slot PDCCH monitoring capability definition   * Alt.1-3: Alt. 1 with fixed X and Y with Y>1 with different PDCCH monitoring capability for Type1(with dedicated RRC config)/3-CSS/USS and Type0/0A/1(without dedicated RRC config)/2-CSS * The location of both X and Y are fixed among different UEs. * Only type1(with dedicated RRC config)/3-CSS/USS are restricted within Y slots and type0/0A/1(without dedicated RRC config)/2-CSS are not restricted in Y slot.   + The number of BD/CCE are calculated for all types of SSs jointly within X slots. * Y is larger than one slot for scheduling flexibility.     Fig.3: An example for Alt.1-3 multi-slot PDCCH monitoring capability definition   * Alt.1-4: Alt. 1 with fixed X and Y with Y=1 with different PDCCH monitoring capability for Type1(with dedicated RRC config)/3-CSS/USS and Type0/0A/1(without dedicated RRC config)/2-CSS * The location of both X and Y are fixed among different UEs. * Only type1(with dedicated RRC config)/3-CSS/USS are restricted within Y slots and type0/0A/1(without dedicated RRC config)/2-CSS are not restricted in Y slot.   + The number of BD/CCE are calculated for all types of SSs jointly within X slots. * Y is one slot and any symbols in Y slot can be the monitoring occasion.     Fig.4: An example for Alt.1-4 multi-slot PDCCH monitoring capability definition   * Alt.2 based multi-slot PDCCH monitoring capability definition   + Alt.2-1: Alt. 2 with Y>1 * All types of SSs are configured within Y slots. * Y is larger than one slot for scheduling flexibility and it can also address the current specification that two consecutive slots are monitored for type0-PDCCH CSS.     Fig.5: An example for Alt.2-1 multi-slot PDCCH monitoring capability definition   * Alt.2-2: Alt. 2 with Y=1 with enhancement of type0-PDCCH CSS configuration * All types of SSs are configured within Y slots. * Y is one slot and any symbols in Y slot can be the monitoring occasion. The monitored slots for type0-PDCCH CSS with SSB and CORESET multiplexing pattern 1 should be enhanced, e.g., n0 slot and n0 + X (+α) slot.     Fig.6: An example for Alt.2-2 multi-slot PDCCH monitoring capability definition  Based on the above, our best preference is Alt.2-1 since it can achieve better scheduling flexibility of UE-SS for different UEs than any other alternatives and there is no need to enhance the monitored slot for type0-PDCCH CSS. On the other hand, even if Alt 1 has to be a baseline, we believe that Alt.1 should follow Rel-15 FG 3-1, i.e., type0/0A/1(without dedicated RRC config)/2-CSS are not restricted in Y slot(s) described as in Alt.1-3 or Alt.1-4 above.  ***Proposal 1****: For defining the multi-slot PDCCH monitoring capability for 480 and 960 kHz SCS,*   * *Support Alt.2 (extension of Rel-16 span PDCCH monitoring) as the baseline with Y larger than one slot.* * *If Alt.1 is considered as the baseline, type0/0A/1(without dedicated RRC config)/2-CSS should not be restricted in Y slot(s) as in Rel-15/16 NR.*   If Alt.2 is supported for defining the multi-slot monitoring capability, one remaining issue could be span pattern, which defines the monitoring occasion in a slot, and the pattern is repeated among all the slots in Rel-15/16 NR. Since the span length would be larger than the one in Rel-15/16 (i.e., more than 1 slot), whether to repeat the span pattern among all the slot groups may need to be discussed to have more flexibility on span pattern configuration. On the other hand, given that only two e-meetings are available for Rel-17 completion, we believe just to align similar principle as in Rel-15/16 should be prioritized for any discussion. Considering that a slot is the length of slot pattern with span-based PDCCH monitoring capability in Rel-16, just to define X slots, which is the same as span gap, as the length of slot pattern can be considered.  ***Proposal 2****: For defining the multi-slot PDCCH monitoring capability for 480 and 960 kHz SCS, support X slots as the unit of span pattern when Alt.2 is supported.* |

### R1-2109778 (Sony)

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| Regarding the start position of the Y consecutive slots, to our understanding, as long as the starting position of Y slots is fixed across the slot groups, it makes no difference in terms of UE monitoring complexity. However, restrict the Y consecutive slots to be at the beginning of each slot group does not harm the network flexibility, especially comparing to the mandatory monitoring capability defined in Rel-15/16. In fact, when the value of Y is more than 1 slot, the flexibility of SS configuration is better than a Rel-15/16 120 kHz SCS carrier. Therefore, allowing the starting position of the Y consecutive slots to be flexible within each slot group may trigger unnecessary discussion on additional parameters and complicate specification.  Regarding the possible value of Y, since Y with values that larger than 1 can flexibility improve the flexibility comparing to the Rel-15/16 120 KHz SCS, while considering the potential X = 4 for 480 KHz SCS, Y = X/2 therefore should be supported.  **Proposal 1: Restrictions on location of the Y slots to start with the beginning of each slot group, while Y = X/2 should be supported.** |

### R1-2109898 (Lenovo, Motorola Mobility)

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| ***Observation 1: For supporting NR between 52.6 GHz and 71 GHz for high subcarrier spacing values including 480kHz and 960kHz with multi-slot PDCCH monitoring, slot group configuration (Alt 1) with PDCCH monitoring occasion only at the beginning of slot group is beneficial to avoid back-to-back issue of PDCCH monitoring across two consecutive slot groups, but not preferable in terms of PDCCH monitoring flexibility***  ***Observation 2: For supporting NR between 52.6 GHz and 71 GHz for high subcarrier spacing values including 480kHz and 960kHz with multi-slot PDCCH monitoring, if Rel-16 like mechanism with span is extended across multiple slots, then the PDCCH monitoring flexibility can be achieved, while also avoiding the issue of back-to-back PDCCH monitoring across continuous multi-slot groups***  Another alternative that has been discussed in RAN1#104-e is Alt 3 where a new principle is introduced to have a sliding window of X slots such that the PDCCH monitoring capability is maintained within that window according to the reported UE capability. The main motivation is to avoid back-to-back PDCCH monitoring. However, as described above in Figure 2 (b), Rel-16 like span based PDCCH monitoring mechanism can be simply extended across multiple slots and the issue of back-to-back PDCCH monitoring is avoided. In our view, Alt 2 and Alt 3 can basically achieve the same thing and therefore Alt 2 should be agreed as it is a simple extension of exiting mechanism and would be easier to specify.  ***Proposal 1: For supporting NR between 52.6 GHz and 71 GHz with high subcarrier spacing values including 480kHz and 960kHz, support Alt 2 i.e., extension of (X, Y) PDCCH monitoring span for multi-slot PDCCH monitoring*** |

### R1-2109904 (InterDigital)

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| ***Observation 1:*** *A fixed pattern of X slots (Alt-1) provides the simplest multi-slot PDCCH monitoring scheme which is similar to UE PDCCH monitoring of 120 kHz SCS.*  ***Observation 2:*** *Span based monitoring (Alt-2) may provide different PDCCH monitoring patterns in every slot, however, requires more complex UE implementation.*  ***Observation 3:*** *Given the short slot duration of 480 kHz and 960 kHz, benefits of distributing the monitoring/processing loads by supporting sliding windows (Alt 3) are doubted.*  ***Proposal 1:*** *For 480 kHz SCS and 960 kHz SCS, support of Alt 1 is preferred for multi-slot PDCCH monitoring.*  ***Proposal 2:*** *Additional need of span based monitoring (Alt-2) should be carefully investigated for 480 kHz and 960 kHz.*  ***Proposal 3:*** *Sliding window based monitoring (Alt-3) is not supported in Rel-17.*  In RAN1#106-e [2], supports of at least X=4 slots and X=8 slots are agreed for 480 kHz and 960 kHz, respectively. In our view, support of various PDCCH slot monitoring capability provides better flexilibty considering various verticals and UE implementations for higher frequency. Especially, per slot PDCCH monitoring is one of the important use cases to support reduced latency as clarified in TR [3]. To avoid complex UE implementation issues as much as possible, it is preferred to support X=4 slots for 480 kHz and X=8 for 960 kHz as a mandatory UE capability while other X values can be indicated as a UE capability. For the candidate values of X, it is preferred to support , where *N*=0,1 and 2 for 480 kHz and *N*=0,1,2 and 3 for 960 kHz.  ***Observation 4:*** *Support of various PDCCH slot monitoring capability provides better flexibility considering various verticals and UE implementations for higher frequency.*  ***Proposal 4:*** *For the candidate values of X, it is preferred to support X=2^N, where N=0,1 and 2 for 480 kHz and N=0,1,2 and 3 for 960 kHz.*  For Alt-1, following issues were raised for further discussion:   * Whether a slot group is aligned with a slot boundary   + In RAN1#106-e [2], some companies argued that more flexibility can be achieved if UE support a slot group boundary which is not mandated to start from a slot boundary. In our view, the flexible slot boundary may provide more flexibility, however, benefits from the flexibility are not clear given the short symbol/slot durations in 480 kHz and 960 kHz. Having said that, it is preferred to support a slot group which starts from a slot boundary to reuse existing UE implementation as much as possible. * Restrictions on location of the Y slots within a slot group, e.g., whether to restrict the location of a SS to be within a slot group.   + In Rel-15 UE capability [5], following PDCCH monitoring occasions are defined:     - For type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS, the monitoring occasion is within the first 3 OFDM symbols of a slot.     - For type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS, the monitoring occasion can be any OFDM symbol(s) of a slot, with the monitoring occasions for any of Type 1- CSS without dedicated RRC configuration, or Types 0, 0A, or 2 CSS configurations within a single span of three consecutive OFDM symbols within a slot.   + Based on the above PDCCH monitoring occasions, following values can be used for Y:     - For type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS, the monitoring occasion can be 1 slot for 480 kHz SCS and 2 slots for 960 kHz SCS, respectively.     - For type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS, the monitoring occasion can be any OFDM symbol(s) of a slot group, with the monitoring occasions for any of Type 1- CSS without dedicated RRC configuration, or Types 0, 0A, or 2 CSS configurations.       * Further study may be needed on how to change the condition ‘within a single span of three consecutive OFDM symbols within a slot’ to a slot group.   ***Observation 5:*** *Flexible slot boundary may provide more flexibility, however, benefits from the flexibility are not clear given the short symbol/slot durations in 480 kHz and 960 kHz.*  ***Proposal 5:*** *For a slot group in Alt 1, a slot group starts from a slot boundary.*  ***Proposal 6:*** *For the values of Y, following PDCCH monitoring occasions are supported:*   * For type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS, the monitoring occasion can be **1 slot for 480 kHz SCS** and **2 slots for 960 kHz SCS**, respectively. * For type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS, the monitoring occasion can be **any OFDM symbol(s) of a slot group**, with the monitoring occasions for any of Type 1- CSS without dedicated RRC configuration, or Types 0, 0A, or 2 CSS configurations. * Further study may be needed on how to change the condition ‘within a single span of three consecutive OFDM symbols within a slot’ to a slot group. |

### R1-2109962 (LG)

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| For both Alt-1 and Alt-2, SS set configurations and dropping rules can be determined simply since basic principles for them are already well established to a single slot or a single span in rel-15/16. However, Alt-2 does not allow multiple discontinuous Y slots/symbols within X slots/symbols by the definition of span in rel-16. In addition, if the duration of Y is much smaller than X, all MOs for both CSS and USS should be in small number of slots/symbols. This may reduce the gNB’s flexibility and restrict the SS set configuration especially for CSS. Therefore, we suggest that Alt-1 should be the baseline to define the BD/CCE capability for multi-slot PDCCH monitoring. One possible issue for Alt-1 has also been raised in the previous meeting, i.e., UE may have higher requirement than expectation on PDCCH monitoring in two consecutive slots across slot-group boundary. However, it may not be the problem if additional constraints for Y on PDCCH monitoring in back-to-back slots.  In this respect, we support Alt-1 and propose some configuration/restriction related to Alt-1 to resolve the possible issues.  **Proposal #2: Adopt Alt-1, with the followings**   * + **Y location has following restrictions**     - **Minimum gap between the previous Y and the next Y over two consecutive X slot-groups should be guaranteed**     - **The start position of Y should be the same in each X slot group (i.e., not different for each X slot-group)**     - **The start position of Y should be configurable (i.e., not fixed location)**   + **Y should be multiple slots (including single slot) with slot-level granularity**   + **FFS: The possibility of different positions of Y for CSS and USS**   In order to support various monitoring situations, Y should also be able to have different values depending on X. Multiple values of Y can be reported as UE capability and the gNB can configure an appropriate Y for each X. For this reason, we can think of an operation that can configure X and Y based on UE capability if multiple values are supported. In addition, it may also be necessary to set the lower and upper bound of Y. As a lower bound, Y=1 (which is the minimum value per slot) is considered appropriate. And Y=X/2 can be a proper upper bound for each X to avoid the back-to-back monitoring issue. Values in between need to be further discussed to support flexible multi-slot monitoring operation.  **Proposal #3: Consider to configure X and Y (i.e. duration) based on UE capability if multiple values are supported**   * + **X=2 for 480kHz and X=2,4 for 960kHz**   + **Y should be determined with respect to X**     - **At least, Y=1 and Y=X/2 should be supported for all X.**     - **Others values are FFS.** |

### R1-2109993 (Sharp)

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| Since multi-slot monitoring is considered to be an extension of single-slot monitoring, Alt.1, which is aligned with a slot boundary, can simplify the enhancement of SearchSpace and reduce the standardization effort. On the other hand, several companies have pointed out that Alt.2 is more flexible than Alt.1 because the span interval can be freely determined. However, Alt.1 also allows flexible MO distribution by considering search space configuration for 480 kHz and 960 kHz SCS with short slot. In addition, Alt.2 requires a discussion on the rules that determine the BD/CCE limits for aligned and non-aligned spans between CCs. We don't know if the rules in Rel-16 are applicable to Alt.2, and defining new rules will take multiple meetings. Therefore, we support Alt1 which is aligned with a slot boundary, which has less standardization effort.  **Proposal 1: We support the fixed pattern of slot groups, which is aligned with a slot boundary.**  Since there does not seem to be a common understanding, we should first clarify the definition of Y. Y is the maximum number of consecutive slots that the UE monitors per slot-group consisting of X slots. After monitoring Y slots in one slot-group, the UE does not monitor during the X-Y slots until Y slots in the next slot group. For resolving the back-to-back problem, it is proposed in previous discussion that Y should be less than X/2 and always start at beginnin of slot gloup. However, to avoid back-to-back problem, we only need to set a gap larger than X/2 between Y slots on the consecutive two slot-groups. This gap is secured by maintaining the location of Y slots within X slots across different slot groups, and floating Y slots implove the flexibility of MO distribution.  **Proposal 2: Y is the number of consecutive slots that the UE monitors PDCCH per slot-group consisting of X slots.**  **Proposal 3: Y slots should be floating, and the location within the X slots is maintained across different slot groups.**  **Figure 1: Example of fixed pattarn of slot-group with floating Y slot.**  At the last meeting, X=4/8 slots were agreed upon as the minimum capability for 480kHz/960kHz SCS, in order to ensure the same processing performance on a time basis as single-slot monitoring at 120 kHz. On the other hand, some companies are of the opinion that smaller values of X should also be supported. However, X=4/8 allows for PDCCH monitoring at sufficiently short intervals, and the benefits of more frequent monitoring are currently not clear. Hence, a value of X smaller than X=4/8 should not be mandatory. If set as an optional capability, the BD/CCE budget should be considered. The first three symbols are set as the minimum requirement for CSS monitoring at 480 kHz and 960 kHz SCS, because the maximum duration of CORESET follows 3. If Y is too small, the flexibility of MO placement will be reduced, and if Y is too large, the microsleep opportunity may be lost. Therefore, Y should be set to 1, taking into account the impact on the specifications.  **Proposal 4: Values of X smaller than X=4/8 should not be mandatory. If values less than X=4/8 set as an optional capability, the BD/CCE budget should be considered.**  **Proposal 5: The following values should be used as basic settings.**   * **for 480 kHz SCS : X = 4, Y = 1** * **for 960 kHz SCS : X = 8, Y = 1** |

### R1-2110022 (Apple)

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| ***Proposal 1:*** *The MSM PDCCH monitoring capability should be based on Alt 1 or Alt 2. Alt. 3 should not be supported.*  ***Proposal 2:*** *The corresponding values of X and Y are set to allow flexibility in the placement of the CSS and USS without undue burden on UE power consumption e.g. Y ≤1.*  ***Proposal 3:*** *On the values of X for Alt-1 and Alt-2:*   * *Additional values smaller than 4/8 slots for 480/960 kHz can be supported based on UE capability.*    + *Larger values than 4/8 slots for 480/960 kHz are not supported.* * *Single-slot PDCCH monitoring for 480 kHz and 960 kHz is not supported.* * *The configurable values for multi-slot PDCCH monitoring operation should be same as the reported X value(s).* * *The UE is not expected to handle a scenario in which they are different and a UE might report its monitoring capability for more than one (X,Y) combination.* * *For each SCS 480 kHz and 960 kHz, the minimum configurable multi-slot PDCCH monitoring periodicity is the smallest value X that a UE supports when reporting its PDCCH monitoring capabilities for the corresponding SCS and are UE specific.*   ***Proposal 4:*** *For Alt-1,*   * *the SS sets are within the first Y slots of the slot group and Y < X i.e., no back-to-back monitoring of PDCCH between slot groups is supported. Y = 1* * *PDCCH monitoring of all SS sets monitored in the Y slots occurs within N consecutive symbols of Y with the following options:*   + *Case 1: PDCCH monitoring limited to within the first N consecutive symbols of Y*   + *Case 2: PDCCH monitoring is on any span of up to N consecutive symbols of Y where Y = 1*   ***Proposal 9:*** *For Alt-2, the value Y should be defined based on symbols*   * *The duration of Y < X with Y ≤ 3 symbols* |

### R1-2110110 (Convida Wireless)

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| Like Rel-16 URLLC PDCCH monitoring span (X, Y) definition, it can be extended to the mobile broadband (EMBB) service for NR from 52.6 GHz and above with few modifications. The PDCCH monitoring span (X, Y) has been agreed in RAN 1 meeting #106-e for higher SCS/numerology (e.g., SCS 480KHz, 960 kHz) where the first number X is the number of slots between the beginning of two consecutive monitoring occasions, the second number Y is the number of slots or symbols needs to be monitored in a monitoring occasion. For NR from 52.6 GHz and above, the duration per span is across several slots to meet the scheduling requirement due to the number of PDCCH candidate and nonoverlapping CCEs being reduced per slot.  PDCCH span length X is preconfigured based on the subcarrier spacing (e.g. X=8 for SCS = 960 KHz) thus the PDCCH monitoring span X may not need to be signalled by the higher layer. To simplify the design, it suggests that the slot group (or each PDCCH monitoring span) is aligned with the slot boundary. An example of a PDCCH monitoring span shown in Figure 1. In Figure 1, we assume a configuration of PDCCH monitoring span for SCS = 960 KHz. For this example, let a span (X=8, Y=4) is configured, note the unit for X and Y can be either based on number of slots or symbols and the slot group (a span) is aligned with slot boundary.    **Figure 1**: Slot group for NR SCS = 960 KHz and is aligned with a slot boundary.  ***Proposal 1. Slot group for PDCCH monitoring span can be aligned with slot boundary for NR from 52.6 to 71 GHz.***  The UE can be configured by the gNB to monitor PDCCH for the maximum number of PDCCH candidates () and nonoverlapping CCEs () defined per span like in Rel-16. In each PDCCH monitoring span, the number of PDCCH candidates and nonoverlapping CCE cannot exceed the UE capability. Therefore, UE behavior can be similar to legacy NR specification even when there is a overbooking. For example, the UE and gNB can map PDCCH candidates in each PDCCH monitoring span as the following mapping rules in legacy NR specification: (1) CSS sets are mapped before USS sets; (2) USS sets are mapped in ascending order of the SS set indices, and if the number of PDCCH candidates/CCEs exceeds either of the UE processing limits, etc.  Alt-3 proposes the multi-slot span with the concept of the "sliding window”. The motivation is to limit the PDCCH processing loads on the UE over any sliding window of, say, slots. The maximum BD/CCEs can be distributed by gNB configuration to (1) all in one slot or (2) over several slots while respecting the maximum capability constraints over any sliding window of slots. One of the advantages is that the loading can be evenly distributed from gNB perspective. The sliding window can be treated as a time offset (number of slots) configuration for USS from the beginning of span. Also, the multi-slot span with the concept of the "sliding window” can be implemented by the PDCCH monitoring span pattern (X, Y) when the following two conditions are satisfied, i.e., X and Y are defined in terms of slots, and X = Y. Therefore, Alt-3 can be treated as a special case of Alt-2. In addition, the “sliding window” (e.g., the USS stating time-offset) for each UE is configured by gNB and UE just follows the configuration to perform PDCCH monitoring in each PDCCH monitoring span.  ***Proposal 2. PDCCH monitoring per span with sliding window (i.e., Alt-3) can be up to gNB configuration for NR from 52.6 to 71 GHz.*** |

### R1-2110173 (Qualcomm)

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| Based on these arguments and considering the limited time budget in Rel-17, it was suggested to prioritize the design for X = 4 for 480 kHz SCS and X = 8 for 960 kHz, and come back to the discussion on the additional X values later. However, for scalability and consistency, we believe that the additional values of X should be kept in mind throughout the design. For example, instead of pursuing separate design for different X values, a scalable rule for the Y value and BD/CCE budget for each X value can be considered. In addition, the support for the additional smaller values of X should be an optional UE capability, while X = 4/8 for 480/960 kHz SCS are mandated as agreed in RAN1 #106-e. In this way, the support for additional X values will not impact the commercialization timeline. Furthermore, although the maximum number of BD/CCE is limited, the smaller values of X may be useful in some use cases, e.g., for serving a low-latency traffic or for channel monitoring outside a COT.  Proposal 1: For the values of X in addition to X = 4 for 480 kHz SCS and X = 8 for 960 kHz SCS, the following sets are considered per UE capability:   * 480 kHz SCS: X = {1, 2} slots, * 960 kHz SCS: X = {1, 4} slots.   If multiple values of X are supported by the UE capability, the default capability, which is supported by all UEs and assumed when there is no dedicated RRC configuration, should be determined, e.g., when 480 kHz SCS is used for initial access. Noting that a smaller value of X would be more demanding for the high SCSs, having a larger value of X, i.e., X = 4 for 480 kHz SCS and X = 8 for 960 kHz SCS, as the default capability is desirable.  Proposal 3: For 480 kHz and 960 kHz SCSs, X = 4 and X = 8 are regarded as the default capability, respectively, and assumed during the idle/inactive mode operation (e.g., for ANR detection) and initial access procedure.  Proposal 4: For 480 kHz and 960 kHz SCSs, any smaller values of X than 4 for 480 kHz SCS and 8 for 960 kHz SCS are supported as an optional UE capability during a connected mode operation.  **Issue 2: Delineation ambiguity**  Not having a fixed slot group, it was observed in [5] that Alt 2 may have an ambiguity in the delineation of PDCCH MOs. As shown in Figure 1, for a give configuration of PDCCH MOs, there can be multiple potential delineations; for a given combination (X, Y) = (4, 2), a delineation of the multi-slot PDCCH monitoring by Delineation 1 satisfies the given (X, Y) combination, while Delineation 2 does not. Therefore, since not all delineations may satisfy a given combination (X, Y), searching for a proper delineation may pose additional processing burden to the UE.  However, it is noteworthy that the delineation issue is cause by a Y value larger than one slot. Thus, as we proposed in Proposal 5, with a Y value no larger than one slot, the issue can be avoided.  Observation 5: For multi-slot PDCCH monitoring capability Alt 2, the delineation ambiguity of PDCCH monitoring occasions can be avoided if Y ≤ 1 slot.    Figure 1: Delineation of PDCCH MOs for Alt 2.  **Issue 3: Complexity of deriving a repeated span pattern**  In the agreement from RAN1 #104bis-e, it was captured as an FFS how a span pattern is defined and applied for Alt 2. The span pattern is given by a bitmap of length M indicating a repeated pattern of PDCCH MOs. During RAN1 #106-e discussion, it was pointed out that the bitmap size could be very large in some cases (e.g., M = 640 slots for 480 kHz SCS and M = 1280 slots for 960 kHz SCS), due to the flexibility of search space periodicity selection. Since the UE should derive the span pattern from the search space configuration, it can result in a very high complexity compared to Alt 1.  In fact, the argument on the repeated span pattern is based on the view that Alt 2 is an extension of Rel-15 PDCCH monitoring capability, i.e., FG 3-5b (*pdcch-MonitoringAnyOccasionsWithSpanGap*). However, in our view, Alt 2 should be regarded as an extension of Rel-16 per-span PDCCH monitoring capability, i.e., *pdcch-Monitoring-r16*, and the notion of the repeated span pattern is not relevant. To clarify, the same definition of span in Rel-16 should be used (Section 10 in TS 38.213):   * A span is a number of consecutive symbols in a slot where the UE is configured to monitor PDCCH. * A span starts at a first symbol where a PDCCH MO starts and ends at a last symbol where a PDCCH MO ends, where the number of symbols of the span is up to Y.   Observation 6: As an extension of Rel-16 per-span PDCCH monitoring capability, multi-slot PDCCH monitoring capability Alt 2 is not related to a repetition of the same span pattern.  Therefore, based on the discussion above, we believe that Alt 2 is more efficient and flexible compared to Alt 1.  Proposal 7: For the definition of multi-slot PDCCH monitoring capability, Alt 2 is supported with the following modification:   * **Alt 2: Use an (X, Y) span as the baseline to define the new capability**   + **X is the minimum time separation between the start of two consecutive spans**   + **The capability indicates the BD/CCE budget within a span of at most Y = 1 slot** |

### R1-2110248 (Charter Communications)

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| **Observation 2: Alt.1 with flexible location for Y-slots cannot solve all the issues of the Alt.1. The flexibility in location of Y-slots can also create new sets of problems.** |

### R1-2110252 (Panasonic)

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| The multi-slot PDCCH monitoring capability needs to have the balance of two requirements, i.e. the scheduling flexibility for gNB and UE complexity/power consumption reduction for UE. From gNB perspective, the maximum number of BD/CCE per monitoring occasion (MO) in 480 and 960 kHz SCS should be similar to the case of 120 kHz SCS to achieve the similar scheduling flexibility per MO. From UE perspective, multi-slot PDCCH monitoring capability should provide mechanisms to relieve UE monitoring burden and reduce UE power consumption.  To address the above-mentioned requirements, one important design point is to define minimum separation in time between two consecutive spans of MOs. A span, per Rel-16 definition, is a number of consecutive symbols in a slot where the UE is configured to monitor PDCCH. A span starts at a first symbol where a PDCCH MO starts and ends at a last symbol where a PDCCH MO ends. The same definition of span can be used in above 52.6 GHz operation for consistency.  The minimum separation can be readily achieved by Alt 2 with the restriction that Y contains one single span. Considering the fact that one MO has duration up to 3 symbols if legacy CORESET length is reused in above 52.6GHz operation, the duration of a span can be limited to a few symbols as well. Then X in Alt 2 becomes the minimum time separation between the start of two consecutive spans. In terms of the units for defining X and Y, Y should be defined in unit of symbols to allow UE to restrict its monitoring within a few symbols. On the other hand, X can be defined in unit of slots because the separation is expected to be as large as multiple slots. Examples could be (X=4 slots, Y=3 symbols) for 480kHz, and (X=8 slots, Y=3 symbols) for 960kHz. Alternatively, X may be defined in unit of symbols as well. Since in Alt 2, Y is always counted from the start of X, defining X in symbols provide the flexibility to locate MO in other symbols than the first symbol of a slot. However, it is unclear whether such flexibility is needed for above 52.6GHz operation considering the fact that slot length is very short for high SCSs.  **Proposal 1: For defining multi-slot PDCCH monitoring capability, select Alt 2 with X in slots and Y in symbols and Y containing one short span (up to a few symbols).**  On the other hand, considering the fact that Alt 1 was preferred by majority companies [1], we are open to further discuss Alt 1.  As shown in the section 1, some decisions have been made on refining Alt 1 in the previous meeting, e.g. Y will be defined in unit of slot with the range of 1<=Y<=X/2. There was also intensive discussion in the previous meeting on whether to fix the location of Y within X. The motivation of having fixed location of Y is to avoid back-to-back monitoring issue which has been acknowledged by companies. But the “fixed location of Y” can be understood in two different ways. The first interpretation is that the location of Y is defined by SFN (similar to the definition of X-slot groups), e.g. the Y slots as the first X slots within the X-slot pattern. The second interpretation is from each UE perspective that the location of Y within X is maintained across different slot groups, but it is not necessarily aligned among different UEs.  The first interpretation (same location of Y for all UEs), although enjoying its simplicity, would have issue for UE to monitor beam-swept CSS. Considering the fact that different UE might monitor different TDMed-beam for CSS, the same location of Y could end up with certain CSS outside Y. To solve this issue, some company suggested that UE is required to monitor broadcast CSS (e.g. Type0/0A/1(without dedicated RRC config)/2-CSS) even if it is located outside Y. From our opinion, such behavior would basically increase the UE complexity and compromise target of defining multi-slot monitoring. So we don't think it is good idea to introduce such exceptional rule for certain type of CSS.  The second interpretation (different UE has different location of Y), on the other hand, would not need exceptional rule for CSS. However, since different UE can have different location of Y, it introduces extra complexity for network side to keep tracking of location of Y for every UE for scheduling.  In order to balance the scheduling flexibility and complexity, we propose that the location of Y is determined by the CSS MOs that UE is configured to monitor. Then it is possible to align the location of Y for a group of UEs monitoring the same CSS MOs, if not all the UEs.  After the location of Y is determined based on the CSS MOs, USS MOs can be further included in Y from USS with lower to higher indices. In an ideal case, the location of Y can be chosen to cover all CSS MOs and USS MOs that are configured to the UE. In other words, it implies that gNB by configuration makes sure that all CSS/USS MOs can fall into Y. However, in reality, this may not be always possible, or not an efficient operation even if possible. For example, considering the TDMed-beam transmission of CSS, UE may need to monitor a different slot for CSS when UE’s serving beam is changed. However, for USS, gNB can simply change the serving beam without changing the MO location since USS MO is unicast to the UE. In this case, it can happen that USS MO becomes far away from the CSS MO of the new serving beam such that Y cannot include both CSS and USS MOs anymore. Therefore, the configuration of USS MOs should not be restricted to Y slots. If a certain USS MO cannot be included in Y, it would be dropped after the location of Y is determined.  The following Fig.1 illustrates one example. As shown, in the first slot group (UE is served by yellow beam), the location of Y is the first slot, covering USS1 MO and CSS MO of the yellow beam. UE is not required to monitor USS2 MO because it is outside Y. When UE moves from the coverage of yellow beam to green beam in the second slot group, the corresponding CSS MO location is also changed. Consequently, the location of Y changes as well, to cover the second slot in the second slot group. As a result, USS1 MO is dropped, and USS2 MO will be monitored by the UE.    Fig.1 Determination of the location of Y  **Proposal 2: For Alt 1, UE determines the location of Y based on the following rule:**   * **Location of Y should first include all CSS MOs that UE is configured to monitor, then USS MOs can be further included in Y from USS with lower to higher indices. Certain USS MO would be dropped if it cannot be included in Y.**   If the Proposal 1that Y contains one single short span for Alt 2 is agreed by RAN1, there is no need for further capability definition discussion within Y. On the other hand, for Alt 1, it has been agreed that Y has range from 1 slot up to X/2 slots. It is our understanding that the underlined assumption is that some symbols of Y may not belong to any span, meaning that UE is not required to monitor every symbol of Y. As a result, it is to be discussed the further capability definition within Y at least for Alt 1. From our point of view, the discussion points include the maximum allowed duration of a MO span and maximum number of allowed MO spans. It also should discuss the minimum time separation between two consecutive MO spans to order to avoid local PDCCH processing overloading issue.  **Proposal 3: For Alt 1, further discuss capability definition within Y in terms of duration of span, number of spans, and minimum separation between two consecutive spans.** |

## Topic A2: Search Space Configuration/Enhancement

### R1-2108768 (Huawei, HiSilicon)

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| The time domain parameters include periodicity, offset, duration, and monitoring symbols within slot as shown in following table.  **Table 5. Search space set configuration**  SearchSpace ::= SEQUENCE {  searchSpaceId SearchSpaceId,  controlResourceSetId ControlResourceSetId  monitoringSlotPeriodicityAndOffset CHOICE {  sl1 NULL,  sl2 INTEGER (0..1),  sl4 INTEGER (0..3),  sl5 INTEGER (0..4),  sl8 INTEGER (0..7),  sl10 INTEGER (0..9),  sl16 INTEGER (0..15),  sl20 INTEGER (0..19),  sl40 INTEGER (0..39),  sl80 INTEGER (0..79),  sl160 INTEGER (0..159),  sl320 INTEGER (0..319),  sl640 INTEGER (0..639),  sl1280 INTEGER (0..1279),  sl2560 INTEGER (0..2559)  }  duration INTEGER (2..2559)  monitoringSymbolsWithinSlot BIT STRING (SIZE (14))  …  **Periodicity and offset**: Assume that multi-slot PDCCH monitoring capability for 480/960 kHz SCS is defined within the first Y slots per X-slot pattern of Alt 1-1 described in section 2.1. Then, a UE can be configured with monitoring periodicity to be integer of X slots so that its monitoring occasion always locates within the Y slots. Moreover, as aforementioned, the number of slots increase by 4/8 times for 480/960 kHz SCS, if the monitoring periodicity of 120 kHz SCS is to be maintained. In order to avoid a large increase of the number of choices in *monitoringSlotPeriodicityAndOffset*, the unit of the periodicity could be X-slots instead of one single slot. Similarly, the offset values should also be scaled by X. For example, “sl4” in Table 4 represents a periodicity of 16/32 slots for 480/960 kHz SCS. In addition, the integers values of (0,1,2,3) for “sl4” correspond to slot#0, slot#3, slot#7, slot#11 with a 16-slot periodicity for 480kHz SCS and slot#0, slot#7, slot#15, slot#23 with a 32-slot periodicity for 960kHz SCS. Furthermore, if monitoring occasions are restricted to be within the first Y>1 slots in a slot group, additional slot-level offsets are needed*.* For example, the number of bits of *monitoringSymbolsWithinSlot* can be increased to cover Y slots (e.g., 28 bits for Y=2 slots) or to 56/112 bits to directly indicate the offset within X slots for 480/960 kHz SCS.  **Duration**: In Rel-15, the duration field in SearchSpace configuration denotes the number of consecutive slots that a SearchSpace lasts in each period. Apparently, the value of duration should be smaller than the periodicity indicated by *monitoringSymbolsWithinSlot*. In order to reuse the field and the corresponding value defined in Rel-15 for 480/960 kHz SCS, a new interpretation is needed. Specifically, if the PDCCH monitoring capability for 480/960 kHz SCS is the same as that for 120 kHz in a given time duration, the duration can be defined as the number of consecutive X-slots where SearchSpace can be located for 480/960 kHz SCS. Within each X-slots, the monitoring occasions are located in the first Y slots, which is configured by *monitoringSymbolsWithinSlot*. An example is shown for 120 kHz and 480 kHz SCSs in **Figure 2**, where Ts denotes the duration of SearchSpace (yellow box), and ks denotes the periodicity.    **Figure 2. TDM-ed search space for different UEs within a monitoring span**   1. ***The time domain parameters of search space set configuration should be revised for multi-slot PDCCH monitoring for 480 kHz and 960 kHz, as follows:***    * ***The unit of monitoringSlotPeriodicityAndOffset is changed to X-slots, with X=4 for 480 kHz and X=8 for 960 kHz.***    * ***The unit of “duration” is changed to X-slots, with X=4 for 480 kHz and X=8 for 960 kHz.***    * ***Additional slot level offset or extension of monitoringSymbolsWithinSlot is required if monitoring occasions are within the first Y>1 slots in an X-slots pattern.***   In NRU Rel-16, search space set group switching is introduced to balance the UE power consumption on PDCCH monitoring and channel access flexibility on gNB side. The gNB can initiate a DL transmission in the middle of a slot after LBT by configuring mini slot PDCCH monitoring (SSSG#0) to a UE. After detecting a scheduling PDCCH or a DCI format 2\_0 with SSSG switching trigger, the UE may switch to SSSG#1 with longer monitoring period within a COT. After the COT ends, the UE switches back to SSSG#0. It takes symbols, as listed in Table 8, for a UE to accomplish a SSSG switching procedure.  **Table 6. Minimum value of [symbols]**   |  |  |  | | --- | --- | --- | |  | **Minimum value for**  **UE processing capability 1 [symbols]** | **Minimum value for**  **UE processing capability 2 [symbols]** | | 0 | 25 | 10 | | 1 | 25 | 12 | | 2 | 25 | 22 |   A slot with 120 kHz SCS has a time duration of about 3 OFDM symbols in a mini-slot with 30 kHz SCS, which brings sufficient flexibility to channel access. Moreover, if slot-based PDCCH monitoring is supported for 480/960 kHz SCS, the PDCCH monitoring periodicity is as small as about 15 us, which is very close to a CCA sensing slot duration. Therefore, there is no need, from the perspective of monitoring periodicity, to introduce SSSG switching between mini-slot monitoring and slot-based monitoring, or between slot-based monitoring and multi-slot monitoring. However, for 480/960 kHz SCS, SSSG switching does save UE power when a multi-slot-based monitoring switch between a small periodicity and a large periodicity.   1. ***SSSG switching can be supported between two different periodicities of multi-slot-based monitoring in order to save UE power consumption on PDCCH monitoring.*** |

### R1-2108783 (Futurewei)

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| The time pattern for monitoring PDCCH is configured to a UE by means of search space (SS) sets: common SS (CSS), and UE specific SS (USS). A UE can be configured up to 10 SS sets for each up to four BWPs in a serving cell. The SS set configuration indicates SS type, DCI format(s), monitoring occasions and the number of PDCCH candidates for each aggregation level (AL) in the SS set. A search space is associated with only one CORESET. A control-resource set consists of resource blocks in the frequency domain and symbols in the time domain. A UE monitors a set of PDCCH candidates in one or more CORESETs on the active DL BWP.  The UE determines what slots to monitor based on the duration, periodicity and offset provided by higher layers. TS 38.331 defines the SearchSpace IE.   * *duration* is the number of consecutive slots that a SearchSpace lasts in every occasion, i.e., upon every period as given in the SlotPeriodicityAndOffset. * *monitoringSlotPeriodicityAndOffset*: number of slots for PDCCH Monitoring configured as periodicity and offset.   With Rel 17, the basic pattern is extended to multiple slots, therefore the specified duration is a repetition of the basic pattern and should be a multiple of the basic pattern length. The basic pattern duration in multi-slot PDCCH monitoring corresponds to X value above. The basic pattern duration for multi-slot PDCCH monitoring consists of an active search period (span) and a period where UE can microsleep (X-Y for instance).  With multi-slot PDCCH monitoring new variables are necessary to describe the extended basic monitoring pattern within a search space duration.   * *spanDuration*, represents the number of slots of span duration where PDCCH may be localized * *patternDuration,* which correspond to X value duration   We note that the existing elements (variables) for search space configuration should keep their definition as the extended basic monitor pattern is repeated for “duration” slots, (duration >X), with periodicity and offset configured as presented in Figure 4.    Figure 4, Search Space timing    In a multi-slot monitoring span UE may be provided with bitmap that indicates the monitoring symbols in each span. We note that this information is already provided in the Rel-15/16 IE by the variable *monitoringSymbolsWithinSlot*, which is the first symbol(s) for PDCCH monitoring in the slots configured for PDCCH monitoring. For instance, UE will monitor just the first 3 symbols in each slot of the multi-slot span X=1. Moreover, the PDCCH schedule and monitoring can be further simplified if the CSS and USS are grouped and scheduled at different time either in the same slot or different slots of the span.  We note that is possible to select between two PDCCH different monitoring behaviors (e.g. per slot vs per multi-slot or per 2 slots vs 4 slots monitoring) through search space set group (SSSG) switching.  As presented in the Figure 4, a particular case for minimum configurable periodicity of the USS and Type3-PDCCH CSS may be the smallest value X that a UE supports. Therefore, we support the following proposal from [4]:  **Proposal 7: For each SCS 480 kHz and 960 kHz, the minimum configurable periodicity of the USS and Type3-PDCCH CSS is the smallest value X that a UE supports when reporting its multi-slot PDCCH monitoring capabilities for the corresponding SCS.** |

### R1-2108887 (Transsion Holdings)

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| In NR, the PDCCH monitoring occasion can be configured by RRC parameter “*SearchSpace*”, which is listed below.  SearchSpace ::= SEQUENCE {  searchSpaceId SearchSpaceId,  controlResourceSetId ControlResourceSetId OPTIONAL, -- Cond SetupOnly  monitoringSlotPeriodicityAndOffset CHOICE {  sl1 NULL,  sl2 INTEGER (0..1),  sl4 INTEGER (0..3),  sl5 INTEGER (0..4),  sl8 INTEGER (0..7),  sl10 INTEGER (0..9),  sl16 INTEGER (0..15),  sl20 INTEGER (0..19),  sl40 INTEGER (0..39),  sl80 INTEGER (0..79),  sl160 INTEGER (0..159),  sl320 INTEGER (0..319),  sl640 INTEGER (0..639),  sl1280 INTEGER (0..1279),  sl2560 INTEGER (0..2559)  } OPTIONAL, -- Cond Setup  duration INTEGER (2..2559) OPTIONAL, -- Need R  monitoringSymbolsWithinSlot BIT STRING (SIZE (14)) OPTIONAL, -- Cond Setup  Regarding the parameter of “monitoringSlotPeriodicityAndOffset” in “*SearchSpace*”, in NR Rel-15 it means the slots for PDCCH monitoring configured as periodicity and the relevant offset. For each slot group, it is better to restrict the PDCCH monitoring occasions within Y slots. Otherwise, the multi-slot PDCCH monitoring capability will be violated. Therefore, the parameter of period in “*SearchSpace*” should be an integer multiple of X. Meanwhile, to ensure the PDCCH monitoring occasions are located within the Y slots, the offset values in “*SearchSpace*” should be associated with the position of Y slots within a slot group.  Regarding the parameter of duration in “*SearchSpace*”, in NR Rel-15 it refers to the number of consecutive slots that a “*SearchSpace*” lasts in every period. However, for 480kHz SCS and 960kHz SCS, these consecutive slots within a search space period may be located outside the Y consecutive slots within a slot group, which may violet the definition of multi-slot PDCCH monitoring capability. Therefore, a new interpretation of *duration* should be defined. Considering the period in “*SearchSpace*” is defined as the integer multiple of X, it is straight forward to interpret the duration as the number of consecutive slot groups that a “*SearchSpace*” lasts in every period.  ***Proposal 4: The search space configuration should be enhanced to accommodate multi-slot PDCCH monitoring.***  In unlicensed band, it is beneficial to access the channel as soon as possible, when gNB passes the LBT. For this reason, the PDCCH monitoring occasion needs to occur frequently in the time domain. However, frequent monitoring of PDCCH consumes a plenty of power on the UE side, which is not beneficial for UE. In order to resolve this issue, a mechanism of search space set group switching is introduced to balance the channel access possibility from gNB side and the power consumption on PDCCH monitoring of UE side. For 480kHz SCS and 960KHz SCS, assuming X=2, the duration of a slot group is 62.5/31.25 us, which is similar to the length of two or one OFDM symbol for 30kHz SCS. Thus, sufficient flexibility in channel access can be ensured even with multi-slot PDCCH monitoring. In additional, supporting slot-based PDCCH monitoring means that additional slot-based PDCCH monitoring capability need to be defined, which requires additional standardization efforts. Therefore, it is not necessary to support search space set group switching between slot-based PDCCH monitoring and multi-slot based PDCCH monitoring. However, the balance between the channel access possibility and the power consumption on PDCCH monitoring is still needed. The periodicity of different search space set groups can be set differently, e.g. shorter periodicity can be set for out of COT period and longer periodicity can be set for in-COT period.  ***Proposal 5：It is not necessary to support search space set group switching between slot-based PDCCH monitoring and multi-slot PDCCH monitoring.***  ***Proposal 6:*** ***Search space set group switching between different search space set groups configured with different period should be supported.*** |

### R1-2108935 (ZTE, Sanechips)

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| If a fixed pattern of slot groups to define the new capability for PDCCH monitoring is adopted, when configuring the search space set by higher layer parameter *monitoringSlotPeriodicityAndOffset*, the gNB needs to ensure that PDCCH monitoring periodicity , the duration *TS* is an integral multiple of X slots (X slots consists a slot group), or is an integral multiple of slot groups, i.e. and *TS* are in the units of slot group. For example, if a slot group includes four slots (X=4), the duration *TS* can be configured as 4, 8, 12, 16, ... of slots. Alternatively, the duration *TS* can be configured as 1, 2, 3, 4, ... of slot groups, i.e. the basic granularity of the duration *TS* should be defined as a slot group. Figure 3 gives one configuration type in a slot group, e.g., PDCCH MO is configured in the first slot within the slot group.    **Figure 3: Configurations if a fixed pattern of slot groups is supported**  Multiple PDSCH/PUSCH scheduling with a single DCI being discussed in agenda item 8.2.5 can not only save DCI overhead, but also reduce PDCCH monitoring frequency without sacrificing scheduling flexibility. Therefore, the design of the new UE capability for PDCCH monitoring, search space set configuration can be considered in combination with multiple PDSCH/PUSCH scheduling by a single DCI.  **Proposal 2: PDCCH monitoring periodicity and the duration *TS* of the search space sets should be configured as an integral multiple of a slot group, if a fixed pattern of slot groups to define the new capability for PDCCH monitoring is supported.**  Search Space Set Group (SSSG) Switching was introduced in Rel-16 NR-U. In order to reduce access delay and save power, the SSSG monitoring periodicity/granularity is increased or decreased according to the channel access procedure. UE has to support frequent PDCCH monitoring outside gNB-COT and infrequent PDCCH monitoring inside COT. The existing SSSG switching is applied for SCS 15/30/60 kHz, for SSSG switching on large SCS values like 120, 480 and 960 kHz, UE needs to dynamically change between two PDCCH monitoring periodicity/granularity. SSS switching operation is also related to whether per slot PDCCH monitoring is supported. Besides, the switching time with all SCSs supported in above 52.6 GHz needs to be defined if SSSG switching is agreed to be supported.  **Proposal 3: Support SSSG switching for SCS 120/480/960 kHz, and the following points can be further studied:**   * **SSSG switching between two different periodicities of multi-slot PDCCH monitoring or between multi-slot and per-slot monitoring if per-slot monitoring is supported for 480/960 kHz** * **The switching time with all SCSs supported in above 52.6 GHz** |

### R1-2108960 (vivo)

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| In NR Rel-15&16, the allowed SS period configuration is from 1 slot to 2560 slots as shown below [8]. When PDCCH uses 480/960K SCS, there are the following two issues to be considered:   * Smaller SS period (e.g. 1 or 2 slots) is not needed for 480/960K SCS with multi-slot-based capability; * The largest configurable SS period, i.e. 2560 slots=80/40ms for 480/960K SCS respectively, is not enough for SS configuration.     **Proposal 8: Search space configuration should be improved for 480K/960K SCS.** |

### R1-2109117 (NEC)

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| For operation in unlicensed band beyond 52.6GHz, in our understanding, the current SSSG switching can be reused for 120 kHz SCS, since it has been concluded: for 120 kHz SCS, no multi-slot UE capability for PDCCH monitoring is needed. So the monitoring capability before and after the switch is the same, both are per-slot based. While for 480 kHz and 960 kHz SCS, PDCCH monitoring capability may be changed along with SSSG switching, e.g. there are 2 configured SSSG, the first search space set defines PDCCH is monitored per 2-slots, and the second set defines PDCCH is monitored per 4-slots, the monitoring time unit and capability is different before and after the switching. If this scenario is supported, how to adapt it to R16 SSSG switching needs to be discussed.  **Proposal 3: For operation in unlicensed band with 480 kHz and 960 kHz SCS, consider whether/how to support SSSG switching along with changing different PDCCH monitoring capability.**  As mentioned in [4], in R16, the switching boundary is the first slot that is at least symbols after some switch indication and the timer decrement value is counted by slot. For 480 kHz and 960 kHz SCS, PDCCH monitoring capability is multi-slot based, e.g. 4 slots for 480 kHz SCS and 8 slots for 960 kHz SCS, the switching boundary and the timer counter should be modified to multi-slot based accordingly.  **Proposal 4: For operation in unlicensed band with 480 kHz and 960 kHz SCS, the switching boundary and the timer counter should be modified to slot group based.**  Currently,, which means the SSSG switching time, is defined for SCS configuration = 0,1,2. For new SCSs adopted beyond 52.6GHz, to operate in unlicensed band, SSSG switching time should be defined and added in the table 10.4-1 of TS 38.213[2].  **Proposal 5: Search space set group switching time should be defined for new SCSs.**  For 480 kHz and 960 kHz SCS, if PDCCH monitoring capability is based on per multi-slot, the UE will decode more DCI than per slot monitoring, the processing time will last longer, and it will have an influence in SSSG switching time estimation. So when we estimate minimum value of, which monitoring capability is the reference, per slot or per multi-slot? It should be determined.  **Proposal 6: For 480 kHz and 960 kHz SCS, which monitoring capability is the reference to estimate the search space set group switching time should be determined.** |

### R1-2109209 (CATT)

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| For the Type0-PDCCH CSS set, the UE requires to monitor two consecutive slots for the CORESET of the Type0-PDCCH CSS. When Y at least equals to 2 slots, this requirement will be satisfied without any specification change. If Y=1 slot, then the requirement of two consecutive slots monitoring cannot be satisfied because at most UE can monitor one slot per slot group. Note Y=1 slot is a configuration not very useful. Therefore, to avoid specification change, Y>1 slot should be required.  One remaining issue is that whether the multi-slot PDCCH monitoring capability can be the default capability for 480 kHz SCS and 960 kHz SCS. Note previously we suggest not to support per slot monitoring capability definition in Rel-17. If this is the case, then the issue is moot. However, if RAN1 decide to support also support per-slot monitoring, then the default capability, which is assumed when there is no dedicated RRC configuration, should be determined. This is required for certain scenarios, for example during 480 KHz SCS initial access. Considering that per-slot PDCCH monitoring would be more demanding for the high SCSs, having multi-slot PDCCH monitoring as the default capability is desirable.  ***Proposal 5：It is recommended that Y > 1 slot to avoid complex changes for Type0-PDCCH CSS set monitoring rules.***  ***Proposal 6：It is recommended to define multi-slot monitoring capability as the default monitoring capability.***  In Rel-15/16, the parameter *monitoringSymbolsWithinSlot* indicates the distribution of MOs within each slot and the length of bitmap is 14. For 480 kHz SCS and 960 kHz SCS, the bitmap with 14bit is not sufficient to indicate the distribution of MO within X-slots. We suggest adding a new bitmap indicating the slots that the search space exists within the multi-slot by *monitoringSlotWithinMulti-Slot*. Thus, the first symbol of the CORESET within multi-slot for PDCCH monitoring can be jointly indicated by the *monitoringSymbolsWithinSlot* and *monitoringSlotWithinMulti-Slot*. It should be noted when the search space exists in multiple slots within multi-slot, the distribution of MOs within each slot is the same.  For example, if the UE is provided the following parameter by *SearchSpace*, the PDCCH monitoring will be as shown in Figure 5:   * *monitoringSlotPeriodicityAndOffset:* the periodicity of search space set is 16 slots and the offset is 0. * *duration*: the unit of the duration is the multi-slot, the value of the duration is 2. * *monitoringSymbolsWithinSlot*: the bitmap of the first symbol MO within each slot is 10001000000000. * *monitoringSlotWithinMulti-slot*: the bitmap of the slots that the search space exists is 1100. * The same span pattern repeats in every slot.     Figure 4: Search space set configuration for 480 kHz SCS  ***Proposal 7：For 480 kHz SCS and 960 kHz SCS, the search space configuration can be enhanced as follows.***   * ***Modifying the value of monitoringSlotPeriodicityAndOffset to the integer of the X-slots.*** * ***Extending the unit of duration from slot to X-slots indicating a number of consecutive multi-slot that the search space exists.*** * ***Adding a new bitmap monitoringSlotWithinMulti-slot indicating the slot that the search space exists within the multi-slot.***   The search space group set switching was introduced in Rel-16 NR-U with 15 kHz SCS, 30 kHz SCS and 30 kHz SCS for dynamic switching between different search spaces. Before the gNB obtains the COT, the frequent monitoring enable the gNB to transmit DCI as soon as possible if gNB’s LBT is successful. However, frequent monitoring is not conducive to power saving of the UE during the COT. When the search space group set switching is configured, the gNB can indicate to UE switching between a search space with long periodicity and a search space with short periodicity to meet different scheduling requirements. Therefore, we suggest the legacy SSSG switching mechanism should be reused for the 120 kHz SCS, 480 kHz SCS and 960 kHz SCS in 60GHz NR-U, as shown in Figure 6.  ***Proposal 8: The Legacy SSSG switching mechanism should be reused for the 120 kHz SCS, 480 kHz SCS and 960 kHz SCS in 60 GHz NR-U.***  It has been agreed that the BD/CCE budget for 120 kHz SCS in 52.6-71 GHz is the same as that for 120 kHz in FR2. Thus, we believe 120 kHz SCS in 52.6-71 GHz doesn’t support the monitoring capability of the span defined in Rel-16 just like 120 kHz in FR2. The PDCCH monitoring capability for 120 kHz SCS is the baseline for study of the PDCCH monitoring capability for 480 kHz SCS and 960 kHz SCS. The motivation to support single slot PDCCH monitoring capability for 480 kHz SCS and 960 kHz SCS out of the COT is not clear. It is not necessary to enhance the SSSG switching to support dynamic switching between single slot PDCCH capability and multi-slot PDCCH capability for 480 kHz SCS and 960 kHz SCS.  ***Proposal 9: SSSG switching is not required to be enhanced to support the switching between single slot PDCCH capability and multi-slot PDCCH capability 480 kHz SCS and 960 kHz SCS.*** |

### R1-2109402 (Xiaomi)

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| How to make sure the CSS, especially for CSS before RRC connection, fall into the Y monitoring occasion as defined by (X/Y) in Alt 1/Alt 2 has been extensively discussed in last meeting. From our view the first thing that needs to considered is, whether multi-slot PDCCH monitoring capability is a mandatory capability that should be applied for RRC idle mode, or it is just a capability applied for RRC connected mode.  A similar PDCCH symbol-level PDCCH monitoring span has been discussed and introduced in R16 URLLC. And in that WI, R15 slot level PDCCH monitoring capability is a mandatory capability that should be applied in RRC idle mode, and if UE is configured with *r16monitoringcapability*, UE will apply symbol-level span PDCCH monitoring capability, which is only possible in RRC connected mode. And in this case, how to guarantee CSS, especially CSS before RRC connection, and USS fall into the PDCCH monitoring span is up to gNB implementation.  If we determine that multi-slot PDCCH monitoring capability is a capability that only can be used after corresponding UE capability reporting and gNB configuration, that is multi-slot PDCCH monitoring capability is only for RRC connected, then for RRC idle mode, UE should apply single-slot PDCCH monitoring similar as in R15, which we slightly prefer, since it is easy to guarantee CSS reception by single-slot PDCCH monitoring.  ***Proposal 3: RAN1 needs to decide whether multi-slot PDCCH monitoring capability is mandatory applied in RRC idle mode. If not, single-slot PDCCH monitoring capability, which is quite easy to handle CSS receiving, should be defined for NR 52.6-71GHz.***  If we determine that multi-slot PDCCH monitoring capability is mandatory for RRC idle, then a suitable mandatory multi-slot PDCCH monitoring pattern should be designed to guarantee Type #0/0-A/1/2 CSS reception in the first place. Take Type #0 CSS as an example, SSB/corset 0 multiplexing pattern 1, index=4 of the Table 13-11 TS 38.213, total SSB number is 8, 15KHz SCS for CORESET 0 with 2 symbol length. The time domain location of Type #0 CSS corresponding to each SSB are,  SSB 0: symbol 0/1 on slot 5, 6 of even SFN  SSB 1: symbol 0/1 on slot 6, 7 of even SFN  SSB 2: symbol 0/1 on slot 7, 8 of even SFN  SSB 3: symbol 0/1 on slot 8, 9 of even SFN  SSB 4: symbol 0/1 on slot 9 of even SFN and symbol 0/1 on slot 0 of odd SFN  SSB 5: symbol 0/1 on slot 0, 1 of odd SFN  SSB 6: symbol 0/1 on slot 1, 2 of odd SFN  SSB 7: symbol 0/1 on slot 2, 3 of odd SFN  It can be seen that on different SSB beams, Type #0 CSS is scattered on almost every slot within a frame. To make sure an idle UE can monitor Type #0 CSS on any SSB beam, the location of Y slots should be floating. So in Alt 1 with a floating Y, or Alt 2 can be adopted for receiving CSS in idle mode.  ***Proposal 4: If to apply multi-slot PDCCH monitoring capability in RRC idle mode, the location of Y slots should not be in fixed location within X slot-group.*** ***Alt 1 with a floating Y, or Alt 2 can be adopted at least for receiving CSS in idle mode.***  In RRC connected mode, USS and some CSS will be configured in addition to the already existed Type #0/0-A/1/2 CSS. To make sure that UE can monitor USS/CSS in the Y slots within X slot-group(or at least X slot-group in Alt 2), USS/CSS should have harmonized periodicity, that is the periodicity of USS/configured CSS is integer factor or multiple of the periodicity of Type #0/0-A/1/2 CSS. That means, the configuration of USS/CSS should be based on the Type #0/0-A/1/2 CSS, as shown in Fig 2.  ***Proposal 5: To make sure USS/CSS can fall into Y slots, the periodicity of USS/configured CSS should be integer factor or multiple of the periodicity of Type #0/0-A/1/2 CSS.***    Fig 2. USS/CSS with harmonized periodicity  But only harmonized SS configuration is not enough, it also depends on the value of (X/Y) to decide whether USS/CSS can fall into the Y slots. If Alt 1 is adopted, to guarantee CSS/USS monitoring as shown in Fig 2, X should be equal to the minimum SS periodicity, that is X=5. And a fixed pattern (5/3) will be feasible. But if X is not equal to the minimum SS periodicity, for example, X=4, then a floating Y will be needed. If Alt 2 is adopted, X value no bigger than the minimum SS periodicity (but no smaller than Y) will be feasible. But if X value is bigger than minimum SS periodicity, then USS/CSS can not always fall into the Y slots.  ***Proposal 6: For harmonized USS/CSS periodicity, X in Alt 1 should be equal to the minimum SS periodicity, otherwise, a floating Y is needed. And X in Alt 2 should be no bigger than the minimum SS periodicity.***  With floating Y, there raise the issue that two monitoring occasion is too close to each other, as shown in Fig.3, and UE may not be able to process PDCCH in so many consecutive slots. Simple solutions may be dropping one of the monitoring occasion. Details or other solutions can be further studied.    Fig 3. Two monitoring occasion is too close to each other  ***Proposal 7: If Alt 1 with floating Y is adopted, how to solve the issue two monitoring occasion is too close to each other.***  ***Summary:***  ***If multi-slot PDCCH monitoring is applied for RRC idle mode, both Alt 1 with floating Y and Alt 2 can be adopted.***  ***If multi-slot PDCCH monitoring is applied for RRC connected mode, both Alt 1 and Alt 2 can be adopted under the following two conditions,***   * ***The periodicity of USS/configured CSS should be integer factor or multiple of the periodicity of Type #0/0-A/1/2 CSS*** * ***X in Alt 1 should be equal to the minimum SS periodicity, otherwise, a floating Y is needed; X in Alt 2 should be no bigger than the minimum SS periodicity***   ***In general, under both Alt1 and Alt 2, gNB should have proper SS configurations that are suitable for the applied multi-slot PDCCH monitoring capability, so that USS/CSS can fall into the Y slots. Otherwise, more complicated solutions will be needed to allow UE to monitor USS/CSS.***  Search space set group switching is introduced in R16 NR-U for power saving propose and group switching time is defined for SCS 15-60kHz. To facilitate unlicensed band operation for NR 52.6-71GHz, group switching time should also be defined for 120/480/960kHz  ***Proposal 10: Search space set group switching time***  ***should be defined for 120/480/960kHz.***  The maximum search space periodicity in current spec is 2560 slots, and with SCS increased to 960kHz, the absolute time of the maximum search space periodicity will be decreased by 8 times. So new periodicity parameters may need to be introduced for the new SCSs, as well as the search space offset/duration parameters.  ***Proposal 11:*** ***New search space periodicity parameters, as well as the search space offset/duration parameters, may need to be introduced for the new SCSs.*** |

### R1-2109477 (Samsung)

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| The limits for PDCCH candidates/non-overlapping CCEs at high SCS can be defined either per slot or per multi-slot span depending on PDCCH monitoring capabilities. For slot based PDCCH monitoring, the value of and of for high SCS should be smaller than the corresponding values for lower SCS in Table 10.1-2 and Table 10.1-3 of [2], respectively.  For multi-slot span based PDCCH monitoring, the limits for PDCCH candidates/non-overlapping CCEs can be defined per combination of (X, Y). Similar to multi-symbol span based PDCCH monitoring in NR Rel-16, and are determined according to the selection of multi-slot span gap, X, and multi-slot span duration, Y. The larger the X or Y a UE supports, the larger the values of and can be.  As and are small for SCS of 120 KHz, further reduction is not practically possible for higher SCS as PDCCH blocking may become an issue particularly when considering support of CSS sets, support of PDCCH candidates for multiple CCE aggregation levels, and application of the PDCCH overbooking procedure per search space set.. Therefore, and need to be defined per multi-slot span for high SCS, such as .  **Proposal 5: Support maximum number of PDCCH candidates, and maximum number of non-overlapped CCEs, per multi-slot span for combination (X, Y), where X >1 slots, Y>=1 slots, and .**  An issue was raised in RAN1#104bis-e regarding switching PDCCH monitoring capability based on SSSG switching. However, that issue is not valid. Based on Rel-15/16 configuration of PDCCH monitoring capability, a UE does not switch PDCCH monitoring capability based on SSSG switching. SSSG switching is performed within an active DL BWP while PDCCH monitoring capability is configured per DL BWP and applies to all search space sets configurations within the DL BWP. Also, it is possible to extend SSSG switching to support switching of UE PDCCH monitoring capability, if necessary. NR supports switching PDCCH monitoring capabilities based on BWP switching and the same principle can apply for switching PDCCH monitoring capabilities based on SSSG switching. However, the motivation for supporting PDCCH monitoring capability switching without BWP switching needs to be justified first before considering any enhancement on Rel-16 SSSG switching to support PDCCH monitoring capability switching.  **Observation 5:** PDCCH monitoring capability switching is supported in NR Rel-16 based on BWP switching.  **Proposal 6: Further study motivation for enhancement of Rel-16 SSSG switching scheme to support PDCCH monitoring capability switching.**  To support multi-slot span based PDCCH monitoring, a UE would expect that a time gap between any two consecutive PDCCH monitoring spans is not smaller than the multi-slot span gap X, while any PDCCH monitoring span duration is up to Y slots. PDCCH monitoring occasions are determined according to configured search space sets, where PDCCH monitoring periodicity and duration are configured in number of slots for a search space set *s*. Two consecutive PDCCH monitoring spans can either be PDCCH monitoring occasions from the same search space set or PDCCH monitoring occasions from different search space sets. Therefore, both intra search space set span gap and inter search space set span gap should be considered – i.e. the span gap should be considered across all search space sets as in Rel-16.  Figure 2 illustrates an example of multi-slot span based PDCCH monitoring with combination of (X = 4, Y =2), the configuration of search space set 3 is invalid because the two consecutive PDCCH monitoring occasions from search space set 1 and search space set 3 is smaller than X, but is not smaller than Y.    **Figure 2: Illustration of search space set configurations limited by combination of (X = 4, Y =2).**  For intra search space set span gap, the PDCCH monitoring periodicity of slots should be limited by the multi-slot span gap X, while the PDCCH monitoring duration of slots should be limited by the multi-slot span Y. Therefore, a PDCCH monitoring periodicity should not be smaller than the multi-slot span gap, i.e. , while PDCCH monitoring duration is not larger than multi-slot span, i.e. .  For inter search space set span gap, two consecutive PDCCH monitoring occasions from different search space sets may belong to different PDCCH monitoring spans. In this case, the gap between the two consecutive PDCCH monitoring occasions from search space set *i*  and search space set *j* is limited by multi-slot span gap, X, such that , where and are offsets for search space set *i*  and search space set *j*. In another case, the two consecutive PDCCH monitoring occasions from different search space sets can belong to the same PDCCH monitoring span. In the latter case, the gap between the two consecutive PDCCH monitoring occasions from search space set *i* and search space set *j* should be limited by multi-slot span duration, Y, such that . For the benefit of simple scheduling and configuration, it’s better to consider applicable values for PDCCH monitoring periodicity to be integer of X.  **Proposal 7: For multi-slot span based PDCCH monitoring based on combination (X, Y), the PDCCH monitoring periodicity is , , and the PDCCH monitoring duration is**  Another PDCCH candidate configuration related aspect impacted by multi-slot based PDCCH monitoring is the determination of CCE locations for a PDCCH candidate. The determination of CCE indexes for a PDCCH candidate is based on a parameter, , where is the slot index of the PDCCH monitoring occasion. For multi-slot based PDCCH monitoring and a PDCCH monitoring duration of X>1 slots, the index of the first slot from the X slots is used to determine i.e. is replaced by *,* for each PDCCH monitoring occasion within the X slots; otherwise, with updated per slot and considering the time-first mapping for PDCCH and that Y can be more than 1 slot, the Rel-16 CCE-based structure for PDCCH transmissions cannot be maintained.  **Proposal 9: For multi-slot PDCCH monitoring according to configuration (X, Y), is replaced by in the search space equation in [2].** |

### R1-2109599 (Intel)

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| According to the revised WID [1], initial access is supported for SCS 480kHz with support of Type0-PDCCH CSS set. Further, for ANR and PCI confusion detection, Type0-PDCCH SCS set is supported for SCS 480kHz and 960kHz. Therefore, for SS/PBCH block and CORESET multiplexing pattern 1 in NR, UE needs to monitor Type 0/0A/1/2 CSS sets with search space set 0 in two consecutive slots. The time position of the two slots depends on the position of the associated with a SS/PBCH block. On the other hand, other CSS/USS sets are configured by high layer parameters *monitoringSlotPeriodicityAndOffset* and *duration*. The combined pattern of slots configured with Type 0/0A/1/2 CSS sets and other CSS/USS sets may satisfy the pattern of the multi-slot PDCCH monitoring capability for a SS/PBCH block of the UE. However, when the SS/PBCH block of the UE changes, the new combined pattern of slots may become invalid for the multi-slot PDCCH monitoring capability.  Instead of reconfiguration of all CSS/USS sets when the SS/PBCH block changes, dropping the PDCCH MOs in a slot can be considered to make the combined pattern valid. However, dropping Type 0/0A/1/2 CSS sets has negative impact on the scheduling of broadcast information. On the other hand, dropping other CSS/USS sets is not desirable for PDSCH/PUSCH scheduling. Since Type 0/0A/1/2 CSS sets only occurs in long cycle, i.e., 20ms, it can be considered to temporarily allow a slot pattern of PDCCH MOs that is different from that of the multi-slot PDCCH monitoring capability around the slot carrying Type 0/0A/1/2 CSS sets. The maximum BDs/CCEs still apply. Such concept is already used in NR FG 3-1. Thought a USS set, Type3 CSS set and type1 CSS set with dedicated RRC configuration is enforced to a fixed position, i.e., the first 3 symbols in a slot, it is allowed that type1 CSS set without dedicated RRC configuration and type 0/0A/2 CSS sets can be in any 3 consecutive symbols in a slot.  **Proposal 3:**   * If Type0/0A/2 CSS sets and Type1 CSS set without dedicated RRC configuration are monitored in a slot, configured PDCCH MOs around the slot can be different from that of the multi-slot PDCCH monitoring capability, with the limitation of maximum number of BDs/CCEs.   In NR Rel-15, according to the UE capability on the maximum number of BDs/CCEs in a slot,   * For PCell or PSCell, it is allowed that the configured number of BDs/CCEs in a slot by the configuration of SS set(s) is larger than the corresponding maximum numbers. Certain dropping rule is defined so that the actual number in the slot doesn’t exceed the corresponding maximum numbers. * For a SCell, the gNB should guarantee that the configured numbers of BDs/CCEs in a slot by the configuration of SS set(s) do not exceed the corresponding maximum numbers.   The similar rules could be extended to multi-slot PDCCH monitoring capability,   * For PCell or PSCell, it is allowed that the configured number of BDs/CCEs in a X-slot group by the configuration of SS set(s) is larger than the corresponding maximum numbers. Certain dropping rule is defined so that the actual number in the X-slot group doesn’t exceed the corresponding maximum numbers. * For a SCell, the gNB should guarantee that the configured numbers of BDs/CCEs in a X-slot group by the configuration of SS set(s) do not exceed the corresponding maximum numbers.   **Proposal 4:**   * When multi-slot PDCCH monitoring capability is supported,   + PDCCH overbooking is supported for PCell or PSCell   + For a SCell, the configured BDs/CCEs do not exceed the corresponding maximum numbers.   The search space set group (SSSG) switching as defined NR-U is shown in Figure 1. The frequent PDCCH monitoring is assumed before gNB gets the channel occupation. For example, search space set with mini-slot level or slot-level PDCCH monitoring can be configured, which is the first search space set group (SSSG). The frequent PDCCH monitoring reduces the delay for gNB to start DL transmission immediately after the LBT is successful. On the other hand, after gNB starts a COT, a second SSSG is configured, which may contain infrequent PDCCH monitoring for power saving. The DL performance for the second SSSG is guaranteed by the configuration of more PDCCH candidates with same or different DCI format in each MO of the second SSSG.    **Figure 1: SSSG switching in NR-U**  Dynamic SSSG switching provides a means to balance the fast channel access right after LBT is successful and effective scheduling and power saving after the COT is obtained. The feature is useful for high frequency too. The configured search space configuration in the two SSSGs has different requirements on the PDCCH monitoring capability. In general, two options can be considered.   * Option 1: switching between per-slot PDCCH monitoring capability and multi-slot PDCCH monitoring capabilities * Option 2: switching between two multi-slot PDCCH monitoring capabilities   As discussed in Proposal 1, per-slot PDCCH monitoring capability is not preferred due to the limitation of PDCCH monitoring or UE complexity for high SCSs. Therefore, the search space set configuration of the two SSSGs can be configured based on Option 2. It is expected that both X and Y are small values to still allow frequent MOs in the first SSSG. On the other hand, the second SSSG relies on a large gap between MOs for the power saving.  Based on the above analysis, UE needs to dynamically change its PDCCH monitoring capability together with SSSG switching.  **Proposal 6:**   * Dynamic SSSG switching is supported for all SCSs 120, 240 and 960kHz. * The search space set configurations of the two SSSG can correspond to two different combinations (X, Y) of the multi-slot PDCCH monitoring capabilities   In NR, a search space (SS) set could be configured for the UE to monitor PDCCH. Up to 10 SS sets can be configured for each DL BWP in a serving cell. The time domain pattern of a SS set is configured by the following RRC parameters  - a PDCCH monitoring periodicity of slots and a PDCCH monitoring offset of slots, by *monitoringSlotPeriodicityAndOffset*  - a PDCCH monitoring pattern within a slot, indicating first symbol(s) of the CORESET within a slot for PDCCH monitoring, by *monitoringSymbolsWithinSlot*  - a duration of slots indicating a number of slots that the search space set exists by *duration*  Specifically, 3 cases for SS set configuration within a slot are supported by parameter *monitoringSymbolsWithinSlot*,   * Case 1: PDCCH monitoring of all SS sets monitored in a slot occurs within 3 consecutive OFDM symbols that have fixed positions in each slot   + Case 1-1: PDCCH monitoring limited to within first three OFDM symbols of a slot   + Case 1-2: PDCCH monitoring on any span of up to 3 consecutive OFDM symbols of a slot     - For a given UE, all search space configurations are within the same span of 3 consecutive OFDM symbols in the slot * Case 2: PDCCH monitoring cases other than Case 1   Case 1-1 is the basic PDCCH monitoring occasion(s) in the beginning of a slot, which should be supported for high SCS. Case 2 is to configure more frequent PDCCH MOs within a slot, which is targeted to reduce scheduling latency. This is important especially for low SCS, e.g. 15kHz or 30kHz. On the other hand, it is not necessary for a high SCS, e.g. 480kHz or 960kHz, given that the slot length is quite short, i.e. 1/32ms or 1/64ms. In this case, there is no clear motivation to allow full flexibility on the positions of PDCCH MO(s) in a slot, i.e. Case 2. Therefore, restriction on PDCCH MOs in a slot can simplify UE implementation without performance degradation.  **Proposal 7:**   * On the PDCCH monitoring occasion in a slot   + Case 1-1 is supported for all SCS 120kHz, 480kHz and 960kHz   + Case 2 is supported for SCS 120kHz   + Case 2 is not supported for SCS 480/960kHz   With the existing SS set configuration, up to 40 SS sets need to be configured to achieve the MO pattern in Figure 1. On the other hand, considering different DCI formats (fallback DCI or normal DCI) and different type of SS set (USS, CSS type0/0A/1/2, CSS type3 with different DCI formats), the required number of SS sets must be much higher than 40. The main drawback of the current SS set configuration comes from the parameter ‘*duration*’which is defined as a number of consecutive slots.To support the MO pattern for SCS 960kHz in Figure 1, a simple extension is to allocate a MO in every N slot, instead of consecutive slot allocation. The parameter ‘*duration*’ is still needed but can be reinterpreted as the window that MOs may be allocated, e.g. the DL period in a TDD period. Denote the number of slots that are configured with MOs of the USS set as M, then . N should larger than or equal to value X that is used in the definition of multi-slot PDCCH monitoring capability.  **Proposal 8:**   * Within a period of a SS set configuration   + The parameter ‘duration’ is reinterpreted as a window on which MOs may be configured.   + One slot in every N slots within the window is configured with PDCCH MOs, N>=X. |

### R1-2109666 (NTT DOCOMO)

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| In Rel-16 NR-U, SSSG switching was introduced to change the PDCCH monitoring periodicity between inside and outside the COT for the sake of energy saving. For the same reason as NR-U, SSSG switching is beneficial for operation with shared spectrum of 60 GHz band. Accordingly, SSSG switching should be supported for 52.6-71 GHz frequency band operation considering the operation with shared spectrum in 60 GHz band.  In the current specification, the SSSG switching time is specified for 15/30/60 kHz SCS. To support the SSSG switching, at least should be discussed for 120/480/960 kHz SCS.  In addition, some companies proposed at the previous meeting that single-slot PDCCH monitoring capability and multi-slot PDCCH monitoring capability can be switched associated with SSSG configuration. This function can be supported, however, the SSSG switching for high SCS and single-slot and multi-slot capability switching associated with SSSG configuration should be discussed separately.  ***Proposal 6:****SSSG switching should be supported for 120/480/960 kHz SCS.*   * *At least search space set group switching time*   *should be defined.* |

### R1-2109778 (Sony)

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| For multi-slot monitoring, there also had been some discussions from RAN1#104 on monitoring location and duration of OFDM symbols:   |  | | --- | | Further discussion on multi-slot span capabilities, monitoring periodicities, corresponding number and location of OFDM symbols for Cases 1-1 and 1-2.   * Case 1: PDCCH monitoring of all SS sets monitored in a slot occurs within 3 consecutive OFDM symbols that have fixed positions in each slot   + Case 1-1: PDCCH monitoring limited to within first three OFDM symbols of a slot   + Case 1-2: PDCCH monitoring on any span of up to 3 consecutive OFDM symbols of a slot     - For a given UE, all search space configurations are within the same span of 3 consecutive OFDM symbols in the slot * Case 2: PDCCH monitoring cases other than Case 1 |   With a limited location of PDCCH monitoring, Case 1-1 is simple for realization, while Case 1-2 is more flexible for gNB scheduling. Thus, we suggest Case 1-1 can be the baseline, and Case 1-2 can be discussed with further benefits evaluation of flexible scheduling.   1. **: PDCCH monitoring limited to within the first several OFDM symbols of a slot can be supported as the baseline.**   As aforementioned, large SCSs with 480kHz and 960kHz cause a relatively short time duration of a symbol. Therefore, if CORESET duration remains up to 3 symbols as in R16, the real-time duration for PDCCH monitoring is quite small, which also puts extra time limitation of UE blind decoding. Therefore, we suggest a large CORESET duration with more than 3 symbols for SCS 480kHz and 960kHz alleviate UE processing capability for PDCCH decoding. Thus, we suggest PDCCH monitoring with a maximum duration of more than 3 OFDM symbols per PDCCH monitoring occasion.   1. **: If CORESET duration remains up to 3 symbols as in R16, the real-time duration for PDCCH monitoring is quite small due to the short symbol duration with large SCS.**   **Proposal 2: PDCCH monitoring with a maximum duration of more than 3 OFDM symbols per PDCCH monitoring occasion is more suitable.**  Although monitoring flexibility is not a big issue through multi-slot monitoring configuration stated in previous section, if more monitoring flexibility and lower power consumption of UE are required, more than one multi-slot monitoring capacities, i.e. multi (X,Y) combinations may be needed. In such cases, SSSG switching among different multi-slot monitoring capacities needs to be considered.  Besides, there also had some discussions on SSS configuration from RAN1#106, and whether to apply multi-slot PDCCH monitoring at all times and for all search spaces are still FFS. This means, there could be possibility for some SSS not supporting multi-slot PDCCH monitoring, and per-slot, even mini-slot monitoring or other non multi-slot monitoring may be supported by these SSS. Therefore, SSSG switching among different types of monitoring capacities should be considered also.   |  | | --- | | Agreement:   * A UE supporting 480 kHz SCS supports multi-slot PDCCH monitoring for 480 kHz SCS. * A UE supporting 960 kHz SCS supports multi-slot PDCCH monitoring for 960 kHz SCS. * FFS: whether to apply multi-slot PDCCH monitoring at all times and for all search spaces. |   For SSSG switching in at least above two cases, one straightforward manner to realize the switching can be to configure SSS with monitoring capacity index. A possible procedure can be as follows: First, When UE reports multi monitoring capabilities, the corresponding monitoring capacities index are also reported. Then, gNB configures each SSS with the associated monitoring capacity index. After SSSG switching is trigged, such as the scheduling needs from gNB or power saving requirement from UE by preferred monitoring capacity index reporting, a DCI with monitoring capability index is scheduled to indicate UE to monitor on SSS with this specified monitoring capability index.  **Proposal 3: SSSG switching can be considered if multi-slot monitoring capacity with multiple (X,Y) or monitoring capacity with multiple types are supported.** |

### R1-2109898 (Lenovo, Motorola Mobility)

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| In addition to the mechanism for multi-slot PDCCH monitoring, also enhancements will be needed for the search space configuration to better facilitate any of the above alternatives. Currently, three main configuration parameters associated with SS configuration includes PDCCH monitoring periodicity, PDCCH monitoring duration within a period and a bitmap to indicate symbols for PDCCH monitoring within a slot. For any of the above three alternatives, one main criterion is that PDCCH monitoring will be configured across multiple slots (group of slots). Therefore, it would make sense to define periodicity only in multiple of these slot groups. Therefore, minimum periodicity should not be less than the multi-slot duration, for example 4 slots for 480 kHz SCS value and higher values of periodicity should be in multiples of 4 slots. Similarly, the duration should be defined in multiples of slot groups.  ***Proposal 2: For supporting NR between 52.6 GHz and 71 GHz with high subcarrier spacing values including 480kHz and 960kHz, search space configuration should be enhanced to support (or restrict) the PDCCH monitoring periodicity and corresponding duration in multiples of slot groups rather than multiples of slots***  Furthermore, in order to facilitate the flexibility for configuring any slot (including more than one slot) within a multi-slot duration for PDCCH monitoring occasion, the existing bitmap for symbols in the SS configuration is not efficient. For example, for 8 slots, the bitmap will be 14\*8 bits long. Therefore, it would make sense to support additional slot-level bitmap for indicating PDCCH monitoring slots within the multi-slot duration. Then the symbol-level bitmap can be applied only to those slots that are indicated to be monitored. For example, if there is a 4-slot monitoring duration, then a slot-level bitmap “1010” would indicate that monitoring occasion is in slot 1 and slot 3. And if symbol-level bitmap is “ 11100000000000” is indicated, then that means for slot 1 and slot 3, PDCCH monitoring occasion is in the first 3 symbols, respectively.  ***Proposal 3: For supporting NR between 52.6 GHz and 71 GHz with high subcarrier spacing values including 480kHz and 960kHz, search space configuration should be enhanced to support slot-level bitmap to indicate the slots where PDCCH monitoring is configured for a multi-slot PDCCH monitoring (for example, if there is a 4-slot monitoring duration, then a slot-level bitmap “1010” would indicate that monitoring occasion is in slot 1 and slot 3)***  In fact, for very high SCS value such as 960kHz, even an entire slot for PDCCH can be considered to allow for only single PDCCH monitoring occasion within a slot.  ***Proposal 5: For supporting NR between 52.6 GHz and 71 GHz with high subcarrier spacing values including 480kHz and 960kHz, CORESET duration longer than 3 symbols should be supported:***   * ***FFS: Maximum duration up to 14 symbols in a slot***   ***Proposal 6: For supporting NR between 52.6 GHz and 71 GHz with high subcarrier spacing values including 480kHz and 960kHz, CORESET structure with only TDM between the DM-RS symbols and control information should be supported***  Another issue related to multi-slot PDCCH monitoring that has been discussed is about potential misalignment between CSS and USS. Currently, the alternatives are still being discussed for multi-slot PDCCH monitoring. However, the issue of CSS and USS misalignment can exist for any of these alternatives. From network perspective, it is quite unlikely that it can configure CSS for all the UEs in a cell such that for each UE the CSS is aligned with USS and both CSS and USS always fall within the PDCCH monitoring occasions within multiple slots. Only USS configuration can be ensured by network such that it is always contained within the PDCCH monitoring occasions. However, for CSS, it may or may not fall within the monitoring occasions. Therefore, this issue can arise whenever within multiple slot (group), CSS is also configured.  ***Observation 3: For supporting NR between 52.6 GHz and 71 GHz with high subcarrier spacing values including 480kHz and 960kHz, with multi-slot PDCCH monitoring, it is unlikely to always ensure that CSS and USS are aligned such that both fall within the PDCCH monitoring occasions within multiple slots (slot group).***  Therefore, some procedure needs to be specified on how to handle such misalignment. One solution that has been discussed is to always prioritize CSS whenever within a slot group, both USS and CSS are configured and if they are misaligned. This has two issues. First, it can be unfair to USS, especially if PDCCH monitoring using USS is associated with some high priority topic. Second, if UE drops/deprioritize USS within the slot group and monitors CSS, it might be outside the originally configured PDCCH monitoring occasion and therefore, it might affect the PDCCH monitoring in the next slot, if the gap is too short between the CSS in one slot and the USS in the next slot. Therefore, this solution is not desirable. One potential solution could be to transmit the control information associated with CSS via USS. Consequently, UE is not required to monitor CSS, but still able to receive the relevant common control information via USS. If the PDCCH monitoring budget is not completely used for USS, then it should be able to additionally accommodate CSS related configuration in USS. However, if the budget is not sufficient for CSS related configuration in USS, then some low-priority USS sets could be deprioritized. But still the others can be monitored.  ***Proposal 8: For supporting NR between 52.6 GHz and 71 GHz with high subcarrier spacing values including 480kHz and 960kHz, with multi-slot PDCCH monitoring, when UE is configured with both USS and CSS within a multi-slot group and if CSS is not aligned with USS and PDCCH monitoring occasions within the group, then support:***   * ***the transmission of CSS associated common control information using the budget of USS and;*** * ***to not monitor CSS outside the PDCCH monitoring occasions*** |

### R1-2109962 (LG)

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| In RAN1#106-e meeting, above agreement was drawn. The multi-slot unit PDCCH monitoring operation can reduce the implementation burden of the UE in a short symbol/slot length for 480/960 kHz and expect a power saving effect, and is well suited to the multi-PDSCH scheduling operation. In this respect, applying multi-slot monitoring to a specific time or specific SS may reduce its effectiveness. We believe that the multi-slot monitoring operation should be applied in initial access procedure as well as connected mode, and we prefer not to make an exception to a specific SS set unless a critical issues are identified.  **Proposal #1: Support multi-slot PDCCH monitoring at all times and for all search spaces.**  SS set configuration can also be set appropriately for the slot-group. Through SS set configuration based on slot-group, PDCCH monitoring occasion could be adjusted properly (e.g., restricted), and then, additional power saving effects would be expected. For slot-group based PDCCH monitoring, specifically, *periodicity* could be configured to a value larger than X (or a multiple of X) slots and *duration* could be configured with respect to X (or Y) slots. Moreover, it can be discussed how to handle the case where the configured slot-group boundary does not exactly match to the union of PDCCH MOs based on SS set configurations. In this case, USS dropping could be enhanced with the unaligned region to reduce the number of blind detection effectively.  **Proposal #5: Consider to configure PDCCH monitoring occasions to be compliant with the slot-group (or multiple of slot-groups), by using search space set configuration parameters (e.g., periodicity, offset, and duration).**  Regarding SSSG switching, in Rel-15/16 NR, one SSSG could be switched to another SSSG at the slot boundary after at least P\_switch symbols from the switching triggering. However, if SSSG switching is introduced for multi-slot monitoring in Rel-17, SSSG switching should be performed at the slot-group boundary in order to be compliant with the slot-group. In addition, it may be necessary to discuss the appropriate P\_switch values for 480 kHz and 960 kHz.  **Proposal #6: For 480 kHz or 960 kHz multi-slot monitoring, SSSG switching should be performed at the slot-group boundary, if supported.**  For SSB/CORESET#0 multiplexing with pattern 1, PDCCH monitoring of Type0-PDCCH CSS set for each SSB index is achieved in two consecutive slots, slot and slot . To avoid PDCCH monitoring over two shortened consecutive slots, PDCCH monitoring over two consecutive slot-groups can be considered for 480kHz and 960kHz. For a given slot index for Type0-PDCCH CSS set monitoring, the next MO can be located in slot index where M corresponds to the size of slot-group. The slot-group for this case can be determined differently than the slot-group for other types of SS set (e.g., USS). In addition, the size of slot-group can be configured by MIB/SIB1 or be predefined for each SCS, e.g., *M*=4 for 480 kHz, *M*=8 for 960 kHz.  **Proposal #7: Multi-slot monitoring of Type0-PDCCH CSS for SSB/CORESET#0 multiplexing pattern 1 should be considered for 480 kHz or 960 kHz SCS.** |

### R1-2109993 (Sharp)

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| The search space for single-slot monitoring of 15~120 kHz SCS is specified by the parameter "*monitoringSlotPeriodicityAndOffset*", "*duration*" and "*monitoringSymbolsWithinSlot*". However, since multi-slot monitoring at 480 kHz and 960 kHz basically monitors every multiple of X slots, such as 4 or 8, there are many periods that cannot be specified by the value of these parameters. Therefore, it is necessary to create an alternative parameter or revise parameter which matches the multi-slot monitoring.  **Figure 2: SearchSpace parameters that need to be rebuilt or revised.**  **Proposal 7: Search Space should be modified to match multi-slot monitoring**  In AI 8.2.1, it was agreed to support Type0-PDCCH CSS of 480 kHz and 960 kHz SCS for initial access in addition to 120 kHz SCS in the frequency band above 52.6 GHz. For Type0-PDCCH CSS with SSB-CORESET multiplexing pattern 1, a UE needs to monitor two consecutive slots (n0 and n0+1 slots) in the current specification. Since the proposed multi-slot monitoring cannot support monitoring of two consecutive slots, the Type0-PDCCH CSS should be redesigned. For example, the slot indices for monitoring the Type0-PDCCH CSS could be n0 and n0+X instead of n0 and n0+1. However, SSBs transmitted between n0 and n0+X slots would not be available since SSBs of 480 kHz and 960 kHz SCS are discussed to be transmitted on a slot-by-slot basis.  **Observation 3: Type0-PDCCH CSS should be redesigned.**  SSSG switching was originally introduced for Rel-16 NR-U. The motivation was to enable dynamic switching between frequent PDCCH monitoring (e.g., out of COT) and infrequent PDCCH monitoring (e.g., within COT) that may consume less UE power. The benefit of reducing power consumption by dynamic SSSG switching is even significant for higher SCSs of 480 kHz and 960 kHz where slots are shorter, in addition to the original motivation for NR-U. Therefore, SSSG switching should also be used for 480kHz/960kHz SCS.  In FR2-2 operation, since the PDCCH monitoring capability is on a multi-slot basis at 480 kHz/960 kHz SCS, the processing load may locally exceed the capability of the UE during SSSG switching. In other words, there is a potential back-to-back problem when performing SSSG switching with multi-slot monitoring.  **Proposal 8: We support SSSG switching with enhancements for 120kHz/480kHz/960kHz SCS.**  **Observation 4: Potential back-to-back problem during SSSG switching in multi-slot monitoring should be investigated.** |

### R1-2110022 (Apple)

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| ***Proposal 5:*** *For Alt-1, the positions of CSS and USS in Y should be clarified based on both network flexibility and UE power consumption.*  ***Proposal 6:*** *For Type0/0A/1(without dedicated RRC config)/2-CSS) enhance the default CSS configuration to ensure that the monitoring occasion is compatible with Alt 1 with fixed Y locations*  ***Proposal 7:*** *there is no need to increase the CORESET duration i.e., the maximum CORESET duration ≤ 3.*  In Rel-16, the switching boundary and the timer decrement value are on the order of slots. In the case of MSM PDCCH monitoring, as the PDCCH may be on the order of multiple slots, both the switching boundary and the timer decrements can be modified to be on the order of multi-slots as needed. The effect of MSM on the transition boundary and the time unit of multiple slots (4 slot) is illustrated in Figure 1.  *A picture containing chart  Description automatically generated*  Figure 1: Example of SSSG switching with multi-slot monitoring limitations  ***Proposal 14:*** *Consider the effect of the change in SCS and of MSS PDCCH monitoring on SSSG switching.* |

### R1-2110110 (Convida Wireless)

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| Since common CORESET configuration and search space are shared by multiple UEs in a serving cell, so accordingly, network need to take care alignment with all UEs for this configuration like PDCCH control region for RAR/paging system information. To support more flexible scheduling for single DCI scheduling multi-PDSCH, the starting location (or slot offset) for slot group in a frame may need to be studied. For example, is equal to 640 for SCS = 960 KHz. For this case, it can have 8 (mod 8) different possible (slot) offset for slot group in a frame as shown in Figure 2.    **Figure 2**: Different staring slot(s) for slot group with SCS = 960 KHz and the slot group is aligned with the slot boundary.  ***Proposal 2. To support more flexible scheduling for single DCI scheduling multi-PDSCH, the starting slot location in a frame for slot group can be studied for NR from 52.6 to 71 GHz.*** |

### R1-2110173 (Qualcomm)

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| As we discussed, one of the key motivations of multi-slot PDCCH monitoring is the improved scheduling flexibility by not reducing the maximum number of BD/CCEs per monitoring occasion (MO). Another important motivation, which should not be overlooked, is the enhanced power efficiency. In general, by separating two PDCCH MOs far enough, the micro-sleep opportunity increases. For example, if there is only one PDCCH MO or one span of up to 3 symbols within X = 4 slots for 480 kHz SCS and X = 8 slots for 960 kHz SCS, at least the same micro-sleep opportunity as that of 120 kHz SCS is guaranteed. Since 480 kHz or 960 kHz SCSs can support a larger bandwidth (i.e., larger portion of RF power in overall power consumption) compared to 120 kHz SCS, the same micro-sleep opportunity may be translated to a higher power saving gain. On the contrary, a larger number of MOs dispersed within X slots may adversely impact the power efficiency by requiring UE   * to keep the RF frontend blocks active for a longer time, * to repeat ramping up and down its frontend blocks more often, and * to perform more FFT operation across MOs.   Observation 1: More than one PDCCH monitoring occasion or span dispersed within a X-slot duration may adversely impact the power efficiency.  Therefore, keeping the value of Y as small as possible, e.g., Y = 1 slot, is desirable from the power saving perspective. In RAN1 #106-e, however, some concerns were raised with supporting a small value of Y. First of all, with a small Y, the flexibility is limited for the network to spread out the USS MOs within the Y slots, e.g., in a staggered manner across UEs. This issue may be addressed by allowing a flexible position of the Y slots within a X slot group for Alt 1 (i.e., fixed pattern of slot groups), and is not present for Alt 2 (i.e., (X, Y) span-based). Furthermore, due to the concern on power consumption and pipelining of processes, supporting additional X values (as discussed in Section 2.1.1) would be a better strategy to improve the scheduling flexibility, rather than increasing Y. Also, it was pointed out that the alignment of USS and CSS MOs within the Y slots would be challenging if Y is small. Although there were different views on whether the CSS MOs should also be placed within the same Y slots as USS MOs, if they should be aligned, the issue cannot be fully resolved unless X = Y and persists in common for Alt 1 and Alt 2. Thus, an enhancement of CSS, in particular Type0/0A CSS is necessary, as will be discussed in Section 2.1.5.  Based on the discussion above, there is little motivation for supporting a value of Y larger than 1 slot.  Proposal 5: The value of Y is no larger than 1 slot:   * **Alt 1: Y = 1 slot,** * **Alt 2: Y ≤ 14 symbols (e.g., Y = 3 symbols).**   For a UE indicating a capability of multi-slot PDCCH monitoring according to more than one (X, Y) combinations, switching between the two different PDCCH monitoring behaviors associated with different (X, Y) combinations may be required. For instance, for the operation in FR2-2 unlicensed band, more frequent PDCCH occasions (i.e., a smaller value of X) would be necessary so that the gNB can start transmitting PDCCH as early as possible after LBT success. On the other hand, for data transmission and reception during a COT, a larger value of X may be assumed at least for the power efficient operation. In Rel-16 per-span PDCCH monitoring, among the multiple supported (X, Y) combinations, the actually used is determined by a search space configuration. That is, if a configuration of search space sets complies with multiple combinations (X, Y) for a BWP, the one associated with the largest maximum number of BD/CCE is applied for the BWP. Different BWPs can be associated with different (X, Y) combinations. Applying the same principle to Rel-17 multi-slot PDCCH monitoring, by changing the search space set configuration across BWPs, the switching between two different PDCCH monitoring behaviors can be through BWP switching.  As an alternative switching mechanism, particularly for the unlicensed band operation, search space set group switching within a BWP can be considered. In this case, each search space set group may be configured to comply with different combinations (X, Y). For example, search space set group 0 (i.e., the default group) can be configured with per-slot PDCCH monitoring (i.e., X = 1) and used when the UE is outside the channel occupancy time. On the other hand, search space set group 1 can be configured with multi-slot PDCCH monitoring and used during a COT. Although search space set group switching has dedicatedly been used for NR-U operation in Rel-16, the discussion on the extension for licensed band operation is in progress in Rel-17 UE power saving WI. Therefore, if supported for the licensed band operation, search space set group switching will provide more dynamic transition between two different PDCCH monitoring behaviors, both for unlicensed and licensed band operation.  Proposal 6: For a UE s supporting more than one (X, Y) combinations, support a dynamic switching mechanism between different PDCCH monitoring behaviors according to different (X, Y) combinations.  Observation 2: Bandwidth part switching and search space set group switching mechanisms can be considered as candidate switching mechanism between different PDCCH monitoring behaviors.  To address the issues, some enhancement and modification for the CSS design is necessary. The enhancement should be applied to search space set #0 configured by *PDCCH-ConfigSIB1* in *MIB* or by *searchSpaceZero* in *PDCCH-ConfigCommon*, as well as other common search spaces than SS set #0 configured by *commonSearchSpaceList* in *PDCCH-ConfigCommon*. Different candidate approaches would be considered to address the issues.  **Alt 1: New CSS design**  As discussed in Issue 1 above, for SSB-CORESET multiplexing pattern 1, the existing SS set #0 design requires the UE to monitor two consecutive slots, slot and slot , which is not compliant with multi-slot PDCCH monitoring. Thus, to address the issue, a new design of SS set #0 may require the UE to monitor two non-consecutive slots, i.e., slot and slot , where satisfies the default UE capability, e.g., for 480 kHz and for 960 kHz, as discussed in Proposal 3**Error! Reference source not found.**. Similar design enhancement can further be discussed for other SSB-CORESET multiplexing pattens, i.e., patterns 2 and 3.  To address Issue 2, the PDCCH transmission in a MO of SS set #0 would be repeated over multiple consecutive slots. For example, in addition to the enhancement discussed above, the same or equivalent PDCCH (and the associated PDSCH) may be repeated over slots , , …, and . It should be noted that the repetition assumes the same QCL-TypeD property, and different from the existing beam sweeping for SS set #0 associated with different SSB beams. Thus, the network can configure different UE’s USS so that at least one occasion of the CSS repetition overlaps with the USS MO, and the UE only monitors a CSS MO that overlap with its USS MO. Furthermore, once the baseline design of the CSS repetition is introduced, it may be enhanced to support extended coverage for FR2-2 in later NR releases.  For other CSSs using a separate search space set configuration (i.e., *commonSearchSpaceList* in *PDCCH-ConfigCommon*) other than search space set #0, the same principle can be applied. For example, Type1/2 PDCCH CSSs may use a search space set configuration with one-slot periodicity, to provide more opportunities for UE to receive a random access response or a paging message during a RAR window or a paging occasion. Then, among the configured CSS MOs, the UE may monitor only a subset on non-consecutive slots. For idle/inactive mode UEs, the actually monitored CSS MOs may be determined by some UE specific parameters, e.g., PRACH preamble index, PO index, etc., for Type1 CSS, and UE index, PF/PO index, etc., for Type2 CSS. For connected mode UEs, the actually monitored CSS MOs may be determined by the alignment with USS MO, as shown in Figure 3.    Figure 3: USS-CSS alignment for connected mode UEs.  **Alt 2: New CSS prioritization rule**  In Rel-15, when the MOs of different CORESETs overlap in time, a prioritization rule is applied. For example, when a CSS MO overlaps with a USS MO with a different QCL-TypeD property, monitoring of the CSS MO is prioritized. To address Issue 2, the CSS prioritization can be extended so that the UE prioritize CSS over USS, not only when they overlap, but also when they are non-overlapping but closely located.  For instance, the prioritization rule may be augmented with a notion of CSS zone. As illustrated in Figure 4, windows of X1 and X2 slots (or symbols) may be placed before and after the CSS MO, respectively, to define a CSS zone, where the values of X1 and X2 may be up to UE capability. If a USS MO falls within the CSS zone, the UE may be expected to prioritize CSS MO and drop the USS MO. From UE’s perspective, among the multiple CSS MOs with different QCL-TypeD properties (i.e., up to different beams), only one or a few of them are actually monitored and associated with CSS zones. The UE and network may agree on the CSS MOs that are actually monitored based on another rule or signaling, which may include:   * A MAC CE activation command indicating a TCI state for the CORESET associated with the CSS (i.e., CORESET #0), * An SSB identified by a recent random access procedure by the UE, which is not initiated by a PDCCH order, * Active TCI states of the active BWP, which includes CSI-RSs quasi-co-located with SSBs, or * Dedicated configuration of Type1/2 PDCCH CSS.   During the connected mode operation, monitoring of CSS is relatively infrequent and thus the actual blockage event of PDCCH transmission in USS would be rare. Also, even though the USS is cancelled by the aforementioned CSS prioritization, the UE can still receive a scheduling grant with C-RNTI within the CSS MO via DCI format 0\_0/1\_0. Therefore, the impact of the extended CSS prioritization rule can be kept marginal.  Since there could be many different alternatives than the two discussed above, it would be desirable to extend the discussion in RAN1 and specify any enhancement of the common search space design.  Proposal 8: If 480 kHz or 960 kHz SCS is used for ANR detection or initial access in the SPCell, common search space set design should be enhanced to address multi-slot-based CSS monitoring and multiplexing with USS:   * The enhancement should be applied search space set #0 (configured by *PDCCH-ConfigSIB1* in *MIB* or by *searchSpaceZero* in *PDCCH-ConfigCommon*), as well as other common search spaces than SS set #0 (configured by *commonSearchSpaceList* in *PDCCH-ConfigCommon*).     Figure 4: CSS prioritization with CSS zone. |

## Topic A3: BD Budget/Dropping

### R1-2108768 (Huawei, HiSilicon)

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| * **Type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS**   According to FG3-1 in Rel-15, for type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS, the monitoring occasion can be any OFDM symbol(s) of a slot, with the monitoring occasions for any of Type 1- CSS without dedicated RRC configuration, or Types 0, 0A, or 2 CSS configurations within a single span of three consecutive OFDM symbols within a slot. Such capability allows UE to monitor Type0/0A/1/2 CSS associated with SearchSpaceZero given in MIB. Similar rules should be inherited for UE with multi-slot PDCCH monitoring capability in FR2-2. Moreover, considering the SSB pattern may not align with fixed X-slots group pattern of multi-slot PDCCH capability, the restriction on monitoring occasions within Y slots should not applied.   1. ***Corresponding to FG3-1 in Rel-15, PDCCH monitoring occasion can be in any symbol(s) of a slot for Type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS.***   **Table 3. Maximum number of monitored PDCCH candidates per slot(s) for a DL BWP with SCS configuration for a single serving cell. for, for . otherwise.**   |  |  | | --- | --- | |  | **Maximum number of monitored PDCCH candidates per slot(s) and per serving cell** | | 0 | 44 | | 1 | 36 | | 2 | 22 | | 3 | 20 | | 5 | 20 | | 6 | 20 |   **Table 4. Maximum number of non-overlapped CCEs per slot(s) for a DL BWP with SCS configuration for a single serving cell. for, for . otherwise.**   |  |  | | --- | --- | |  | **Maximum number of non-overlapped CCEs per slot(s) and per serving cell** | | 0 | 56 | | 1 | 56 | | 2 | 48 | | 3 | 32 | | 5 | 32 | | 6 | 32 |  1. ***The BD and CCE budgets for multi-slot PDCCH monitoring are defined within the Y consecutive slots per slot group. The maximum number of PDCCH candidates and non-overlapped CCEs per X slots for 480 kHz and 960 kHz SCSs is the same as for 120 kHz SCS with slot-level PDCCH monitoring.*** 2. ***For UE with multi-slot PDCCH monitoring capability, NB should ensure the number of monitored PDCCH candidates and non-overlapped CCEs for configured CSS sets and all search spaces on secondary cell not exceeding the maximum number per X slots.***   Suppose that the maximum number of PDCCH candidates/CCEs are defined per X slots (as shown in **Table 3** and **Table 4**) such that the maximum number of PDCCH candidates/CCEs per X slots for 480/960 kHz SCS is the same as that per slot for 120 kHz SCS. Then, the Rel-15/16 overbooking rule for PCell with respect to a slot can be directly extended to multi-slot monitoring for 480/960 kHz SCS. The number of PDCCH candidates and non-overlapped CCE for a search space across all monitoring occasions in Y slots of X-slot pattern will be accumulated as a whole. If the number of monitored PDCCH candidates and non-overlapped CCE exceeding the maximum numbers per X-slot after SS *j* is added, all PDCCH candidates for UE-SS *k with k>=j* across the Y slots will be dropped.   1. ***All PDCCH candidates for UE-SS k with k>=j across the Y slots will be dropped if the number of monitored PDCCH candidates and non-overlapped CCE exceeding the maximum numbers per X-slot after SS j is added.*** |

### R1-2108783 (Futurewei)

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| A gNB can configure the UE with several PDCCH candidates/CCEs per slot that exceeds the UE capability, which is referred to as overbooking. As specified in TS 38.213 “A UE does not expect to be configured CSS sets that result to corresponding total, or per scheduled cell, numbers of monitored PDCCH candidates and non-overlapped CCEs per slot or per span that exceed the corresponding maximum numbers per slot or per span, respectively.” In Rel 15 the monitoring capability is defined per slot, in Rel 16 the monitoring capability per span is added, where the span length ls shorter than a slot. The monitoring capability is defined by *monitoringCapabilityConfig* for a serving cell.  For multi-slot PDCCH monitoring it is expected that UE maps the PDCCH candidates using the Y span, where the span may be larger than one slot. Reusing the existing approach for overbooking rules is a natural choice.  **Proposal 6: Reuse the Rel-15/16 overbooking rules when PDCCH candidates/CCEs exceeds either of the UE processing limits per span.** |

### R1-2108887 (Transsion Holdings)

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| The BD/CCE budget is closely related to the values of X in multi-slot PDCCH monitoring. When the value of X can be 4 or 8 for 480kHz SCS or 960kHz SCS respectively, the duration of one slot group is equal to that of one slot with 120kHz SCS. In order to maintain the same PDCCH monitoring complexity as in 120kHz SCS, the same maximum number of monitored PDCCH candidates and non-overlapped CCEs can be applied to multi-slot PDCCH monitoring. Regarding X=2 for 480kHz SCS or X=4 for 960kHz SCS, the maximum number of monitored PDCCH candidates and non-overlapped CCEs can be scaled down to half.  **Table 1. Maximum number of monitored PDCCH candidates per X slots for a DL BWP with SCS configuration  for a single serving cell.**   |  |  |  |  | | --- | --- | --- | --- | |  | **Maximum number of monitored PDCCH candidates per X slots and per serving cell** | | | | **X=2** | **X=4** | **X=8** | | 5 | 10 | 20 | - | | 6 | - | 10 | 20 |   **Table 2. Maximum number of non-overlapped CCEs per X slots for a DL BWP with SCS configuration  for a single serving cell.**   |  |  |  |  | | --- | --- | --- | --- | |  | **Maximum number of non-overlapped CCEs per X slots and per serving cell** | | | | **X=2** | **X=4** | **X=8** | | 5 | 16 | 32 | - | | 6 | - | 16 | 32 |   ***Proposal 2: Additional values of X could be 2 for 480kHz SCS and 4 for 960kHz SCS respectively for multi-slot PDCCH monitoring.***  According to the revised WID [4], in addition to 120kHz SSB, 480kHz SSB for initial access had been introduced with the limitation of supporting only 480kHz CORESET#0/Type0-PDSCH SCS. The following lists the SSB related part in revised WID:   |  | | --- | | * In addition to 120kHz, support 480 kHz SSB for initial access with support of CORESET#0/Type0-PDCCH configuration in the MIB with following constraints:   + Limited sync raster entry numbers     - It is assumed that RAN4 supports a channelization design which results in the total number of synchronization raster entries considering both licensed and unlicensed operation in a 52.6 – 71 GHz band no larger than 665 (Note: the total number of synchronization raster entries in FR2 for band n259 + n257 is 599). If the assumption cannot be satisfied, it’s up to RAN4 to decide its applicability to bands in 52.6 – 71 GHz.   + only 480kHz CORESET#0/Type0-PDCCH SCS supported for 480 kHz SSB SCS.   + Prioritize support SSB-CORESET#0 multiplexing pattern 1. Other patterns discussed on a best effort basis.   + 960 kHz numerology for the SSB is not supported by the UE for initial access in Rel-17.   + Note: Strive to minimize specification impact by reusing tables for CORESET#0 and type0-PDCCH CSS set configuration defined for FR2 in Rel-15, as much as possible   + Note: 480 kHz is an optional SSB numerology for initial access for the UE. A UE supporting a band in 52.6-71 GHz must at least support 120 kHz SCS (for initial access and after initial access)   + Note: Dependency or lack thereof for a UE supporting 480kHz and/or 960kHz numerology for data and control to also support 480kHz SSB numerology for initial access is to be tackled as part of UE capability discussion. |   Furthermore, for ANR and PCI confusion detection, only one CORESET#0/Type0-PDCCH SCS is supported for each SSB SCS, i.e., (120, 120), (480, 480) and (960, 960).  Based on the above conclusions, the multi-slot PDCCH monitoring capability of CORESET#0/Type0-PDCCH CSS needs to be solved. For SS/PBCH block and CORESET#0 multiplexing pattern 1, the PDCCH monitoring occasions are located within two consecutive slots which are associated with the SS/PBCH block. However, when the UE changes its tracking SS/PBCH block, the relevant PDCCH occasions may be located outside the Y consecutive slots, which will affect the UE’s monitoring capability. Given the long period of Type0-PDCCH CSS (e.g. UE may assume 20ms as a default cycle), and the UE does not need to monitor Type0-PDCCH in every cycle, the location of CORESET#0/Type0-PDCCH CSS in time domain should not be restricted, when introducing new multi-slot monitoring capability.  ***Proposal 3: The location of CORESET#0/Type0-PDCCH CSS in time domain should not be restricted, when introducing new multi-slot monitoring capability.*** |

### R1-2108935 (ZTE, Sanechips)

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| Regarding USS set dropping in multi-slot PDCCH monitoring, same as in Rel-15, a USS set with higher SS set index is dropped. There are two alternative options when the USS set is configured in multiple slots,  Alt1: The USS set in multiple slots with higher SS set index is dropped slot by slot when overbooking happens.  Alt2: The whole USS set in multiple slots with higher SS set index is dropped when overbooking happens.  Considering configuration and standardization complexity, we slightly prefer Alt 2 even though Alt1 can save more slots of USS.  **Proposal 4: For multi-slot PDCCH monitoring capability, the similar dropping rule as Rel-15 can be used.**   * **The SS set dropping rule is only allowed for PCell or PSCell** * **The gNB should guarantee that the configured CSS sets do not exceed a UE’s capability** * **The whole USS set in multiple slots with higher SS set index is dropped when overbooking happens.** |

### R1-2108960 (vivo)

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| For Alt. 1/Alt. 3 in Section 2.1.2, the BD/CCE budget is defined per fixed or sliding slot group, i.e. PDCCH candidates and non-overlapped CCEs among the Y slots within the slot group should be less than .  For Alt. 2 in Section 2.1.2, the BD/CCE budget is defined per Y-slot/symbol span, i.e. PDCCH candidates and non-overlapped CCEs among the Y slots within the slot group should be less than .  The following alternatives are the candidate method to determine the value of :   * Alt. 1: =X\*, X\*, where per slot limit and should be defined first; * Alt. 2: Use the value in 120K as the reference, = and = * Alt. 3: Determine each value for supported (X, Y) using the following table:  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | Maximum number of non-overlapped CCEs per slot group for combination and per serving cell | | | | | |  | (4, 1) | (4, 2) | (8, 1) | (8, 2) | (8, 4) | | 5 |  |  |  |  |  | | 6 |  |  |  |  |  |   Among the above alternatives, Alt. 3 is a similar way with that for span-based capability, which clearly provides the BD/CCE budget value as well as supported (X, Y) value.  **Proposal 5: For NR Rel-17 UEs, supported (X, Y) value should be determined first and then decide corresponding BD/CCE budget value for each (X, Y) case by case.**  In NR operation from 52.6-71GHz, BD/CCE budget will be defined for multiple slot as agreed. In this case, PDCCH candidates should be allocated for multiple slots in overbooking case. In existing NR operation, PDCCH candidates are allocated per slot in granularity of SS. However, in multi-slot-based PDCCH monitoring capability case, PDCCH candidates could be allocated to multiple slots in granularity of SS and slot. How to allocate the PDCCH candidates in two dimensions should be considered.  **Proposal 7: In multi-slot-based PDCCH monitoring capability case, PDCCH candidates could be allocated to multiple slots in granularity of SS and slot.** |

### R1-2109434 (Ericsson)

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| With Rel-17 work approaching closing, RAN1 should strive to progress in the multi-slot PDCCH processing capabilities for 480/960 kHz SCS. Toward this end, we propose the following starting exemplary lower and upper bounds as the starting point for RAN1 discussion:   * 480 kHz SCS with window size of X=4 * 960 kHz SCS with window size of X=8   Note that the capabilities of a UE supporting 960 kHz SCS can be higher than those for supporting only 480 kHz SCS since the former is equipped with higher processing powers to address larger bandwidths with shorter OFDM symbol and slot times.   1. RAN1 agrees to the following multi-slot PDCCH processing capability ranges for 480/960 kHz SCS as the starting point to progress the Rel-17 specification effort:    1. 480 kHz SCS with window size of X=4: and .    2. 960 kHz SCS with window size of X=8: and . |

### R1-2109443 (Nokia, Nokia Shanghai Bell)

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| ***Proposal 6****: For the cases with X=4 slots for 480 kHz SCS and X=8 for 960 kHz SCS*   * *support 20 PDCCH candidates per 120 kHz SCS slot duration* * *support 32 non-overlapped CCEs per 120 kHz SCS slot duration.*   ***Proposal 7****: For smaller values of X, select values defined in Table 1 as the baseline*   * *support at least 20 PDCCH candidates per 120 kHz SCS slot duration* * *support 32 non-overlapped CCEs per 120 kHz SCS slot duration.* |

### R1-2109477 (Samsung)

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| Slot-based PDCCH monitoring could be considered as a baseline at high SCS (480 KHz and 960 KHz), e.g. for the case UE capability is not available, wherein the maximum number of monitored PDCCH candidates and maximum number of non-overlapping CCEs in a slot can be estimated by extrapolating Rel-16 numbers for other SCSs. Table 1 suggests corresponding numbers as reference for discussion and whether to keep the minimum maximum number of CCEs as 16 for 960 kHz SCS can be further discussed.  **Proposal 1: Support slot-based PDCCH monitoring for 480 KHz and 960 KHz, and use Table 1 as a reference for the maximum number of monitored PDCCH candidates and non-overlapped CCEs per slot.**  Table 1: Maximum number  of monitored PDCCH candidates and non-overlapped CCEs per slot for a DL BWP with SCS configuration for a single serving cell   |  |  |  | | --- | --- | --- | |  | Maximum number of monitored PDCCH candidates per slot and per serving cell | Maximum number of non-overlapped CCEs per slot and per serving cell | | 5 | [10-12] | [18-20] | | 6 | [8-9] | [14-16] |   In Rel-16, a procedure to resolve overbooking conditions for PDCCH monitoring per slot or span in a slot as specified in TS38.213 [2]. When for a search space set, a resulting total of monitored PDCCH candidates or non-overlapped CCEs would exceed corresponding maximum values in a slot or span, the UE will drop PDCCH monitoring for the search space set and for remaining search space sets with higher indexes.    **Figure 3: Allocation of PDCCH candidates with combination (X = 4, Y =2).**  For multi-slot span based PDCCH monitoring as illustrated in Figure 2, a span for PDCCH monitoring can be over multiple slots based on combination (X, Y). The PDCCH candidate allocation/dropping rule from Rel-16 should be extended to support PDCCH monitoring in a multi-slot span.  When a UE is configured with CA operation, the PDCCH candidate allocation/dropping rule per multi-slot should be extended to multiple CCs that are configured with multi-slot PDCCH monitoring capability. For a UE configured with CA operation, NR Rel-16 supports multiple PDCCH monitoring capabilities, such that gNB can configure some cells with Rel-15 per slot based PDCCH monitoring capability, and some other cells with Rel-16 per span based PDCCH monitoring capability. The same principle can be reused to include multi-slot PDCCH monitoring capability as another candidate for PDCCH monitoring capability configuration.  **Proposal 8: Support PDCCH candidate allocation/dropping per a span over multiple slots for a single serving cell and across multiple CCs in CA.** |

### R1-2109599 (Intel)

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| As in Rel-15, it is desired there is no dropping for CSS sets even for PCell/PSCell. Therefore, it is up to gNB to guarantee that CSS sets are properly configured. One thing to note is that multiple slots in a X-slot group may contain MOs for a CSS set subject to gNB configuration. In this case, the total numbers of BDs/CCEs in the multiple slots for the CSS set are multiple times of that configured in single slot. Consequently, the numbers of available BDs/CCEs for USS sets are reduced. The UE capability on maximum numbers of BDs/CCEs needs to consider the increase of BDs/CCEs in the X-slot group for a CSS set.  Regarding handling USS sets if total number of BDs/CCEs exceed the corresponding maximum numbers, a same principle as in Rel-15 can be reused, i.e., a USS set with high SS set index is dropped. Further, since the PDCCH MOs of the USS set may be configured in multiple slots in the X-slot group, a discussion point is whether the USS set in all the multiple slots is dropped as a whole or dropped slot by slot. The latter option is preferred since it allows more capacity for PDCCH monitoring without exceeding UE capability.  **Proposal 5:**   * To handling USS dropping in PDCCH overbooking   + A USS set with largest SS set index is dropped   + If the PDCCH MOs of a USS set are configured in multiple slots in the X slots, the USS set in the multiple slots is dropped slot by slot. |

### R1-2109666 (NTT DOCOMO)

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| At RAN1#106-e meeting, it was agreed that X=4/8 slots are supported for 480/960 kHz SCS for multi-slot PDCCH monitoring capability. The duration of 4/8 slots for 480/960 kHz SCS are same as that of 1 slot for 120 kHz SCS. Thus, the same maximum number of monitored PDCCH candidates and non-overlapped CCEs per slot for 120 kHz SCS as below table 10.1-2 and 10.1-3 should be supported per 4/8 slots for 480/960 kHz SCS, i.e., the maximum number of monitored PDCCH candidates per 4/8/ slots for 480/960 kHz SCS should be 20 and the maximum number of non-overlapped CCEs per 4/8/ slots for 480/960 kHz SCS should be 32.  ***Proposal 3:*** *For defining the multi-slot PDCCH monitoring capability for 480 and 960 kHz SCS,*   * *the maximum number of monitored PDCCH candidates per X slots and per serving cell should be 20 when X=4/8 for 480/960 kHz SCS respectively.* * *the maximum number of non-overlapped CCEs per X slots and per serving cell should be 32 when X=4/8 for 480/960 kHz SCS respectively.*   In Rel-15/16, the SS set can be overbooked per NW configuration, and the SS set dropping rule is defined per slot/span to deal with the situation when the BD/CCE exceed their budget from UE perspective. More specifically, PDCCH candidates or non-overlapped CCEs can exceed BD/CCE limit only for USS in PCell and PSCell to allow NW to configure proper SS set locations considering all the UEs in the cells. These PDCCH overbooking rules can be reused for multi-slot PDCCH monitoring capability, i.e., for USS in PCell and PSCell, PDCCH overbooking should be allowed.  When SS set overbooking happens as a result, a UE drops search space set(s) with higher index to ensure actual PDCCH candidates or non-overlapped CCEs to be no more than their budget per slot in Rel-15/16. To extend it considering multi-slot PDCCH monitoring capability, at least the rule for the case when a SS set is configured across multiple slots in a slot group needs to be discussed. If SS set(s) is checked and dropped slot by slot, how many SS set(s) is dropped may be divergent per slot, which will cause more UE complexity and specification effort in our view. Therefore, the USS set in multiple slots should be checked and dropped per slot group.  ***Proposal 4:*** *The SS set overbooking can be allowed with multi-slot PDCCH monitoring capability same as the current specification, i.e., SS set overbooking is allowed for USS in PCell and PSCell and UE expects no overbooking for CSS and CSS/USS in SCell.*  ***Proposal 5:*** *The dropping rule for multi-slot PDCCH monitoring capability can be the same as the current specification, i.e., a UE drops UE specific search space set(s) with higher index when SS sets are overbooked and expects there is no overbooking for CSS sets. In addition, if USS set is configured across multiple slots in a slot group, USS set should be checked and dropped as a whole.* |

### R1-2109962 (LG)

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| Regarding the PDCCH monitoring per slot-group, USS overbooking and dropping procedure may also be enhanced. Basically, if the total number of BDs (or CCEs) exceeds the corresponding maximum number, the same principle as in Rel-15 can be reused, i.e. a USS set(s) with the highest SS set index(es) is dropped. In addition, since BD/CCE budget would be handled in unit of slot-group, additional dropping rules may be considered, e.g., by applying dropping rules in slot-by-slot manner within a slot group or by applying dropping rules considering all SS set indexes in all slots within a slot group.  **Proposal #4: How to perform SS set dropping due to overbooking should be further discussed for multi-slot monitoring.** |

### R1-2109993 (Sharp)

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| For 120 kHz SCS, the BD/CCE budget is set to (M, C) = (20, 32). Since the value of X is determined to maintain the same monitoring capability as 120 kHz SCS, the BD/CCE budget should be (M, C) = (20, 32) for X=4/8 at 480kHz/960kHz SCS. If a smaller X value is set as an optional capability, the BD/CCE budget will be reduced because the gap between Y slots becomes shorter. Even though the symbol length is shorter than 120 kHz, ensuring the same budget may affect the processing time of PDSCH/PUSCH (N1/N2).  **Proposal 6: For X=4/8 at 480kHz/960kHz SCS, the BD/CCE budget should be set to (M, C) = (20, 32).**  **Observation 1: If a smaller X value is set as an optional capability, the BD/CCE budget will be reduced.**  **Observation 2: Ensuring the budget may affect the processing time of PDSCH/PUSCH (N1/N2).** |

### R1-2110022 (Apple)

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| ***Proposal 8:*** *For Alt-1, the Max # of monitored PDCCH candidate per (multi-)slot per CC (BD) can and the Max # 8f non-overlapped CCEs per (multi-)slot per CC can be set as in Table 1.*  Table 1: BD/CCE Budget for Alt. 1   |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | | *μ* | Maximum number of monitored PDCCH candidates | | | | Maximum number of non-overlapping CCEs | | | | | X=1 | X=2 | X=4 | X=8 | X=1 | X=2 | X=4 | X=8 | | 3 | 20 | - | - | - | 32 | - | - | - | | 5 | N/A | 10 | 20 | - | N/A | 18 | 32 | - | | 6 | N/A | 8 | 10 | 20 | N/A | 14 | 18 | 32 |   ***Proposal 10:*** *The Max # of monitored PDCCH candidate per slot/span per CC (BD) and the Max # of non-overlapped CCEs per slot/span per CC can be set as in Table 2.*  Table 2: BD/CCE Budget for Alt. 2   |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | Max. # of monitored PDCCH candidates per slot/span per combination (X,Y) and per serving cell | | | | Max. # of non-overlapped CCEs per slot/span for per combination (X,Y) and per serving cell | | | | | *μ* | Slot-based | (28, Y) | (56, Y) | (112, Y) | Slot based | (28, Y) | (56, Y) | (112, Y) | | 3 | 20 | - | - | - | 32 | - | - | - | | 5 | N/A | 10 | 20 | - | N/A | 18 | 32 | - | | 6 | N/A | 8 | 10 | 20 | N/A | 14 | 18 | 32 | |

### R1-2110110 (Convida Wireless)

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| The UE can be configured by the gNB to monitor PDCCH for the maximum number of PDCCH candidates () and nonoverlapping CCEs () defined per span like in Rel-16. In each PDCCH monitoring span, the number of PDCCH candidates and nonoverlapping CCE cannot exceed the UE capability. Therefore, UE behavior can be like legacy NR specification when there is an overbooking. For example, the UE and gNB can map PDCCH candidates in each PDCCH monitoring span as the following mapping rules in legacy NR specification: (1) CSS sets are mapped before USS sets; (2) USS sets are mapped in ascending order of the SS set indices, and if the number of PDCCH candidates/CCEs exceeds either of the UE processing limits, etc.  ***Proposal 3. UE behavior can be like legacy NR specification when there is an overbooking for single DCI scheduling multi-PDSCHs.*** |

### R1-2110173 (Qualcomm)

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| Not to harm the performance compared to that of 120 kHz SCS, the same number of BD/CCE limit should be considered as the starting point with X = 4 slots for 480 kHz SCS and X = 8 slots for 960 kHz SCS.  Proposal 2: For the multi-slot PDCCH monitoring capability with X = 4 for 480 kHz SCS and X = 8 for 960 kHz SCS, at least the same maximum numbers of PDCCH candidates and non-overlapped CCEs as 120 kHz SCS are supported (i.e., 20 BDs and 32 CCEs). |

### R1-2110252 (Panasonic)

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| In Rel-15/16, gNB is allowed to configure UE with UE-specific search spaces (USS) exceeding the BD/CCE limits that UE is capable of processing, which is referred to as overbooking. When allocating PDCCH candidates for monitoring, the USS with higher set index can be dropped in order to respect the UE capability. The overbooking with dropping rules facilitate gNB to use UE capability to its maximum. Otherwise, the configuration of MOs would be restricted to the worst case, resulting in resource under-utilization for typical cases.  The existing dropping rules for overbooking are applicable for individual slot or individual span within one slot. In the context of multi-slot monitoring capability, there is a need to extend the dropping rules for overbooking to across-slots or across-spans. However, the design would depend on whether Alt 1 or Alt 2 is selected for the multi-slot capability definition, and how further capability is defined for Y slots within X. Therefore, the details of enhancement can be further discussed when the multi-slot capability definition as discussed in previous two sections is finalized.  **Proposal 4: Dropping rules for overbooking need to be extended to across-slots or across-spans for multi-slot monitoring capability. Details are FFS after multi-slot monitoring capability definition is clear.** |

## Topic A4: PDCCH Extensions for e.g. Coverage, Reliability

### R1-2108935 (ZTE, Sanechips)

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| For the newly introduced SCS i.e. 480/960 kHz in Rel-17 NR above 52.6 GHz, the length of the slot/symbol becomes shorter. Given the current CORESET configuration in Rel-16, the PDCCH is transmitted on up to 3 OFDM symbols which are quite short and limited. In addition, since a single DCI can schedule multiple PDSCH/PUSCH over multi-slot PDCCH monitoring slots, the DCI transmission reliability is essential to the data transmission efficiency and system performance. Therefore, we suggest considering a duration of more than 3 OFDM symbols for 480/960 kHz SCS since it is beneficial for improving PDCCH coverage and PDCCH monitoring capability.  **Proposal 7: Considering a duration of more than 3 OFDM symbols for 480/960 kHz SCS in Rel-17 NR above 52.6 GHz.** |

### R1-2109071 (OPPO)

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| With the introduction of 480 kHz and 960 kHz for data and control transmission in the high frequency range, compared to existing SCS, the symbols become much shorter and the frequency range will be much larger for a given CORESET configuration. Figure 1 compares the CORESET configuration of {12RBs, 2symbols} for 120kHz and 480kHz respectively.    **Figure 1: CORESET configuration of {12RBs, 2symbols} for 120kHz and 480kHz**  From Figure 1, it can be observed that to keep same CORESET configurations and same PDCCH candidates being monitored, compared to 120kHz SCS, the coverage of PDCCH transmission would be impacted due to the reduced transmission duration, and UE is required to estimate much higher frequency range with the SCS of 480kHz. While the maximum number of non-overlapped CCEs would be smaller for 480kHz SCS than 120kHz SCS. The difference would be much larger if 120kHz and 960kHz SCSs are compared. Therefore, enhancements to CORESET configuration, i.e., reducing CORESET RBs and increasing CORESET symbols for a given higher SCS, seem beneficial.  **Proposal 2: CORESET configuration with less RBs and more symbols for 480kHz and 960kHz SCS should be supported.** |

## Topic B: Multiple PDSCH/PUSCH by a single DCI

### R1-2109898 (Lenovo, Motorola Mobility)

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| In our view, if new DCI format can be agreed to be supported for high SCS values such as 480kHz and 960kHz, then PDCCH monitoring can be further reduced by restricting the need for UE to monitor other DCI formats for scheduling DL/UL such as DCI format 0\_1 and format 1\_1. If such restriction is supported, then the number of blind detections for a UE can be significantly reduced or at least not expected to increase from the current UE capabilities.  ***Proposal 4: For supporting NR between 52.6 GHz and 71 GHz with high subcarrier spacing values including 480kHz and 960kHz, if a new DCI is agreed to schedule multiple PDSCH/PUSCH, then restrictions on monitoring of other DCI formats (such as DCI format 0\_1/1\_1) should be supported i.e., search space set configuration with restricted combination of DCI formats should be supported to not increase the number of blind decodes*** |

## Topic C: Multi-Beam Aspects

### R1-2108783 (Futurewei)

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| In 60 GHz bands due to higher pathloss corresponding to high frequency it is expected that the transmitters use directional beams. In TS 38.213 Clause 10.1, the *ControlResourceSet* variables are defined. The antenna port quasi co-location is provided by *TCI-State* indicating the quasi co-location of the DM-RS antenna port for PDCCH reception in the respective CORESET.If the UE is not provided with a configuration of TCI state(s)the UE assumes that the DM-RS antenna port associated with PDCCH receptions is quasi co-located with SS/PBCH the UE identified during the initial access procedure.  **Proposal 8: Use the existing mechanism for beam configuration and activation for multi-slot PDCCH monitoring.** |

### R1-2109209 (CATT)

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| In Rel-16, the DCI format 2\_0 is used for indicating the slot format, COT duration, available RB set and search space group switching to a group of UEs. The UEs within the group should monitor the Type-3 PDCCH CSS on the indicated beam direction according to the TCI state of the associated CORESET. There are proposals to enhance DCI format 2\_0 to indicate COT duration, available RB set and search space group switching in a beam specific manner. In our opinion, the beam management related enhancement of DCI format 2\_0 can be further studied in the Rel-18 to ensure a unified solution with all other related issues.  ***Proposal 10：The enhancement of DCI format 2\_0 can be further studied in the Rel-18 to ensure a unified solution with all beam management issues.*** |

### R1-2109443 (Nokia, Nokia Shanghai Bell)

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| One more issue related to DL control seems to be operation of DCI format 2\_0 in a beam based system. In Rel. 15, DCI format 2\_0 contained only SFI, and from SFI point of view, UL and DL direction is clearly beam agnostic due to strong self-coupling between different panels. On the other hand, in R16 DCI format 2\_0 contains also other information, such as COT or SS-group switching trigger, RB-sets. Any of these pieces of information could become beam dependent. However, support for beam-dependent configurations of DCI format 2\_0 is not possible in FR2 currently. Although a UE can be indicated a change of active-TCI, DCI format 2\_0 PDCCH candidates and, payload location remains the same and thus cannot be beam specific.    ***Observation 2:*** *GC-PDCCH is an essential part of unlicensed band system, and there seems to be a need to support beam-dependent information, particularly if some form of directional LBT is chosen as coexistence mechanism.*  In addition, for 480kHz and 960kHz SCS, the beam agnostic SFI becomes lengthy and thus leads to increased configuration overheads. Moreover, for 5ms COT and 960kHz the SFI may become as long as 320 slots that exceeds the legacy format limit of 256 slots, so SFI cannot be made with a single DCI 2\_0 message in the beginning of the COT with current FR2 signalling. Hence, support for improved SFI format in DCI 2\_0 is desired.  ***Proposal 8:****Changes to DCI format 2\_0 may be beneficial for at least unlicensed 60GHz NR operation.* |

### R1-2109477 (Samsung)

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| For 60 GHz unlicensed band, transmissions are expected to be highly directional. To address the channel access efficiency, a transmitter can choose an intended beam direction to perform the channel access procedure, and the sensed result is exclusively applicable to that intended beam direction only. Hence, indicating COT, available RB set, and search space group switching should be associated with the beam direction, wherein such feature was introduced in Rel-16 NR-U by using DCI format 2\_0 and in a cell-specific manner. Generalizing the feature to a beam-specific manner is beneficial to address different interference situations along beam directions, and is compatible with the intention to introduce directional LBT.  **Proposal 10: Support indicating COT, available RB set, and search space group switching in a beam-specific manner for 60 GHz licensed band.** |

### R1-2109778 (Sony)

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| As haven been mentioned by multiple companies in previous meetings [3]-[7]: In Rel-16 NR-U, several fields such as CO duration, SS-group switching trigger, RB-sets, etc., were introduced to DCI format 2\_0. In the frequency range above 52.6 GHz, that information can be beam-dependent due to the utilization of beamforming. Therefore, there is a need to consider per beam indication of DCI format 2\_0.  **Proposal 4: Support per beam indication of DCI format 2\_0 for above 52 GHz unlicensed operation.** |

### R1-2109898 (Lenovo, Motorola Mobility)

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| Another important aspect for PDCCH monitoring is related to directional LBT. Directional LBT may cause some issues in comparison with omni-directional LBT. For example, different Tx beams used by gNB may correspond to different COTs, thus different CORESETs which are configured with different Tx beams by higher layer signaling may also correspond to different COTs. From power saving perspective, according to the indicated sensing beam(s) used by the gNB to initiate a COT, a UE can stop monitoring the PDCCH occasions in the CORESET corresponding to a different Tx beam which is not ‘covered’ by the indicated sensing beam(s) until the current COT ends, which can reduce the power consumption cause by blind decoding. After transmitting a PDCCH to a UE within a COT, the gNB will not transmit PDCCH to this UE in the CORESET corresponding to another COT until the current COT ends.  ***Proposal 7: For NR unlicensed bands between 52.6 GHz and 71 GHz with directional LBT based channel access mechanism, within a COT, PDCCH monitoring is not supported in the CORESETs corresponding to other COTs (PDCCH monitoring restricted to monitoring corresponding to only one COT at a time)*** |

### R1-2109962 (LG)

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| In Rel-16 NR-U, several fields such as RB set indicator, CO duration and SS set group switching trigger were introduced to DCI format 2\_0, in addition to SFI. However, for FR2-2 in Rel-17 where the use of directional beams may be essential, it can be worth considering the beam dependent GC-PDCCH configuration. In other words, it may be beneficial to give a spatial relation for a beam to which information of DCI format 2\_0 is applied. One simple conceivable method is to define some fields in DCI format 2\_0 separately for each beam. For example, RB set indicator and CO duration could be configured separately for each beam, but SFI could be configured as beam agnostic. Alternatively, a new field can be additionally introduced in DCI format 2\_0 to indicate the availability of each beam. In this method, UE receiving DCI format 2\_0 may determine the channel availability for each beam through a combination of the new field and existing fields (i.e., RB set indicator and CO duration).  **Proposal #8: Consider per beam indication of available RB set, CO duration, and/or SS set switching by using DCI format 2\_0.** |

### R1-2110022 (Apple)

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| In R16 NR-U, DCI format 2-0 is enhanced to carry channel access related information: RB allocation, COT duration and search space set switching indication. While RB allocation information may not be needed depending on LBT bandwidth discussion, the COT duration and SSSG switching should be supported.  COT duration and SSSG switching information should be sent at the beginning of the COT as shown in Fig.1. However, current design of DCI format 2-0 transmission limit to one beam per slot. Therefore, it takes multiple slots to finish the beam sweeping transmission of DCI format 2-0. For example, with 120KHz SCS and 32 beams, it takes 4ms to finish beam sweeping. Considering maximum COT duration is 5ms defined by EN 302 567, more efficient transmission scheme of DCI format 2-0 is needed.  ***Proposal 15:*** *Consider enhancement of DCI 2-0 transmission to signal COT duration and SS adaptation at the beginning of the COT.* |

## Topic D: Multi-Cell Operation, Cross-carrier scheduling

### R1-2108935 (ZTE, Sanechips)

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| The cross-carrier scheduling here mainly refers to cross-carrier scheduling of a cell within 52.6-71GHz band from/to a cell within FR1/FR2. Although a cell within 52.6-71GHz band cross-carrier schedules other cells within FR1/FR2 is less likely, it should not be ruled out unless we find enough proof. Similarly, we do not think that we can rule out the case of a cell with low SCS (e.g. 15kHz) cross-carrier schedules other cells with high SCS (e.g. 480kHz) in this phase before sufficient research. Moreover, in order to further reduce the scheduling complexity, we support the cross-carrier scheduling via adding some restrictions.  **Proposal 5: Cross-carrier scheduling of a cell within 52.6-71 GHz band from/to a cell within FR1/FR2 is supported, at least for |*μPDCCH* − *μPDSCH* | ≤ k.**  Another problems related to cross-carrier scheduling are minimum PDSCH scheduling delay and minimum A-CSI- RS trigger delay. In Rel-15/16 NR, cross-carrier scheduling only supports four cases of PDCCH with u = 0, 1, 2 and 3, as given in Table 5.5-1 and Table 5.2.1.5.1a in TS 38.214. The 120kHz SCS in above 52.6GHz band can reuse the value of u = 3. But the values of *µPDCCH* with 480/960kHz SCS needs to be determined. The same values of *µPDCCH* for minimum PDSCH scheduling delay and minimum A-CSI-RS trigger delay can be used for 480/960kHz SCS.  TS 38.214 Table 5.5-1: *Npdsch* as a function of the subcarrier spacing of the scheduling PDCCH   |  |  | | --- | --- | | ***µPDCCH*** | ***Npdsch* [symbols]** | | 0 | 4 | | 1 | 5 | | 2 | 10 | | 3 | 14 |   TS 38.214 Table 5.2.1.5.1a: *Ncsirs* as a function of the subcarrier spacing of the triggering PDCCH   |  |  | | --- | --- | | ***µPDCCH*** | ***Ncsirs* [symbols]** | | 0 | 4 | | 1 | 5 | | 2 | 10 | | 3 | [14] |   **Proposal 6: The values of *µPDCCH* with 480/960kHz SCS for minimum PDSCH scheduling delay and minimum A-CSI-RS trigger delay should be determined.** |

### R1-2108960 (vivo)

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| For NR Rel-16 UEs, there exists two types of PDCCH monitoring capability (i.e. slot-based and span-based) if it reports ***pdcch-Monitoring-r16***. In this case, gNB may configure the capability type for a serving cell. If not configured, Rel-15 slot-based capability if the default one to be used. Then the following two types of serving cell may exist for one UE:   * Cell Type 1 (FR1/FR2): Serving cell with slot-based PDCCH monitoring capability; * Cell Type 2 (FR1 only): Serving cell with span-based PDCCH monitoring capability.   Thus, the following cases may occur for one UE:   * Case 1: All serving cells belongs to cell type 1; * Case 2: All serving cells belongs to cell type 2; * Case 3: At least one serving cell belongs to cell type 1 and at least one serving cell belongs to cell type 2.   In general, the following table summarizes the relation of UE reporting capability and allowed gNB configuration cases:   |  |  |  | | --- | --- | --- | | UE type | Reporting capability | Allowed Operation | | Rel-16 UEs | - | Case 1 only | | Rel-16 UEs | ***pdcch-Monitoring-r16*** | Case 1/Case 2 | | Rel-16 UEs | ***pdcch-Monitoring-r16***  ***pdcch-MonitoringMixed-r16*** | Case 1/Case 2/Case 3 |   Besides, NR Rel-16 UEs will report capability related parameters (e.g. ) for each case respectively.  If multi-slot-based capability is introduced for NR Rel-17 UEs, how to configure or determine the capability type needs to be considered. As long as multi-slot-based capability is the mandatory one for BWP with 480K/960K SCS according to , configuration of 480K/960K SCS for a BWP implies multi-slot-based capability for that BWP, which means PDCCH monitoring capability should be defined per BWP.  Proposal 3: For NR Rel-17 UEs, PDCCH monitoring capability is defined per BWP and configuration of 480K/960K SCS for a BWP implies multi-slot-based capability for that BWP.  After defining the PDCCH monitoring capability per BWP, the capability for one serving cell should also be determined for calculation of BD/CCE budget in multiple serving cell case. The straight forward way is to adopt the PDCCH monitoring capability for active BWP or configured first active BWP as the capability of the serving cell.  Proposal 4: PDCCH monitoring capability for a serving cell is the capability for its active BWP or configured first active BWP when it is deactivated.  Compared to NR Rel-16, one additional cell type occurs:   * Cell Type 3 (FR2-2 only): Serving cell with multi-slot-based PDCCH monitoring capability.   In addition to the operation cases in NR Rel-16, there may be more cases as listed below:   * Case 4: All serving cells belongs to cell type 3; * Case 5: At least one serving cell belongs to cell type 1 and at least one serving cell belongs to cell type 3; * Case 6: At least one serving cell belongs to cell type 2 and at least one serving cell belongs to cell type 3; * Case 7: At least one serving cell belongs to cell type 1, at least one serving cell belongs to cell type 2 and at least one serving cell belongs to cell type 3.   Observation 1: More additional cases are brought by introduction of multi-slot-based PDCCH monitoring capability.  In multi-cell operation scenario, BD/CCE budget calculation becomes more complex by introducing such multi-slot-based BD/CCE budget definition, i.e. more additional cases as described in 2.1.3.  As one straightforward way, the BD/CCE budget calculation adopts the same way for NR Rel-16, i.e. serving cells with the same PDCCH monitoring type are grouped together for further handling. Particularly, the follows steps apply:   * Determination of : UE needs to report respective for different cases, i.e. Case 1-7 as described in 2.1.3. For the case with mixed capability, *L* values need to be reported where *L* is the number of capability types in that case (e.g. 3 in case 7); * Determination of total limit for each group of serving cells:   + If the group adopts slot-based or span-based capability, legacy way is used;   + If the group adopts multi-slot-based capability, further divide the cell group into different parts depending on SCS and/or value of X/Y. Then BD/CCE budget for the serving cells will follow one total limit. Note that there may have certain limits in the group or part of serving cells.   As another alternative, the serving cell with SCS µ and multi-slot-based capability can be transformed to an equivalent virtual serving cell with SCS µ’ and slot-based capability, e.g. e.g. cell A with 480KHz SCS and BD/CCE budget per 4 slots is equivalent to a virtual cell A’ with 120KHz and BD/CCE budget per slot.  **Proposal 6: For multi-cell operation, the following alternatives could be considered:**  **Alt. 1: Serving cells with the same PDCCH monitoring type including multi-slot-based capability are grouped together for further BD/CCE budget calculation;**  **Alt. 2: Transform the serving cell with multi-slot-based capability to equivalent serving cell with slot-based capability for further BD/CCE budget calculation.** |

### R1-2109209 (CATT)

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| In the RAN1#106-e, the maximum difference of SCS of cross-carrier scheduling, i.e, , has been discussed. In the Rel-16, the maximum difference of SCS is equal to 3. However, 480 kHz SCS and 960 kHz SCS have been supported for 52.6-71GHz. We believe the maximum difference of SCS of cross-carrier scheduling should be expanded to support of new SCS, and there is no motivation to limit the difference of SCS of cross-carrier scheduling.  ***Proposal 11：In order to better support cross-carrier scheduling of the new SCS, i.e. 480 kHz and 960 kHz, the difference of SCS of cross-carrier scheduling should not be limited.*** |

### R1-2109402 (Xiaomi)

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| In current spec, UE can report its cross carrier scheduling capability for DL/UL separately by one of { low-to-high, high-to-low, both}, which has no restriction on the SCS difference of the carrier pair(the scheduling/scheduled carriers). but with the introduction of SCS 480/960KHz in NR 52.6-71GHz, the SCS difference of the carrier pair would be too large for UE to handle, for example, with carrier pair=15/480KHz, a slot in PDCCH channel would cover 32 slots in PDSCH channel. suppose the PDCCH channel is 3 symbol length, and UE need 2 symbol(in PDCCH channel) to decode the PDCCH, then and UE has to buffer all the PDSCH information with length of 5\*32=160 symbol in PDSCH channel. this would be challenging for UE implementation. So some restriction on cross carrier scheduling would be desirable, for example, UE can report its capability for supported carrier pair like .  ***Proposal 9: Some restriction on cross carrier scheduling would be desirable, for example, UE can report its capability for supported carrier pair like*** |

### R1-2109599 (Intel)

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| Cross-carrier scheduling is a quite useful feature for NR. Therefore, it is expected that cross-carrier scheduling between serving cells using SCS 120/480/960kHz can be supported. On the other hand, one more discussion point is the carrier aggregation (CA) between a cell in FR2-2 and a cell in FR2-1 or even FR1. From specification completeness point of view, such CA scenario could be supported, especially considering a PCell in lower frequency than 52.6-71GHz is more appropriate for coverage/robustness. As discussed in MR-DC in Rel-16, the minimum PDSCH scheduling delay and minimum A-CSI RS triggering offset applicable to SCS 480kHz and 960kHz should be discussed. On the other hand, if such kind of CA is supported and cross-carrier scheduling is considered, an extreme case could be that a slot with SCS 15kHz is used to schedule up to 64 slots with SCS 960kHz. Without a clear motivation, we prefer to avoid unnecessary optimization.  **Proposal 9:**   * Cross-carrier scheduling of cell in FR2-2 from/to a cell of FR1 and FR2-1 is allowed by specification   + The minimum PDSCH scheduling delay and the minimum A-CSI RS triggering offset applicable to SCS 480kHz and 960kHz needs to be discussed.   + Additional enhancements are deprioritized unless a clear motivation is identified. |

### R1-2109962 (LG)

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| For carrier aggregation in rel-15/16, if a UE is configured with DL cells greater than the number of BD capable cells (reported by *pdcch-BlindDetectionCA*), the total number of PDCCH candidates or non-overlapped CCEs per slot or per span should be recalculated according to the following specifications in 38.213 clause 10.1.   |  | | --- | | If a UE  - is configured with downlink cells for which the UE is not provided *monitoringCapabilityConfig,* or is provided *monitoringCapabilityConfig-r16* = *r15monitoringcapability* but not provided *coresetPoolIndex*,  - with associated PDCCH candidates monitored in the active DL BWPs of the scheduling cell(s) using SCS configuration , where , and  - a DL BWP of an activated cell is the active DL BWP of the activated cell, and a DL BWP of a deactivated cell is the DL BWP with index provided by *firstActiveDownlinkBWP-Id* for the deactivated cell,  the UE is not required to monitor more than PDCCH candidates or more than non-overlapped CCEs per slot on the active DL BWP(s) of scheduling cell(s) from the downlink cells. is replaced by if a UE is configured with downlink cells for which the UE is provided both *monitoringCapabilityConfig-r16* = *r15monitoringcapability* and *monitoringCapabilityConfig-r16* = *r16monitoringcapability*.  << omitted >>  If a UE is configured only with downlink cells for which the UE is provided *monitoringCapabilityConfig* = *r16monitoringcapability* and with associated PDCCH candidates monitored in the active DL BWPs of the scheduling cells using SCS configuration , and with of the downlink cells using combination for PDCCH monitoring, where , a DL BWP of an activated cell is the active DL BWP of the activated cell, and a DL BWP of a deactivated cell is the DL BWP with index provided by *firstActiveDownlinkBWP-Id* for the deactivated cell, the UE is not required to monitor more than PDCCH candidates or more than non-overlapped CCEs  - per set of spans on the active DL BWP(s) of all scheduling cell(s) from the downlink cells within every symbols, if the union of PDCCH monitoring occasions on all scheduling cells from the downlink cells results to PDCCH monitoring according to the combination and any pair of spans in the set is within symbols, where first symbols start at a first symbol with a PDCCH monitoring occasion and next symbols start at a first symbol with a PDCCH monitoring occasion that is not included in the first symbols  - per set of spans across the active DL BWP(s) of all scheduling cells from the downlink cells, with at most one span per scheduling cell for each set of spans, otherwise  where is a number of configured cells with associated PDCCH candidates monitored in the active DL BWPs of the scheduling cells using SCS configuration . If a UE is configured with downlink cells for which the UE is provided both *monitoringCapabilityConfig* = *r15monitoringcapability* and *monitoringCapabilityConfig* = *r16monitoringcapability*, is replaced by . |   These operation can be reused (or with simple modification) for 480 kHz and 960 kHz when multi-slot PDCCH monitoring is applied and X (or Y) for each cell or each SCS are (timely) aligned. However, if X(or Y) value is the same but its location is not aligned for each numerology or for each cell (or if X,Y values are different across serving cells), it may be uncertain whether above operation could be reused as it is. To figure out the uncertainty, it should be investigated how to handle BD/CCE capabilities of multi-slot monitoring for carrier aggregation.  **Proposal #9: It is necessary to study how to handle BD/CCE capability when the number of configured DL cells is greater than .** |

### R1-2110022 (Apple)

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| For cross carrier scheduling the following issues should be studied:   1. *RAN1 should modify the parameter Npdsch to account for the new SCSs:* The parameter *Npdsch,* i.e., the # of PDCCH symbols after the end of the PDCCH scheduling the PDSCH needs to be modified for the new SCSs. 2. *RAN1 should study the effect of a large differential between the SCSs of the carriers involved in the cross carrier scheduling procedure.* In a scenario with different numerologies between PDSCH and PUCCH, a large differential between the SCSs may result in a large gap between a transmitted PDSCH(s) and its corresponding PUCCH. In one simple example, assume that the transmission occurs such that the HARQ is on FR1 with the SCS set to 15 kHz which is equivalent to 32 480 kHz slots. A frame structure of DDDSU would require an aggregation of up to 96 slots. The maximum differential changes from 8 (120 kHz to 15 kHz) to 64 (960 kHz to 15 kHz). 3. *The maximum number of carriers that can be simultaneously scheduled from a single carrier should be defined as a UE capability.* This may be necessary given the possible increase in the bandwidth of the different transmissions, and the increase in data rate for the new SCSs.   ***Proposal 11****: RAN1 should modify the parameter Npdsch, i.e. the # of PDCCH symbols after the end of the PDCCH scheduling the PDSCH, to account for the new SCSs.*  ***Proposal 12:*** *RAN1 should study the effect of a large differential between the SCSs of the carriers involved in the cross-carrier scheduling procedure.*  ***Proposal 13:*** *for cross-carrier scheduling, the max number of CCs that can be scheduled from a single CC is reported as UE capability.* |

### R1-2110173 (Qualcomm)

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| **Issue 1: Complexity of multi-carrier PDCCH BD/CCE calculation and overbooking**  If a UE is configured with multiple downlink cells of 480 kHz or 960 kHz SCSs, and each of the multiple cells is configured with multi-slot PDCCH monitoring, the distribution of the budget of monitored PDCCH candidates and non-overlapped CCEs across the carriers should be considered. A potential benefit of adopting the Alt 2 definition of the multi-slot PDCCH monitoring is that the existing rules associated with Rel-16 per-span PDCCH monitoring capability (*pdcch-MonitoringCA-r16*) may directly be applied (Section 10.1 in TS 38.213). That is, the distribution rules depend on the SCSs of active BWPs of the active cells, and on whether the spans of Y symbols/slots are aligned or not aligned across cells.  However, a concern raised in RAN1 #106-e was whether the same rule in Rel-16 is really applicable to Alt 2 [4]. The problematic case is when the span, i.e., Y, is larger than one slot. However, as we proposed in Proposal 5, if the value of Y is no larger than one slot, the existing Rel-16 rule can be directly used.  Observation 3: For multi-slot PDCCH monitoring capability Alt 2, at least when Y ≤ 1 slot, the existing rules for Rel-16 per-span PDCCH monitoring can directly be applied to determine multi-carrier PDCCH monitoring capability.  Similarly, for PDCCH overbooking, the existing rules associated with Rel-16 per-span PDCCH monitoring capability can directly be applied. That is, overbooking is allowed only on a primary cell, and dropping of PDCCH candidates and non-overlapped CCEs is performed on a span-basis.  Observation 4: For multi-slot PDCCH monitoring capability Alt 2, the existing rules for Rel-16 per-span PDCCH monitoring can directly be applied for PDCCH overbooking and dropping.  To support both SA and NSA operations efficiently for cells in 52.6-71 GHz, extending the use of cross-carrier scheduling seems necessary. However, when the SCS difference between the scheduling and scheduled cells are very large (e.g., scheduling from 15 kHz SCS to 960 kHz SCS, and vice versa), the gain of cross-carrier scheduling may be harmed, while the design (e.g., timeline design) would be complicated. Therefore, it would be fair to put some restriction on the selection of SCSs. Since Rel-15 already supports cross-carrier scheduling between 15 kHz and 120 kHz SCSs as the extreme case, the same ratio of SCSs may be assumed for 51.6-71 GHz.  Proposal 9: Cross-carrier scheduling of a cell within 52.6-71 GHz from/to a cell outside 52.6-71 GHz is supported, at least for |*μPDCCH* − *μPDSCH* | ≤ *k*.   * **FFS: value of *k* (e.g., *k* = 3)** |

## Topic E: Other

# List of submitted TDocs

The following TDocs have been used to compile above summary:

**R1-2108768 Enhancement on PDCCH monitoring Huawei, HiSilicon**

**R1-2108783 PDCCH monitoring enhancements FUTUREWEI**

**R1-2108887 Discussion on PDCCH monitoring enhancements for above 52.6GHz Transsion Holdings**

**R1-2108935 Discussion on the PDCCH monitoring enhancements for 52.6 to 71GHz ZTE, Sanechips**

**R1-2108960 Discussions on PDCCH monitoring enhancements for NR operation from 52.6GHz to 71GHz vivo**

**R1-2109071 Discussion on PDCCH monitoring enhancement OPPO**

**R1-2109117 Discussion on PDCCH monitoring enhancements supporting NR from 52.6GHz to 71 GHz NEC**

**R1-2109209 PDCCH monitoring enhancements for up to 71GHz operation CATT**

**R1-2109402 PDCCH monitoring enhancement for NR 52.6-71GHz Xiaomi**

**R1-2109434 PDCCH Monitoring Enhancements Ericsson**

**R1-2109443 PDCCH monitoring enhancements Nokia, Nokia Shanghai Bell**

**R1-2109477 PDCCH monitoring enhancements for NR from 52.6 GHz to 71 GHz Samsung**

**R1-2109560 PDCCH monitoring enhancement for 52.6-71 GHz NR operation MediaTek Inc.**

**R1-2109599 Discussion on PDCCH monitoring enhancements for extending NR up to 71 GHz Intel Corporation**

**R1-2109666 PDCCH monitoring enhancements for NR from 52.6 to 71 GHz NTT DOCOMO, INC.**

**R1-2109778 PDCCH enhancement for NR from 52.6GHz to 71GHz Sony**

**R1-2109898 PDCCH monitoring enhancements for NR from 52.6 GHz to 71GHz Lenovo, Motorola Mobility**

**R1-2109904 Discussions on PDCCH monitoring enhancements InterDigital, Inc.**

**R1-2109962 PDCCH monitoring enhancements to support NR above 52.6 GHz LG Electronics**

**R1-2109993 PDCCH monitoring enhancements Sharp**

**R1-2110022 PDCCH Enhancements for above 52.6 GHz Apple**

**R1-2110110 PDCCH Monitoring for NR from 52.6 GHz to 71 GHz Convida Wireless**

**R1-2110173 PDCCH monitoring enhancements for NR in 52.6 to 71GHz band Qualcomm Incorporated**

**R1-2110248 PDCCH monitoring enhancements Charter Communications**

**R1-2110252 PDCCH monitoring for NR operation from 52.6 to 71 GHz Panasonic**