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

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

**Agenda Item: 8.8.1.3**

**Source: Moderator (China Telecom)**

**Title: [106bis-e-NR-R17-CovEnh-03] Summary of email discussion on joint channel estimation for PUSCH**

**Document for: Discussion**

1. Introduction

In RAN #90 e-meeting, a new Rel-17 work item on NR coverage enhancements was approved [1] and was revised in [2]. The objective of this work item is to specify enhancements for PUSCH, PUCCH and Msg3 PUSCH for both FR1 and FR2 as well as TDD and FDD.

The detailed objectives are as follows.

* *Specification of PUSCH enhancements [RAN1, RAN4]*
  + *Specify the following mechanisms for enhancements on PUSCH repetition type A [RAN1]*
    - *Increasing the maximum number of repetitions up to a number to be determined during the course of the work.*
    - *The number of repetitions counted on the basis of available UL slots.*
  + *Specify mechanism(s) to support TB processing over multi-slot PUSCH [RAN1]*
    - *TBS determined based on multiple slots and transmitted over multiple slots.*
  + *Specify mechanism(s) to enable joint channel estimation [RAN1, RAN4]*
    - *Mechanism(s) to enable joint channel estimation over multiple PUSCH transmissions, based on the conditions to keep power consistency and phase continuity to be investigated and specified if necessary by RAN4 [RAN1, RAN4]*
      * *Potential optimization of DMRS location/granularity in time domain is not precluded*
    - *Inter-slot frequency hopping with inter-slot bundling to enable joint channel estimation [RAN1]*
* *Specification of PUCCH enhancements [RAN1, RAN4]*
  + *Specify signaling mechanism to support dynamic PUCCH repetition factor indication [RAN1]*
  + *Specify mechanism to support DMRS bundling across PUCCH repetitions [RAN1, RAN4]*
    - *When applicable, based on similar mechanism(s) for enabling joint channel estimation for PUSCH*
* *Specify mechanism(s) to support Type A PUSCH repetitions for Msg3 [RAN1, RAN2]*

This contribution is a summary of joint channel estimation for PUSCH.

1. Summary of contributions

## 2.1 Conditions to keep power consistency and phase continuity

Based on the LSs between RAN1 and RAN4 [3]-[10], the conditions for UE to keep power consistency and phase continuity among PUSCH transmissions for different scenarios can be summarized as follows:

**Back-to-back transmissions with zero gap in-between adjacent transmissions**

In order to maintain phase continuity, the following conditions should be met:

* Modulation order does not change.
* RB allocation in terms of length and frequency position should not be changed, and intra-slot and inter-slot frequency hopping is not enabled within a repetition bundle.
* No change on transmission power level of its own CC, i.e., no change on the power control parameters specified in TS 38.213, and also when own CC is not impacted by other concurrent CC(s) that are configured for inter-band CA or DC for same UE with dynamic power sharing and no change in any configured CC s that are part of configured intra-band uplink CA or DC.
* No UL beam switching for FR2 UE occurs.
* Applying the same TPMI precoder across PUSCH transmissions.
* TA adjustment and UE uplink timing autonomous adjustments cause the phase to change. RAN4 is still investigating the full impacts of the detailed scenarios, and will provide a final view about this at the next RAN4 meeting.

**Non-back-to-back transmission with non-zero gap in-between adjacent transmissions**

For non-back-to-back transmission with non-zero gap in-between adjacent transmissions, RAN4 concluded that at least following additional condition also need to be met in addition to the conditions for Back-to-back transmissions:

* No downlink reception in-between the PUSCH or PUCCH repetition in the same band for TDD case.
  + The “downlink reception” means downlink symbols with actual DL transmission from gNB to UE and/or DL monitoring with the assumption that UE is receiving information.
  + Regarding whether “downlink reception” include downlink symbols without actual DL transmission from gNB to UE and without DL monitoring, it would be helpful if RAN1 could provide more information on the exact scenario.
  + Phase discontinuity tolerance LLS is ongoing in RAN4 study and conditions of whether the phase continuity can be maintained in TDD case that has downlink reception in-between the PUSCH or PUCCH repetition could be revisited in future meeting with consideration of phase discontinuity tolerance. RAN4 is also still checking whether there are any optional UE antenna configurations where a UE could overcome this problem and still gain from using the feature.
* In scenario of no more than X un-scheduled OFDM symbols in-between the PUSCH or PUCCH repetition (e.g., X = 0, 1, 2, …, 14), RAN4 confirms the feasibility of phase continuity and power consistency for non-zero un-scheduled gap case for a gap less than 14 symbols when UE is not required to meet the existing off power requirements. RAN4 has further agreed that the 13-symbol is the maximum length for the gap for all SCS, and that the 14-symbol or 1ms will not be discussed in RAN4 anymore for un-scheduled gap in Rel-17 [8].
* In scenario of other UL channels in-between PUCCH or PUSCH repetitions, e.g., SRS or other PUCCH, at least if the other scheduled signals/channels during the non-zero gap have the same settings in antenna port, allocated number and locations of PRBs transmitted, and PAPR and average power, e.g., PUSCH/PUCCH part of repetitions and SRS has same PAPR and average power, it is feasible to maintain the phase continuity and power consistency across the repetitions. RAN4 has agreed that it is not considered for UE to transmit other channels in the gap with different settings.
* RAN4 has not agreed detailed requirement for phase continuity and plans to revisit the above agreement in the scenario of other UL signals/channels in the gap once the requirement is defined. Therefore, RAN4 would like to ask RAN1 what are the consequences if phase continuity cannot be maintained in that scenario?

In [10], RAN1 provide the following information to RAN4 on the scenario when “downlink reception” from UE point of view includes downlink symbols without actual DL transmission from gNB to UE and UE is not assumed to do DL monitoring:

* In RAN1 understanding, regarding to the “downlink reception”, there are actually three scenarios:
  + Scenario 1: downlink or flexible symbols with actual DL transmission from gNB to UE, with/without DL monitoring occasion configured.
  + Scenario 2: downlink or flexible symbols without actual DL transmission from gNB to UE, but with DL monitoring occasion configured.
  + Scenario 3: downlink or flexible symbols without DL monitoring occasion configured.

RAN1 further respectfully asks RAN4 to provide answer to the following question.

* Question 1: In additional to scenario 1 and 2, does the “downlink reception” in RAN4 reply LS R4-2103393 (“No downlink reception in-between the PUSCH or PUCCH repetition in the same band for TDD case”) further include scenario 3?

**The maximum duration**

In the latest LS from RAN4 [9], RAN4 replied RAN1’s questions related to the maximum duration and provided further agreement for the gap between PUSCH/PUCCH transmissions, details are listed as follows:

|  |  |
| --- | --- |
| **RAN1’s questions** | **RAN 4’s answers** |
| For joint channel estimation, is there a maximum duration during which UE is able to maintain power consistency and phase continuity under certain tolerance level? If any, how long is it? | Yes, there is a maximum duration but RAN4 has not agreed how many slots it is. |
| What factors determine the maximum duration? | RAN4 has agreed that TA adjustment should be avoided across the PUSCH/PUCCH transmissions (i.e., from start of first transmission until the end of last transmission) for joint channel estimation. RAN4 is still investigating other factors impact in more detail. |
| Whether the maximum duration should be the same for different cases for both PUSCH and PUCCH? | Yes. |
| Whether the maximum duration is dependent on the modulation order of transmission, e.g., QPSK, 16QAM, 64QAM? | Considering the scenario of coverage extension, RAN4 recommends to only focus on modulation orders not higher than QPSK, i.e., focus on QPSK (PUCCH and PUSCH), Pi/2 BPSK (PUCCH and PUSCH), BPSK (PUCCH). RAN4 is still discussing whether maximum duration depends on modulation order for the above modulation schemes. |
| Whether the maximum duration is dependent on UL waveform (DFT-s-OFDM vs. OFDM)? | No. |
| Besides the factors listed above, whether or not the maximum duration is further dependent on UE capabilities (e.g., multiple possible values for a given set of factor(s)), and if so, whether the UE should report such a duration. | Still under discussion in RAN4. |

## 2.2 Use cases for joint channel estimation

RAN1 has identified the potential use cases for joint channel estimation for PUSCH.

* Use case 1: back-to-back PUSCH transmissions within one slot.
* Use case 2: non-back-to-back PUSCH transmissions within one slot.
  + Use case 2a: no uplink transmission in the middle of two PUSCH transmissions
  + Use case 2b: other uplink transmissions in the middle of two PUSCH transmissions
* Use case 3: back-to-back PUSCH transmissions across consecutive slots.
* Use case 4: non-back-to-back PUSCH transmissions across consecutive slots.
  + Use case 4a: no uplink transmission in the middle of two PUSCH transmissions
  + Use case 4b: other uplink transmissions in the middle of two PUSCH transmissions
* Use case 5: PUSCH transmissions across non-consecutive slots.
  + Use case 5a: no uplink transmission in the middle of two PUSCH transmissions
  + Use case 5b: other uplink transmissions in the middle of two PUSCH transmissions

Note: RAN1 assumes “back-to-back PUSCH transmission” has zero gap in-between adjacent PUSCH transmissions.

Note: intervening “other uplink transmissions” can be either on the same component carrier or a different component carrier.

In the past RAN1 meetings, it was discussed whether joint channel estimation can be applied to the above uses cases. In addition, during online discussion of RAN1 #106-e meeting, according to the guidance from Chair there would be no further discussion for transmissions with different TBs. Based on the discussion and agreements so far, the situation is summarized in the following table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Use cases | Repetition type A for the same TB | Repetition type B for the same TB | Transmissions with different TBs | TBoMS |
| 1: B2B PUSCH transmission within one slot | / | Support | Not support | / |
| 2: Non-B2B PUSCH transmission within one slot | / | Not support | Not support | / |
| 3: B2B PUSCH transmissions across consecutive slots | Support | Support | **No further discussion** | Working Assumption |
| 4: Non-B2B PUSCH transmissions across consecutive slots | Support  (4a) | Support  (4a) | **No further discussion** | TBD |
| TBD  (4b) | TBD  (4b) |
| 5: PUSCH transmissions across non-consecutive slots | TBD | TBD | **No further discussion** | TBD |

Thus, it can be seen that only TBoMS (Use case 3 and Use case 4a), Use case 4b and Use case 5 are remained to be discussed.

### 2.2.1 TBoMS for Use case 3 and Use case 4a

Regarding TBoMS for Use case 3, a working assumption was achieved in RAN1 #104-e meeting as follows:

|  |
| --- |
| **Working assumption:**   * For back-to-back PUSCH transmissions across consecutive slots, support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation for the following case:   + Over back-to-back PUSCH transmissions for one TB processed over multiple slots     - It’s subject to UE capability |

Regarding TBoMS for Use case 4a, 4 companies (Spreadtrum, CTC, Sony, WILUS) propose to support it.

One company (LG) proposes that reusing the technology for PUSCH repetition type A can be considered for TBoMS and do not support the technology dedicated for TBoMS.

### 2.2.2 Use case 4b

For use case 4b, companies’ views are summarized as follows:

* Use case 4b: non-back-to-back PUSCH transmissions across consecutive slots w/ other uplink transmissions in the middle of two PUSCH transmissions.
  + **Support**: Sony (TBoMS), Nokia, NSB, InterDigital (?)
  + **Not Support**: ZTE, Spreadtrum, vivo, TCL, Panasonic, Qualcomm

**Nokia:** For non-back-to-back PUSCH transmissions, in case the other UL transmission in between two successive PUSCHs has different settings than PUSCH, the gNB indicates one of the following options to the UE:

* Option 1: Adapt the settings of the other UL transmission to make it be the same as PUSCHs.
* Option 2: Multiplex the data of the other UL transmission on PUSCH.
* Option 3: Drop the other UL transmission with different settings.
* Option 4: Transmit the other UL transmission with different settings and break the phase continuity.

Dropping/transmitting only part of the UL transmissions with different settings within the repetition period/time-domain window is also possible and should be indicated by the gNB.

|  |
| --- |
| Option 1 Option 2 Option 3 |

**Sony**: Introduce a capability defining if UE support of JCE with UL transmissions in between two PUSCH transmissions.

### 2.2.3 Use case 5

For use case 5, Companies’ views are summarized as follows:

* Use case 5a: PUSCH transmissions across non-consecutive slots w/ no uplink transmission in the middle of two PUSCH transmissions.
  + **Not Support**: ZTE, vivo, CTC, CMCC, Intel, Sierra Wireless, WILUS, Qualcomm
* Use case 4b: PUSCH transmissions across non-consecutive slots w/ other uplink transmissions in the middle of two PUSCH transmissions.
  + **Not Support**: ZTE, vivo, CTC, CMCC, Panasonic, Intel, Sierra Wireless, WILUS, Qualcomm

### 2.2.4 Use case for UL CA

One company (ZTE) analyzes the benefit of using two carriers w/ Tx switching over single carrier under UL CA scenario. As shown in the following figure, there are two inter-band carriers with unaligned frame boundary, if Tx switching is considered It is also pointed out that the phase continuity can be kept for CA at least when PUSCH is only transmitted in one carrier at a given time.



Fig. Tx switching with unaligned frame boundary for CA

## 2.3 Time domain window for joint channel estimation

In RAN1 #104b-e meeting, a time domain window (TDW) was agreed to be specified, during which **UE is expected to** maintain power consistency and phase continuity among PUSCH transmissions subject to power consistency and phase continuity requirements. In RAN1 #105-e meeting, the maximum duration is defined to facilitate the discussion (whether it is specified is up to RAN4), during which **UE is able** to maintain power consistency and phase continuity subject to power consistency and phase continuity requirements. It is understood that for a UE, the maximum duration is no less than the time domain window duration. In RAN1 #106-e meeting, a working assumption for the framework of TDW is achieved, but there are some FFS needs further discussion. In this section, companies’ views on the TDW design are summarized.

### 2.3.1 Configured time domain window

Based on companies’ contributions, several issues about configured TDW are discussed. The issues as well as companies’ views are summarized as follows.

#### Issue #1: The window length *L* of the configured TDW

**Issue #1-1: The maximum value of *L***

* **Option 1:** The maximum value of window length *L* should not exceed the maximum duration.
  + **Support**: HW, HiSilicon, ZTE, Spreadtrum, vivo, OPPO, CATT, CMCC, Samsung, MediaTek, Intel, Sierra Wireless, InterDigital, Lenovo, Motorola Mobility, WILUS, Sharp, Qualcomm, WILUS, Panasonic
* **Option 2:** The maximum value of window length *L* can exceed the maximum duration e.g. equals to the duration of all repetitions.
  + **Support**: CTC, Apple, LG, Nokia, NSB, Ericsson

If the maximum value of window length *L* exceeds the maximum duration, some companies find that misalignment on actual TDW between gNB and UE may happen, e.g. if events are triggered by dynamic signaling and the dynamic signaling is missed, error propagation may be raised. However, some companies point out that on one hand, only dynamic events may cause error propagation; on the other hand, unicast PDCCH should always be considered as a reliable channel, even in coverage shortage scenario. Thus, “missing DCI” can be considered as a corner case.

Regarding the issue of error propagation, one company (Nokia) proposes the following options to handle it by gNB:

* If the gNB anticipates that there is a chance of missing DCI, it may configure a short configured TDW size L such that the impact of error propagation is minimized.
* The gNB may try to detect the dynamic event and know whether the actual TDWs are determined without or with the dynamic event by the UE and perform JCE accordingly.
* The gNB may apply a conservative approach by performing JCE only on the PUSCHs repetitions that are not impacted by the error propagation.

**Issue #1-2: Configuration/Indication of *L***

* Configured by RRC or indicate by DCI?

Three companies (HW, Sharp, vivo) propose that *L* could be configured by RRC, while one company (NTT DOCOMO) propose to indicate *L* by DCI dynamically, according to PUSCH resource allocation, interval of updating power and frequency offsets, gain of joint channel estimation, and effect of error propagation.

One company (Panasonic) supports to use an entry of TDRA table to signal the window length *L* of the configured TDW(s) for DG-PUSCH and Type 2 CG-PUSCH and use RRC configuration to signal *L* for CG type 1.

* Configured per BWP or per channel?

Two companies (HW, Sharp) propose that *L* could be configured per UL BWP by RRC, while one company (vivo) proposes to configure *L* per channel/signal instead of per BWP and support to configure *L* separately for PUSCH and PUCCH.

* Default value of *L*

When L is not configured by network, one company (Lenovo) thinks the value of *L* be equal to the maximum duration while one company (Ericsson) thinks the value of *L* be equal to the scheduled duration of the repeated PUSCH.

#### Issue #2: The determination of configured TDW

**Issue #2-1: The start of the first configured TDW**

In the agreed working assumption, the start of the first configured TDW is the first PUSCH transmission. However, whether the start of the first configured TDW is the first available slot/symbol, or the first physical slot/symbol for the first PUSCH transmission needs further discussion. Companies’ views are summarized as:

* **Option 1:** The start of the first configured TDW is the first available slot for the first PUSCH transmission.
  + **Support**: HW, HiSilicon, vivo, CATT, CMCC, Samsung, InterDigital, WILUS, Nokia, NSB, Qualcomm, OPPO, Sharp, LG, Apple, Intel
* **Option 2:** The start of the first configured TDW is the first available symbol for the first PUSCH transmission.
  + **Support**: Spreadtrum, vivo, Samsung
* **Option 3:** The start of the first configured TDW is the first physical slot for the first PUSCH transmission.
  + **Support**: ZTE, CATT, CTC, MediaTek, OPPO, Sharp, Apple, Intel

**Issue #2-2: The start of other configured TDW**

In the agreed working assumption, the start of other configured TDWs can be implicitly determined prior to first repetition, details need further discussion. Companies’ views are summarized as:

For paired spectrum, it seems all companies support that the configured TDWs are consecutive.

For SUL band, companies (CTC, CMCC, WILUS) support that the configured TDWs are consecutive.

For unpaired spectrum, companies (CMCC, TCL, Intel, WILUS, Qualcomm, vivo) support that the start of the configured TDWs is implicitly determined based on semi-static DL/UL configuration. To be more specific, one company (CTC) proposes the start of other configured TDWs to be the physical slots right after DL slots for PUSCH transmission based on *tdd-UL-DL-ConfigurationCommon* and *tdd-UL-DL-Configuration Dedicated*. One company (Sony) propose to avoid using UL/DL configuration for definition of start of other configured TDW.

Some companies (Sharp, Nokia, NSB, ZTE) also think the configured TDWs can be consecutive regardless of paired spectrum/SUL band or unpaired spectrum.

Thus, in summary, there are three options as follows:

* **Option 1:** The configured TDWs are consecutive regardless of paired spectrum/SUL band and unpaired spectrum, i.e. the start of other configured TDWs is the first physical slot right after the previous TDW.
* **Option 2:** The start of other configured TDW is different for paired spectrum/SUL band and unpaired spectrum as follows:
  + For paired spectrum/SUL band, the configured TDWs are consecutive, i.e. the start of other configured TDWs is the first physical slot right after the last TDW.
  + For unpaired spectrum, the start of the configured TDWs is implicitly determined based on semi-static DL/UL configuration.

**Issue #2-3: The end of the last configured TDW**

In the agreed working assumption, the end of the last configured TDW is the end of the last PUSCH transmission. However, whether the end of the last configured TDW is the last available slot/symbol, or the last physical slot/symbol for the last PUSCH transmission needs further discussion. Companies’ views are summarized as:

* **Option 1:** The end of the last configured TDW is the last available slot for the last PUSCH transmission.
  + **Support**: CATT, CMCC, InterDigital, WILUS, Nokia, NSB, Samsung, OPPO, Sharp, LG, Apple, Intel
* **Option 2:** The end of the last configured TDW is the last available symbol for the last PUSCH transmission.
  + **Support**: Spreadtrum, HW, HiSilicon
* **Option 3:** The end of the last configured TDW is the last physical slot for the last PUSCH transmission.
  + **Support**:ZTE, CATT, CTC, MediaTek, OPPO, Sharp, Apple, Intel, Qualcomm

### 2.3.2 Actual time domain window

Based on companies’ contributions, several issues about actual TDW are discussed. The issues as well as companies’ views are summarized as follows.

#### Issue #3: The determination of actual TDW

**Issue #3-1: The start of the first actual TDW**

In the agreed working assumption, the start of the first actual TDW is the first PUSCH transmission within the configured TDW. However, whether it is the first available slot/symbol, or the first physical slot/symbol for the first PUSCH transmission needs further discussion. Companies’ views are summarized as follows.

* **Option 1:** The start of the first actual TDW is the first available slot for the first PUSCH transmission.
  + **Support**: HW, HiSilicon, ZTE, MediaTek, CMCC, Lenovo, Motorola Mobility, WILUS, InterDigital, Samsung, OPPO, LG, Apple, Intel
* **Option 2:** The start of the first actual TDW is the first available symbol for the first PUSCH transmission.
  + **Support**: ZTE, MediaTek, CATT, CTC, Lenovo, Motorola Mobility, Nokia, NSB, InterDigital, Samsung, Sharp
* **Option 3:** The start of the first actual TDW is the first physical symbol for the first PUSCH transmission.
  + **Support**: CATT

**Issue #3-2: The end of the actual TDW**

In the agreed working assumption, after one actual TDW starts, UE is expected to maintain the power consistency and phase continuity until one of the following conditions is met, then the actual TDW is ended.

* Condition 1: The actual TDW reaches the end of the last PUSCH transmission within the configured TDW.
* Condition 2: An event occurs that violates power consistency and phase continuity.

Regarding condition 1, whether the end of the actual TDW is the last available slot/symbol, or the last physical slot/symbol for the last PUSCH transmission within the configured TDW needs further discussion. Companies’ views are summarized as:

* **Option 1:** The end of the actual TDW is the last available slot for the last PUSCH transmission within the configured TDW.
  + **Support**: ZTE, MediaTek, CMCC, Samsung, InterDigital, Lenovo, Motorola Mobility, WILUS, OPPO, Apple, Intel
* **Option 2:** The end of the actual TDW is the last available symbol for the last PUSCH transmission within the configured TDW.
  + **Support**: HW, HiSilicon, ZTE, MediaTek, CATT, CTC, InterDigital, Lenovo, Motorola Mobility, Nokia, NSB, Sharp
* **Option 3:** The end of the actual TDW is the last physical symbol for the last PUSCH transmission within the configured TDW.
  + **Support**: CATT

Regarding condition 2, whether the end of the actual TDW is the last available slot/symbol of the PUSCH transmission right before an event such that the power consistency and phase continuity are violated needs further discussion. Companies’ views are summarized as:

* **Option 1:** The end of the actual TDW is the last available slot of the PUSCH transmission right before an event such that the power consistency and phase continuity are violated.
  + **Support**:ZTE, MediaTek, Samsung, InterDigital, Lenovo, Motorola Mobility, WILUS, OPPO, LG, Apple, Intel
* **Option 2:** The end of the actual TDW is the last available symbol of the PUSCH transmission right before an event such that the power consistency and phase continuity are violated.
  + **Support**: HW, HiSilicon, ZTE, MediaTek, CATT, CTC, CMCC, InterDigital, Lenovo, Motorola Mobility, Nokia, NSB, Sharp

**Issue #3-3: Events that violate power consistency and phase continuity**

There are two types of events, i.e., semi-static events and dynamic events. The potential events are summarized based on companies’ views.

|  |  |
| --- | --- |
| **Event type** | **Potential events** |
| Semi-static event | DL slot or DL reception/monitoring based on DL/UL configuration for unpaired spectrum |
| SSB transmission |
| CORESET0 with Type0-PDCCH CSS set |
| Invalid UL symbols |
| The actual TDW reaches the maximum duration |
| Frequency hopping (depend on whether it is an event) |
| Beam switching |
|  | |
| Dynamic event | High priority transmission |
| Transmission gap of more than 13 un-scheduled symbols |
| Transmission of an UL transmission with different settings than PUSCH repetitions in the middle of two PUSCH transmissions |
| Dynamic SFI |
| UL CI |
| TPC command (depend on whether it is an event) |
| TA adjustment (depend on whether it is an event) |
|  | Precoder cycling (?) |

**Other considerations:**

**ZTE**: Existing Rel-15/16 dropping/cancellation rules for PUSCH repetition type A and repetition type B are all defined as events that violate power consistency and phase continuity, including both semi-static and dynamic events need to be considered.

**LG**: The classification of event is necessary considering the start of actual time domain window.

* Event type 1 (e.g., downlink reception/monitoring and other uplink transmission): the start of following actual time domain window after the event should be postponed at least one slot.
* Event type 2 (e.g., applying TPC command and TA adjustment): the start of following actual time domain window after the event can be adjacent slot.



Fig. Illustration of Event type 1 and Event type 2

**Issue #3-4: Restarting DMRS bundling**

In the agreed working assumption, if the power consistency and phase continuity are violated due to an event, whether a new actual TDW is created is subject to UE capability of supporting restarting DMRS bundling.

Regarding this UE capability, two companies (vivo, CATT) think UE capability of restarting DMRS bundling is applied only to dynamic events. One company (Samsung) think the additional UE capability of supporting restarting DMRS bundling is not needed. One company (CMCC) proposes to discuss whether the resuming of capability to maintain the phase continuity and power consistency would cost some time.

Thus, there are two options for UE capability of restarting DMRS bundling:

* Option 1: UE capability of restarting DMRS bundling is applied only to dynamic events.
* Option 2: UE capability of restarting DMRS bundling is applied to both semi-static events and dynamic events.

If UE is capable of restarting DM-RS bundling, one new actual TDW is created after the event, companies’ views on whether the start of the new actual TDW is the first available slot or symbol for PUSCH transmission after the event are summarized as follows:

* **Option 1:** The start of the new actual TDW is the first available slot for PUSCH transmission after the event.
  + **Support**: HW, HiSilicon, ZTE, MediaTek, InterDigital, WILUS, Lenovo, Motorola Mobility, Samsung, OPPO
* **Option 2:** The start of the new actual TDW is the first available symbol for PUSCH transmission after the event.
  + **Support**: ZTE, MediaTek, CATT, CTC, InterDigital, Nokia, NSB, Lenovo, Motorola Mobility

**Other considerations:**

**Samsung**: When a new actual TDW is generated after the event, the minimum length of an actual TDW is 2 slots.

**Apple**: Actual time domain window is determined in the order of TDD UL/DL configuration, maximum duration, and event triggered by dynamic signalling.

### 2.3.3 TDW determination for PUSCH repetition type B

Although current TDW design is mainly for PUSCH repetition type A, companies (HW, HiSilicon, CTC, InterDigital) propose that the mechanism of TDW determination can be reused for PUSCH repetition type B.

**CATT:** For PUSCH transmissions (of the same TB) for repetition Type B across consecutive slots, it has been agreed to be supported if it only reuses those joint channel estimation specification enhancements defined to support repetition Type A. However, the ‘reuse range’ is unclear. Whether it includes the use of configured time domain window, the bundle size of inter-slot frequency hopping or something else needs further clarification.

**Lenovo:** For PUSCH coverage enhancement in NR Rel-17, joint channel estimation is applied to PUSCH repetition type B across consecutive slots with similar enhancements as for PUSCH repetition type A, i.e., no specific enhancements are needed on top of enhancements for PUSCH repetition type-A.

### 2.3.4 Coherent transmission indication

In RAN1#106-e, it was discussed the following scenarios that UE may lose transmission coherence (cannot perform DM-RS bundling) during the time domain window while gNB is not aware of it.

* transmission power drop due to dynamic power sharing of DC
* transmission is dropped due to uplink collision of CA/DC
* UE operates fine timing tracking to adjust FFT boundary when UE receive DL signal
* autonomous timing adjustment
* open loop power control
* large temperature variations

Based on the discussion, it seems companies acknowledge that UE may lose transmission coherence while gNB is not aware of it for CA/DC, but most companies think CA/DC is not a typical scenario for coverage enhancement. For “fine timing tracking”, “open loop power control” and “autonomous timing adjustment”, most companies think these should not be done during a TDW. Some companies thinks the UE should report DMRS bundling is not supported in case of large temperature variations. Then it seems the key point is whether CA/DC should be considered for coverage enhancements.

**Qualcomm**: UE signals a bundling indication in the UCI multiplexing with PUSCH transmission to indicate whether a PUSCH transmission is coherent with respect to the other PUSCH transmission. The motivation of the coherent transmission indication is due to the fact that some events on the UE side may impact the phase continuity but such change may not be known to the gNB. These events may include: frequency error correction, timing correction, RF calibration, antenna virtualization and etc.

**LG**: UE report the end of actual time domain window due to the dynamic event and/or start of the following actual time domain window by using DMRS resource (e.g., DMRS port, DMRS phase).

**Sierra Wireless**: dynamic coherent transmission indication by the UE is not supported in Rel-17.

### 2.3.5 The maximum duration

Based on the contributions, companies’ views about maximum duration are summarized below.

* **UE report its capability for the maximum duration**
  + **Support**: Spreadtrum, xiaomi (in initial access), Panasonic, Samsung

**CATT**: Whether the maximum duration should be reported by UE or not is up to the number of the maximum duration determined by RAN4.

**CMCC:** The time domain window during which a UE is expected to maintain power consistency and phase continuity among PUSCH transmission should be at least a UE capability. It should be defined in RAN1 and the specific values should be studied in RAN4.

## 2.4 Inter-slot frequency hopping with inter-slot bundling

In RAN1 #104b-e meeting, two options were agreed to be down selected about the bundle size of inter-slot frequency hopping with inter-slot bundling and companies’ views are summarized as follows:

* Option 1: The bundle size (time domain hopping interval) equals to the time domain window size.
* Option 2: The bundle size (time domain hopping interval) can be different from the time domain window.

Based on the working assumption, there are two kinds of TDWs, i.e., configured TDW and actual TDW, then Option 1 can further be split into two sub-options as follows.

* Option 1-1: The actual TDWs are determined first, then the time domain hopping intervals are implicitly determined based on the actual TDWs.

Note: There may be multiple time domain hopping intervals, each one equals to the length of corresponding actual TDW.

* + **Support**: Nokia, NSB, LG (?), ZTE, Apple (?)
* Option 1-2: The configured TDWs are determined first, then the time domain hopping interval is implicitly determined based on the configured TDWs.

Note: There is only one time domain hopping interval, which equals to the length L of configured TDWs.

* + **Support**: HW, HiSilicon, vivo, NTT DOCOMO, Sharp, Panasonic

For original Option 2, it can be further updated as:

* Option 2: The time domain hopping interval is configured or implicitly derived based on the number of repetitions. Inter-slot frequency hopping with inter-slot bundling is an event that violates power consistency and phase continuity.
  + FFS: Whether the time domain hopping interval is the divisor of the window length of the configured TDW
  + FFS: Whether the time domain hopping interval can be larger than the window length of the configured TDW

Note: The time domain hopping interval can be different from the window length of configured TDW and actual TDW.

* + **Support**: Qualcomm, OPPO, CATT, CTC, TCL, xiaomi, CMCC, Intel, Ericsson

The above three options are illustrated below:



Fig. Illustration of Option 1-1



Fig. Illustration of Option 1-2



Fig. Illustration of Option 2 (time domain hopping interval < configured TDWs window length)



Fig. Illustration of Option 2 (time domain hopping interval > configured TDWs window length)

For option 2, regarding how to determine the time domain hopping interval, there can be two alternatives.

* Alt 1: Inter-slot bundle size is implicitly determined by the number of repetitions K within one actual time domain window, e.g., M=K or floor (K/2) or cell(K/2).
* Alt 2: Inter-slot bundle size is RRC configured or dynamically indicated to a UE.

**Other considerations:**

**CTC**: Whether the bundle size can be configured larger than the window length of the configured TDWs needs further study.

**WILUS:** For inter-slot frequency hopping with inter-slot bundling, up to M’ consecutive UL slots are determined as the same frequency hop index (Option 3), where M’ is no more than the configured/indicated number of slots for an inter-slot bundling.



**Ericsson:** The network is able to configure the FH configuration independently of any JCE windows, and the patterns should be configurable for all UEs, even if they do not use DMRS bundling.

**FL comments:** This issue is discussed under AI 8.8.2.

## 2.5 TPC command

In RAN1 106-e, down-selection is agreed to be made between the following two alternatives about TPC command:

* Alt 1: UE is not expected to receive TPC commands during the current time domain window.
* Alt 2: UE receives and accumulates TPC commands without taking effect during the current time domain window.

In RAN1 106-e, it was further discussed on the two alternatives below. Companies’ views are summarized as follows.

* Alt 1: UE is not expected to receive TPC commands that would take into effect after the start of a time domain window.
  + - FFS: Such TPC commands constitute events for TDW determination
  + **Support**: ZTE, Intel, Ericsson, Sharp, Qualcomm, CATT
* Alt 2: If UE receives TPC commands that would take into effect after the start of a time domain window, UE accumulates TPC commands without taking effect during the current time domain window.
  + **Support**: HW, HiSilicon, Spreadtrum, vivo, OPPO, CMCC, xiaomi, Panasonic, Samsung, NTT DOCOMO, Sony, Sierra Wireless, LG, InterDigital, Sharp, Nokia, NSB

|  |  |
| --- | --- |
| **Alternative** | **Companies’ views** |
| Alt 1 | * May lead to power control deviation especially when the window length is large. * It requires more restriction for gNB scheduling. DCI format 2\_2 is a group-common DCI serving multiple UEs simultaneously. Restriction on group-common DCI may have very large impact on scheduling. * If the UE is configured with group common power control command reception of DCI format 2\_2, e.g. for configured grant operation, it is not likely that power control latency is a crucial problem. * For UEs in coverage enhancement mode, it is expected that UE would apply maximum transmit power for the transmission of PUSCH repetitions. In this case, power control accumulation mechanism may not be necessary for DMRS bundling. * There is no spec change while the scheduler has to adjust transmission timing of TPC command such that the UE is not expected to receive the TPC command during the TDW. * When the TDWs are back-to-back during a PUSCH transmission, the TPC commands would have to be sent between PUSCH transmissions which could be a long time, it seems Alt1 can’t work well for this case. |
| Alt 2 | * Based on current specification, the received TPC command is accumulated for a certain time, which means TPC command would not be immediately applied. Even though TPC is received during the current TDW, UE can accumulate TPC command and take effect after a certain time. * It is more straightforward to restrict UE not to adjust the transmission power during the JCE window instead of further limiting the gNB behavior. * It will get the better performance by adjusting the power according to channel condition. * For TPC handling, since the TPC command for PUSCH is indicated via DCI, the scenario of receiving TPC command within an actual TDW is invalid. Indeed, with the maximum unscheduled gap being equal to 13 symbols, JCE (and hence actual TDW) should happen between consecutive UL slots only, at least for TDD. The only potentially valid scenario is for FDD, if PDCCH is within the valid unscheduled gap and if PDCCH reception/monitoring does not break phase continuity in FDD. |

Another important issue is to further clarify whether the TDW referred to in the above agreements is the actual TDW or the configured TDW.

**Other considerations:**

**Sony**: propose a UE capability indicating if a UE support DL within a TDW or an actual TDW.

**Apple**: Wait RAN4’s input to determine which power control alternative is adopted.

**Sharp**: For CG-PUSCH repetitions, If UE receives TPC commands that would take into effect after the start of a TDW, UE should accumulate TPC commands without taking effect during the current TDW or UE should not be expected to receive TPC commands that would take into effect after the start of the TDW. Moreover, the transmission occasion i should be defined as the configured TDW if UE receives TPC commands during the TDW and accumulates the TPC commands without taking effect during the current TDW. For DG-PUSCH with accumulation mode, no special handling is necessary.

## 2.6 TA adjustment

Companies’ views on TA adjustment are summaries as follows:

* **Option 1**: UE does not expect to receive TA commands indicating TA adjustment during the TDW.
  + **Support**: Qualcomm, ZTE
* **Option 2**: UE ignores the TA command which indicates TA adjustment during the TDW.
  + **Support**: CMCC
* **Option 3**: UE performs TA adjustment after the TDW if it receives any TA command indicating TA adjustment during the TDW.
  + **Support**: Spreadtrum, vivo, Panasonic, NTT DOCOMO, Sony, Apple, InterDigital, Ericsson, Sharp, Nokia, NSB

**HW**: TA adjustment should be performed timely and taken as an event for the determination of actual TDWs.



**xiaomi**: UE should not perform TA adjustment during the time domain window. Similar to TPC command, we suggest UE receive but ignore the TA command without taking effect during the TDW. For TA adjustment, a lifecycle P of TA adjustment command should be introduced. If the command is still within the lifecycle after the TDW of joint channel estimation, continue to perform TA adjustment.



## 2.7 Others

**Dynamic signaling to enable/disable joint channel estimation for PUSCH**

Regarding whether additional dynamic signaling is needed to enable/disable joint channel estimation for PUSCH transmissions, companies’ views are summarized as follows:

* Dynamic signaling to enable/disable JCE for PUSCH transmissions.

**Support:** Sierra Wireless

**Not support:** Intel, LG

**FL comments:** This issue is discussed under AI 8.8.2.

**Phase drifting**

**CMCC**: The impact of phase drifting to the performance of joint channel estimation under a large number of consecutive slots should be studied.

**Samsung:** Support a same power, precoding, RV, and frequency position within time domain window.



Fig. Illustration of power control method over multiple PUSCH repetitions for joint channel estimation

**Power consistency for high power UE**

**vivo:** For high power UE, if the uplink duty cycle exceeds the threshold during the time domain window for joint channel estimation, and UE changes the transmission power, the power consistency across repetitions cannot be fulfilled. Thus, for high power UE, if joint channel estimation is enabled during the TDWs, a certain power class should be determined prior to the first PUSCH transmission.



**PTRS:**

**InterDigital:** Support to include PTRS in a DMRS bundle. Parameters of PTRS in the DMRS bundle depend on duration of the time window, SCS, bandwidth for PUSCH, and MCS used with DMRS bundling.

**Qualcomm:** Support different criteria for activation of PTRS or its density for the case of joint channel estimation.

**Phase correction at gNB**

**Ericsson**: gNB can correct for a wideband phase error between repetitions of an uplink channel in different slots, such that the performance is relatively close to where the ideal relative phase is known. Thus, further study the benefit of gNB estimated inter-slot relative phase correction for PUSCH, addressing how frequency selective such phase corrections would need to be for UEs and/or conditions that do not sufficiently support maintaining inter-slot relative phase.

1. Email discussion (1st round)

## 3.1 Use cases for joint channel estimation

**Use case 3 (TBoMS):**

**Proposal:** **Confirm the following working assumption.**

**Working assumption:**

* For back-to-back PUSCH transmissions across consecutive slots, support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation for the following case:
  + Over back-to-back PUSCH transmissions for one TB processed over multiple slots
    - It’s subject to UE capability

Companies are encouraged to provide comments on the above proposal.

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| Sony | Support |
| QC | Support |
| Intel | We are fine to confirm the working assumption. |
| Lenovo, Motorola Mobility | We support to confirm the WA |
| NTT DOCOMO | Support the proposal. |
| LG | We can support to confirm the WA if it reuses only those joint channel estimation specification enhancements defined to support repetition Type A. |
| Sharp | Support |
| ZTE | Support |
| vivo | Support. |
| TCL | Support |
| Samsung | Support |
| OPPO | support |
| Panasonic | Support |
| CMCC | Fine to confirm the WS. |
| CATT | Support. |
| China Telecom | Support |
| Xiaomi | Support |
| Apple | Support |
| WILUS | Support |
| InterDigital | Support |
| Huawei, HiSilicon | Support |
| Spreadtrum | Support |
| Ericsson | Support; OK to have LG’s update as well. |
| Sierra wireless | Support |
| FL | Let’s discuss it later. |

**Use case 4a (TBoMS):**

**Proposal:**

* For non-back-to-back PUSCH transmissions across consecutive slots (no uplink transmission in the middle of two PUSCH transmissions), support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation for the following case:
  + Over non-back-to-back PUSCH transmissions for one TB processed over multiple slots
    - It’s subject to UE capability

Companies are encouraged to provide comments on the above proposal.

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| Sony | Support |
| QC | Support |
| Intel | We are fine with the proposal. |
| Lenovo, Motorola Mobility | We support the proposal |
| NTT DOCOMO | Support the proposal. |
| LG | Same comment for use case 3. |
| Sharp | Support |
| ZTE | Support |
| vivo | Support. |
| TCL | Support |
| Samsung | Support |
| OPPO | support |
| Panasonic | Support |
| CATT | Support. |
| China Telecom | Support |
| Xiaomi | Support |
| Apple | Support |
| WILUS | Support |
| InterDigital | Support |
| Huawei, HiSilicon | Support |
| Spreadtrum | Support |
| Ericsson | Support; OK to have LG’s update as well. |
| Sierra wireless | Support |
| FL | Let’s discuss it later. |

**Use case 4b:**

**Companies are encouraged to provide views on whether use case 4b (other uplink transmission in the middle of two PUSCH transmissions has the same setting with PUSCH) is supported or not.**

**Companies are encouraged to provide comments on the following options to handle the case that the other UL transmission in between two successive PUSCHs has different settings than PUSCH.**

* Option 1: Adapt the settings of the other UL transmission to make it be the same as PUSCHs.
* Option 2: Multiplex the data of the other UL transmission on PUSCH.
* Option 3: Drop the other UL transmission with different settings.
* Option 4: Transmit the other UL transmission with different settings and break the phase continuity.

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| Sony | Option 4 with a capability, e.g. a UEs may be able to keep phase continuity and amplitude consistency in FR2, if the alternative beam is from a different panel. |
| Nokia/NSB | From our perspective, use case 4b is very relevant especially considering that PUSCH and PUCCH repetitions could often be staggered in case of coverage shortage of the UE. In this context, each of the above options has its merit. We are not sure RAN1 should select only one of those. Further discussion is needed. |
| QC | Option 4 for both cases (different or same settings). Regarding same settings --- the RAN4 constraints are quite stringent, and we don’t think there can be meaningful scenarios where two different uplink transmissions with the exact settings can occur. We therefore prefer that RAN1 not support this case as well. |
| Intel | In case of other uplink transmission in the middle of two PUSCH transmissions, we think that for the same setting with PUSCH, and based on RAN4 feedback, the use case 4b can be supported according to the UE capability.  For the case of has different settings than PUSCH, we prefer option 4. This may be treated as event for TDW determination. |
| Lenovo, Motorola Mobility | With the same setting UL transmission in the middle of two PUSCHs, we agree to support the use case (4b)  However, if the setting for the UL transmission in the middle of two PUSCHs is different, then we prefer option 4. We don’t prefer option 3 as the other UL transmission in between could possibly be of high priority. Also, the requirements determined for the UL transmission should not be adjusted as suggested in option 1. Option 2 will lead to more complexities |
| LG | Before discussion to select options, it should be clarified what the same setting is, but to our understanding, it is up to RAN4 and currently under discussion. Therefore, it is difficult to adapt the same settings at present, and from the joint channel estimation’s point of view, multiplexing data and performing other UL transmissions is identical in terms of phase continuity and power consistency. That is, since option 2 and option 4 are essentially the same, it should be discussed whether to give priority to other uplink or whether to prioritize transmission to the joint CE as in option 3. Therefore, considering the priority setting of the uplink transmission in which the joint CE is configured should be discussed first. |
| Sharp | Use case 4b should be deprioritized in Rel-17 to facilitate discussions of TDW design. |
| ZTE | For the same setting case, we don’t support as it is almost impossible to meet the conditions defined RAN4 for maintaining phase continuity.  For the different setting case, it has already precluded by RAN4 based in the LS in R1-2108703. |
| vivo | According to conditions provided by RAN4, same RB allocation, same antenna port setting are too strict conditions to fulfil. Besides, same PAPR is not clear from RAN1 perspective. Hence, we suggest to not support use case 4b to save RAN1/RAN4 effort.  For the 4 options to handle other UL in between transmissions, we prefer Option3 and Option4. |
| TCL | Option 4 is preferred. This may be treated as event for TDW determination. |
| Samsung | Prefer Option 4. In our point of view, the case of the other UL transmission in the middle of PUSCH repetitions can be addressed as the event. |
| Panasonic | We share the view from Qualcomm. |
| CMCC | Option 4 is preferred.  Supporting the Use case 4b will put a stringent limitation for the “other UL transmission” in the middle of two PUSCH transmissions. If it is supported, gNB scheduling based mechanism should be the baseline, no additional optimization such as option 1, 2 and 3 should be introduced. Option 4 would be the consequence according to RAN4’s information. If there is demand to transmit the UCI during the TDW, multiplexing based Rel-15/16 could be used. |
| CATT | Q1: Although it seems workable to support JCE in Option 4b when the settings are the same, the use case is very restrictive. To save time we should deprioritize the case, or handle it as the same way of ‘different setting’ case.  Q2: Option 4 is preferred for simplicity (the UL transmission in gap may become a dynamic event, and another actual TDW may resume after the UL transmission gap) |
| China Telecom | As long as power consistency and phase continuity can be maintained, use case 4b can be supported.  For the case that the other UL transmission in between two successive PUSCHs has different settings than PUSCH, Option 4 is preferred. |
| Xiaomi | Option 4 is preferred for simplicity. |
| Apple | For case 4b, it’s really restrictive to be implemented by gNB scheduling, if the transmission in the middle is SRS or PUCCH, we don’t see these channels could have the same setting with PUSCH. Thus, the only use case is another PUSCH is transmitting in the middle with the same setting. Considering the PUSCH already performs repetition, it will be allocated most of the symbols in a slot, so the left symbols for PUSCH in the middle could be minor. The benefits of supporting case 4b is questionable.  For the case with different setting than PUSCH, as others commented Option 4 seems simple, the PUSCH in the middle can be treated as a dynamic event, then new actual TDW can be created. |
| WILUS | For the same setting, we propose to deprioritize this use case even with same setting. It will cause scheduling restriction.  For different settings, Rel-15/16 rule can be reused, i.e., Option 4. |
| InterDigital | Support **use case 4b (other uplink transmission in the middle of two PUSCH transmissions has the same setting with PUSCH).**  For the **case that the other UL transmission in between two successive PUSCHs has different settings than PUSCH,** we support Option 4. |
| Huawei, HiSilicon | Option 4 is preferred because it fits in the current framework of TDW and treats the other UL transmission as an event to split a configured TDW into two actual TDWs. |
| Spreadtrum | Not support Use case 4b for JCE, due to really restrictions. |
| Ericsson | We understand the desire to support use case 4b. However, given the limitations we now have, I don’t see that the cross slot estimation gains will tend to outweigh the losses from constraining the other channel to match the PUSCH. So not supporting use case 4b even if transmissions occasionally have the same settings seems a reasonable way to go. On the other hand, if there is no spec impact I see no problem reason to preclude it. |
| Sierra Wireless | We prefer that RAN1 not support this case. |

**Use case 5:**

**Proposal:**

* Joint channel estimation over PUSCH transmissions across non-consecutive slots is not supported in Rel-17.

Companies are encouraged to provide comments on the above proposal.

|  |  |
| --- | --- |
| **Companies** | **Comments** |
|  | Do not support. We think that this can be a UE capability. |
| Nokia/NSB | Given the confirmation from RAN4 on the maximum unscheduled gap, we are fine with the FL’s proposal. |
| QC | RAN4 precludes this case. Support. |
| Intel | We are fine with the proposal. |
| Lenovo, Motorola Mobility | We support FL’s proposal |
| NTT DOCOMO | Support the proposal. |
| LG | Support. |
| Sharp | Support the proposal. |
| ZTE | Support. RAN4 already agreed that the 13-symbol is the maximum length for the gap for all SCS, and that the 14-symbol or 1ms will not be discussed in RAN4 anymore for un-scheduled gap in Rel-17. |
| Vivo | Support |
| TCL | We are fine with the proposal. |
| Samsung | Fine with FL’s proposal. |
| OPPO | support |
| Panasonic | We support the proposal. |
| CMCC | Support the proposal. |
| CATT | Agree. |
| China Telecom | Support |
| Xiaomi | Agree |
| Apple | Support this Proposal. |
| Huawei, HiSilicon | OK |
| Spreadtrum | Support |
| Ericsson | It is unfortunate that this use case is not supported so far in the feedback we have from RAN4, given the potential for it to improve the usefulness of JCE for TDD configurations. But at this stage of Rel-17, it is hard to design the RAN1 specifications to support JCE across non-consecutive slots. |
| Sierra Wireless | Agree |

## 3.2 Time domain window

**Proposal: Confirm the following working assumption**

|  |
| --- |
| **Working assumption:**  For joint channel estimation for PUSCH repetition type A of PUSCH repetitions of the same TB, all the repetitions are covered by one or multiple consecutive/non-consecutive configured TDWs.   * Each configured TDW consists of one or multiple consecutive physical slots. * The window length *L* of the configured TDW(s) can be explicitly configured with a single value ~~and~~ *~~L~~* ~~is no longer than the maximum duration~~.   + FFS: The maximum value of *L* ~~is the duration of all repetitions~~   + FFS: Solutions to error propagation issue if ~~for~~ *L* is longer than the maximum duration is to be discussed further.   + FFS: The window length *L* is configured per UL BWP * The start of the first configured TDW is the first PUSCH transmission   + FFS: The first available slot/symbol, or the first physical slot/symbol for the first PUSCH transmission. * The start of other configured TDWs can be implicitly determined prior to first repetition.   + FFS: The configured TDWs are consecutive for paired spectrum/SUL band   + FFS: The start of the configured TDWs for unpaired spectrum is implicitly determined based on semi-static DL/UL configuration. * The end of the last configured TDW is the end of the last PUSCH transmission.   + FFS: The end of the configured TDW is the last available slot/symbol, or the last physical slot/symbol for the last PUSCH transmission. * Within one configured TDW, one or multiple actual TDWs can be implicitly determined:   + The start of the first actual TDW is the first PUSCH transmission within the configured TDW.     - FFS: The first available slot/symbol, or the first physical slot/symbol for the first PUSCH transmission.   + After one actual TDW starts, UE is expected to maintain the power consistency and phase continuity until one of the following conditions is met, then the actual TDW is ended.     - The actual TDW reaches the end of the last PUSCH transmission within the configured TDW.       * FFS: The end of the actual TDW is the last available slot/symbol, or the last physical slot/symbol for the last PUSCH transmission.     - An event occurs that violates power consistency and phase continuity       * FFS: The events may include e.g., a DL slot based on DL/UL configuration for unpaired spectrum, the actual TDW reaches the maximum duration, DL reception/monitoring occasion for unpaired spectrum, high priority transmission, frequency hopping, precoder cycling.       * FFS: The end of the actual TDW is the last available slot/symbol of the PUSCH transmission right before an event such that the power consistency and phase continuity are violated.   + If the power consistency and phase continuity are violated due to an event, whether a new actual TDW is created is subject to UE capability of supporting restarting DMRS bundling.     - If UE is capable of restarting DM-RS bundling, one new actual TDW is created after the event,       * FFS: The start of the new actual TDW is the first available slot/symbol for PUSCH transmission after the event.     - If UE is not capable of restarting DM-RS bundling, no new actual TDW is created until the end of the configured TDW.     - FFS: UE capability of restarting DMRS bundling is applied only to dynamic event or not   Note 1: A ‘configured TDW’ refers to a time domain window whose length can be configured to ‘L’ and whose start and end is determined as described above.  Note 2: An ‘actual TDW’ refers to a time domain window during whose entire duration the DM-RS bundling is actually applied. An ‘actual TDW’ duration is always less than or equal to the ‘configure TDW’ duration.  Note 3: Whether the terms ‘configured TDW’ and ‘actual TDW’ are revised to other terms and if such terminology is used in specifications is to be further discussed. |

Companies are encouraged to provide comments on the above proposal.

|  |  |
| --- | --- |
| **Companies** | **Comments** |
|  | In general we support this proposal.  We promote the idea that if a UE can handle DL within a configured TDW (subject to a capability), implicitly defining TDW based on UL/DL switching shall be avoided.  Regarding Note 2, It is our understanding that the actual TDW will depend on UE capability and can be different for different UEs. |
| Nokia/NSB | We are fine with the FL’s proposal. The FFS in the above WA can be further discussed. |
| QC | We prefer to wait for more clarity on L. |
| Intel | We are fine to confirm the working assumption. |
| Lenovo, Motorola Mobility | We are fine to confirm the WA |
| NTT DOCOMO | Support the proposal |
| LG | Support to confirm the working assumption. |
| Sharp | Support the proposal. |
| ZTE | Support |
| TCL | We are fine to confirm the WA. The FFS can be further discussed. |
| Samsung | Generally, we are fine to confirm the WA. However, the details of FFS in the above WA should be further discussed. It would be better to resolve the FFS first and then confirm the WA. |
| OPPO | support |
| Panasonic | Although we are ok to confirm the WA, we prefer to discuss/address the described FFS points firstly because it is more important than spending time to confirm the working assumption. |
| CATT | Support. |
| China Telecom | Support |
| Xiaomi | Fine with the WA |
| Apple | We support to confirm the working assumption, then move forward. Otherwise, we are stuck here. |
| InterDigital | We support to confirm the working assumption. |
| Spreadtrum | Support to confirm the WA. |
| Ericsson | OK to confirm the WA, but the details may be more important to discuss than the confirmation. |
| Sierra Wireless | Although we are ok to confirm the WA, we feel this is low priority and little meeting time should be spent on this. Instead, we prefer to discuss/address the described FFS points. |
| FL | Let’s discuss the confirmation later. |

### 3.2.1 Configured TDW

#### Issue #1: The window length L of the configured TDW

**Issue #1-1: The maximum value of *L***

**FL comments:** Based on companies’ views, if L can be configured as the whole duration of all repetition, it can achieve the best performance in case of no events or only semi-static events. However, there may be error propagation in case of dynamic events, if the window length L of the configured TDW exceeds the maximum duration. From FL understanding, if the window length L of the configured TDW exceeds the maximum duration, restricting to only semi-static events can potentially solve the problem. Thus, a compromised proposal is proposed.

**Proposal:**

* The maximum value of the window length L of the configured TDW is the duration of all repetitions.
* If the window length L of the configured TDW is longer than the maximum duration, UE does not expect dynamic events.
  + FFS: details of dynamic events.

Companies are encouraged to provide comments on the above proposal.

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| Sony | Support |
| Nokia/NSB | Thank you, the FL, for the great efforts on formulating a middle ground proposal!  As summarized by the FL in Section 2.3.1, the error-propagation issue, which is caused by missing DCI, can be considered as a corner case. Whenever this corner case happens, it can be handled by the gNB by at least one of the following approaches:   * If the gNB anticipates that there is a chance of missing DCI, it may configure a short configured TDW size L such that the impact of error propagation is minimized. * The gNB may try to detect the dynamic event and know whether the actual TDWs are determined without or with the dynamic event by the UE and perform JCE accordingly. * The gNB may apply a conservative approach by performing JCE only on the PUSCHs repetitions that are not impacted by the error propagation.   Our first preference is not to exclude the dynamic events when L>maximum duration is configured. Moreover, we think that determining L implicitly by using the UL/DL configuration can avoid the RRC overhead introduced by configuring L explicitly, in case of unpaired spectrum. However, we don’t want to block the discussion. Therefore, if this proposal can be agreeable to the group, and same configured TDW location determination approach is used for paired and unpaired spectrum (with reference to Issue #2-2), then we can be fine with the FL’s proposal. |
| QC | We appreciate the effort at finding a compromise.  If no dynamic events are expected, then its not clear why L > max duration can achieve better performance than the case where L <= max duration.  Prefer to not overcomplicate this procedure. The simplest fix would be go with L <= max duration as indicate by many companies in their tdocs. |
| Intel | We still believe it is more appropriate to only consider the case when configured TDW duration is less than or equal to maximum duration. It is very clear the issue with mis-alignment between gNB and UE on the determination of TDW and potential error propagation. In addition, based on our simulation results and as shown below, further extension of TDW duration, e.g., from 4 to 8 slots only provides marginal performance gain. In this case, we do not think this is really necessary to support large TDW duration for joint channel estimation.    Based on the above, we do not support this proposal. |
| Lenovo, Motorola Mobility | Although, we don’t think that L > maximum duration should be configured, however, we are fine to support the proposal for sake of progress if the majority is fine. |
| NTT DOCOMO | As dynamic events have not been defined yet, it is difficult to support the proposal itself at this juncture.  However, we can support the idea of combining company’s preferences. The other compromised proposal is to support the window length longer than the duration of all repetitions only when UE has its capability. |
| LG | According to the LS of RAN4, it is not even clear what the maximum duration will be. However one thing is clear that the L value should not be small for the performance gain of the joint CE. Therefore, all repetitions will be appropriate for L. |
| Sharp | Excluding dynamic events from actual TDW determination is not preferred. Excluding dynamic events for actual TDW determination leads to unnecessary restriction on gNB scheduling. For example, the gNB cannot schedule high priority transmission within the actual TDW. In our view, the maximum value of window length L of configured TDW should not exceed the maximum duration. |
| ZTE | Not support. The proposal would result in two kinds of UE behaviors and complicate the discussion unnecessarily. So, we still prefer that ‘The maximum value of window length *L* should not exceed the maximum duration.’ |
| vivo | For the 2nd bullet, we prefer the TDW length L would be configured to be no longer than the maximum duration.  Even if L is longer than the maximum duration, the event that the actual TDW reaches the maximum duration would make the maximum length of actual windows to be the maximum duration. Hence, L > max duration is meaningless. |
| TCL | We have similar view with Lenovo |
| Samsung | A gNB should not configure L larger than the MD (assumed to be a UE capability). It would be an incorrect configuration. Hence, we see no need to specify such case. |
| OPPO | It is not clear why L should be configured to be larger than maximum duration. |
| Panasonic | In order to simplify the design, our preference is with L <= max duration. The max duration is also restricted by UE capability. |
| CMCC | Share a similar view with Qualcomm we should not complicate the procedure. We can go straightforward that the L should be below the maximum duration. |
| CATT | We think limiting ‘L <= maximum duration’ is the simplest choice to restrict error propagation. |
| China Telecom | We see the benefit when L > maximum duration if gNB and UE have the same understanding on actual TDWs. Support the compromised proposal for the sake of progress. |
| Xiaomi | Fine with the first bullet, for the second bullet, we don’t support L > maximum duration should be configured. |
| Apple | As we recalled the process of reach the WA on TDW, the window length L can be equal to all repetition, it can achieve implicit determination of TDW. This is the main difference of Alt 2-B from Alt2-C/C’. It’s the big compromise from companies supporting Alt 2-B to reach the WA.  Going back to the proposal, for the first bullet, it can be updated for TDD, and the second bullet can be removed.   * At least for TDD, the maximum value of the window length L of the configured TDW is the duration of all repetitions.  |  |  | | --- | --- | |  | Support | | Alt 2-B | Lenovo, Motorola Mobility, Panasonic, Nokia/NSB, WILUS, Ericsson, Sharp, Sierra Wireless, vivo, TCL, CATT, Samsung, CMCC, LG, Apple, Sony, Xiaomi, Samsung,OPPO | | Alt 2-C | Qualcomm, ZTE, InterDigital | | Alt 2-C’ | NTT DOCOMO, vivo, TCL, CATT, ZTE, CMCC, MediaTek, Sharp, Xiaomi, Samsung, Intel | |
| WILUS | We are fine with FL’s proposal in principle. However, dynamic events should be clarified to support L > the maximum duration. |
| InterDigital | We do not see the motivation for configuring the length longer than the maximum duration. L can be less than or equal to the maximum duration. |
| Huawei, HiSilicon | OK for the first bullet. For the second bullet, it is confusing. Since the L is always equal to the whole duration of repetitions and no actual TDW splitting is caused by any dynamic event, a UE can simply derive the L value from the indicated whole duration. It is redundant to indicate the L to a UE. |
| Spreadtrum | We still prefer L <= max duration, which can be the most reasonable configuration for window length. |
| Ericsson | While the proposal can work from a technical perspective, we’re wondering how it works from a signaling and UE capability perspective. The proposal presumes that a UE will use its max duration L0 from its UE capability to decide when to create actual windows. So it applies L0 even when configured with a TDW length L > L0. In some senses the UE is applying functionality that is not configured, but depends on capability. This may be contrary to the RAN2 guidance on UE capability R1-2001513, which says to “Avoid defining functionality that has no RRC configuration but is dependent on capability bits”.  So, after some more thought, we think it may be better to configure L to match the UE’s max duration if L the configured TDW length can exceed L. If L is not configured, the window length L of the configured TDW is the duration of all repetitions, and does not exceed the maximum duration. |
| Sierra Wireless | Do not support the proposal.  Limiting ‘L <= maximum duration’ is the simplest choice to restrict error propagation |

**Issue #1-2: Configuration/Indication of *L***

**Companies are encouraged to provide views on the configuration/ indication of L.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Configured by RRC | Indicated by DCI | Add an entry of TDRA table to signal L |
| DG-PUSCH | Nokia/NSB, QC, Intel, Lenovo, Motorola Mobility, Sharp, ZTE, vivo, TCL, Samsung,OPPO, CMCC, CATT, China Telecom,Xiaomi, Apple, InterDigital, Huawei, HiSilicon, Spreadtrum, Ericsson | DCM, CMCC | DCM, Panasonic |
| Type 1 CG-PUSCH | Nokia/NSB, QC, Intel, Lenovo, Motorola Mobility, DCM, Sharp, ZTE, vivo, TCL, Samsung,OPPO, Panasonic, CMCC, CATT, China Telecom,Xiaomi, Apple, InterDigital, Huawei, HiSilicon, Spreadtrum, Ericsson |  |  |
| Type 2 CG-PUSCH | Nokia/NSB, QC, Intel, Lenovo, Motorola Mobility, Sharp, ZTE, vivo, TCL, Samsung,OPPO, CMCC, CATT, China Telecom,Xiaomi, Apple, InterDigital, Huawei, HiSilicon, Spreadtrum, Ericsson | DCM, CMCC | DCM, Panasonic |

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| **Companies** | **Comments** |
| Intel | RRC configuration of TDW duration would be sufficient. |
| NTT DOCOMO | The optimum configured TDW length is subject to PUSCH TDRA, maximum duration, interval of updating power and frequency offsets, gain of joint channel estimation, and effect of error propagation. For example, the optimum window length changes depending on whether the TDRA is larger than maximum duration. If maximum duration is 5 and up to 5 slots are allocated for PUSCH, the largest JCE gain can be achieved by window length = 5. However, if 6 slots are allocated for PUSCH, one TDW cannot cover all repetitions due to short maximum duration. In this scenario, window length = 3 is preferred rather than 5, because it avoids long duration prohibiting from updating power and frequency offsets. If optimum configured TDW length is subject to dynamic factors, window length should be indicated dynamically.  Accordingly, we prefer dynamic window length indication to maximize the coverage performance according to above factors. |
| Samsung | RRC configuration is enough. Also in case of frequency hopping, the TDW length can be equal to the duration of a frequency hop if L is not configured. |
| Panasonic | In order to capture the changes of channel conditions, dynamical adjustment of L is necessary. Using TDRA field does not increase DCI overhead and it can be commonly used for all DG-PUSCH, Type 1 CG-PUSCH, and Type 2 CG-PUSCH |
| CMCC | RRC configuration could be a baseline. On the other side, we share a similar view that the TDW could be indicated implicitly and combined with the indication of repetition or TDRA. Please note that configuring the TDW as long as the repetition durations is also a kind of dynamic indication, as the repetition factor could also be indicated through TDRA. |
| Ericsson | If L is not configured, the window length is equal to the duration of the PUSCH transmission. |

**Companies are encouraged to provide views on the granularity of signaling of L.**

|  |  |
| --- | --- |
| Per BWP | Per Channel |
| Nokia/NSB, Intel, Lenovo, Motorola Mobility, ZTE, TCL, Samsung, CATT, China Telecom, Xiaomi,Ericsson(PUSCH) | QC, vivo,OPPO, CMCC,Ericsson(PUCCH) |

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| **Companies** | **Comments** |
| QC | Keep PUCCH and PUSCH parameters separated. PUCCH is a single port transmission while PUSCH could be multi-port, so some additional considerations could apply. |
| vivo | We prefer the L is separately configured for PUCCH and PUSCH, due to different number of repetitions may be configured/scheduled for these two channels. |
| Samsung | We can determine the granularity of signaling of L based on the granularity of PUSCH repetition as discussed in AI 8.8.1.1, e.g. {n2, n3, n4, n7, n8, n12, n16, n20, n24, n28, n32} for PUSCH. |
| OPPO | L is relevant with the channel condition, not needed to be configured per BWP |
| Panasonic | If L configuration is RRC parameter, it should be configured per BWP and per channel. Per BWP and Per channel would not be alternatives. |
| CMCC | Share similar views that PUCCH and PUSCH should be configured separately. |
| Apple | If RAN4 defines the maximum duration is different for PUSCH and PUCCH, the L can be signalled per channel. Otherwise, per BWP is enough. |
| Spreadtrum | Agree with Apple. We are open for separate configuration for PUCCH and PUSCH if RAN4 decides. |
| Ericsson | Agree to keep PUCCH and PUSCH parameters separate. After seeing contributions into the meeting, we are open to discuss per BWP vs. per PUCCH format. However, per BWP configuration may be sufficient for PUSCH. |
| Sierra Wireless | We should be as flexible as possible here since this is RRC config so both per BWP and per channel. |

**Companies are encouraged to provide answers to the following questions.**

**Q1: Whether default value of L is needed?**

**Q2: If the answer to Q1 is yes, what’s the default value?**

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| **Companies** | **Comments** |
| Nokia/NSB | Q1: The default value of L is only needed when it is not configured in RRC. Therefore, whether default value of L is needed or not may depend on whether activation/deactivation of TDW is independent with the configuration of L or not (it is worth noting that as per the agreement made in RAN1#106-e meeting, TDW and JCE feature should be jointly activated/deactivated). If L is needed for TDW determination, then the natural consequence would be to consider TDW and JCE as: activated when L is configured and deactivated when L is not configured. On the other hand, if a separate parameter is introduced for activating/deactivating TDW and JCE feature, then the default value of L can be configured.  Q2: If default value of L is needed, we prefer it to be the repetition duration. This option offers longer duration for actual TDW than considering L as maximum duration. |
| QC | Yes, it may be helpful. If L is not indicated via RRC, it can be the same as max duration. |
| Intel | Q1: it is based on RRC configuration and no default value is needed. |
| Lenovo, Motorola Mobility | Q1: Yes, the default value of L would be needed in case of no configuration.  Q2: The default value of L should be equal to the maximum duration |
| NTT DOCOMO | Q1: If enable/disable DMRS bundling is automatically determined by window length indication, default value is not necessary. If enable/disable DMRS bundling is configured from window length indication, default value is beneficial.  Q2: we prefer maximum duration is the default value of window length. |
| Sharp | Q1: In our view, it depends on Issue#2-1 and whether the window length L and enabling/disabling of DMRS bundling are separately configured. |
| ZTE | Q1: Fine to define a default value.  Q2: It could be the maximum duration reported by UE. |
| vivo | Q1: NO. If the new parameter is introduced, we do not see why a default value is needed. |
| TCL | Q1: Yes, the default value is useful when L is not configured by RRC.  Q2: The default value of L is equal to the maximum duration. |
| Samsung | Q1: The default value of L may be needed only for the case joint CE is enabled without configuration of window length L by RRC. If frequency hopping is enabled, it can be used the duration of a frequency hop, hence the default value may not be needed.  Q2: The default value of L can possibly be the maximum duration. |
| Panasonic | If it is RRC configuration, the amount RRC signalling reduction is very small. We don't see the need of the discussion on the default value, so that we can have more time to discuss other important topics. |
| CMCC | Q1: No.  If the length L is not configured or indicated, the JCE or DMRS bundling is not enabled. |
| CATT | Q1: No. The UE shall perform DMRS bundling only if the RRC parameters are properly configured. We think it is natural that *L* will be signalled in this case. |
| China Telecom | Q1: Fine to define a default value.  Q2: The default value is the duration of all repetitions. |
| Xiaomi | Q1: Yes  Q2: The default value of L is equal to the maximum duration. |
| Apple | Q1: yes.  Q2: the default value means the L is equal to the duration of all repetitions. |
| InterDigital | Q1 : No, the value of L should be configured by RRC. There is no need to have the default value. |
| Huawei, HiSilicon | Q1: Similar view as Nokia. In our understanding, L is always configured and is the signalling to enable JCE. |
| Spreadtrum | Q1: Yes.  Q2: maximum duration. |
| Ericsson | Q1: Yes  Q2: If L is not configured, then the duration of the configured TDW should be equal to the length of the PUSCH transmission. |
| Sierra Wireless | No strong view  But a Default = Maximum Duration could save some RRC configuration. |
| FL | It seems whether default value is needed depends on whether to introduce two RRC parameters to indicate enabling of DM-RS bundling and the window length of the configured TDW respectively or introduce only one RRC parameter to indicate both of them, which is under discussion in [106bis-e-R17-RRC-CovEnh]. Let’s discuss it later. |

#### Issue #2: The determination of configured TDW

**Issue #2-1: The start of the first configured TDW**

**FL comments:** It seems the majority support the start is slot-level. The key point is whether physical slot or available slot. The difference between physical slot and available slot is demonstrated in the following figure.



* **Option 1:** The start of the first configured TDW is the first available slot for the first PUSCH transmission.
  + **Support**: HW, HiSilicon, vivo, CATT, CMCC, Samsung, InterDigital, WILUS, Nokia, NSB, Qualcomm, OPPO, Sharp, LG, Apple, Intel
* **Option 3:** The start of the first configured TDW is the first physical slot for the first PUSCH transmission.
  + **Support**: ZTE, CATT, CTC, MediaTek, OPPO, Sharp, Apple, Intel

Companies are encouraged to provide comments on the above two options.

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| **Companies** | **Comments** |
| Nokia/NSB | We prefer Option 1. Given that the PUSCH transmission cannot start before the first available slot, it is unclear why the configured TDW should start from the first physical slot, which in general could occur earlier than the first available slot. Indeed, this would have the effect of reducing the maximum number of DMRS that can be bundled together, in turns reducing channel estimation accuracy. |
| QC | Prefer Option 1.  Its not clear what is meant by “first physical slot”. We can determine the locations of configured TDWs based on physical slot indices (independent of PUSCH scheduling), but its not clear if that is what is being proposed. “First available slot” seems to offer better clarity.  The figures don’t seem to be accurate. As per the working assumption, the cTDWs are determined before the start of the repetitions, so its not clear how dynamic events can influence their placement. |
| Intel | Our view is that this depends on whether PUSCH repetition is counted based on physical slots or available slots. If this is based on physical slots, we can consider Option 3, where for available slots, it is Option 1. |
| Lenovo, Motorola Mobility | We prefer option 1 as it gives the most accurate determination of the TDW. |
| LG | We prefer option 1.  In our understanding, a physical slot means that an actual PUSCH is transmitted. Then, whether or not the actual PUSCH is transmitted can be determined at that time based on the available slot. Therefore, when the starting point of the configured TDW is set based on the physical slot, the determination of the starting point of the time domain window is delayed, which affects all window boundaries. Therefore, this is not appropriate, and an available slot that can be determined in advance by the UE and the gNB regardless of actual transmission is required as a unit. |
| Sharp | Prefer Option 3. The events and available slots can be considered by actual TDW. |
| ZTE | We have similar view as Intel. The start of the first configured TDW should depend on the counting method. |
| vivo | Opt-1 is preferred, since opt-3 may lead to over creation of actual TDW, which will lead to performance loss. |
| TCL | Option 1 is preferred |
| Samsung | We prefer Option 1. It is also aligned with Rel-17 PUSCH repetition type A. The first available slot determines the start of the configured TDW. |
| Panasonic | Our usage of "available slot" here is the same as the one used in agenda item 8.8.1.1 Rel. 17 PUSCH repetition Type A of the following procedure. It means available slot is determined by only semi-static information. If available slot as the meaning after dropping in the step 2, we don't agree the option 1. It should clarify what is the meaning of "available slot" in this agenda.   * Step 1: Determine available slots for K repetitions based on RRC configuration(s) in addition to TDRA in the DCI scheduling the PUSCH, CG configuration or activation DCI, * Step 2: The UE determines whether to drop a PUSCH repetition or not according to Rel. 15/16 PUSCH dropping rules, but the PUSCH repetition is still counted in the K repetitions. |
| CMCC | Option 1, since it could fit for both paired and unpaired spectrums. |
| CATT | Assuming that the determination of ‘available slot’ follows that in 8.8.1.1, we share similar views with Intel and ZTE. If the case that ‘a UE does not support “counting based on available slot’ but support JCE” is allowed, whether available slot or physical slot is adopted depends on the UE capability.  Another concern is, available slot in 8.8.1.1 is defined for PUSCH repetition type A. What if we agree using ‘available slot’ here but adopt JCE to repetition type B case? |
| Xiaomi | Prefer Option 3, the event can be considered by actual TDW. An event can trigger the split of configured TDW into multiple actual TDWs. |
| Apple | We share the same view as Intel. It’s up to the applied counting scheme. |
| WILUS | To guarantee more slots for JCE, Option 1 is preferred. |
| InterDigital | Option 1 |
| Huawei, HiSilicon | Option 1 is preferred. Considering that the only the available slot are used for PUSCH transmission, taking the first available slot as the start of the configured TDW is more friendly for a UE implementation. |
| Spreadtrum | We agree with Intel. If a UE does not support available slot based repetition, it still can separate support JCE. So these two features can be configured separately. In this case, tUhe starting of the first configured TDW can be first physical slot or available slot. |
| Ericsson | Option 1. The configured TDWs start with the first PUSCH transmission, so we don’t see how they can start with an unavailable slot. |
| Sierra Wireless | Option 1 |

**Issue #2-2: The start of the other configured TDW**

* **Option 1:** The configured TDWs are consecutive regardless of paired spectrum/SUL band and unpaired spectrum, i.e. the start of other configured TDWs is the first physical slot right after the previous TDW.
* **Option 2:** The start of other configured TDW is different for paired spectrum/SUL band and unpaired spectrum.
  + For paired spectrum/SUL band, the configured TDWs are consecutive, i.e. the start of other configured TDWs is the first physical slot right after the last TDW.
  + For unpaired spectrum, the start of the configured TDWs is implicitly determined based on semi-static DL/UL configuration.

Companies are encouraged to provide comments on the above two options.

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| **Companies** | **Comments** |
| Nokia/NSB | We prefer Option 1. If TDW is also determined using UL/DL configuration, then the motivation of configuring L is unclear. Indeed, based on the UL/DL configuration, the configured TDW size L can be implicitly determined. In this case, L is not necessarily to be explicitly configured. Therefore, the more reasonable approach is that RAN1 should either adopt Option 1 or implicitly determine configured TDW size L based on UL/DL configuration and the explicit configuration of L is not considered. |
| QC | We have Option 2 in mind. For unpaired spectrum, we determine it based on the next available slot (which is in turn dependent on the semi-static DL/UL configuration. |
| Intel | We slightly prefer Option 2. It may also depend on whether PUSCH repetition is counted based on physical slots or available slots |
| Lenovo, Motorola Mobility | Option 1 is preferred |
| LG | Assuming that the configured TDW is determined by the available slot of the PUSCH as a unit, above options are unnecessary and can be considered as a unified rule, so it should be specified that the unit for counting the configured TDW is the available slot. |
| Sharp | Prefer Option 1. It is simpler than Option 2 and the available slots can be considered by the actual TDW. |
| ZTE | Prefer Option 1 for simplicity. Option 2 would open more discussion on how to implicitly determine the start of TDW for unpaired spectrum. For instance, whether it should also consider SSB transmission (align with the definition of available slot), and whether it should depend on counting method etc. In addition, we suggest to simply Option 1 to ‘The configured TDWs are consecutive, i.e. the start of other configured TDWs is the first physical slot right after the previous TDW.’ |
| vivo | Option 2 is preferred. |
| TCL | Option 1 is preferred |
| Samsung | Support Option 2.  Regardless of the paired spectrum/SUL band and unpaired spectrum, the start of other configured TDWs can be determined based on the available slot. For example, in the case of paired spectrum/SUL band, each of other configured TDWs will be consecutive across the available slot. In addition, for unpaired spectrum, the other configured TDWs are implicitly determined according to the available slot. The available slot can be determined as discussed in AI 8.8.1.1. |
| Panasonic | We are not sure why the discussion is separated between "the start of the first configured TDW" and "the start of the other configured TDW". Our preference is the first configured TDW are counted only within available slots using of "available slot" is the same as the one used in agenda item 8.8.1.1 Rel. 17 PUSCH repetition Type A. |
| CMCC | Option 2, the starting of the other configured TDW could start with the flexible and UL slots in the paired spectrum. And it also fits for the paired spectrum. |
| CATT | Option 2 is preferred. For unpaired spectrum, we think the start of the configured TDWs implicitly determined based on semi-static DL/UL configuration can be combined with consecutive configured. For example, if the DL/UL configuration is DSUUUUUUUU, *L* is 4 and the start of the first configured TDW is the first U slot after S slot. The start of the second configured TDW can be the the first U slot right after the previous TDW. The third configured TDW is implicitly determined based on semi-static DL/UL configuration, e.g. the first U slot after S slot in the next TDD period. |
| China Telecom | We support option 2. For option 1, contiguous UL slots may be segmented to different configured TDWs. |
| Xiaomi | Option 1 is preferred. If configured TDW is also determined using UL/DL configuration, then the motivation of configuring default L value is no need. And events and available slots can be considered by the actual TDW. |
| Apple | Option 2 is preferred. For option1 it the start of other configured TDW is the DL slot, then the TDW window length would be shorten than expected, it could not get the fully joint channel estimation gain. |
| InterDigital | We prefer Option 2. Option 2 seems to be more aligned with determination mechanism for TDD or FDD. |
| Huawei, HiSilicon | Option 2 is preferred. It is more straightforward and simple to determine the configured TDWs by taking into accout the semi-static DL/UL configuration. |
| Spreadtrum | We prefer to use same method for the start of the other configured TDW as the start of the first configured TDW. Like if it is based on physical slot repetition, when all the starts of the configured TDW are consecutive for paired or unpaired spectrum. Otherwise, if it is based on available slot repetition, when the starts of the configured TDW can be dis consecutive for unpaired spectrum, e.g. Option 2. |
| Ericsson | Somewhat prefer Option 1 |

**Issue #2-3: The end of the last configured TDW**

**FL comments:** It seems the majority support the start is slot-level. The key point is whether physical slot or available slot. The difference between physical slot and available slot is demonstrated in the following figure.

****

* **Option 1:** The end of the last configured TDW is the last available slot for the last PUSCH transmission.
  + **Support**: CATT, CMCC, InterDigital, WILUS, Nokia, NSB, Samsung, OPPO, Sharp, LG, Apple, Intel
* **Option 3:** The end of the last configured TDW is the last physical slot for the last PUSCH transmission.
  + **Support**:ZTE, CATT, CTC, MediaTek, OPPO, Sharp, Apple, Intel, Qualcomm

Companies are encouraged to provide comments on the above two options.

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| --- | --- |
| **Companies** | **Comments** |
| Nokia/NSB | We prefer Option 1. Same comments as for Issue #2-1. |
| QC | Option 1 (don’t think we indicated support for the other option). Since Ctdw is determined before start of repetitions, it will end with the last available slot. |
| Intel | Same as above. This may depend on whether PUSCH repetition is counted based on physical slots or available slots. If this is based on physical slots, we can consider Option 3, where for available slots, it is Option 1. |
| Lenovo, Motorola Mobility | We prefer option 1 for same reasons as for 2#1 |
| LG | For the same reason as the previous comments, it is preferable to determine all units as available slots in order to determine the boundary of the configured TDW in advance. |
| Sharp | Prefer Option 3. The events and available slots can be considered by the actual TDW. |
| ZTE | Prefer Option 3. We think the solution of this issue should align with Issue#2-2, where the end of a configured TDW is determined by the start of the TDW and the length L at least for paired spectrum, which basically means Option 3. In other words, Option 1 contradicts with the two options in Issue#2-2. |
| Vivo | Option 1 is preferred.  In our view, no matter PUSCH repetition is counted on physical slots or available slots, the starting and ending of configured/actual TDW can de determine based on available slots. |
| TCL | Option 1 is preferred |
| Samsung | Prefer Option 1. Same reason mentioned in the above Issue #2-1. |
| Panasonic | We are not sure why the discussion is separated between “the start of the first configured TDW”, “the start of the other configured TDW” and “the end of the last configured TDW “. Our preference is the first configured TDW are counted only within available slots using of “available slot” is the same as the one used in agenda item 8.8.1.1 Rel. 17 PUSCH repetition Type A. |
| CATT | This is related to the Question in Issue#2-1. The same design should be applied to the first and the last TDW. |
| Xiaomi | Prefer Option 3, events and available slots can be considered by the actual TDW. |
| Apple | It’s depending on counting scheme, if it’s available based counting, Option 1 is applied; otherwise, Option 3 is applied. |
| CMCC | Option 1 is preferred. We should stick to the same principle for the beginning and the end of configured TDW. |
| InterDigital | Option 1. |
| Huawei, HiSilicon | As discussed in our contribution, the last available symbol is better than the last available slot. Because the last symbol within the last slot may be used to transmit a SRS which should not be covered by the configured TDWs. |
| Spreadtrum | We prefer to use same method for the end of the configured TDW as the start. Like if it is based on physical slot repetition, Option 3 is applied, otherwise Option 1 for available slot based. |
| Ericsson | Support option 1 using the same rationale as for Issue #2-1 |

### 3.2.2 Actual TDW

#### Issue #3: The determination of actual TDW

**Issue #3-1: The start of the first actual TDW**

**FL comments:** It seems the majority support the start is first available slot or first available symbol. It has been agreed repetition type B will reuse the mechanism of repetition type A. From FL understanding, if the start of the first actual TDW is the first available slot, then additional specification enhancements may be needed otherwise repetition type B may not work properly. Second, there can be unavailable symbols e.g., DL symbols in special slots, that UE cannot maintain power consistency and phase continuity. The difference between available slot and available symbol is demonstrated in the following figure.



* **Option 1:** The start of the first actual TDW is the first available slot for the first PUSCH transmission.
  + **Support**: HW, HiSilicon, ZTE, MediaTek, CMCC, Lenovo, Motorola Mobility, WILUS, InterDigital, Samsung, OPPO, LG, Apple, Intel
* **Option 2:** The start of the first actual TDW is the first available symbol for the first PUSCH transmission.
  + **Support**: ZTE, MediaTek, CATT, CTC, Lenovo, Motorola Mobility, Nokia, NSB, InterDigital, Samsung, Sharp

Companies are encouraged to provide comments on the above two options.

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| **Companies** | **Comments** |
| Nokia/NSB | We prefer Option 2 because of the following reasons:   * Unlike the configured TDWs, which are the nominal time durations, the UE needs to keep the power consistency and phase continuity within each actual TDW. Therefore, the unit of the actual TDWs should be more precise compared to configured TDWs. * Unlike configured TDWs whose size is RRC configured, the size of actual TDW is implicitly determined, therefore concern on indication of the actual TDW size does not exist. Therefore, symbol should be used as the unit for actual TDWs. * In addition, and most importantly, it has been agreed that JCE is supported for both PUSCH repetition type A and type B with no specific optimization for PUSCH repetition type B. Therefore, by considering the start of the first actual TDW as the first available symbol, the actual TDW determination procedure can cover both PUSCH repetition type A and type B. |
| Intel | gNB knows where the starting symbol is in the first slot for the PUSCH repetition in order to perform joint channel estimation. In this case, it may not be much different whether this is first available slot or available symbol. We slightly prefer Option 1 as this is aligned with TDW duration definition. |
| Lenovo, Motorola Mobility | Although we are fine with either options, but if granularity of symbol level is desired, then option 2 is preferred |
| LG | According to the reply LS of RAN4, joint CE should be supported at a low MCS level. It means that the probability of transmission occupying only a small portion in the TDRA table as in the example is very low. In addition, in order to support PUSCH repetition type B in the use case to be supported, it was agreed to reuse the technique of PUSCH repetition type A. Also, considering that it is not supported if the unscheduled gap exceeds 13 symbols, slot is sufficient for unit and we do not see any strong reason why it should be a symbol. |
| Sharp | Prefer Option 2. This is because un-scheduled gap is defined by symbol level, and in special slot, the actual TDW should not include DL symbols and flexible symbols for DL-to-UL switching. |
| ZTE | We don’t see much difference between the two options. |
| vivo | Agree with intel.  For JCE on type-B PUSCH repetition, the UE behaviour is also clear if actual TDW is counted in slot level. Type-B PUSCH are typically intended for good coverage UEs for low latency, optimization on JCE for type-B PUSCH repetition is not critical for coverage enhancement. |
| TCL | We are fine with either options. |
| Samsung | We are fine with the both options, but slightly prefer Option 2. Option 2 can be seen as an optimized design for the actual TDW for both repetition type A and repetition type B. |
| Panasonic | In order to complete the working item timely, we propose to finalize the design of joint channel estimation for repetition type A first. Then, we come back to discuss the design of joint channel estimation for repetition type B. Hence, we propose to leave this discussion later. |
| CATT | ‘Available symbol’ is a new concept different from ‘available slot’ in 8.8.1.1. Assuming the difference (between configured TDW and actual TDW) is just the granularity of the unit, we prefer symbol-level for better accuracy. |
| China Telecom | Support option 2. We are not sure whether UE is required to maintain power consistency and phase continuity for DL symbols in available slots for option 1. |
| Xiaomi | Prefer alt 2. The granularity of un-scheduled OFDM which affects the power consistency and phase continuity is symbol level. |
| Apple | We don’t see much the difference between two options. If the unit of the TDW is slot, then Option 1 makes more sense, the PUSCH transmission is starting from the first available symbol. |
| WILUS | We prefer the Option 1 and share the similar view with Intel. |
| CMCC | Support option 1.  And share similar views as Intel. The specific PUSCH time domain resources no matter for repetition type A or repetition type B depends on the time domain resource allocations indications. Once the allocated resources are within the actual TDW, the JCE could be used. To fitting for both repetition type A and repetition type B, the option 1 “the available slot” is more simple and preferred.  The actual TDW is defined to deal with the interruption events based on the definition of the configured TDW but not for the resources allocation. |
| InterDigital | We support Option 2.  Our initial proposal to support slot-based starting position was based on TDW design for Type A repetition. However, if we want compatibility with type B repetition, the start of the first actual TDW can be the first symbol. |
| Huawei, HiSilicon | Option 1 is preferred. Taking the first available slot as the start of the actual TDW is more friendly for a UE implementation. |
| Spreadtrum | We prefer slot based, Option 1. |
| Ericsson | Somewhat prefer Option 1; agree with others that there may not be much difference in behavior. |

**Issue #3-2: The end of the actual TDW**

**FL comments:** It seems the majority support the end is last available slot or last available symbol. The difference between last available slot and last available symbol is demonstrated in the following figure.



Fig. Illustration of the end of actual TDW is the last available slot



Fig. Illustration of the end of actual TDW is the last available symbol

Condition 1: The actual TDW reaches the end of the last PUSCH transmission within the configured TDW.

* **Option 1:** The end of the actual TDW is the last available slot for the last PUSCH transmission within the configured TDW.
  + **Support**: ZTE, MediaTek, CMCC, Samsung, InterDigital, Lenovo, Motorola Mobility, WILUS, OPPO, Apple, Intel
* **Option 2:** The end of the actual TDW is the last available symbol for the last PUSCH transmission within the configured TDW.
  + **Support**: HW, HiSilicon, ZTE, MediaTek, CATT, CTC, InterDigital, Lenovo, Motorola Mobility, Nokia, NSB, Sharp

Condition 2: An event occurs that violates power consistency and phase continuity.

* **Option 1:** The end of the actual TDW is the last available slot of the PUSCH transmission right before an event such that the power consistency and phase continuity are violated.
  + **Support**:ZTE, MediaTek, Samsung, InterDigital, Lenovo, Motorola Mobility, WILUS, OPPO, LG, Apple, Intel
* **Option 2:** The end of the actual TDW is the last available symbol of the PUSCH transmission right before an event such that the power consistency and phase continuity are violated.
  + **Support**: HW, HiSilicon, ZTE, MediaTek, CATT, CTC, CMCC, InterDigital, Lenovo, Motorola Mobility, Nokia, NSB, Sharp

Companies are encouraged to provide comments on the above two options.

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| Nokia/NSB | We prefer Option 2. Same comments as for Issue #3-1. |
| Intel | Gnb knows where the ending symbol is in the last slot for the PUSCH repetition in order to perform joint channel estimation. In this case, it may not be much different whether this is last available slot or available symbol. We slightly prefer Option 1 as this is aligned with TDW duration definition. |
| Lenovo, Motorola Mobility | Although we are fine with either options, but if granularity of symbol level is desired, then option 2 is preferred |
| NTT DOCOMO | Prefer Option2.  The definition of TDW is the duration during which UE is expected to maintain power consistency and phase continuity. If the slot is the unit of actual time domain window, it implies that UE is expected to maintain power and phase continuity even after PUSCH transmissions until the last slot ends. As UE may transmit DMRS-bundled PUSCH and non-overlapping PUCCH within the last slot of TDW, single actual TDW might cover separate channels when the unit of actual TDW is slot. To avoid it, the unit of TDW should be symbol. |
| LG | Like the comment at the beginning of actual TDW, it would be appropriate to be an available slot. In addition, the meaning that the actual TDW has reached the end within the configured TDW is understood the same as the event. We do not see any strong reason why the two conditions need to be separated. In our understanding, both are terminations due to the same event, so they should have aligned UE ehaviour. |
| Sharp | We prefer Option 2. |
| ZTE | Option 2 is slightly preferred. Because, in case of the events occur in the middle of a slot, it can make the next actual TDW still in the slot (this only happens in case of PUSCH repetition type B). |
| vivo | Similar view as intel. |
| TCL | We are fine with either options. |
| Samsung | Same comments as the above Issue #3-1. |
| Panasonic | In order to complete the working item timely, we propose to finalize the design of joint channel estimation for repetition type A first. Then, we come back to discuss the design of joint channel estimation for repetition type B. Hence, we propose to leave this discussion later. |
| CATT | Option 2 is preferred for more accuracy for actual TDW. A unified design for the start and the end of an actual TDW should be pursued as much as possible. |
| China Telecom | Support option 2. We are not sure whether UE is required to maintain power consistency and phase continuity for other UL transmission with different setting in available slots illustrated in the above Figure for option 1. |
| Xiaomi | Prefer alt 2, same comments as the above issue#3-1 |
| Apple | Same view as Intel. |
| CMCC | For the condition 1, it is the same situation and reasons as in #Issue 3-1.  Fort the condition 2, since the interruption event could happen at any time, then the symbol level is more appropriate. The option 2 is preferred for condition 2. |
| InterDigital | Ok with option 2 for both conditions. |
| Huawei, HiSilicon | As discussed in our contribution, the last available symbol is better than the last available slot. Because the last symbol within the last slot may be used to transmit a SRS which should not be covered by the configured TDWs. |
| Spreadtrum | We prefer Option1. |
| Ericsson | Options 1 and 2 imply different granularity with which the UE can control events. This may depend on the events. |

**Issue #3-3: Events that violate power consistency and phase continuity**

|  |  |
| --- | --- |
| **Event type** | **Potential events** |
| Semi-static event | DL slot or DL reception/monitoring based on DL/UL configuration for unpaired spectrum |
| SSB transmission |
| CORESET0 with Type0-PDCCH CSS set |
| Invalid UL symbols |
| The actual TDW reaches the maximum duration |
| Frequency hopping (depend on whether it is an event) |
| Beam switching |
|  | |
| Dynamic event | High priority transmission |
| Transmission gap of more than 13 un-scheduled symbols |
| Transmission of an UL transmission with different settings than PUSCH repetitions in the middle of two PUSCH transmissions |
| Dynamic SFI |
| UL CI |
| TPC command (depend on whether it is an event) |
| TA adjustment (depend on whether it is an event) |
|  | Precoder cycling (?) |

**Companies are encouraged to provide views on the above events.**

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| Nokia/NSB | Other UL transmission with different settings could also be semi-static event, e.g., PUCCH carrying P-CSI or SRS. In addition, whether frequency hopping could be an event or not would depend on the discussion on inter-slot FH with inter-slot bundling, which will be carried out under AI. 8.8.2 as recommended by the FL. |
| Intel | The lists are good starting points. For semi-static event, “The actual TDW reaches the maximum duration” may depend on whether it is an event.  In addition, PUCCH overlapping handling may be considered as an event. For instance, if multi-slot PUCCH overlaps with PUSCH repetition, then PUSCH is dropped, which would need to be considered for TDW determination.  Our view is that precoder cycling should be part of event. This may be the case when multi-TRP based operation is used for PUSCH repetition and different precoders are applied for different repetitions. |
| LG | The example divided into dynamic/semi-static event seems desirable. However, the discussion on whether to treat frequency hopping as an event or not should be preceded. In addition, among the above events, those having a time duration and those without a time duration are mixed, and it is necessary to distinguish them. This is because the starting point of the subsequent actual TDW is different depending on whether the event has a time duration or not. |
| Sharp | In our view. the events based on CORESET0 with Type0-PDCCH CSS set and invalid UL symbol are applicable only for repetition type B. Therefore, that should be clarified. The events  should not include precoder cycling because gNB cannot identify that UE implicitly changes precoder. |
| ZTE | For the events that are due to Rel-16 collision rules, it could be sufficient to make it more general to avoid missing any events, e.g., events due to dropping/cancellation based on Rel-16 collision rules, and FFS Rel-17 collision rules. |
| vivo | 1, Transmission gap of more than 13 un-scheduled symbols is applicable for both semi-static events and dynamic events. For example, the gap can be created by combination of semi-static configured Invalid UL symbols and DL/UL configuration.  2, For CORESET0 with Type0-PDCCH CSS set, it can be covered by a more general event as ‘semi-static’ configured DL reception, including PDCCH monitoring, measurement, SPS PDSCH reception, etc.  3, High priority transmission can also be semi-static.  4. If support the window length L cannot be configured to be longer than the maximum duration, the event that the actual TDW reaches the maximum duration should be precluded. |
| Samsung | Regarding ‘The actual TDW reaches the maximum duration’, we don’t think it is necessary if we configure the window length L of the configured TDW is no longer than MD.  For TPC command and TA adjustment, we have to discuss first whether the TDW is the actual TDW or the configured TDW. Other potential events relevant to dynamic event should be addressed as the event. |
| Panasonic | In order to avoid the discussion on the each of the event cases and to have the common design among all repetition framework, we propose to use the framework in agenda item 8.8.1.1 Rel. 17 PUSCH repetition Type A of the following procedure. It means available slot is determined by only semi-static information.   * Step 1: Determine available slots for K repetitions based on RRC configuration(s) in addition to TDRA in the DCI scheduling the PUSCH, CG configuration or activation DCI, * Step 2: The UE determines whether to drop a PUSCH repetition or not according to Rel. 15/16 PUSCH dropping rules, but the PUSCH repetition is still counted in the K repetitions. |
| CATT | It seems contradictory to consider ‘Precoder cycling’ in JCE case. The precoder should remain the same when JCE is applied. |
| China Telecom | Regarding frequency hopping, in our understanding, gNB can has the flexibility to configure the time domain hopping intervals taking into account both gain of frequency hopping and gain of joint channel estimation. Inter-slot frequency hopping with inter-slot bundling can be deemed as one kind of events that violates the power consistency and phase continuity. |
| Apple | SSB transmission on flexible symbols could be the event for physical slot based repetition. For available slot based repetition and TBoMS, it’s not event. SSB is counted as RRC signaling in the first step to determine the available slot.  “Transmission gap of more than 13 un-scheduled symbols”, this seems not an independent event. Before the transmission, no repetition or TBoMS resource allocation will have this large gap. If this larger gap is created, it should be triggered by other events, such as DL slot, cancellation. |
| CMCC | The CORESET0 with Type0-PDCCH CSS set should be one case of “DL slot or DL reception/monitoring based on DL/UL configuration for unpaired spectrum”.  The frequency hopping should be clarified that as we still have on-going discussion about how to use frequency hopping under JCE. Then the FH here as an event should be differentiated.  The beam sweeping should be clarified it is for uplink or downlink ?  The transmission gap of more than 13 un-scheduled symbol should be clarified in which scenario this will happen. Since the UL transmissions are mostly based on gNB scheduling, if gNB want to use the JCE there will not be a transmission gap beyond 13 symbols. This should not be considered as an event.  The TPC and TA adjustments should follow the conclusion of this agenda which could not impact the power consistency and phase continuity. |
| Huawei, HiSilicon | In our understanding, a UE receives a TA command only if the network have confirmed the necessity for TA adjustment. If the UE does not expect to receive it, ignores it, or even postpones its implementation, then it can cause ICI to other UEs, which should be avoided from network perspective.  Therefore, a reasonable method is taking TA command an event used to determine the actual TDWs. |
| Ericsson | Frequency hopping can be dynamically indicated or not, and so it could be viewed as either dynamic or semi-static accordingly.  If Option 2 in Issue 3-4 is agreeable, we may not need to dwell too much on how to classify events according to semi-static or dynamic.  Most of these events are really in RAN4’s domain, so I’m not sure how useful it is for us to compile a list, and whether the RAN1 specs refer to RAN4 for event determination should be discussed. |

**Issue #3-4: Restarting DMRS bundling**

* **Option 1:** UE capability of restarting DMRS bundling is applied only to dynamic events.
* **Option 2:** UE capability of restarting DMRS bundling is applied to both semi-static events and dynamic events.

Companies are encouraged to provide comments on the above two options.

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| Nokia/NSB | We prefer Option 2. When the UE has the restarting capability, it should be applicable to both dynamic and semi-static events. |
| Intel | We prefer Option 2. |
| Lenovo, Motorola Mobility | We prefer option 2 |
| FL | It seems there is some mis-understanding on option 1. Option 1 is revised as follows:  **Option 1:** If DM-RS bundling is supported, UE is mandatory to support restarting DM-RS bundling due to semi-static events. UE capability of restarting DMRS bundling is applied only to dynamic events. |
| LG | This issue appears to be the actual TDW configuration action the event in the configured TDW. In our understanding, after the semi-static event, at least the start of the actual TDW can be configured. However, it should be specified that the starting point is different according to the time duration of the event as well. |
| ZTE | Option 1 is preferred. For semi-static events, UE could know the events in advance and doesn’t require additional complexity compared to re-starting DMRS bundling across different configured TDWs. |
| vivo | Considering semi-static configurations are known before transmission, like TDD UL/DL Configuration, we don’t think this capability is applied to semi-static events. |
| TCL | Option 2 is preferred. |
| Samsung | We don’t think a UE capability for restarting DMRS bundling is needed. A UE capable of DMRS bundling is also able to apply DMRS bundling after an event. |
| Panasonic | Our view is UE capability is taken into account when setting L of the configured TDW length by the gNB. |
| CATT | We prefer Option 1 (updated by FL). When only semi-static events are involved, both gNB and UE are able to know the position of each actual TDW without confusion. The UE can predict and prepare its hardware even before the first actual TDW. It is reasonable that a UE is capable of restarting DM-RS bundling for semi-static event. |
| China Telecom | Support option 1. |
| Xiaomi | Prefer option 1 |
| Apple | Option 1 is ok. |
| CMCC | Option 2 is preferred.  A little confused why UEs cannot restart from the semi-static or dynamic events. Or in some cases, UE cannot recover from the dynamic events. |
| InterDigital | Prefer Option 2. |
| Spreadtrum | Option 2 |
| Ericsson | Prefer Option 2: in order to simplify the design, we don’t see the need to distinguish semi-static and dynamic events; anything that restarts a window is an event. |

If UE is capable of restarting DM-RS bundling, one new actual TDW is created after the event.

* **Option 1:** The start of the new actual TDW is the first available slot for PUSCH transmission after the event.
  + **Support**: HW, HiSilicon, ZTE, MediaTek, InterDigital, WILUS, Lenovo, Motorola Mobility, Samsung, OPPO
* **Option 2:** The start of the new actual TDW is the first available symbol for PUSCH transmission after the event.
  + **Support:** ZTE, MediaTek, CATT, CTC, InterDigital, Nokia, NSB, Lenovo, Motorola Mobility

Companies are encouraged to provide comments on the above two options.

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| Nokia/NSB | We prefer Option 2. Same comments as for Issue #3-1. |
| Intel | We prefer Option 1 as mentioned above. |
| Lenovo, Motorola Mobility | Although we are fine with either options, but if granularity of symbol level is desired, then option 2 is preferred |
| LG | Option 1 is supported. It should be aligned to the start of the actual TDW. |
| Sharp | Prefer Option 2. |
| ZTE | Option 2 is slightly preferred. It would be more compatible to PUSCH repetition type B as mentioned above. |
| Vivo | Prefer Opt-1. |
| TCL | We are fine with either options. |
| Samsung | Same comments as the above Issue #3-1. |
| Panasonic | As UE capability is taken into account for the configured TDW setting of L, this discussion is unnecessary in our view. |
| CATT | The time unit of a restarted actual TDW and that of the first actual TDW should be the same.  Option 2 is preferred. |
| China Telecom | Support option 2. |
| Xiaomi | Prefer option2 |
| Apple | Option 1 is preferred. |
| CMCC | If we remembered correctly, it was discussed in the last meeting, how many time are needed for UE to recover from an event and maintain the power consistency and phase continuity is one UE capability. Then I am not sure the “first available symbol” is accurate, though the “first available slot” is also not that accurate. This is why we raise the question on when a new actual TDW is created. |
| InterDigital | Although we prefer Option 2, we would also like to discuss other options where the actual TDW can be aligned with the start of actual/nominal repetition for Type B repetition. We are also open to consider the number of gap symbols needed for the UE to recover from the break in phase continuity or power consistency. |
| Spreadtrum | Option 1 |
| Ericsson | These seems like something we should be asking RAN4; propose we send an LS. |

## 3.3 TPC command

* Alt 1: UE is not expected to receive TPC commands that would take into effect after the start of a time domain window.
  + - FFS: Such TPC commands constitute events for TDW determination
  + **Support**: ZTE, Intel, Ericsson, Sharp, Qualcomm, CATT
* Alt 2: If UE receives TPC commands that would take into effect after the start of a time domain window, UE accumulates TPC commands without taking effect during the current time domain window.
  + **Support**: HW, HiSilicon, Spreadtrum, vivo, OPPO, CMCC, xiaomi, Panasonic, Samsung, NTT DOCOMO, Sony, Sierra Wireless, LG, InterDigital, Sharp, Nokia, NSB

Companies are encouraged to provide comments on the above alternatives and clarify whether the TDW is the actual TDW or the configured TDW.

|  |  |  |
| --- | --- | --- |
|  | Alt 1 | Alt 2 |
| Configured TDW | QC, Intel | DCM, Samsung, Huawei, HiSilicon (2nd preference) |
| Actual TDW | Nokia/NSB, Sharp, ZTE, CATT, Ericsson | Nokia/NSB, Lenovo, Motorola Mobility, Sharp, vivo, TCL, Samsung, OPPO, China Telecom, Xiaomi , CMCC, InterDigital, Huawei, HiSilicon (1st preference), Spreadtrum |

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| Nokia/NSB | It is worth noting that if the TPC command is applied in the unit of actual TDW, then the scenario that the UE receives TPC command during actual TDW would not happen. In this case (i.e., TPC command is applied in the unit of actual TDW), both Alt. 1 and Alt. 2 should work. The DCI that carries TPC command can be considered as an event that breaks phase continuity for actual TDW determination under the form of DL reception/monitoring, as discussed in Issue #3-3. |
| QC | Prefer Alt 1. We could not understand why a gNB would send TPC commands that take effect during a cTDW. This is a gNB implementation issue and the burden should not be shifted to the UE. |
| Intel | We prefer Alt. 1. In our view, this may be only possible for UE to receive TPC command in FDD system. Further, for UEs in coverage enhancement mode, it is expected that UE would apply maximum transmit power for the transmission of PUSCH repetitions. In this case, power control accumulation mechanism may not be necessary for DMRS bundling.  Note that gNB has full control and is aware the status that UE needs to power consistency, gNB may not need to send the TPC command during the current time domain window. |
| NTT DOCOMO | Since Alt1 imposes gNB scheduling restriction, we support Alt2. |
| LG | Perfer Alt. 2. Since the TPC command disables to continue power consistency, the unit for the application of it should be the actual TDW. Although it depends on the window size, if the TPC command is not received for the time corresponding to the window, it may act as interference inside and outside the cell, so it is not desirable for the UE not to receive the TPC command. |
| Sharp | Our understanding of TPC accumulation for DG-PUSCH in the current specification is that the TPC is NOT updated by TPC command between any two PUSCH repetitions. Therefore, in our view, neither Alt 1 nor Alt 2 is necessary for DG-PUSCH. Please correct us if our understanding on the existing behavior is wrong. |
| ZTE | We have similar understanding as Nokia. TPC could be an event to violate the phase continuity. So, gNB can send TPC during a configured window while no need within an actual time domain window. |
| Samsung | We support Alt 2. Alt1 is not correct. For format 2\_2 (configured by RRC and carrying TPC commands), it cannot be guaranteed that UE will not receive TPC commands. |
| Panasonic | We prefer Alt.2 as the dynamic range of TPC command can be increased compared with Alt.1. In Alt.1, the amount of TPC change is limited depending on TDW. |
| CATT | Agree with Nokia and ZTE that, the UE shall maintain power consistency during an actual TDW, not configured TDW. In this regard, the TDW should be the actual TDW.  It is not surprising the gNB also knows that the change of transmitted power will violate the JCE. However, it is possible if the gNB thinks it is now more important to raise the UE Tx power than combining the DMRS (for the current) for channel estimation. Otherwise, the gNB can of course avoid sending a TPC during any TDW of JCE.  So we prefer Alt.1 – specifically, TPC should be regarded as a dynamic event. No restriction on gNB scheduling. If a TPC takes effect, the UE shall increase the Tx power, and violate the DMRS bundling of the remaining part of the current actual TDW, and may restart a new actual TDW (up to UE capability). |
| CMCC | Support Alt 2 and actual TDW.  gNB should have the knowledge when will the actual TDW happens and could choose not to send the TPC command. But if it happens, the power consistency should not be interrupted. Then it could work if the TPC command could be delayed to taking effect.  As the actual TDW is derived from the configured TDW and could be smaller than the configured TDW, then the actual TDW is preferred. |
| InterDigital | We have a slight preference for Alt. 2. The accumulated TPC commands should be applied to the next available actual time window. |
| Huawei, HiSilicon | We support Alt 2 for better performance.  If the error propagation can be solved, we prefer accumulating TPC commands per actual TDW for better performance. Otherwise, it may be simple to accumulate per configured TDW. However, if the length of a TDW is too long, the gain of Alt2 decreases. So our second preference is per configured TWD with limited length.  In addition, the scenarios where Alt2 applies need to be clarified. There is no doubt that FDD and SUL are valid scenarios. Actually, TPC commands that do not take effect at the first transmission occasion of a TDW but will take effect during the TDW are of concern. For TDD, according to the spec TS 38.213, the range of valid TPC commands for transmission occasion  is defined by , which has an advance .   |  | | --- | | -  is the PUSCH power control adjustment state  for active UL BWP  of carrier  of serving cell  and PUSCH transmission occasion  if the UE is not provided *tpc-Accumulation*, where  - The  values are given in Table 7.1.1-1  -  is a sum of TPC command values in a set  of TPC command values with cardinality  that the UE receives between  symbols before PUSCH transmission occasion  and  symbols before PUSCH transmission occasion  on active UL BWP  of carrier  of serving cell  for PUSCH power control adjustment state , where  is the smallest integer for which  symbols before PUSCH transmission occasion  is earlier than  symbols before PUSCH transmission occasion  - If a PUSCH transmission is scheduled by a DCI format,  is a number of symbols for active UL BWP  of carrier  of serving cell  after a last symbol of a corresponding PDCCH reception and before a first symbol of the PUSCH transmission  - If a PUSCH transmission is configured by *ConfiguredGrantConfig*,  is a number of  symbols equal to the product of a number of symbols per slot, , and the minimum of the values provided by *k2* in *PUSCH-ConfigCommon* for active UL BWP  of carrier  of serving cell |   For example, the accumulation of TO1 accumulates only the TPC commands before the blue line, and the TPC commands received during the red range will take effect at TO2. Thus, the discussion also makes sense in TDD. The current wording is good enough. |
| Ericsson | Prefer Alt 1 for the actual TDW: if the UE does receive a TPC command, this constitutes an event, and the UE does not maintain continuity. |

## 3.4 TA adjustment

* **Option 1**: UE does not expect to receive TA commands indicating TA adjustment during the TDW.
  + **Support**: Qualcomm, ZTE
* **Option 2**: UE ignores the TA command which indicates TA adjustment during the TDW.
  + **Support**: CMCC
* **Option 3**: UE performs TA adjustment after the TDW if it receives any TA command indicating TA adjustment during the TDW.
  + **Support**: Spreadtrum, vivo, Panasonic, NTT DOCOMO, Sony, Apple, InterDigital, Ericsson, Sharp, Nokia, NSB

Companies are encouraged to provide comments on the above three options and clarify whether the TDW is the actual TDW or the configured TDW.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Option 1 | Option 2 | Option 3 |
| Configured TDW | QC, Intel |  | DCM, Samsung, Apple, Ericsson |
| Actual TDW | ZTE, CATT | CMCC | Nokia/NSB, Lenovo, Motorola Mobility, Sharp, vivo, TCL, Samsung, OPPO, China Telecom, Xiaomi, CMCC, InterDigital, Spreadtrum, Ericsson |

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| Nokia/NSB | Ignoring the TA adjustment should be avoided, otherwise the timing misalignment strongly impact system performance, especially in coverage shortage scenario. |
| QC | There is currently no concept of “accumulating TA commands”. We prefer to keep it this way and not have to introduce a new procedure. Hence, we prefer to go with Option 1 or 2. |
| Intel | We prefer option 1 to be align with TPC proposal. |
| LG | We prefer option 3. According to the reply LS of RAN4, the TA adjustment should not be performed within the DMRS bundle, and it should be performed at the boundary of the DMRS bundle. Therefore, all three options can be considered, but from the gNB's point of view, the role of TA is to align the uplinks of different UEs to be received at the same time (within the CP), so it must be guaranteed. Therefore, the UE should perform all the instructed TAs, but it is desirable to apply only the TA at the boundary of the TDW. |
| Sharp | For TA command, if the TA command is received, a slot applying the TA adjustment cannot be flexibly determined because the applied slot is subject to the minimum SCS among SCSs of configured BWPs. Therefore, Option 1 impacts scheduler and we support Option 3. |
| ZTE | Prefer similar solution as for TPC. |
| Samsung | Prefer Option 3. TA adjustment can be applied similar as TPC commands. |
| Panasonic | The amount of TA adjustment is limited in option 1. In order to have the same amount of TA relative change, we prefer Option 2. |
| CATT | The UE shall maintain phase continuity during an actual TDW, not configured TDW. In this regard, the TDW should be the actual TDW.  Note that TA has more serious effect on performance than TPC. An impropriate TA results in decoding problem in gNB side, regardless DMRS bundling is applied or not. If the gNB cannot receive PUSCH properly due to TA issue (e.g. unacceptable TA offset), JCE cannot improve the performance. So, reaction to a TA command shall be as fast as possible.  So we prefer Alt.1 – TA command should be regarded as a dynamic event. No restriction on gNB scheduling. If a TA command takes effect, the UE shall adjust the TA, and violate the DMRS bundling of the remaining part of the current actual TDW, and may restart a new actual TDW (up to UE capability). |
| Apple | If the TA is applied to actual TDW, it could cause misalignment between gNB and UE, due to UE could miss the dynamic signalling which trigger the actual TDW. |
| CMCC | Our original thinking is that gNB could send another timing adjustment which could taking effect after the TDW, since the gNB and UEs have a same knowledge of where the TDW is. From this perspective, the gNB could choose when to send timing adjustment through implementation. But if the timing adjustment accidently will take effect during the TDW, we have no problem to delay it after the actual TDW. |
| Huawei, HiSilicon | In our understanding, a UE receives a TA command only if the network have confirmed the necessity for TA adjustment. If the UE does not expect to receive it, ignores it, or even postpones its implementation, then it can cause ICI to other UEs, which should be avoided from network perspective.  Therefore, a reasonable method is taking TA command an event used to determine the actual TDWs. Ignoring a TA command by a UE should be avoided. |
| Ericsson | The UE should not ignore a TA command, and we think the timing is not as tight as for the TPC case. So here the TA commands can be deferred in both configured and actual TDWs. |

1. Email discussion (2nd round)

## 4.1 Use cases

**Use case 4b:**

**Proposal 1:**

* For non-back-to-back PUSCH transmissions across consecutive slots, if there is other uplink transmission in the middle of two PUSCH transmissions and the condition of power consistency and phase continuity cannot be met, the other uplink transmission constitutes an event that violates power consistency and phase continuity.

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| **Companies** | **Comments** |
| WILUS | Support |
| QC | Agree. Isnt this just restating what RAN4 already told us? |
| Spreadtrum | Support |
| vivo | Support |
| TCL | Support |
| Sharp | Support |
| CATT | Support.  However, one critical issue is still open yet: what if other UL transmission has the same FDRA, power, TMPI…? Should we consider it is NOT an event? Or just handle it the same as the case when the parameters are different, for the sake of simplicity? |
| NTT DOCOMO | Support the proposal. |
| LG | Support. If there is uplink transmission between the TDW, whatever the UE behaviour is, for example UCI multiplexing or prioritization for transmission power reduction, the UE cannot maintain the power consistency and phase continuity. It is natural to handle other uplink transmission as an event. |
| Panasonic | Support |
| Nokia/NSB | We are fine with the proposal. Our understanding on the part “and the condition of power consistency and phase continuity cannot be met” is that if the condition of power consistency and phase continuity can be met, e.g., same settings (to be confirmed by RAN4), then JCE can be applied across the other UL transmission. |
| ZTE | Support |

**Use case 5:**

**Proposal 2:**

* Joint channel estimation over PUSCH transmissions across non-consecutive slots is not supported in Rel-17.

**Support**: Nokia/NSB, Qualcomm, Intel, Lenovo, Motorola Mobility, NTT DOCOMO, LG, Sharp, ZTE, Vivo, TCL, Samsung, OPPO, Panasonic, CMCC, CATT, China Telecom, Xiaomi, Apple, Huawei, HiSilicon, Spreadtrum, Sierra Wireless

**Not Support**: Sony

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| **Companies** | **Comments** |
| WILUS | Support |
| vivo | Support |
| TCL | Support |
| Sharp | Support |
| CATT | Support |
| NTT DOCOMO | Support the proposal. |
| LG | Support it due to the RAN4’s conclusion. |
| Panasonic | Support |
| Nokia/NSB | Support. This seems to be clear from the RAN4 confirmation that the maximum unscheduled gap is 13 symbols. |
| ZTE | Support |

## 4.2 Time domain window

### 4.2.1 Configured TDW

#### Issue #1: The window length L of the configured TDW

**Issue #1-1: The maximum value of *L***

**FL comment**: As commented by Apple, a large number of companies support original Alt 2-B in last meeting. The main point of the original Alt 2-B is the window length L can be equal to all repetition (i.e. L can be larger than maximum duration). The benefits of original Alt 2-B based on companies’ comment in last meeting are listed as follows:

* It can achieve the best performance for joint channel estimation.
* It does not require additional signalling to explicit configure the length of TDW.
* It is beneficial for the interaction with frequency hopping and precoder cycling.

FL would like to check if it is common understanding on the above benefits of L> maximum duration. From FL’s perspective, suggest to take Option 1 (majority view) or take Option 3 as a compromise.

**Proposal 3:** Down-select one of the following options:

**Option 1**:

* The maximum value of window length *L* of the configured TDW should not exceed the maximum duration.

**Option 3**:

* The maximum value of the window length *L* of the configured TDW is the duration of all repetitions.
  + Whether *L* can be longer than maximum duration is subject to UE capability.
  + If *L* is longer than the maximum duration, UE does not expect dynamic events.
    - FFS: details of dynamic events.

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| **Companies** | **Comments** |
| WILUS | Support and we prefer Option 1. |
| QC | Prefer Option 1. Its best to keep the overall process simple and straightforward. A more robust and deterministic approach leads to a design that is easy to implement, test and deploy.  We appreciate the effort to optimize bundling in the case of dynamic events by allowing L > max. duration, but its side effects are proving to be hard to ignore. |
| Spreadtrum | Support the proposal, Option 1 is our preference. |
| vivo | Prefer option 1.  For opt-3, it is strange that ‘Whether *L* can be longer than maximum duration is subject to UE capability’, considering the maximum duration length is already an UE capability, if L> maximum duration reported by UE, why not defining/reporting an even higher capability for maximum duration?  Besides, ‘UE does not expect dynamic events’ put to much restrictions at scheduler.  Hence, we do not support option 3. |
| TCL | Support the proposal and option 1 is preferred. |
| Sharp | Support and prefer Option 1. |
| CATT | Prefer Option 1.  For Option 3, a contradictory point is that, if ‘UE does not expect dynamic events’ is valid when *L* is large, it seems even easier for gNB to guarantee this when *L* is small. Then why not just say the UE does not expect dynamic events in Option 3. |
| LG | As a matter of fact, all we have regarding the maximum duration is definition of it from following agreement during RAN1#105-e.  Agreement:   * Definition of **the maximum duration**: a maximum time duration during which **UE is able to** maintain power consistency and phase continuity subject to power consistency and phase continuity requirements. * FFS whether or not such a definition is necessary for RAN1 specifications.   + Note: whether such a definition is to be specified in RAN4 specifications is up to RAN4. * FFS the maximum duration may be reported by UE. * Note: it is understood that for a UE, the maximum duration is no less than the time domain window duration   From the note highlighted, it is our understanding that the time domain window should be equal to or larger than the maximum duration, and actual time domain window is the time domain window here, since actual time domain window cannot exceed it due to the definition of maximum time duration. From that, we are quite not sure why do we need to limit the configured TDW size with respect to the maximum duration.  Furthermore, the maximum duration can be time-varying value according to velocity of UE. In that sense, to make option 1 possible, the maximum value of window length L should not exceed the minimum of maximum duration, which does not make sense. |
| Panasonic | Our understanding on "the maximum duration" is the duration which UE is able to maintain power consistency and phase continuity subject to power consistency and phase continuity requirements. We proposed that it is reported as UE capability. Therefore, we propose to clarify option 1 as following.  Option 1:   * The maximum value of window length L of the configured TDW should not exceed the maximum duration, which is reported as UE capability as the duration where UE is able to maintain power consistency and phase continuity subject to power consistency and phase continuity requirements. |
| Nokia/NSB | We prefer Option 3 and do not want to repeat here again the benefit of considering L>maximum duration. However, we would like to highlight that the current TDW determination procedure came from the great flexibility from all companies to find a middle ground. Initially, many companies, including us, did not think that explicit configuration of L is even needed. However, we have been flexible to consider it with the understanding that this can be equal to the repetition duration or not, and up to gNB to configure. If L cannot be greater than maximum duration the whole intention of finding the middle ground is gone. Now coming back to the problem at hand, Option 3 is yet another effort to find a compromise, we don’t see the reason why letting L> maximum duration or not cannot be subject to UE capability. |
| ZTE | Support and prefer Option 1. |

**Issue #1-2: Configuration/Indication of *L***

**Proposal 4:**

* For DG-PUSCH, Type1 CG-PUSCH and Type2 CG-PUSCH, the window length L of the configured TDW is at least configured by RRC.
* FFS: For DG-PUSCH and Type2 CG-PUSCH, whether the window length *L* of the configured TDW can be indicated by DCI or indicated by TDRA table with one additional entry.

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| **Companies** | **Comments** |
| WILUS | Support |
| QC | Agree |
| Spreadtrum | Support |
| vivo | Agree with the first bullet. But OK to live with the FFS for progress.  For the FFS, in our understanding, indicating configured TDW length L in TDRA is not necessary, for the following reasons:  1, we already have mechanisms to determine actual TDW, the dynamic indicated L length will not make much difference on the segmentation point of actual TDW and the overall performance, especially in TDD.  2, Even if in FDD, in our understanding, the time domain filtering length in joint channel estimation may be determined semi-static rather than dynamic changed in NW receiver, when JCE is enabled. Hence, it seems no strong motivation to have L in TDRA table. |
| TCL | Support |
| Sharp | Support |
| CATT | Support. |
| NTT DOCOMO | We are generally fine, but strongly prefer window length indication by TDRA entry.  If only one window length is used for all rows in TDRA, the gap of configured TDW lengths between multiple configured TDWs might get large in some cases.  In general, larger window length up to maximum duration achieves larger JCE gain without error propagation. On the other hand, as longer TDW causes less frequent update of power, frequency offset calibration and TA adjustment, short TDW length is preferred under the same JCE gain. Given this fact, window length = maximum duration is not desired, especially when duration of all repetitions is longer than maximum duration. The below figure illustrates the problem of one common window length. As can be seen in this figure, one common window length (window length = maximum duration) causes the unbalanced configured TDW length. In that situation, one long TDW delays the update of power, frequency offset calibration and TA adjustment, which results in poor coverage performance. This issue can be solved by configuring window length per row in TDRA table.    As desired window length is dependent on TDRA of PUSCH, it is better to configure window length per row in TDRA table. With this approach, overhead of DCI is not increased.  We could not find any motivation to make window length common per channel. |
| LG | We do not see strong reason why the length L is configured if it is the duration of all repetitions. |
| Panasonic | Our understanding on FFS of the proposal is that when the window length L of the configured TDW is indicated by DCI or the TDRA table, the candidate value or the entry of TDRA table is configured at least by RRC. We agree to support the proposal. |
| Nokia/NSB | We are fine with the FL’s proposal. |
| ZTE | Support the proposal. |

**Proposal 5:**

* The window length L of the configured TDW is configured separately for PUSCH and PUCCH.
  + For PUSCH, *L* is configured per BWP.
  + For PUCCH, whether *L* is configured per PUCCH format is discussed in AI 8.8.2.

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| **Companies** | **Comments** |
| WILUS | Support |
| QC | Agree. |
| Spreadtrum | Support |
| vivo | Support |
| TCL | Support |
| Sharp | Support |
| CATT | OK. |
| NTT DOCOMO | This topic should be discussed after reaching the agreement on proposal 4. |
| LG | Same comment as proposal 4. |
| Panasonic | Agree. |
| Nokia/NSB | We support the FL’s proposal |
| ZTE | Support |

**Issue #2: The determination of configured TDW**

**Proposal 6:**

* For PUSCH repetition type A counting based on physical slots
  + The start of the first configured TDW is the first physical slot for the first PUSCH transmission.
  + The end of the last configured TDW is the last physical slot for the last PUSCH transmission.
* If PUSCH repetition type A is counted based on available slots
  + The start of the first configured TDW is the first available slot for the first PUSCH transmission.
  + The end of the last configured TDW is the last available slot for the last PUSCH transmission.
  + Note: The determination of available slots for PUSCH repetition Type A is defined in AI 8.8.1.1.

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| **Companies** | **Comments** |
| WILUS | Support with minor editorial modification:  **Proposal 6:**   * For PUSCH repetition type A counting based on physical slots   + The start of the first configured TDW is the first physical slot for the first PUSCH transmission.   + The end of the last configured TDW is the last physical slot for the last PUSCH transmission. * ~~If~~ For PUSCH repetition type A ~~is counted~~ counting based on available slots   + The start of the first configured TDW is the first available slot for the first PUSCH transmission.   + The end of the last configured TDW is the last available slot for the last PUSCH transmission.   + Note: The determination of available slots for PUSCH repetition Type A is defined in AI 8.8.1.1. |
| QC | Agree. Okay with edits by WILUS above. |
| Spreadtrum | Support. |
| vivo | In our understanding, NO need to differentiate for the two counting method for type-A PUSCH repetition.  Considering we already have an initial version actual TDW window determination mechanism, and the actual TDW may be determined by many semi-static events, which may include semi-static DL transmission (including SSB), other semi-static UL transmissions, TDD DL/UL configurations, beam switching, and even dynamic event, which is more complicated than the semi-static factors to determine available slots we considered in AI.8.8.1.1. It is not surprising that UE may also have capability on counting available slots using the mechanism defined in AI8.8.1.1, No matter whether UE have claimed the capability on FG30-1.  Hence, we prefer the start/end of the first/last configured TDW are first/last available slot for PUSCH transmission. |
| TCL | Support |
| Sharp | Support |
| CATT | Support. |
| LG | Prefer available slots.  We would like to ask companies who support physical slots that whether the physical slot means uplink slot indicated by semi-static configuration or actual PUSCH transmission. If it is uplink slot indicated by semi-static configuration, it is very likely to be concluded that PUSCH is not actually transmitted on the slot. Otherwise, if it is actual PUSCH transmission, the start and end of configured TDW is determined on the fly and that could lead misunderstanding of window boundary. From those perspectives, we think configured TDW should be determined available slots which can prevent frequent event that PUSCH is not actually transmitted and misunderstanding of window. |
| Panasonic | Does this proposal intend to explain the meaning for the following proposal 7? |
| Nokia/NSB | Support FL’s proposal 6 with edits from WILUS. |
| ZTE | Fine with the proposal |

**Proposal 7:** Down-select one of the following options:

* **Option 1:** The configured TDWs are consecutive regardless of paired spectrum/SUL band and unpaired spectrum, i.e. the start of other configured TDWs is the first physical slot right after the previous TDW.

**Support:** Nokia, NSB, Lenovo, Motorola Mobility, Sharp, ZTE, TCL, xiaomi, Ericsson

* **Option 2:** The start of other configured TDW is different for paired spectrum/SUL band and unpaired spectrum.
  + For paired spectrum/SUL band, the configured TDWs are consecutive, i.e. the start of other configured TDWs is the first physical slot right after the last TDW.
  + For unpaired spectrum, the start of the configured TDWs is implicitly determined based on semi-static DL/UL configuration.

**Support:** Qualcomm, Intel, vivo, Samsung, CMCC, CATT, CTC, Apple, InterDigital, Huawei, HiSilicon

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|  | Companies’ views |
| Option 1 | * Based on the UL/DL configuration, the configured TDW size L can be implicitly determined. In this case, L is not necessarily to be explicitly configured. Therefore, the more reasonable approach is that RAN1 should either adopt Option 1 or implicitly determine configured TDW size L based on UL/DL configuration and the explicit configuration of L is not considered. * It is simpler than Option 2 and the available slots can be considered by the actual TDW. * Contiguous UL slots may be segmented to different configured TDWs for unpaired spectrum. * For option1 it the start of other configured TDW is the DL slot, then the TDW window length would be shorten than expected, it could not get the fully joint channel estimation gain. |
| Option 2 | * Option 2 would open more discussion on how to implicitly determine the start of TDW for unpaired spectrum. For instance, whether it should also consider SSB transmission (align with the definition of available slot), and whether it should depend on counting method etc. * It is more aligned with determination mechanism for TDD or FDD. * It is more straightforward and simple to determine the configured TDWs by taking into account the semi-static DL/UL configuration. |

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| **Companies** | **Comments** |
| WILUS | Support the proposal and we prefer Option 2. Semi-static DL/UL configuration should be taken into account for unpaired spectrum. |
| QC | Can we take an approach similar to Proposal 6, where we outline how the process would work based on whether we count based on physical slots or available slot? This lets us sidestep debate on paired/unpaired spectrum.  If this change is made, then tying configured TDWs to available slots seems quite straightforward.  Our concern with Option 1 is inadvertently splitting two consecutive U slots into separate configured TDWs. Consider a PUSCH transmission with 4 repetitions and TDD slot pattern DDDSUDDDUU. Assuming L=2, and S slot can accommodate a full repetition, Option 1 would give us the following cTDWs: DDDSUDDDUUDDDSU whereas Option 2 gives us this: DDDSUDDDUU. Its clear to see why Option 2 might work better.  Note that since we already run the procedure outlined in 8.8.1.1 to identify the available slots, no additional spec effort is required to determine cTDW locations.  **Modified Option 2 (to streamline with Proposal 6):**   * For PUSCH repetition type A counting based on physical slots   + the configured TDWs are consecutive, i.e. the start of other configured TDWs is the first physical slot right after the last configured TDW. * If PUSCH repetition type A is counted based on available slots   + The configured TDWs are determined based on available slots, i.e., start of a configured TDWs is the next available slot after the conclusion of a previous configured TDW.   Note: The determination of available slots for PUSCH repetition Type A is defined in AI 8.8.1.1. |
| Spreadtrum | Agree with QC, support the above **Modified Option 2 (to streamline with Proposal 6).** |
| vivo | Fine with the proposal, and opt-2 is preferred. |
| Sharp | We prefer Option 1. Currently, Option 2 is unclear and more discussions are needed such as how to implicitly determine, what it is based on, impacts on the events, counting method, etc. |
| CATT | QC’s modification seems reasonable, which combines the original Option 1 and Option 2 with different assumptions that whether counting based on available slot is supported by the UE.  Support Option 2 of QC’s version. Minor changes to QC’s version in the sub-bullet:   * For PUSCH repetition type A counting based on physical slots   + the configured TDWs are consecutive, i.e. the start of other configured TDWs is the first physical slot right after the last physical slot of a previous configured TDW. * If PUSCH repetition type A is counted based on available slots   + The configured TDWs are determined based on available slots, i.e., start of a configured TDWs is the ~~next~~ first available slot after the ~~conclusion~~ last available slot of a previous configured TDW.   Note: The determination of available slots for PUSCH repetition Type A is defined in AI 8.8.1.1. |
| LG | We think this proposal should take account for the previous proposal. The unit of configured TDW should be available slots. |
| Panasonic | We support the proposal from Qualcomm to use the term physical slot or available slots as proposed in proposal 6. Our position is to use available slots. |
| Nokia/NSB | In principle, we don’t see the need of implicit determination of configured TDWs based on UL/DL configuration. On the other hand, the modified Option 2 from Qualcomm seems reasonable, since categorizing based on the counting method is more appropriate, which doesn’t preclude the back-to-back configured TDWs in TDD when counting on physical slots. However, we would like to make the following modification to make sure that this option also takes into account PUSCH repetition type B, given the agreement that to specific enhancements for PUSCH repetition type B is allowed. In the modifications below, transmission occasions aim to cover actual repetitions within the current or next slot.  **Modified Option 2 (to streamline with Proposal 6):**   * For PUSCH repetition type A counting based on physical slots   + the configured TDWs are consecutive, i.e. the start of other configured TDWs is the first physical slot right after the last configured TDW. * ~~If PUSCH repetition type A is counted based on available slots~~For all other cases   + The configured TDWs are determined based on available slots and transmission occasions, if applicalbe, i.e., start of a configured TDWs is the next transmission occasion in the current or next available slot after the conclusion of a previous configured TDW.   Note: The determination of available slots for PUSCH repetition Type A is defined in AI 8.8.1.1. |
| ZTE | Prefer Option 1. But, as we commented before, we suggest deleting ‘regardless of paired spectrum/SUL band and unpaired spectrum’ in Option 1. This could also align with the discussion for Option 2. |

### 4.2.2 Actual TDW

#### Issue #3: The determination of actual TDW

**Issue #3-1: The start/end of the actual TDW**

**Proposal 8:** For the start/end of actual TDW, down-select one of the following options:

**Option 1:**

* The start of the first actual TDW is the first available slot for the first PUSCH transmission within the configured TDW.
* The end of the actual TDW is
  + the last available slot for the last PUSCH transmission within the configured TDW if the actual TDW reaches the end of the last PUSCH transmission within the configured TDW.
  + the last available slot of the PUSCH transmission right before the event if an event occurs that violates power consistency and phase continuity.
* For UE capable of restarting DM-RS bundling, the start of the new actual TDW is the first available slot for PUSCH transmission after the event violates power consistency and phase continuity.

**Option 2:**

* The start of the first actual TDW is the first available symbol for the first PUSCH transmission within the configured TDW.
* The end of the actual TDW is
  + the last available symbol for the last PUSCH transmission within the configured TDW if the actual TDW reaches the end of the last PUSCH transmission within the configured TDW.
  + the last available symbol of the PUSCH transmission right before the event if an event occurs that violates power consistency and phase continuity.
* For UE capable of restarting DM-RS bundling, the start of the new actual TDW is the first available symbol for PUSCH transmission after the event violates power consistency and phase continuity.

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| **Companies** | **Comments** |
| WILUS | Support and prefer Option 1. |
| Spreadtrum | Support the proposal. Option 1 is our preference. |
| vivo | Fine with the proposal, and opt-1 is preferred. |
| TCL | We are fine with either options. |
| Sharp | We prefer Option 2 but can follow majority’s view for sake of progress. |
| CATT | Support. Prefer Option 2. |
| NTT DOCOMO | Prefer Option2.  It was agreed that the definition of TDW is the duration during which UE is expected to maintain power consistency and phase continuity. If option 1 is supported, UE is expected to maintain power and phase continuity after PUSCH transmission. Otherwise, it is against the agreed definition of TDW. |
| LG | According to the agreements of use cases, it is clearly stated that repetition type B is supported if it reuses only those joint channel estimation specification enhancements defined to support repetition Type A. Therefore we should focus on repetition type A, which makes option 1 should be supported. |
| Panasonic | We support the proposal 8. |
| Nokia/NSB | Support, we prefer Option 2. Since actual TDWs are implicitly determined, we don’t see why the actual TDW size should be longer than the duration where the PUSCHs are spanned. In addition, if an event, e.g., PDCCH reception/monitoring arrives at the beginning of a slot, if we define the start of the actual TDW is the first available slot after the event then the PUSCH in the current slot (after the event) is not included in the actual TDW, as shown in figure below. Is there any technical reason for excluding it, given that the actual TDWs are anyhow implicitly determined? |
| ZTE | Either option is ok for us. But for Option 1, it may need to clarify the ‘available slot’ is the slot in which PUSCH can be transmitted, instead of the ‘available slot’ defined for counting based on available slot. |

**Issue #3-3: Events that violate power consistency and phase continuity**

**FL comments:** Regarding the events, since there are quite a number of events, companies are encouraged to answer following questions.

**Q1:** Whether all events need to be explicitly listed, or we can make it more general to avoid missing any events, e.g., events due to dropping/cancellation based on Rel-16 collision rules, and FFS Rel-17 collision rules, as suggested by ZTE.

**Q2**: If we consider the general method, which additional events that are not covered by existing rules should be considered?

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| **Companies** | **Comments** |
| WILUS | Q1: All events are no need to be explicitly listed.  Q2: Common rule can cover all events. |
| vivo | Q1: Events can be a general description if there is no ambiguity  .  Q2: The events can generally be characterized as follows, at least including   * Collision in rel-15/16/[17], e.g. dropping, cancellation, power change due to simultaneous transmission in multiple CCs, in rel-15/16 * DL reception * Other UL transmission in between repetition * Beam switching * Gap more than 13 symbols. |
| Sharp | We prefer to make it more general as much as possible. |
| CATT | Q1: OK with the suggestion to make it general as much as possible.  Q2: At least, if TPC/TA command are regarded as an event (still discussing in the next section), they should be additionally captured. |
| LG | It would be safer approach to make general rule to avoid missing events. In that perspective, we think event should be classified by time duration of it. For example, any kind of DL monitoring/reception and other UL transmission needs at least one slot and transmit power change, TA and TPC adjustment do not need a slot. |
| Panasonic | Before listing all events, whether/how to use the 2-step procedure framework of PUSCH repetition Type A defined in AI 8.8.1.1 should be concluded. Our preference is to reuse it. Then multiple of listed events could be resolved smoothly. |
| Nokia/NSB | At least the basic events that have been identified in the 1st round of discussion can be explicitly listed, to make it clear. We can then cover the potential remaining events by a generic term. |
| ZTE | Q1: Making it general seems sufficient, and can save our time for discussing each event. If needed, we can make the general events as WA, and we can come back to a specific even if any critical issues identified later.  Q2: Ok with the list from vivo. |

**Issue #3-4: Restarting DMRS bundling**

**Proposal 9:** Down-select one of the following options:

* **Option 1:** If DM-RS bundling is supported, UE is mandatory to support restarting DM-RS bundling due to semi-static events. UE capability of restarting DMRS bundling is applied only to dynamic events.
* **Option 2:** UE capability of restarting DMRS bundling is applied to both semi-static events and dynamic events.

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| **Companies** | **Comments** |
| WILUS | Among two options, Option 1. Conditions for JCE (e.g., same transmission power and PRB allocation) depends on gNB scheduling, while DMRS bundling is performed at gNB for JCE. We are not sure such conditions are limited w.r.t the UE capability. |
| Spreadtrum | Support the proposal. Option 2 is our preference. |
| vivo | Fine with the proposal |
| Sharp | Prefer Option 2 to make the events more general. |
| CATT | Fine with the proposal and prefer Option 1. |
| NTT DOCOMO | Support. |
| LG | To achieve maximum performance gain of DMRS bundling, the size of actual TDW should be large enough and as many as possible transmission occasions should be included in the actual TDW. From that perspective, we support option 1 since semi-static events are predictable and known to both of gNB and UE in advance. |
| Panasonic | We support the proposal 9. However, we prefer to discuss this proposal after discussion on proposals 7 and 8. |
| Nokia/NSB | We are fine with the FL’s proposal and prefer Option 1. |
| ZTE | Support and prefer Option 1. |

## 4.3 TPC command

**FL comments:** It seems companies’ views are quite divergent. The key point is whether TPC is an event.

**Q1: Whether TPC is an event?**

If the answer to Q1 is yes, from FL understanding, UE will not receive TPC commands that would take into effect during the actual TDW, but will receive TPC commands that would take into effect during the configured TDW. Thus it seems not necessary to discuss the two alternatives in section 3.3.

If the answer to Q1 is no, then the question is how to handle TPC commands that would take into effect during the actual TDW and configured TDW. For actual TDW, there are two options: UE does not expect TPC commands and UE accumulates TPC commands that would take into effect during the actual TDW. For configured TDW, there can be three options, no special handling, UE does not expect TPC commands and UE accumulates TPC commands that would take into effect during the configured TDW

**Q2: If the answer to Q1 is no, how to handle TPC commands that would take into effect during the actual TDWs.**

**Q3: If the answer to Q1 is no, how to handle TPC commands that would take into effect during the configured TDWs.**

**Companies are encouraged to answer the above questions.**

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|  | **Yes** | **No** |
| **Q1** | [Company name] Spreadtrum, CATT, ZTE | vivo, Sharp, DCM, LG |

|  |  |  |
| --- | --- | --- |
|  | **Alt 1: UE does not expect TPC commands that would take into effect during the actual TDW.** | **Alt 2: If UE receives TPC commands that would take into effect after the start of a time domain window, UE accumulates TPC commands without taking effect during the current actual TDW.** |
| **Q2** | [Company name] | vivo, Sharp, DCM, LG |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Alt 1: UE does not expect TPC commands that would take into effect during the actual TDW.** | **Alt 2: If UE receives TPC commands that would take into effect after the start of a time domain window, UE accumulates TPC commands without taking effect during the current actual TDW.** | **Alt 3: No special handling** |
| **Q3** | [Company name] | vivo, Sharp, DCM | LG |

**Any other comments?**

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| Spreadtrum | TPC is an event. Because it is carried in a PDCCH, which is DL reception. |
| vivo | @Spreadtrum In FDD, TPC can be transmitted during the PUSCH repetitions. |
| CATT | TPC is considered the dynamic event, terminates the current actual TDW, and may resume a new actual TDW (up to UE capability). This makes no restrictions to both gNB and UE on the scheduling.  The gNB can still guarantee that DMRS bundling is not violated and avoid sending TPC command if desired. |
| LG | Considering the TPC commands that UE can receive during the UL transmission is group common, the actual TDW can be shortened if the TPC command is an event. And there can be misunderstanding between gNB and UE if UE simply ignores it. The basic idea of TPC command is that it should not take into effect during the actual TDW, regardless of configured TDW. |
| Panasonic | After the 1st round, we observed that Alt 2 is supported by majority of companies (17 companies) and Alt 2 is clear enough (i.e., If UE receives TPC commands that would take into effect after the start of a time domain window, UE accumulates TPC commands without taking effect during the current actual TDW). We are not sure the motivation to have more questions raised by FL. |
| Nokia/NSB | Q1: If TPC command is an event, it has already been considered under the form of DCI reception.  Q2: When the DCI carrying TPC command is considered as an event for actual TDWs determination then the scenario of UE receiving TPC command during actual TDW would not happen. |
| ZTE | Agree that TPC command can be regarded as an event. |

## 4.4 TA adjustment

**FL comments:** Similar with TPC, the key point is whether TA is an event.

**Q1: Whether TA is an event?**

**Q2: If the answer to Q1 is no, how to handle TA commands that would take into effect during the actual TDWs.**

**Q3: If the answer to Q1 is no, how to handle TA commands that would take into effect during the configured TDWs.**

**Companies are encouraged to answer the above questions.**

|  |  |  |
| --- | --- | --- |
|  | **Yes** | **No** |
| **Q1** | [Company name] CATT, ZTE | vivo, Sharp, DCM, LG, Nokia/NSB |

|  |  |  |
| --- | --- | --- |
|  | **Alt 1: UE does not expect to receive TA commands indicating TA adjustment during the actual TDW.** | **Alt 2: UE performs TA adjustment after the actual TDW if it receives any TA command indicating TA adjustment during the actual TDW.** |
| **Q2** | [Company name] | vivo, Sharp, DCM, LG, Nokia/NSB |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Alt 1: UE does not expect to receive TA commands indicating TA adjustment during the configured TDW.** | **Alt 2: UE performs TA adjustment after the configured TDW if it receives any TA command indicating TA adjustment during the configured TDW.** | **Alt 3: No special handling** |
| **Q3** | [Company name] | vivo, Sharp, DCM | LG |

**Any other comments?**

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| CATT | If TA offset is too large and TA command is needed to be sent, any PUSCH (w/ or w/o JCE) is a waste of resource since the gNB cannot decode it at all. The UE shall adjust the TA as soon as possible, when TA adjustment command is received. |
| LG | As many other companies pointed out, ignoring TA adjustment should be avoided. Same rule for TPC command without accumulating can be applied for TA adjustment. |
| Panasonic | After the 1st round, we observed that Option 3 is supported by majority of companies and Option 3 is clear enough (i.e., UE performs TA adjustment after the TDW if it receives any TA command indicating TA adjustment during the TDW). We are not sure the motivation to have more questions raised by FL. |
| ZTE | Prefer the same handling as TPC, i.e., TA command can be considered as an event. |

1. Agreements at RAN1#106-e

**Agreement: Confirm the following working assumption.**

**Working assumption:**

* For non-back-to-back PUSCH transmissions (at least for the case of the same TB) across consecutive slots, support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation for the following cases:
  + Over non-back-to-back PUSCH transmissions (of the same TB) for repetition type A scheduled by dynamic grant or configured grant.
  + Over non-back-to-back PUSCH transmissions (of the same TB) for repetition type B scheduled by dynamic grant or configured grant, if it reuses only those joint channel estimation specification enhancements defined to support repetition Type A.
    - FFS: additional specification enhancements on top of that defined to support repetition Type A
    - Only for single layer transmissions
    - Subject to UE capability
  + FFS: Over non-back-to-back PUSCH transmissions with different TBs
  + FFS: Over non-back-to-back PUSCH transmissions for TBoMS
  + For the non-back-to-back PUSCH transmissions, it is defined as at least when there is no UL transmission between the two successive PUSCH transmissions
  + Subject to UE capability with details FFS (e.g., separate vs. joint capability for type A & type B, w.r.t. OFF power requirements, etc.)
* FFS: Joint channel estimation over non-back-to-back PUSCH transmissions with other uplink transmissions between the two successive PUSCH transmissions across consecutive slot.

**Conclusion**

* Optimization of DMRS location in time domain for PUSCH is not considered for joint channel estimation in Rel-17.

**Agreement**

* Joint channel estimation for PUSCH transmissions and the time domain window are jointly enabled or disabled via RRC configuration for a UE.
  + Note: Enabling/disabling of joint channel estimation for PUSCH transmissions means enabling/disabling of DMRS bundling for PUSCH transmissions under the condition of power consistency and phase continuity.

**Agreement**

**Make down-selection between the following two alternatives:**

* Alt 1: UE is not expected to receive TPC commands during the current time domain window.
* Alt 2: UE receives and accumulates TPC commands without taking effect during the current time domain window.

**Agreement**

* UE should not perform TA adjustment during the time domain window.
  + FFS: UE does not expect to receive TA command to indicate TA adjustment during the TDW.
  + FFS: UE ignores any TA command which indicates TA adjustment during the TDW.
  + FFS: UE performs TA adjustment after the TDW if it receives any TA command indicating TA adjustment during the TDW.

**Working assumption:**

For joint channel estimation for PUSCH repetition type A of PUSCH repetitions of the same TB, all the repetitions are covered by one or multiple consecutive/non-consecutive configured TDWs.

* Each configured TDW consists of one or multiple consecutive physical slots.
* The window length *L* of the configured TDW(s) can be explicitly configured with a single value ~~and~~ *~~L~~* ~~is no longer than the maximum duration~~.
  + FFS: The maximum value of *L* ~~is the duration of all repetitions~~
  + FFS: Solutions to error propagation issue if ~~for~~ *L* is longer than the maximum duration is to be discussed further.
  + FFS: The window length *L* is configured per UL BWP
* The start of the first configured TDW is the first PUSCH transmission
  + FFS: The first available slot/symbol, or the first physical slot/symbol for the first PUSCH transmission.
* The start of other configured TDWs can be implicitly determined prior to first repetition.
  + FFS: The configured TDWs are consecutive for paired spectrum/SUL band
  + FFS: The start of the configured TDWs for unpaired spectrum is implicitly determined based on semi-static DL/UL configuration.
* The end of the last configured TDW is the end of the last PUSCH transmission.
  + FFS: The end of the configured TDW is the last available slot/symbol, or the last physical slot/symbol for the last PUSCH transmission.
* Within one configured TDW, one or multiple actual TDWs can be implicitly determined:
  + The start of the first actual TDW is the first PUSCH transmission within the configured TDW.
    - FFS: The first available slot/symbol, or the first physical slot/symbol for the first PUSCH transmission.
  + After one actual TDW starts, UE is expected to maintain the power consistency and phase continuity until one of the following conditions is met, then the actual TDW is ended.
    - The actual TDW reaches the end of the last PUSCH transmission within the configured TDW.
      * FFS: The end of the actual TDW is the last available slot/symbol, or the last physical slot/symbol for the last PUSCH transmission.
    - An event occurs that violates power consistency and phase continuity
      * FFS: The events may include e.g., a DL slot based on DL/UL configuration for unpaired spectrum, the actual TDW reaches the maximum duration, DL reception/monitoring occasion for unpaired spectrum, high priority transmission, frequency hopping, precoder cycling.
      * FFS: The end of the actual TDW is the last available slot/symbol of the PUSCH transmission right before an event such that the power consistency and phase continuity are violated.
  + If the power consistency and phase continuity are violated due to an event, whether a new actual TDW is created is subject to UE capability of supporting restarting DMRS bundling.
    - If UE is capable of restarting DM-RS bundling, one new actual TDW is created after the event,
      * FFS: The start of the new actual TDW is the first available slot/symbol for PUSCH transmission after the event.
    - If UE is not capable of restarting DM-RS bundling, no new actual TDW is created until the end of the configured TDW.
    - FFS: UE capability of restarting DMRS bundling is applied only to dynamic event or not

Note 1: A ‘configured TDW’ refers to a time domain window whose length can be configured to ‘L’ and whose start and end is determined as described above.

Note 2: An ‘actual TDW’ refers to a time domain window during whose entire duration the DM-RS bundling is actually applied. An ‘actual TDW’ duration is always less than or equal to the ‘configure TDW’ duration.

Note 3: Whether the terms ‘configured TDW’ and ‘actual TDW’ are revised to other terms and if such terminology is used in specifications is to be further discussed.

1. Agreements at RAN1#105-e

Agreement**:**

* Joint channel estimation over non-back-to-back PUSCH transmissions within one slot is not supported.

Agreement:

* Definition of **the maximum duration**: a maximum time duration during which **UE is able to** maintain power consistency and phase continuity subject to power consistency and phase continuity requirements.
* FFS whether or not such a definition is necessary for RAN1 specifications.
  + Note: whether such a definition is to be specified in RAN4 specifications is up to RAN4.
* FFS the maximum duration may be reported by UE.
* Note: it is understood that for a UE, the maximum duration is no less than the time domain window duration

Agreement:Send LS to RAN4 asking the following questions

* For joint channel estimation, is there a maximum duration during which UE is able to maintain power consistency and phase continuity under certain tolerance level? If any, how long is it?
  + What factors determine the maximum duration?
  + Whether the maximum duration should be the same for different cases for both PUSCH and PUCCH?
  + Whether the maximum duration is dependent on the modulation order of transmission, e.g., QPSK, 16QAM, 64QAM?
  + Whether the maximum duration is dependent on UL waveform (DFT-s-OFDM vs. OFDM)?
  + Whether the maximum duration is band specific?
  + Besides the factors listed above, whether or not the maximum duration is further dependent on UE capabilities (e.g., multiple possible values for a given set of factor(s)), and if so, whether the UE should report such a duration

Agreement:

* Optimization of DMRS granularity in time domain for PUSCH is not considered for joint channel estimation in Rel-17.

Agreement:

* For back-to-back PUSCH transmissions within one slot, support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation for the following cases:
  + Over back-to-back PUSCH transmissions (of the same TB) for repetition type B scheduled by dynamic grant or configured grant, if it reuses only those joint channel estimation specification enhancements defined to support repetition Type A with consecutive slots
    - FFS: additional specification enhancements on top of that defined to support repetition Type A
    - Only for single layer transmissions
    - Subject to UE capability
* Joint channel estimation over back-to-back PUSCH transmissions with different TBs within one slot is not supported.

**Working assumption:**

* For non-back-to-back PUSCH transmissions (at least for the case of the same TB) across consecutive slots, support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation for the following cases:
  + Over non-back-to-back PUSCH transmissions (of the same TB) for repetition type A scheduled by dynamic grant or configured grant.
  + Over non-back-to-back PUSCH transmissions (of the same TB) for repetition type B scheduled by dynamic grant or configured grant, if it reuses only those joint channel estimation specification enhancements defined to support repetition Type A.
    - FFS: additional specification enhancements on top of that defined to support repetition Type A
    - Only for single layer transmissions
    - Subject to UE capability
  + FFS: Over non-back-to-back PUSCH transmissions with different TBs
  + FFS: Over non-back-to-back PUSCH transmissions for TBoMS
  + For the non-back-to-back PUSCH transmissions, it is defined as at least when there is no UL transmission between the two successive PUSCH transmissions
  + Subject to UE capability with details FFS (e.g., separate vs. joint capability for type A & type B, w.r.t. OFF power requirements, etc.)
* FFS: Joint channel estimation over non-back-to-back PUSCH transmissions with other uplink transmissions between the two successive PUSCH transmissions across consecutive slot.

Agreement:

* Joint channel estimation for PUSCH transmissions is enabled or disabled via RRC configuration for a UE
  + FFS: whether additional dynamic signaling is needed to enable/disable joint channel estimation for PUSCH transmissions
  + Note: the enabling of such a feature is subject to certain prerequisites
  + FFS RRC parameter details (including explicit vs. implicit configuration)
* FFS For joint channel estimation for PUSCH, the time domain window is not explicitly enabled or disabled separately from joint channel estimation.

Note: Enabling/disabling of joint channel estimation for PUSCH transmissions means enabling/disabling of DMRS bundling for PUSCH transmissions under the condition of power consistency and phase continuity.

Agreement:

For joint channel estimation for PUSCH repetition type A of PUSCH repetitions of the same TB, down select one of the following alternatives for the time domain window.

* Alt 1: All the repetitions are covered by one single time domain window
  + The start of the window is the first PUSCH transmission
  + FFS: how to handle non-consecutive physical slots for UL transmission, e.g., due to DL/UL configuration for unpaired spectrum
  + FFS: frequency hopping and precoder cycling
* Alt 2: All the repetitions are covered by one or multiple time domain windows
  + For the start of each window,
    - The start of the first window is the first PUSCH transmission.
    - FFS: how to determine the start of other windows, e.g., whether multiple windows are consecutive or non-consecutive, whether the start of the window depends on DL/UL configuration for unpaired spectrum
  + For the length of each window,
    - FFS Each window consists of at least two adjacent physical slots for UL transmission.
    - The length of each window is no longer than the maximum duration.
    - FFS: how to determine the length of each window
    - FFS: whether the length of each window depends on DL/UL configuration for unpaired spectrum
  + FFS: how to handle non-consecutive physical slots for UL transmission, e.g., due to DL/UL configuration for unpaired spectrum.
  + FFS: frequency hopping and precoder cycling
* Other alternatives are not precluded.

1. Agreements at RAN1#104b-e

Agreements:

* For joint channel estimation, specify a time domain window during which a UE is expected to maintain power consistency and phase continuity among PUSCH transmissions subject to power consistency and phase continuity requirements.
  + FFS how the time domain window is determined (e.g., via explicit configuration and/or implicitly derived) and whether or not to have the possibility of enabling/disabling the time domain window
  + FFS the units the time domain window (e.g. repetitions, slots, and/or symbols)
    - FFS : association between the potential use case(s) and units of the time window
  + FFS: single or multiple time domain windows
* FFS: relation with UE capability
* FFS: whether the term "time domain window" is used in the specification or replaced by other technical terms
* FFS whether or not to further consider impacting of timing advance

**Agreements:**

* A new DMRS pattern equally spaced among PUSCH transmissions is not considered for joint channel estimation in Rel-17.

**Agreements:**

* For inter-slot frequency hopping with inter-slot bundling, down select on the following two options:
  + Option 1: The bundle size (time domain hopping interval) equals to the time domain window size.
  + Option 2: The bundle size (time domain hopping interval) can be different from the time domain window size.
    - FFS: Whether the bundle size (time domain hopping interval) is explicitly configured or implicitly determined.
    - FFS: Whether/How the bundle size (time domain hopping interval) is defined separately for FDD and TDD.
    - FFS: relation between the bundle size (time domain hopping interval) and the time domain window size

**Conclusion:**

* For optimization of DMRS granularity in time domain with joint channel estimation, the proponents are encouraged to provide more simulation results in next meeting

**Agreements:**

* For the time domain window for joint channel estimation, down select on the following two options:
  + Option 1: The unit of the time domain window is defined separately for the following PUSCH transmissions:
    - PUSCH repetition type A
    - PUSCH repetition type B, if agreed
    - TBoMS, if agreed
    - Different TB, if agreed
  + Option 2: The unit of the time domain window is the same for the following PUSCH transmission:
    - PUSCH repetition type A
    - PUSCH repetition type B, if agreed
    - TBoMS, if agreed
    - Different TB, if agreed

**Agreement:**

* For back-to-back PUSCH transmissions across consecutive slots, support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation for the following cases:
  + Over back-to-back PUSCH transmissions (of the same TB) for repetition type B scheduled by dynamic grant or configured grant, if it reuses only those joint channel estimation specification enhancements defined to support repetition Type A.
    - FFS: additional specification enhancements on top of that defined to support repetition Type A
    - Only for single layer transmissions
    - Subject to UE capability
  + FFS: Over back-to-back PUSCH transmissions with different TBs

1. Agreements at RAN1#104e

**Agreements**:

* Following potential use cases are considered for joint channel estimation for PUSCH:
  + Use case 1: back-to-back PUSCH transmissions within one slot.
  + Use case 2: non-back-to-back PUSCH transmissions within one slot.
  + Use case 3: back-to-back PUSCH transmissions across consecutive slots.
  + Use case 4: non-back-to-back PUSCH transmissions across consecutive slots.
  + Use case 5: PUSCH transmissions across non-consecutive slots.

Note: RAN1 assumes “back-to-back PUSCH transmission” has zero gap in-between adjacent PUSCH transmissions.

Agreements:

* For back-to-back PUSCH transmissions across consecutive slots, support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation at least for the following case:
  + Over back-to-back PUSCH transmissions (of the same TB) for repetition type A scheduled by dynamic grant or configured grant
  + FFS details (including possible other cases)

Agreements:

* For joint channel estimation, ~~define~~ a time domain window is introduced to facilitate further discussion, during which UE is expected to maintain power consistency and phase continuity among PUSCH transmissions subject to power consistency and phase continuity requirements.
  + FFS: whether the window should be specified
  + FFS: the length of the time domain window is defined by a set of repetitions/slots/symbols
  + FFS: single or multiple time domain windows
* FFS: relation with UE capability
* FFS: the time domain window may or may not be configured ~~or specified~~.
* FFS: whether the term "time domain window" is used in the specification or replaced by other technical terms
* FFS: Whether the window is determined by the power consistency and phase continuity requirements and/or by other factors is to be decided.

Agreements:

* Companies are encouraged to study optimization of DMRS granularity in time domain with joint channel estimation, including:
  + Use cases
  + Simulations results
  + Enhanced schemes, e.g.,
    - Different DMRS density for different PUSCH transmissions
    - No DMRS for some PUSCH transmissions
  + If applicable, impact of dynamic changes, e.g., cancellation of a repetition and companies report the evaluation method.
* Companies are encouraged to study optimization of DMRS location in time domain with joint channel estimation, including:
  + Use cases
  + Simulations results
  + Enhanced schemes, e.g.,
    - DMRS equally spaced among PUSCH transmissions
    - DMRS located in special slots
    - Orphan symbol上 used for DMRS
  + If applicable, impact of dynamic changes, e.g., cancellation of a repetition and companies report the evaluation method.
* Note: the simulation assumptions for DM-RS in TR 38.830 are used as baseline for performance evaluation on optimization of DMRS location/granularity in time domain.
  + Take into account impairments such as frequency offset, and report corresponding parametrization together with the results. Further discuss impairment details.

**Working assumption:**

* For back-to-back PUSCH transmissions across consecutive slots, support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation for the following case:
  + Over back-to-back PUSCH transmissions for ~~TB processing~~ one TB processed over multiple slots
    - It’s subject to UE capability

Agreements:

* For joint channel estimation.
  + Take into account the residual frequency error, e.g., +/- 0.1 ppm as upper bound.
  + Companies can report other values and frequency error model.

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6. 3GPP R4-2105417, “Reply LS on PUCCH and PUSCH repetition”, Qualcomm, RAN4#98b-e, April 12th – 20th April, 2021.
7. 3GPP R1-2104119, “Reply LS on PUCCH and PUSCH repetition”, Qualcomm, RAN1#104bis-e, April 12th – April 20th, 2021.
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9. 3GPP R4-2107880, “Reply LS on PUCCH and PUSCH repetition”, Qualcomm, RAN4#99-e, May 2021.
10. 3GPP R4-2114991, “LS on joint channel estimation for PUSCH and PUCCH (R1-2106212, R4-2111706)”, Qualcomm, RAN4#100-e, Aug. 2021.
11. 3GPP R1-2108458, “Reply LS on PUCCH and PUSCH repetition”, Qualcomm, RAN1#106-e, August 16th – 27th, 2021.
12. 3GPP R1-2108740 Discussion on joint channel estimation for PUSCH Huawei, HiSilicon
13. 3GPP R1-2108847 Discussion on joint channel estimation for PUSCH ZTE
14. 3GPP R1-2108921 Discussion on joint channel estimation for PUSCH Spreadtrum Communications
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16. 3GPP R1-2109090 Consideration on Joint channel estimation for PUSCH OPPO
17. 3GPP R1-2109242 Discussion on joint channel estimation for PUSCH CATT
18. 3GPP R1-2109249 Remaining issues on joint channel estimation for PUSCH China Telecom
19. 3GPP R1-2109297 Discussion on joint channel estimation for PUSCH CMCC
20. 3GPP R1-2109330 Discussion on joint channel estimation for PUSCH TCL Communication Ltd.
21. 3GPP R1-2109426 Discussion on joint channel estimation for PUSCH Xiaomi
22. 3GPP R1-2109459 Discussion on joint channel estimation for PUSCH Panasonic Corporation
23. 3GPP R1-2109506 Joint channel estimation for PUSCH Samsung
24. 3GPP R1-2109572 Discussion on Joint channel estimation over multi-slot MediaTek Inc.
25. 3GPP R1-2109626 Discussion on joint channel estimation for PUSCH Intel Corporation
26. 3GPP R1-2109694 Joint channel estimation for PUSCH NTT DOCOMO, INC.
27. 3GPP R1-2109799 Views on Joint Channel Estimation for PUSCH Sony
28. 3GPP R1-2109888 Joint channel estimation for PUSCH coverage enhancements Nokia, Nokia Shanghai Bell
29. 3GPP R1-2109991 Design Considerations for Joint channel estimation for PUSCH Sierra Wireless. S.A.
30. 3GPP R1-2110002 Joint channel estimation for multiple PUSCH transmission Sharp
31. 3GPP R1-2110048 Discussion on joint channel estimation for PUSCH Apple
32. 3GPP R1-2110098 Discussions on joint channel estimation for PUSCH LG Electronics
33. 3GPP R1-2110124 Joint Channel Estimation for PUSCH Ericsson
34. 3GPP R1-2110154 Joint channel estimation for PUSCH InterDigital, Inc.
35. 3GPP R1-2110203 Joint channel estimation for PUSCH Qualcomm Incorporated
36. 3GPP R1-2110239 Enhancements for joint channel estimation for multiple PUSCH Lenovo, Motorola Mobility
37. 3GPP R1-2110329 Discussion on joint channel estimation for PUSCH WILUS Inc.