# **[100b-e-NR-5G\_V2X\_NRSL-SL\_PHY\_Procedure-01] Handling TX and RX of multiple PSFCHs**

[100b-e-NR-5G\_V2X\_NRSL-PHY-Procedure-01] Email discussion/approval regarding handling TX and RX of multiple PSFCHs

* PSD of each PSFCH when transmitting multiple PSFCH TX
* Prioritization between TX and RX when the UE is required to TX/RX multiple PSFCH

till 4/23, with potential TPs by 4/28 (Hanbyul, LGE)

**1. PSD of each PSFCH when transmitting multiple PSFCH TX**

Assumption: The UE supports up to Nmax simultaneous PSFCH transmissions in a PSFCH TX occasion, and Nreq PSFCH transmissions are requested for the UE in a given PSFCH TX occasion. The UE selects N PSFCH transmissions for the actual PSFCH transmission.

Q1: How does the UE determine N for the following cases?

Q1-1: Nreq<=Nmax and TX power limit is not reached (i.e., the sum of Nreq PSFCH transmissions power before applying the upper limit does not exceed Pc,max)

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| Company | Answer |
| NTT DOCOMO | N = Nreq.In case that TX power limit is not reached, the UE should transmit PSFCHs as many as possible. |
| Apple | N=Nreq |
| ZTE, Sanechips | The message from RAN4 suggests that, even if Pcmax is not reached, there are some other reasons to require N<Nreq. Please also see our answer for Q1-2.  |
| OPPO | N=Nreq |
| vivo | We agree with ZTE, N is up to UE implementation for all sub-questions of Q1 |
| CATT | N=Nreq |
| LG | N is equal to Nreq. It is understood that even for the case of power sharing between UL and SL, the sum of Nreq PSFCH transmissions power before applying the upper limit does not exceed the total power of SL. For non-power-limited case, there is no reason that the UE drop PSFCH transmission.  |
| CMCC | N=Nreq |
| Intel | N is Nreq. We understand the capability based Nmax is the value supported under any power conditions, thus a value < Nmax should have no issue to be transmitted. |
| Huawei, HiSilicon | UE should transmit N=Nreq PSFCHs since the sum of the simultaneous PSFCH transmissions power does not exceed Pc,max |
| Samsung | N=Nreq |
| Fraunhofer | N = Nreq. |
| ITRI | N=Nreq |
| Ericsson  | N = Nreq i.e. all the required PSFCH transmissions |
| Nokia, NSB | N=Nreq, which is an obvious choice since the sum of Nreq Tx power does not reach Pc, max. |
| Spreadtrum | N=Nreq |
| Qualcomm | Pcmax depends on MPR/A-MPR (see TS 38.101, section6.2.4 ). MPR/A-MPR is a function of N. So we cannot determine Pcmax without knowing N, and in some case event the exact locations of the requested PSFCH. **for Q1-1, Q1-2, Q1-3, Q1-4, we have the same unified answer:** **N PSFCH are selected based on priority, where N≤ min{Nreq, Nmax} and exact value of N is by UE implementation.** |
| Futurewei | N=Nreq |
| Lenovo&MotM | One question is whether Nreq PSFCHs are FDMedFor PSFCH resources mapping Option 2(The set of PRBs for the candidate PSFCH resource is determined by the sub-channel(s) and slot used for that PSSCH.) the RX UE may receive two PSSCHs and there are part of overlapped sub-channels between two PSSCHs, in this case the UE may be requested to transmit two CDMed PSFCHs.So we propose that we should select one PSFCH among CDMed PSFCHs based on the priority and then select N PSFCH from the FDMed PSFCHs. Nreq should be the number of FDMed PSFCHs.N=Nreq |
| Panasonic | We agree ZTE comment.  |

**Observation:**

* **N=Nreq: DOCOMO, Apple, OPPO, CATT, LGE, CMCC, Intel, Huawei, Samsung, Fraunhofer, ITRI, Ericsson, Nokia, Spredtrum, Futurewei, Lenovo (16)**
* **N is up to UE implementation: ZTE, vivo, Qualcomm, Panasonic (4)**

Q1-2: Nreq<=Nmax and TX power limit is reached (i.e., the sum of Nreq PSFCH transmissions power before applying the upper limit exceeds Pc,max)

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| Company | Answer |
| NTT DOCOMO | N is up to UE implementation.If N = Nreq, power of each PSFCH transmission could be quite small. PSFCH transmission with higher priority is failed due to PSFCH transmission with lower priority. This means, a UE which supports larger Nmax has disadvantage from reliability perspective of PSFCH transmissions with higher priority. We believe that it is undesirable situation. |
| Apple | $N=\left⌊10^{\frac{P\_{CMAX}-P}{10}}\right⌋, $where P is the transmit power calculated with the existing formula in Section 16.2.3 of TS38.213, for a single PSFCH transmission.  |
| ZTE, Sanechips | We have a fundamental question upon the way these questions are asked. How to judge “Tx power limit is not reached”? The equation in Q2 for single PSFCH is capped by $P\_{CMAX}-10log\_{10}\left(N\right)$. The FL intention for the PSFCH Tx power allocation procedure seems to be framed as following: * Step-1: Tx power calculation for single PSFCH based on DL pathloss, i.e., apply equation in Q2 w/o the upper-bound of $P\_{CMAX}-10log\_{10}\left(Nreq\right)$.
* Step-2: derive number of actual PSFCH to be transmitted, N, based on {step-1 result, Nreq, Nmax}
* Step-3: With N determined, apply the equation in Q2 again, but this time with the upper-bound of $P\_{CMAX}-10log\_{10}\left(N\right)$

The three above steps construct an overall strange framework. With step-2, the capping of $P\_{CMAX}-10log\_{10}\left(N\right)$ in step-3 may not be necessary. In addition, neither RAN1 agreement nor current RAN1 spec relies on the logic that the same pathloss-based power adjustment should be applied twice. We also have a concern for using spec to mandate Nreq reduction (PSFCH dropping) just because DL pathloss based Tx power exceeds a threshold, given the DL pathloss calculation is generally not accurate enough and the parameters in the power control formula may also not be configured as optimized. Our preference is that: the determination of N from {Nreq, Nmax} is an UE implementation issue, which may take power limitation into consideration. But such consideration may or may not drop PSFCH every time when DL-pathloss drives the total PSFCH power beyond Pcmax. So **for Q1-1, Q1-2, Q1-3, Q1-4, we have the same unified answer:** **N PSFCH are selected based on priority, where N≤ min{Nreq, Namx} and exact value of N is by UE implementation.** |
| OPPO | N is up to UE implementationWe tends to agree with DCM. If the total power of Nreq is larger than Pmax, the TX power of each PSFCH will be scaled, and result in poor performance for PSFCH transmission.  |
| vivo | N is up to UE implementation |
| CATT | N is up to UE implementation |
| LG | The value of N is up to UE implementation. We are supportive that N can be less than Nreq. Since each PSFCH transmission by a UE in a PSFCH TX occasion will have the same power, as the number of simultaneous PSFCH TX increases, the detection performance of PSFCH would be degraded further. Furthermore, considering power sharing between UL and SL, it would be beneficial to further drop PSFCH transmission to increase PSD of each PSFCH transmission. On the other hand, excessive dropping of PSFCH TXs can cause unnecessary retransmissions. The actual value of N would be dependent on whether SL is transmitted together with UL or not, whether excessive retransmission due to dropping PSFCH TX is acceptable or not, and whether power scaling on PSD of each PSFCH is acceptable or not. In other words, the suitable value of N would be different case by case. In those points of views, N can be up to UE implementation.  |
| CMCC | UE selects N PSFCH(s) transmissions based on priority, and N is up to UE implementation. TX power of each PSFCH is upper-bounded by P\_{CMAX}/N. Always transmitting Nmax PSFCH may result in limited transmission power for each PSFCH, which is not flexible enough. |
| Intel | Leaving the situation completely up to UE implementation may be undesirable. There may need to be some target that a UE should achieve, e.g. maximize N under a maximum PSD backoff value.In general, such discussion could be more elaborated if concrete Nmax values are discussed, e.g. 4. In this case, sharing power between up to 4 PSFCH does not seem very large degradation given the link budget difference between PSCCH and PSFCH. |
| Huawei, HiSilicon | UE should select the N< Nreq PSFCHs with the highest priorities resulting in the highest total transmission power which does not exceed Pc,max. If left to implementation entirely, then the performance of the system is difficult (or even impossible) to predict from the specifications or simulations, because there is no way to know if a UE will choose to send a PSFCH in response to any particular PSSCH when Nreq>1. For this reason, there needs to be some amount of specification bounding.  |
| Samsung | N=Nreq, and the N PSFCHs use the same power scalling factor, i.e.,  |
| Fraunhofer | Maximize N such that the power constraint is met. |
| ITRI | N is up to UE implementation |
| Ericsson | N = Nreq. In our view N should not be left to UE implementation because it may lead to different UE behaviors, especially for groupcast case when different UEs in the group behave differently for the transmission of PSFCHs. Furthermore, in issue 2 below, when a UE needs to decide between multiple transmissions and receptions, selecting the lower value of N may lead to undesirable prioritization between transmission and reception of PSFCHs. |
| Nokia, NSB | N cannot be up to UE implementation. N shall be limited by the maximum power Pc,max, and the Tx power of a single PSFCH. |
| Spreadtrum | UE should select N<Nreq PSFCHs, otherwise the PSFCH transmission is not reliable. |
| Qualcomm | Agree with ZTE. **for Q1-1, Q1-2, Q1-3, Q1-4, we have the same unified answer:** **N PSFCH are selected based on priority, where N≤ min{Nreq, Nmax} and exact value of N is by UE implementation.** |
| Futurewei | The N selected PSFCHs are the N highest priority PSFCHs to transmit. N is the larger number that can be transmitted while still meeting the power constraint |
| Lenovo&MotM | N=Nreq, and the power of each PSFCH among N PSFCHs is upper-bounded by Pcmax-10log10(N) |
| Panasonic | We agree ZTE comment.  |

**Observation:**

* **N is up to UE implementation: DOCOMO, ZTE, OPPO, vivo, CATT, LGE, CMCC, ITRI, Spreadtrum, Qualcomm, Panasonic (10)**
* **N is the largest value which doesn’t lead to the power limited case: Intel, Huawei, Fraunhofer, Nokia, Futurewei (5)**
* **N = Nreq: Samsung, Ericsson, Lenovo (3)**
* **Other view: Apple**

Q1-3: Nreq>Nmax and TX power limit is not reached (i.e., the sum of Nmax PSFCH transmissions power before applying the upper limit does not exceed Pc,max)

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| Company | Answer |
| NTT DOCOMO | N = Nmax.In case that TX power limit is not reached, the UE should transmit PSFCHs as many as possible. |
| Apple | N=Nmax |
| ZTE, Sanechips | The message from RAN4 suggests that, even if Pcmax is not reached, there are some other reasons to require N<min{Nreq,Nmax}. Please also see our answer for Q1-2. |
| OPPO | N=Nmax |
| vivo | Up to UE implementation |
| CATT | No need to discuss this scenario. Nreq shall be equal to or less than Nmax. |
| LG | N is equal to Nmax. The UE will chose Nmax PSFCH transmission among Nreq PSFCH transmissions by using the priority of the associated PSCCH/PSSCH. For non-power-limited case, there is no reason that the UE further drop PSFCH transmission.  |
| CMCC | N=Nmax |
| Intel | N=Nmax, this case is covered by existing prioritization agreements. |
| Huawei, HiSilicon | UE should select N=Nmax PSFCHs with the highest priorities to ensure that the sum of the transmission power does not exceed Pc,max. |
| Samsung | N=Nmax |
| Fraunhofer | N = Nmax. |
| ITRI | N=Nmax |
| Ericsson | N = Nmax |
| Nokia, NSB | N=Nmax, which is the UE capability of max number of simultaneous PSFCH transmissions. |
| Spreadtrum | N=Nmax |
| Qualcomm | Agree with ZTE. **for Q1-1, Q1-2, Q1-3, Q1-4, we have the same unified answer:** **N PSFCH are selected based on priority, where N≤ min{Nreq, Nmax} and exact value of N is by UE implementation.** |
| Futurewei | N=Nmax. The N PSFCHs are the highest priority ones |
| Lenovo&MotM | N=Nmax |
| Panasonic | We agree ZTE comment.  |

**Observation:**

* **N=Nmax: DOCOMO, Apple, OPPO, LGE, CMCC, Intel, Huawei, Samsung, Fraunhofer, ITRI, Ericsson, Nokia, Spredtrum, Futurewei, Lenovo (15)**
* **N is up to UE implementation: ZTE, vivo, Qualcomm, Panasonic (4)**
* **Other view: CATT**

Q1-4: Nreq>Nmax and TX power limit is reached (i.e., the sum of Nmax PSFCH transmissions power before applying the upper limit exceeds Pc,max)

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| Company | Answer |
| NTT DOCOMO | N is up to UE implementation.If N = Nmax, power of each PSFCH transmission could be quite small. PSFCH transmission with higher priority is failed due to PSFCH transmission with lower priority. This means, a UE which supports larger Nmax has disadvantage from reliability perspective of PSFCH transmissions with higher priority. We believe that it is undesirable situation. |
| Apple | $N=\left⌊10^{\frac{P\_{CMAX}-P}{10}}\right⌋, $where P is the transmit power calculated with the existing formula in Section 16.2.3 of TS38.213, for a single PSFCH transmission. |
| ZTE, Sanechips | Please see our response for Q1-2.  |
| OPPO | N is up to UE implementation and N<=Nmax |
| Vivo | Up to UE implementation |
| CATT | No need to discuss this scenario. Nreq shall be equal or less than Nmax.  |
| LG | The value of N is up to UE implementation. In a similar manner of Q-2, N can be less than Nmax, and the suitable value of N would be different case by case.  |
| CMCC | UE selects N PSFCH(s) transmissions based on priority, where decision on N is up to UE implementation, and TX power of each PSFCH is upper-bounded by P\_{CMAX}/N. |
| Intel | First, the prioritization rule is applied to make Nreq’ = Nmax. After that, the same rule as in Q1-2 is applied. |
| Huawei, HiSilicon | UE should select N<= Nmax PSFCHs with the highest priorities resulting in the highest transmission power which does not exceed Pc,max. |
| Samsung | N=Nmax, and the N PSFCHs use the same power scalling factor, i.e.,  |
| Fraunhofer | N = Nmax if the TX power limit is met, otherwise maximize N < Nmax such that the power constraint is met. |
| ITRI | It is up to UE implementation |
| Ericsson | N = Nmax (see our comment in Q1-2). |
| Nokia, NSB | N=Nmax, when the Tx power reaches Pc,max.  |
| Spreadtrum | UE should select N<Nmax PSFCHs, otherwise the PSFCH transmission is not reliable. |
| Qualcomm | Agree with ZTE. **for Q1-1, Q1-2, Q1-3, Q1-4, we have the same unified answer:** **N PSFCH are selected based on priority, where N≤ min{Nreq, Nmax} and exact value of N is by UE implementation.** |
| Futurewei | The N selected PSFCHs are the N highest priority PSFCHs to transmit. N is the larger number that can be transmitted while still meeting the power constraint (N<Nmax in that case) |
| Lenovo&MotM | N=Nmax, and the power of each PSFCH among N PSFCHs is upper-bounded by Pcmax-10log10(N) |
| Panasonic | We agree ZTE comment.  |

**Observation:**

* **N is up to UE implementation: DOCOMO, ZTE, OPPO, vivo, LGE, CMCC, ITRI, Spreadtrum, Qualcomm, Panasonic (10)**
* **N is the largest value which doesn’t lead to the power limited case: Intel, Huawei, Fraunhofer, Futurewei (4)**
* **N=Nmax: Samsung, Ericsson, Nokia, Lenovo (4)**
* **Other view: Apple, CATT**

Q2: Once N is determined by the answer to Q1, do you agree that the TX power of each PSFCH is given by the following modified equation (to replace the one in Section 16.2.3 of TS 38.213)?

$P\_{PSFCH,k}(i)=min\left(P\_{CMAX}-10log\_{10}\left(N\right),P\_{O,PSFCH}+10log\_{10}\left(2^{μ}\right)+α\_{PFSCH}⋅PL\right)$ [dBm]

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| Company | Answer |
| NTT DOCOMO | OK |
| Apple | We think each PSFCH transmit power is still given by the existing formula in Section 16.2.3 of TS38.213. No need to modify the equation. |
| ZTE, Sanechips | Ok. |
| OPPO | OK |
| vivo | Agree |
| CATT | Agree |
| LG | We are supportive of the proposal.  |
| CMCC | OK |
| Intel | OK |
| Huawei, HiSilicon | We understand why it superficially seems the equation might need to change. But consider this:When determining the value of N, UE should first consider the transmission power of one PSFCH as $P\_{O,PSFCH}+10log\_{10}\left(2^{μ}\right)+α\_{PFSCH}⋅PL$, which is based on the DL path loss based OLPC. Then, * If $P\_{O,PSFCH}+10log\_{10}\left(2^{μ}\right)+α\_{PFSCH}⋅PL$ > $P\_{CMAX}$, it is obvious that N=1 and the actual transmission power of the PSFCH is $P\_{CMAX}$;
* Otherwise, UE should determine the value of N under the $P\_{CMAX}$ constraint and MPR constraint to ensure that the actual transmission of each PSFCH is $P\_{O,PSFCH}+10log\_{10}\left(2^{μ}\right)+α\_{PFSCH}⋅PL$. Note that, in this case, we always have $P\_{O,PSFCH}+10log\_{10}\left(2^{μ}\right)+α\_{PFSCH}⋅PL$ < $P\_{CMAX}-10log\_{10}\left(N\right)$

Thus the current equation in 38.213 appears to operate correctly without alteration：$P\_{PSFCH,k}(i)=min\left(P\_{CMAX},P\_{O,PSFCH}+10log\_{10}\left(2^{μ}\right)+α\_{PFSCH}⋅PL\right)$ [dBm] |
| Samsung | OK |
| Fraunhofer | Agree |
| ITRI | Agree |
| Ericsson | OK  |
| Nokia, NSB | N is determined in the sense that the combined Tx power shall not exceed Pc,max. Therefore, we may claim that N is determined so that$$P\_{O,PSFCH}+10log\_{10}\left(2^{μ}\right)+α\_{PFSCH}⋅PL\leq P\_{CMAX}-10log\_{10}N$$There is no need to have this change. |
| Spreadtrum | OK |
| Qualcomm | Agree |
| Futurewei | OK |
| Lenovo&MotM | Agree |
| Panasonic | OK |

**Observation:**

* **Majority agreed to the proposal but it seems that the exact change might be dependent of the outcome of the above discussions.**

**2. Prioritization between TX and RX when the UE is required to TX/RX multiple PSFCH**

Q3: Do you agree the following proposal to determine the priority of PSFCH TX and RX when the UE is required to transmit/receive multiple PSFCHs?

* Proposal:
	+ When the UE is required to transmit more than one PSFCH, the highest priority of the associated PSCCH/PSSCH is used for prioritization of the PSFCH transmission.
	+ When the UE is required to receive more than one PSFCH, the highest priority of the associated PSCCH/PSSCH is used for prioritization of the PSFCH reception.

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| Company | Answer |
| NTT DOCOMO | Direction is OK.One comment is, the proposal should be clarified that the assumed case is collision between PSFCH TX and PSFCH RX, where at least either TX or RX is more than one.Question is saying that, while proposal does not. We believe that other case does not use the above rule. |
| Apple | Agree |
| ZTE, Sanechips | Yes, agree. We also have the same feel as DoCoMo: the proposal should clarify the scope where the rule applies.  |
| OPPO | Agree |
| CATT | Agree |
| LG | We are supportive of the proposal. In addition, we think that the UE can receive all the PSFCHs when PSFCH RXs are prioritized over PSFCH TXs. |
| CMCC | Agree. We also think that it should be clarified that the proposal is for the case of simultaneous transmitting and receiving more than one PSFCH. |
| Intel | In general OKFor same priority TX, we also prefer to apply tie-breaking so that NACK-only PSFCH is prioritized |
| Huawei, HiSilicon | Yes (where highest priority is reflected by the lowest value of the SCI “priority” field). More precisely, the proposal should say:…the highest priority among the associated PSSCH(s) is used for prioritization of …since: (i) to ensure the plural; (ii) PSCCH does not have a priority. |
| Samsung | Agree |
| Fraunhofer | We are in general OK with using the priority of a transmission.Additionally, only PSFCHs with ACK should be considered, with an exception to the NACK-only case for GC option 1. Transmission of a NACK is not required, since the RX UE will assume a NACK anyways, except for NACK-only PSFCH transmissions. Hence, the PSFCH carrying an ACK which is associated to the PSCCH/PSSCH with highest priority, determines the priority for TX. |
| ITRI | Agree. The proposal need to clarify that if there is more than one PSFCH TX/RX with the same priority.  |
| Ericsson  | OK.  |
| Nokia, NSB | Agree. |
| Spreadtrum | Agree |
| Qualcomm | Agree to take the max of the priorities of the PSFCH in each of the 2 gruops(Tx and Rx) for comparison. Furthermore, if the 2 final priorities under comparison end up being equal, we need to prioritize transmitting PSFCH groupcast option 1, since DTX means no feedback here. If UE transmit PSFCH, it needs to assume worst case that there is NACK and packet needs to be retransmitted. |
| Futurewei | OK |
| Lenovo&MotM | Agree |
| Panasonic | Agree |

**Observation:**

* **All the responded companies agree with the basic principle of the proposal for the prioritization between TX and RX of multiple PSFCHs**
	+ **Some companies proposed to consider a tie-break rule.**

**Proposal 1-1: When the UE supports up to Nmax simultaneous PSFCH transmissions in a PSFCH TX occasion and UE received Nreq PSCCH/PSSCHs that indicated HARQ feedback to be transmitted in a given PSFCH TX occasion, the UE selects N PSFCHs for actual transmission based on the priority in a PSFCH TX occasion as follows:**

* **Case 1: When Nreq<=Nmax,**
	+ **Case 1-1: N=Nreq if the sum of** $P\_{O,PSFCH}+10log\_{10}\left(2^{μ}\right)+α\_{PFSCH}⋅PL$ **for the Nreq PSFCHs is smaller than or equal to** $P\_{CMAX}$ **determined for the Nreq PSFCH transmissions.**
	+ **Case 1-2: Otherwise, N is up to UE implementation under N >= X (FFS where X>=1).**
* **Case 2: When Nreq>Nmax, the UE firstly selects Nmax PSFCHs based on the priority.**
	+ **Case 2-1: N=Nmax if the sum of** $P\_{O,PSFCH}+10log\_{10}\left(2^{μ}\right)+α\_{PFSCH}⋅PL$ **for the Nmax PSFCHs is smaller than or equal to** $P\_{CMAX}$ **determined for the Nmax PSFCH transmissions.**
	+ **Case 2-2: Otherwise, N is up to UE implementation under N >= X (FFS where X>=1).**

// FL’s note

* “Nreq PSFCH transmissions are requested” means that the UE received Nreq PSCCHs that indicate HARQ feedback in the concerned PSFCH TX occasion.
* In Case 1, the UE can calculate $P\_{CMAX}$ assuming that all the Nreq PSFCHs are transmitted. If the power limited case happens, the UE goes to Case 1-2.
* In Case 1-2, UE implementation can be a balance between reducing N to keep the power of each PSFCH and keeping N=Nreq with reduced power for each PSFCH. We can consider a lower bound of N (which should be a positive value in my view) to avoid an undesirable implementation which drops too many PSFCHs. For example, “the largest value which doesn’t lead to the power limited case” might be the lower bound.
* Case 2 is basically the same as Case 1 with the exception that the UE firstly selects Nmax PSFCHs based on the priority in order to check whether power limited case happens.

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**Proposal 1-2: For the prioritization between PSFCH TX and PSFCH RX,**

* + **When the UE is required to transmit more than one PSFCH, the highest priority of the associated PSCCH/PSSCH is used for prioritization of the PSFCH transmission.**
	+ **When the UE is required to receive more than one PSFCH, the highest priority of the associated PSCCH/PSSCH is used for prioritization of the PSFCH reception.**

// FL’s note

* The above proposal does not preclude further discussion on the tie-break. But I’m reluctant to add an explicit FFS for it unless there are majority support.
* Update to the PSFCH power control equation seems dependent of the final outcome of the discussion about the two proposals. It is proposed to discuss the update during the TP phase considering the input to Q2.

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