3GPP TSG RAN WG1 Meeting #105e R1-2104776

**e-Meeting, May 10th – 27th, 2021**

Agenda Item: 8.4.4

Source: Moderator (OPPO)

Title: Summary #1 of 8.4.4 Other Aspects of NR-NTN

Document for: Discussion and Decision

# Introduction

This document contains a summary of the contributions under AI 8.4.4 at RAN1#105e. This include the topics for RAN1 that should be specified if beneficial and needed as listed in Release-17 NR NTN WID:

* *Enhancement on the PRACH sequence and/or format and extension of the ra-ResponseWindow duration (in the case of UE with GNSS capability but without pre-compensation of timing and frequency offset capabilities) [RAN1/2].*
* *Feeder link switch [RAN2,RAN1]*
* *Beam management and Bandwidth Parts (BWP) operation for NTN with frequency reuse [RAN1/2]*
  + *Including signalling of polarization mode*

# Beam management discussions

In this section, we discuss beam management related issues and potential enhancements.

## NR-NTN beam management issues

### Background

In RAN1#104-e meeting, the following list of issues were raised and companies were encouraged to provide further contributions to analyse these issues. The analysis of these listed issues can help reaching decisions on potential beam management enhancements in this release.

Conclusion:

Discuss whether or not at least following issues are valid and decide whether or not enhancements are needed in addition to current NR specification for supporting NTN beam management:

* Issue 1: NR BWP is not directly associated with a beam. Thus, when using TCI to change beam from beam 1 to beam 2, it does not trigger NR BWP switching. However, in NTN FRF>1 case, beam switching may result in a BWP switching.
* Issue 2: NR BWP switching in UL and DL are not jointly triggered for FDD. However, in NTN FRF>1 FDD scenario, beam switching may result in a BWP switching in both DL and UL.
* Issue 3: NR dynamic BWP switching requires data scheduling. While in NTN FRF>1 scenario, we may need a fast BWP switching triggering without data scheduling.
* Issue 4: NR BWP switching does not require re-synchronization. However, in NTN FRF>1 scenario, when a satellite beam switching is triggered, UE may need to perform re-synchronization in the switched BWP.
* Issue 5: Since satellite beam switching can be frequent and often highly predictable, mechanisms of configured BWP switching (can be a sequence of BWPs) may be preferred but current NR does not allow it.
* Issue 6: How to deal with BWP switching triggered by bwpInactivityTimer, RA procedure, or simply a need to increase throughput instead of for beam-level mobility.
* Issue 7: NR BWP switching/beam switching is done with UE specific signalling due to UE movement’s. However, in NTN scenario, a satellite BWP/beam switching is common for set of UEs, we may need to a common BWP/beam switching mechanism to save the signalling overhead.

Company’s contributions on issue analysis

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| --- | --- |
| THALES | **Observation 9 In the proposed solution, an a-priori BBWP planning can be used to allocate the BWP to each beam. Or a dynamic allocation can be performed by the gNB to configure beam-specific BWP based on the traffic distribution between the beams within the cell**  **Proposal 3 The new beam-specific BWP (BBWP) concept should be introduced on top of existing UE specific BWP**  **Proposal 4 The new beam-specific BWP (BBWP) should reuse Release-15/16 BWP operation procedures with the enhancements provided in this TDOC**  **Observation 10 The size of the common Initial-active BWP should be defined carefully to avoid any congestion and blocking within the cell**  **Proposal 5 Bandwidth part indicator field on DCI should be unchanged**  **Proposal 6 MAC CE transmission configuration indication (MAC CE TCI) can be used to indicate and update serving beam and implicitly the BBWP** |
| vivo | ***Observation 4: The following issues require enhancements on NTN beam management:***   * ***Beam switching may result in a BWP switching.*** * ***Beam switching in FDD systems may result in a BWP switching in both DL and UL.*** * ***Dynamic BWP switching triggering without data scheduling if support beam switching based on BWP switching.***   ***Observation 5: In some NTN scenarios, NR BWP switching mechanism and NR TCI framework can be reused for beam switching.*** |
| Spreadtrum Communications | ***Proposal 1: Additional association to map SSB index and BWP index is not needed.***  ***Proposal 2: BWP switching of UL and DL simultaneously in NTN FRF>1 FDD scenario should be supported.***  ***Proposal 3: BWP switching without data scheduling should be supported in NTN FRF>1 FDD scenario.*** |
| CATT | **Major issues:**   * **Issue 1**: NR BWP switching in UL and DL are not jointly triggered. However, in NTN FRF>1 FDD scenario, beam switching should result in a BWP switching in both DL and UL. * **Issue 2**: NR dynamic BWP switching requires data scheduling. While in NTN FRF>1 scenario, we may need a fast BWP switching triggering without data scheduling. * **Issue 3**: NR BWP switching does not require re-synchronization. However, in NTN FRF>1 scenario, when a satellite beam switching is triggered, UE needs to perform re-synchronization in the switched BWP.   **Minor Issues**:   * **Issue 1**: NR BWP is not directly associated with a beam. Thus, when using TCI to change beam from beam 1 to beam 2, it does not trigger NR BWP switching. However, in NTN FRF>1 case, beam switching should result in a BWP switching. * **Issue 2:** Since satellite beam switching can be frequent and often highly predictable, mechanisms of configured BWP switching (can be a sequence of BWPs) is preferred but current NR does not allow it. * **Issue 3**: How to deal with BWP switching triggered by bwpInactivityTimer, RA procedure, or simply a need to increase throughput instead of for beam-level mobility. * **Issue 4**: NR BWP switching/beam switching is done with UE specific signalling due to UE movements. However, in NTN scenario, a satellite BWP/beam switching is common for set of UEs, we need to a common BWP/beam switching mechanism to save the signalling overhead.  1. **Support BWP based beam switching enhancement in NTN to reduce beam switching latency.** 2. **Enable BWP switching of UL and DL simultaneously and support UE confirmation after BWP switching successfully.** 3. **Support DCI to indicate beam switching with BWP index indication.** |
| CMCC | ***Observation 1:*** Enhancement on association of NR BWP with NR beam is not essential but it is beneficial.  ***Proposal 1:*** Further discuss on the issue of enhancement on association of NR BWP with NR beam, if needed.  ***Observation 2:*** Enhancement on joint trigger of NR BWP switching in UL and DL for FDD is not essential but it is beneficial.  ***Proposal 2:*** Further discuss on the issue of enhancement on joint trigger of NR BWP switching in UL and DL for FDD, if needed.  ***Observation 3:*** Enhancement on new DCI for fast BWP switching triggering without data scheduling is not essential.  ***Observation 4:*** Enhancement on UE group DCI to trigger BWP/beam switching for a set of UEs is not essential but it is beneficial.  ***Proposal 3:*** Further discuss on the issue of enhancement on UE group DCI to trigger BWP/beam switching for a set of UEs, if needed.  ***Proposal 4:*** If a new DCI format is to be designed for fast BWP/beam switching in NTN, joint support of one or more enhancements for Issue 1, Issue 2, Issue 3, and Issue 4 can be considered. |
| Qualcomm Incorporated | **Proposal 1: Support satellite beam specific initial BWPs.**  **Proposal 5: Consider increasing the number of bits for the BWP ID (bwp-Id)**   * **The network can signal the difference between a BWP and a reference BWP to reduce the signalling overhead of BWP configuration.**   **Proposal 6: Support BWP frequency shift through DCI and/or configuration.**  **Proposal 7: Support RRC configuration to indicate BWP switching through DCI by either BWP ID or BWP frequency hopping.** |
| OPPO | **Proposal 1: From the listed issues in RAN1#104-e meeting, at least the issue 5 and issue 7 are valid issues.**  **Proposal 2: Enhancements to BWP operation are needed to address the issue 5 and issue 7.** |
| Samsung | Proposal 1: Enhancement for BWP switching needs to be deprioritized. |
| Ericsson | [Observation 5 Issue #1 is not valid, because it is not necessary to directly associate a NR BWP with a beam and there is no need to necessarily trigger BWP switching upon beam switching.](#_Toc71640607)  [Observation 6 Issue #2 is not valid, because it is not necessary to trigger BWP switching upon beam switching, let alone simultaneous BWP switching in both DL and UL.](#_Toc71640608)  [Observation 7 Issue #3 is not valid, because it is not justified to introduce DCI based BWP switching without data scheduling.](#_Toc71640609)  [Observation 8 Issue #4 is not valid, because it is not necessary for the UE to perform re-synchronization upon BWP switching.](#_Toc71640610)  [Observation 9 Issue #5 is not valid, because BWP switching is not predictable and there is no need for configured BWP switching.](#_Toc71640611)  [Observation 10 Issue #6 is not valid, because it is unclear what this issue is in the first place.](#_Toc71640612)  [Observation 11 Issue #7 is not valid, because the need of group switching is not motivated.](#_Toc71640613)  [Proposal 1 RAN1 to discuss the scope of beam management, i.e., whether NR beam management framework (TCI state and spatial relations) should be restricted within the same satellite or support the switching of the service links associated with different satellites.](#_Toc71640615)  [Proposal 4 RAN1 to conclude that there is no need for additional enhancements for using BWPs to enable a frequency reuse.](#_Toc71640618) |
| Nokia, Nokia Shanghai Bell | **Proposal 10: For Rel-17, do not support FRF>1 through the beam management framework.**  **Proposal 11: Reuse existing Rel-16 NR framework for beam and BWP management for NTN operation.** |
| Apple | ***Proposal 1:*** *Consider the association between satellite beam switching and BWP switching.*  ***Proposal 2:*** *Consider the joint UL BWP switching and/or DL BWP switching, following the corresponding satellite beam switching.* |
| Panasonic | **Observation 1: Issue#1 for beam management is not a valid issue and BWP operation per Rel-15/16 is sufficient to handle it.**  **Observation 2: Issue#2 for beam management is not a valid issue and BWP operation per Rel-15/16 is sufficient to handle it.**  **Observation 3: Issue#3 for beam management is not motivated.**  **Observation 4: Issue#4 for beam management is not a valid issue.**  **Observation 5: Issue #5 for beam management is not well phased in the sense that it mixes the issue of frequent beam switching with the issue of linking beam switching to BWP switching.**  **Observation 6: Issue #6 is unclear and further clarification is needed.**  **Observation 7: There is a common assumption behind Issues #5 and #7 (called #8 below), which should be discussed first:**  **Issue #8: Increased signaling overhead and UE power consumption caused by frequent beam switching by Rel-15/16 beam switching mechanism (i.e. relying on UE-specific MAC CE and DCI).**  **Proposal 1: Rephase the Issue #5 for beam management as following:**  **Issue #5 (rephased): Since satellite beam switching can be frequent and often highly predictable, mechanisms of configured beam switching (can be a sequence of beams) may be preferred but current NR does not allow it**  **Proposal 2: Agree on Issue #8 before discussing Issues #5 and #7.**  **Issue #8: Increased signaling overhead and UE power consumption caused by frequent beam switching by Rel-15/16 beam switching mechanism (i.e. relying on UE-specific MAC CE and DCI).** |
| Sony | **Observation 1: in Earth-fixed beam scenario, beam selection in UE side may be needed.**  **Observation 2: in Earth-moving beam scenario, beam selection in at gNB side is needed while at UE side it may be needed.**  **Observation 3: Introducing a fixed linkage between BWP and satellite beam is unnecessary.**  **Proposal 1: SSBs of satellite beams in the same cell are transmitted in the same BWP, e.g., BWP#0.**  **Proposal 2: The beam used in UE side should be indicated by gNB via downlink information in NTN.**  **Proposal 3: Support pre-configured timer and/or location-based beam switching in NTN.**  **Proposal 4: Reuse the beam indication and BWP indication method in Rel.15/16. Furthermore, the BWP indication and beam indication should be coordinated.**  **Proposal 5: Further study BWP switching without data scheduling or with invalid data scheduling.** |
| ZTE | ***Observation 1:*** *Similar trend on the channel condition is shared by the UEs within a large geographic zone.*  ***Observation 2:*** *For issue 5, the timer based solution may not work well within consideration on the channel conditions and RAN’s progress on the UE location reporting.*  ***Proposal 5:*** *The issue-7 should be prioritized and the common DCI based beam/BWP switching should be supported.*  ***Proposal 6:*** *The issue 2 and 3 can be addressed by defining the common DCI for issue 7.*  ***Proposal 7:*** *The issue 1 and 4 should be deprioritized and corresponding function can be handled by scheduling without performance degradation.*  ***Proposal 8:*** *No additional enhancement is needed for addressing issue 6.*  ***Proposal 9:*** *For issue 5, to achieve the predictable based beam switching, the UE dominant solution should be considered.* |
| Fraunhofer IIS, Fraunhofer HHI | **Observation 1: Switching Beam should not always trigger BWP switching and vice versa.**  **Observation 2: Enhancement of TCI beam switching or introduction of a new beam switching mechanism that assists NTN UE switch BWP is required, taking the constraint of Observation 1 into account.**  **Observation 3: In NTN, the issue related to joint UL BWP and DL BWP switching in FDD and for FRF > 1 should be discussed after the issue with association between beams and BWP is resolved.**  **Observation 4: The necessity in BWP switching with data scheduling is not a valid issue.**  **Observation 5: Re-synchronization after beam/BWP in NTN is not required.**  **Observation 6: Predictive movement of a satellite should be exploited for beam/BWP management enhancement in NTN.**  **Observation 7: It should be clear for NTN UE if the triggered BWP switch is associated with beam switching or none-beam switching procedures.**  **Observation 8: UE common signaling for beam/BWP switching can be further studied for a satellite with fixed beams scenario.**  **Observation 9: To maintain the existing use cases of BWP mechanism and distinguish them from the new use case of BWP, i.e., beam switching in NTN, the number of configured DL/UL BWPS for NTN UE need to be increased.**  **Observation 10: Beam-specific BWPs consideration for NTN facilitates the design of unified solution for beam switching indication in NTN.**  **Proposal 1: In NTN, it is sufficient to switch the BWP when data is scheduled.**  **Proposal 2: RAN1 should increase the number of configured DL and UL BWPs for NTN UE.**  **Proposal 3: RAN1 to strive for a unified solution to indicate beam switching in NTN.**  **Proposal 4: RAN1 to introduce beam-specific BWPs for NTN.**  **Proposal 5: RAN1 to clarify the scope of beam management enhancement.** |
| Lenovo, Motorola Mobility |  |
| ETRI | **Proposal 1: When FRF>1, implicit BWP switching of the UE may be considered according to the configuration of the BWP for beam measurement.**  **Proposal 2: When FRF>1, re-synchronization in the switched BWP may be revisited after discussion of the TA update procedure.**  **Proposal 3: In a fixed beam scenario, TCI may be configured according to beam characteristics (time, angle, etc.) to reduce overhead due to beam switching.** |
| LG Electronics | **Observation 3. Most of listed issues can be handled by current BM and/or BWP operation. Group-based BM and BWP operation can be further studied for signaling overhead saving.**  **Proposal 2. For NTN, potential enhancement on BWP switching can consider at least following aspects:**   * Enhancement on *bwp-InactivityTimer* including value range extension and (re)start timing, * PDSCH transmission after transmission of ACK for BWP switching command. |
| Huawei, HiSilicon | ***Observation 2****: Beam switching and BWP switching are independent procedures in NR specification.*  ***Observation 3:*** *Current NR specification supports beam switching and BWP switching at the same time.*  ***Proposal 1:*** *BWP configuration enhancement scheme should be studied for NTN, e.g.*   * *Extending the number of supported BWPs per cell* * *Introducing a scaling factor to adjust the cell-specific BWP common configuration*   ***Proposal 2****: Support signalling a list of TCI-states based on the predictable serving beams for the UE and the beam switching is triggered by the gNB.*  ***Proposal 3:*** *Consider the possibility of broadcasting satellite beam information in system information for UE dominant beam/BWP switching to reduce beam measurement.*  ***Proposal 4:*** *The function of bwp\_InactivityTimer should be reconsidered in NR NTN.* |
| Xiaomi | ***Proposal 4: The association between BWP ID and beam ID can be considered.***  ***Proposal 5: DL BWP switching and UL BWP switching simultaneously should be supported.***  ***Proposal 6: Timer based BWP switching can be supported.*** |
| InterDigital, Inc. | ***Observation 1:*** *non-essential issues to enable FRF>1 should be down-prioritized in Rel-17 if FRF>1 is supported in Rel-17*  ***Proposal 4:*** *if FRF>1 is supported in Rel-17, RAN1 should focus on only essential issues (e.g., Issues 1, 4, and 6) to enable FRF>1.* |

There are 20 companies contributed in analysing the issues and propose the potential enhancements. A summary of the company’s view is given below. The issues that received the most supported are issue 1, 5, and 7.

Issue 1: THALES, vivo, CATT, CMCC(?), QC, Apple, ETRI(?), Xiaomi (8)

Issue 2: vivo, Spreadtrum, CATT, CMCC(?), Apple, Xiaomi (6)

Issue 3: vivo, Spreadtrum, CATT, CMCC(?), Sony (5)

Issue 4: CATT (1)

Issue 5: CATT, OPPO, Panasonic(?), Sony, ZTE, Fraunhofer HHI, ETRI(?), Huawei, Xiaomi (9)

Issue 6: CATT, LG, Huawei (3)

Issue 7: CATT, CMCC(?), OPPO, Panasonic, ZTE, Fraunhofer HHI, Huawei(?) (8)

**Newly raised issues:**

Issue 8: BWP configuration enhancement (Huawei, QC, Fraunhofer HHI, Lenovo(?), CATT)

* extending the number of supported BWPs per cell
* cell-specific BWP common configuration

Issue 9: NR BM framework (TCI state and spatial relations) should be restricted within the same satellite or support the switching of the service links associated with different satellites. (Ericsson)

Issue 10: For NTN, current NR based measurement-based beam management will result in large signaling overhead and long latency for periodic exchange of CSI-RS transmissions and corresponding reporting. (Lenovo)

### Discussion point 1

**Summarized reasoning for addressing issue 1**

In the scenario of multiple-beam per cell, frequency reuse factor >1 is used to mitigate inter-beam interference, where neighbouring beams are transmitted in different BWPs. A NTN beam switching naturally triggers BWP switching. This is the motivation to have an association between NTN beam and BWP.



**Summarized reasoning for addressing issue 5**

Additionally, the gNB should be able to adjust the beam direction in UE side for other purposes such as uplink interference coordination from the network perspective, in that sense, it is better for gNB to decide the UE side beam. As the satellite beam switching can be frequent and often highly predictable, it is beneficial to reduce the signaling overhead and latency if the target beam(s) and switching condition(s) are pre-configured to UE.

**Summarized reasoning for addressing issue 7**

In NTN case, since the footprint for each beam is much larger than terrestrial network, which will lead to different distribution on the channel quality and criteria for beam switching. For example, as illustrated in the Figure 3, the distribution of channel quality for a group of UE, which is uniformly distributed within the certain geographic zone has been evaluated with following cases:

* Case-1: LEO-600, FRF=1, area range = 5 km, duration: 10 second, time granularity: 0.2 seconds
* Case-2 LEO-600, FRF=3, area range = 5 km, duration: 20 second, time granularity: 0.2 seconds



(a) Case-1 (b) Case-2

Figure 3 The illustration of DL SINR experienced by a group of UEs along with the movement of satellite

According to the results shown in Figure 3, it can be observed that similar trend of SINR variation with negligible difference is shared by UE within larger geographic region. In this way, it means that same scheduling strategy can be used and common signalling for addressing the beam switching related behaviour is feasible and beneficial for signalling overhead reduction. And the corresponding group of UE can be done by the network at least based on the collected report of channel conditions. If the location of UEs can be reported to the gNB, the gNB can also group UEs according to their location information. Then, the issue-7 should be prioritized.

**FL initial proposal**

Support BWP operation enhancement for NR-NTN to facilitate NTN satellite beam switching to address issues 1,5,7 concluded in RAN1#104-e.

* FFS: whether issue 8, 9 and 10 are to be addressed.

### Company view first round

|  |  |
| --- | --- |
| company | Views and comments |
| APT | Agree |
| ZTE | W.r.t the beam related enhancement for NTN, there are mainly two direction for the enhancement as below:   * D1: Enhancement on the legacy signalling for BS dominant mechanism * D2: Enhancement on the legacy mechanism by introducing the prediction based solution   **For the D1 part**, enhancement on signalling overhead optimization should be the baseline step since most of functionality/issue identified above can be implemented by legacy system with one or more signalling.  **Then, issue-7 should be prioritized** and further optimization**,** e.g., to jointly switching the DL and UL BWP (issue-2) and switching the BWP by DCI without scheduling (issue-3) can be easily implemented based on the common DCI design.  W.r.t the issue-1, it can also be considered with issue-7 together, but it may not aligned with the design principle of legacy design system that independent bit-filed is designed for different purpose. It should be noticed that, in NTN with FR>1, indication on the BWP changes and TCI information for channel tracking can still be indicated by different bit-field by implementation since the selected TCI states may applicable for all BWP within one cell according to existing spec:  **38.214**  *The UE receives an activation command, as described in clause 6.1.3.14 of [10, TS 38.321], used to map up to 8 TCI states to the codepoints of the DCI field 'Transmission Configuration Indication' in one CC/DL BWP or in a set of CCs/DL BWPs, respectively. When a set of TCI state IDs are activated for a set of CCs/DL BWPs, where the applicable list of CCs is determined by indicated CC in the activation command, the same set of TCI state IDs are applied for all DL BWPs in the indicated CCs.*  **38.321**  *The TCI States Activation/Deactivation for UE-specific PDSCH MAC CE is identified by a MAC subheader with LCID as specified in Table 6.2.1-1. It has a variable size consisting of following fields:*  *- Serving Cell ID: This field indicates the identity of the Serving Cell for which the MAC CE applies. The length of the field is 5 bits. If the indicated Serving Cell is configured as part of a CC-list as specified in TS 38.331 [5], this MAC CE applies to all the CCs in the CC list;*  *- BWP ID: This field indicates a DL BWP for which the MAC CE applies as the codepoint of the DCI bandwidth part indicator field as specified in TS 38.212 [9]. The length of the BWP ID field is 2 bits.* ***This field is ignored if this MAC CE applies to a CC list;***  The needs on the introduction of additional linkage between TCI and BWP is not well justified.  **For the D2 part**, w.r.t the issue-5, it’s fine to further discuss it as new mechanism, but since the location of UE is not available at gNB side according to current RAN2 progress, detailed solutions should be checked. |
| Panasonic | Our views are not well captured in the above summary. We don’t support Issues 5 and 7 in current formulation.  For Issue 5, it mixes the issue of frequent beam switching with the issue of linking beam switching to BWP switching. Therefore, we suggest to rephase Issue 5 as  **Issue 5 (modified): Since satellite beam switching can be frequent and often highly predictable, mechanisms of configured beam switching (can be a sequence of beams) may be preferred but current NR does not allow it.**  For Issue 7, it is unclear under what assumption the group-common beam switching is needed. The proposal seems targeted at reducing the signalling overhead, similar to Issue 5 but with a different approach. For the progress, we should first achieve consensus **on the issue of signalling overhead and UE power consumption caused by frequent beam switching by Rel-15/16 beam management**. Then we can further discuss which approach or both mentioned in Issues #5 and #7 are needed.  For Issue 1, as mentioned in our tdoc, we think it is not a valid issue and BWP operation per Rel-15/16 is sufficient to handle it. |
| Ericsson | We feel that we should discuss the root of issue rather than simply counting the number of supporting companies.  **Issue#1 is not valid:** When UE moves around and/or serving satellite/beam moves, it is not always necessary to switch the BWP upon beam switching or vice versa for mitigating interference and managing intra-cell UE mobility. First of all, UE can still communicate via the same BWP even when switching to new beam. One example of this scenario is that it is not necessary to switch the UE beam indicated by QCL type-D. This is especially relevant for satellite communication as the transmission point has a large distance from the UE and the direction of the UE beam can be the same for satellite neighbor beams. Similarly, even if the UE switches the beam, the BWP is not necessarily required to be changed. Therefore, the BWP/BM procedures including the BWP/beam switching should be performed dynamically with respect to UE position, interference level, channel condition, etc. And it is not desirable to associate the BWP switching with beam switching. The current design of NR BM/BWP procedures can fully support dynamic interference management and BWP/beam switching at the same time if necessary.  **Issue#5 is not valid:** The beam switching also depends on the UE mobility as well as interference level. Therefore, in general, it is not a predicable event, and depends on the measurements performed by the UE. So, even if BWP switching and beam switching were coupled, BWP switching would not be a predictable event. Further, as pointed out above, it is not necessary to couple BWP switching and beam switching, casting further doubt on the claim that BWP switching is predictable. In short, the configured BWP switching is against the dynamic and flexible scheduling principles.  **Issue #7 is not valid:** The scenario mentioned in Issue 7 is not representative for satellite communication. For earth fixed beam scenario, the beam/BWP switching also depends on the UE mobility and level of interference and needs to be addressed for each UE separately and dynamically, based on the UE measurements and condition. For earth moving beam scenario, the satellite beam moves gradually on the surface of earth and the switching point in time is different for different UEs, unless the UEs are in a close distance in relation with the beam edge, which is not predictable and not valid all the time. Therefore, the need of group switching of UEs is not motivated. |
| CMCC | In our view, enhancements on Issue 1, Issue 2, Issue 3, Issue 7 are not essential but they are beneficial. If a new DCI format is to be designed for fast BWP/beam switching in NTN, joint support of one or more enhancements for Issue 2, Issue 3, and Issue 7 can be considered.  Thus, Issue-7 can be prioritized, and other enhancements, e.g., to jointly switching the DL and UL BWP (Issue-2) and switching the BWP by DCI without scheduling (Issue-3), may be further studied based on the common DCI design (Issue-7). |
| Samsung | We think Issue#1 is not needed. The current NR supports dynamic BWP switching, so the gNB can rely on the mechanism.  For Issue#5/7, the soluations for the issues are about the optimizations. Without the solutions, NTN still can work. Therefore, if RAN1 discusses, those issues should be depriorized. |
| Lenovo/MM | Our first preference is that issue#1, 2, 3 should be addressed. We think allocating neighboring footprints with different beams and BWPs can mitigate interference and improve spectral efficiency. So the scenario should be supported. We understand that BWP indication and beam indication in legacy NR specification are separated, and all possible beam id can be indicated for a specific BWP by RRC, MAC CE or DCI for different RS/channel. For DCI indicated PDSCH/PUSCH beam switching, the same DCI can also carry corresponding updated neighboring BWP id for BWP switching. However, there area also CORESET beam indicated by MAC CE, when the beam for coreset is changed, there isn’t DCI to carry BWP id update. So we prefer a relationship between BWP and beam id is constructed and maintained between gNB and UE, so that beam switching and bwp switching can be performed based on the restricted relationship between beam and bwp. For issue#2 and issue#3, we think signanling reduction can be achived by these mechanisms, and we also support them.  Regarding issue#7, we think that the footprint of a beam coverage is relatively large, so we can group at least several UEs together to perform beam/bwp switching. So we also support issue#7 for siganling overhead reduction.  Regarding issue#5, we understand that a sequence of beam/bwp id configured can save signaling overhead. However, we think the condition and timing to change beam/bwp id should be studied to guarantee common understanding between gNB and UE.  Regarding issue#4 and issue#8, our proposal is on CSI-RS configuration enhancement. Our view is that if multiple NZP CSI-RS resources can be transmitted in multiple BWPs for a single measurement, enhancement for CSI measurement/reporting is necessary, especially for aperiodic CSI-RS reporting. As in legacy NR, for aperiodic CSI-RS resource, a trigger state list is associated with a NZP-CSI-RS resource set, and all NZP CSI-RS resources in the set have the same BWP id and the same triggering offset. If the NZP CSI-RS are located at different BWPs, the trigger offset should be configured per BWP.  Regarding issue#10, our intention is to adjust UE’s measurement/reporting procedure(e.g. periodicity) based on UE’ location or the satellite’s elevation angle. The reason is that UE on cell edge to performe measurement more frequent than a UE on other areas due to the possibllity for beam/bwp switching. |
| LG | For Issue#1, we agree with Panasonic, Ericsson, Samsung and CMCC, it is not essential issue.  For Issue#5, current DCI based BWP switching seems flexible enough to do the same functionality. So, without this potential solution, NTN still can work.  For Issue#7, we are open for further discussion. |
| Nokia, Nokia Shanghai Bell | On top of already good comments from Panasonic, Ericsson, Samsung, CMCC, and LG we have the following comments:  Prior to starting any discussion in this domain, it is essential to highlight that it is crucial that the existing SSB structure is maintained. That is, it is not expected to have different SSBs located at different frequency offsets. With that in mind, it would be difficult to implement any concept of frequency reuse through NR beams. Hence, we basically see the various options presented above as severely breaking the existing framework for BWPs and Beam management, and would encourage that the main priority is directed towards implementing basic functionality instead of implementing another way of frequency reuse. It is in this context worth highlighting that frequency reuse is possible to implement using existing Rel-15 NR features by creating separate cells with separate center carriers. |
| Sony | For issue#1, association beween BWP and beam is not necessary as dynamic BWP switching and TCI indication were supported. We think the existing NR solutions on beam and BWP management should be adapted for NTN prior to considering issues for enhancement. The essence of TCI is reference signal, such as CSI-RS, which is located at specific BWP based on RRC configuration. Then how to perform RS measurement on different BWPs and how to coordinate with the BWP indication when indicating the TCI should be considered.  Issue#5 and issue#7 are for optimization which can be depriorized. |
| Huawei, HiSilicon | Our view is that we can first focus on issue 1 and discuss whether any additional enhancement is necessary since it is coupled with several other issues such as Issue 2, Issue 3 and Issue 4.  In current NR specification, beam switching and BWP switching are two independent procedures. However the current specification can already support some association between beam, e.g. CSI-RS resource index, and BWP. As an example, CSI-RS can be used for beam measurement at least for UEs in the connected mode. In NTN, each BWP/beam can be configured with one or more CSI-RS resource, e.g. UEs in different beams or BWPs will be configured with different CSI-RS resources and each BWP can be identified by a corresponding CSI-RS resources index. Given that both BWP and beam switching can be triggered by DCI using different independent DCI fields, the current specification actually allows beam and BWP switching at the same time to some extend.  For Issue 5, we are open to consider some further enhancement. Due to the high speed of satellite movement, the UE in a satellite cell can be considered to have a predictable route traversing through several satellite beams.   * As a first alternative, the gNB can determine the beam for the UE based on the beam topology, satellite movement and UE location information. When UE approaches the beam edge, it will be informed by gNB to perform beam switching. One benefit of this scheme is that measurement at the UE side can be reduced with some assistant information from UE side. * As another alternative, beam information could be broadcast in the system information for UE dominant beam/BWP switching. Once the beam information (e.g. the beam width of BWPs/beam, centre elevation and azimuth) are broadcast in the system information, the UE can calculate the topology of its surrounding beams (e.g., the footprint of the surrounding beams).With GNSS ability, UE will have the full map of when to do beam switching and which beam to switch to. Therefore, UE can trigger beam/BWP switching once it approaches the beam edge without only replying on measurement.   For Issue 7, the scenario is not clear to us and it is not clear how satellite BWP/beam switching can be common for set of UEs in case of moving beams. It will be good for the proponent to clarify this. |
| Apple | Agree  In case of multiple-beam per cell, the coverage of different satellite beams will have large overlap, and the inter-beam interference needs to be controlled. One straightforward way of mitigating inter-beam interference is using different frequencies on neighbor beams. The frequency reuse factor > 1 could be achieved via different BWPs on neighbor beams.  In the deployment scenario of FRF>1, the satellite beam switching implies BWP switching. This justifies the joint satellite beam switching and BWP switching. This joint beam switching and BWP switching is common for earth beam moving scenario, where a static UE will experience the switching of both BWP and beam simultaneously. Hence, we think issue #1 should be considered. Subsequently, we could consider issue #2 as well. |
| vivo | W.r.t the issue-1, the TCI mechanism is independent from the BWP switching, then they can be simultaneously configured in a DCI, which can be up to the scheduling.  W.r.t the issue-5, the prediction of satellites movement can be utilized to assistant the beam switching. Furthermore, sometimes UE movement could result in beam switching in the dwell time. Thus, current measurement and reporting mechanism can be reused and some enhancement on the latency of this procedure can be considered.  W.r.t the issue-7, group common signaling for beam switching can be considered to save signaling overhead. However, UEs in the same group could have the different best timing for beam switching. Thus, this group common signaling could result in the waste of transmission occasion for some UEs. |

### Summary of first round

### Company view second round

### Summary of second round

### Final conclusion

## NR-NTN satellite beam deployment

### Background

During the rel-16 NR NTN SI, it was observed that the rel-15 NR beam management and BWP procedures can be re-used with the assumption that the beams are not co-located. Rel-15 NR UE uses initial BWP#0 for initial cell access including SSB, paging, and PRACH. There can be up to 4 BWPs configured in Rel-15 NR – i.e. BWP#0, BWP#1, BWP#2, and BWP#3.

There were two options for mapping of PCI and SSB in TR 38.821 [2].

* Option a: multiple SSB beams per PCI.
* Option b: one SSB beam per PCI.



***Figure 1: Mapping options for PCI/SSBs in NTN***

Further, in RAN1#103e meeting, we have discussed the following two beam layout options corresponding to two different relationship between BWP#0 and BWP#x. Option 1 implements a narrow beam in BWP#0, which has the same beam width as the data beam. While Option 2 has a hierarchical beam layout, which implements a cell-level large beam in BWP#0, a.k.a. umbrella beam.



*(a)* ***Option-1****: Same beam layout in BWP#0 and BWP#x (b)* ***Option-2****: hierarchical beam for BWP#0*

In this meeting, the company’s contributions are in this aspect are captured below

|  |  |
| --- | --- |
| CATT | 1. **For RRC-IDLE UE, one cell is only associated with one satellite beam, no enhancement needed.** 2. **For RRC-Connected UE, one small enhancement is considered:**  * **A cell comprises of multiple satellite beams with different coverage areas, wherein only one beam is linked to one initial BWP and other beams are linked to different active BWPs.**  1. **SSB configuration in one BWP follows NR Rel-15 framework, no enhancement needed.** |
| vivo | ***Observation 1: There is no significant necessity to support the explicit association between SSBs and BWPs.***  ***Observation 2: Both Option-1 and Option-2 can be supported.***   * ***Option-1: Same beam layout in BWP#0 and BWP#x*** * ***Option-2: Hierarchical beam for BWP#0***   ***Observation 3:*** ***In LEO scenario with earth-moving beams, beam switching can reduce handover interruption time at leaset for multiple beams per cell case.*** |
| Apple | ***Proposal 3:*** *Consider performing beam measurement either in initial BWP or in different BWPs with BWP switching.* |
| InterDigital, Inc. | ***Proposal 1:*** *consider different BWP allocation per beam (e.g., at least for the neighboring beams) as baseline when multiple beams per cell are used*  ***Proposal 2:*** *study a mechanism to reduce the time gap to measure neighboring beams when frequency reuse is used for multiple beams in a cell*  ***Proposal 3:*** *consider Option-1/2 as baseline and study further the Option-3/4 to identify the potential benefits and specification impacts* |
| THALES | **Observation 8 Deploying multi-beam cell and using beam management will not be applicable to all NTN deployment scenarios** |
| Ericsson | [Observation 1 Both multiple-beam and one-beam per PCI mapping schemes can be realized for NTN with current NR specifications without any enhancement.](#_Toc71640603) |
| Huawei | ***Observation 1****: BWP#0 with narrow beam width (option-1) has a better coverage of SSBs.* |

### Discussion point 2

**FL suggestion:**

Option a (multiple SSB beams per PCI) and Option b (one SSB beam per PCI) are supported. Further beam management enhancement at least for option a) depends on the outcome of the discussion point 1. Thus, we can discuss the discussion point 1 first.

**Initial Proposal-DP2-1**

Option 1 (Same beam layout in BWP#0 and BWP#x) and Option 2(hierarchical beam for BWP#0) are supported.

### Company view first round

|  |  |
| --- | --- |
| company | Views and comments |
| APT | Agree |
| ZTE | We are supportive on the FL’s suggestion and proposal 1. Actually, to enable these two Options, no additional spec enhancement is needed and only optimization for the signalling overhead can be taken as baseline target. |
| Panasonic | Both options 1 and 2 can be realized by current NR spec without further enhancement. |
| Ericsson | Same view as Panasonic: Both Options 1 and 2 can be realized by current NR spec without further enhancement. |
| CMCC | Agree. |
| Samsung | Same view as Panasonic in that the current NR supports. |
| Lenovo/MM | Agree with moderator’ proposal to support both option 1 and 2. We understand that SSBs are transmitted in BWP#0 mainly for initial access. We have a follow-up question for clarification is that whether CSI-RS for channel measurement is transmitted in BWP#0 or other BWPs. Our understanding is that CSI-RS can be transmitted in other BWPs. In that case, enhancement for CSI measurement/reporting is necessary, especially for aperiodic CSI-RS reporting. As in legacy NR, for aperiodic CSI-RS resource, a trigger state list is associated with a NZP-CSI-RS resource set, and all NZP CSI-RS resources in the set have the same BWP id and the same triggering offset. If the NZP CSI-RS are located at different BWPs, the trigger offset should be configured per BWP. |
| LG | Same view as Panasonic, both options can be realized by current spec. |
| Nokia, Nokia Shanghai Bell | We are supportive of FL suggestion. Given that the considered concepts of option 1 and option 2 are supposed to be facilitated by existing specifications, we would prefer if Initial-Proposal-DP2-1 is made as a conclusion. |
| Sony | Support. |
| Huawei, HiSilicon | Both options can be supported based on the previous discussion. |
| Apple | Agree, with no NR spec impact. |
| vivo | Support the FL’s proposal. |

### Summary of first round

### Company view second round

### Summary of second round

### Final conclusion

## NR-NTN beam measurement and reporting

### Background

In this meeting, there are 6 companies provided contributions on the NTN beam measurement and reporting enhancements.

|  |  |
| --- | --- |
| vivo | ***Proposal 3: gNB dominates beam switching mechanism can be considered in NTN based on ephemeris information of satellites, UE positions and other assistant information, e.g. beam measurement and reporting.***  ***Proposal 4: Support to enhance beam measurement and reporting mechanism for NTN.*** |
| Qualcomm | **Proposal 8: Consider enhancements on radio link monitoring to support efficient reference resource configuration and measurement outside the active BWP.** |
| Apple | ***Proposal 3:*** *Consider performing beam measurement either in initial BWP or in different BWPs with BWP switching.* |
| Lenovo | ***Observation 1: For NTN, current NR based measurement-based beam management will result in large signaling overhead and long latency for periodic exchange of CSI-RS transmissions and corresponding reporting.***  ***Proposal 4: Study further methods to perform beam measurements in order to reduce the signaling overhead and avoid long latency.***  ***Proposal 10: Measurement and reporting signaling for polarization is needed for efficient beam switching and handover. CSI-RS may be used for polarization measurements.*** |
| ETRI | **Proposal 1: When FRF>1, implicit BWP switching of the UE may be considered according to the configuration of the BWP for beam measurement.** |
| Huawei | ***Proposal 3:*** *Consider the possibility of broadcasting satellite beam information in system information for UE dominant beam/BWP switching to reduce beam measurement.* |

**Vivo**: considering UE movements, current beam measurement and reporting mechanism could be also considered. A set of candidate target beams could be provided to UEs to measure and report. And due to large beam diameter in NTN scenario, candidate target beams are usually not all beams under the satellite, just several adjacent beams, which reduces unnecessary measurement and reporting on beams with low correlation. In addition, the set of candidate target beams could be a sequence of beams, descending or ascending order of priority. Thus, enhancements on beam measurement and reporting mechanism could be considered.

**QC**: To help the network decide on the best BWP or satellite beam for a UE to switch to, it is important that the UE measures the quality of its current serving satellite beam and neighboring satellite beams and reports the measurements back to the network. Frequent satellite beam switching leads to frequent reconfiguration of reference signals for radio link measurement. Because the measurement of a neighboring satellite beam may need to be performed in a BWP that is different from the active BWP, extra time is needed for frequency retuning and preparation for the frequency compensation and it is beneficial to minimize the measurement overhead.

**Apple**: The beam measurement in NR terrestrial network is based on SSB or CSI-RS. Since different satellite beams in NTN may be associated with different BWPs, BWP may be either switched or extended in order to measure CSI-RS in different beams. The former approach requires additional gap between beam measurement, while the latter approach has a large specification impact. We prefer the approach for BWP switching for CSI measurement in a different beam. An alternative approach is to make all the beam measurement in initial BWP, which reduces the total number of BWP switching for beam measurement.

**Lenovo**: Assuming the scenario shown in Fig 1, where multiple beams are in a cell and each beam is mapped to a BWP, one major issue could be large signaling overhead and long latency associated with the beam switching procedure that includes periodic CSI-RS transmissions and corresponding reporting. For LEO satellites, the beams might need to be updated frequently and signaling overhead could be large.

One potential solution could be based on location-aware CSI-RS transmissions and measurements. As shown in Figure 3, UEs on cell-edge needs to perform frequent measurements (UEs near gray area in Fig 3) while other UEs either do not require measurements, or the frequency of measurements can be reduced significantly. Therefore, such procedure can be adopted either based on the location or based on a L1- RSRP mapping table.



Fig 3. An example of location-based beam measurements

### Discussion point 3

**FL initial proposal-DP3-1**

For CSI-RS-based beam measurement of a serving cell, support enhancements to address at least the following aspects

* Measurement gap for BWP switching when measured CSI-RS is outside active BWP
* Reduction of power consumption for cases when measurement can be avoided.
* FFS: further restrict CSI-RS in initial DL BWP.

**FL initial proposal-DP3-2**

For SSB-based beam measurement of a serving cell, support enhancements to address at least the following aspects

* Measurement gap for BWP switching when measured SSB is outside active BWP
* Reduction of power consumption for cases when measurement can be avoided.

### Company view first round

|  |  |
| --- | --- |
| company | Views and comments |
| APT | No. RSRP (SSB/CSI measurement) is non-essential for L1/L2 mobility, e.g., HO/CHO.  Time-based BWP switching (like time-based CHO) can be considered. NW provides the time (timer/UTC) after which the UE can execute BWP switching to the candidate target BWP. If the time-based BWP switching fails, then the legacy BWP inactive timer (bwpInactivityTimer) can bring the UE back. NW can take full control of this L1 mobility. |
| ZTE | For these two proposal, actually, it is intended to address same issue for legacy BM mechanism, i.e., beam measurement outside active BWP. For optimizing this functionality, we need to consider the whole mechanism including RS configuration and report mechanism.  Then, it’s preferred to modify and merge these two proposals as below:  Updated proposal  Enhancements to achieve the BM management cross BWPs (including BWP outside the active BWP) should be supported at least on following aspects:   * RS/reporting configuration * Measurement gap |
| Panasonic | We are open to further discuss to reduce UE power consumption by frequent beam measurement, although we think some enhancement can rely on gNB implementation. |
| Ericsson | This topic is related to discussion point 1 about the 7 listed issues. Before achieving consensus on the issues that need to be addressed, it is pre-mature to discuss enhancements of the SSB/CSI-RS measurements.  In short, we are not ok with these proposals at this stage. |
| CMCC | As summaried in section 2.5, NR-NTN SSB transmission in BWP#0 is supported by most companies, thus, the motivation of the first subbullet in FL initial proposal-DP3-2 needs more clarification. |
| Samsung | We can futher discuss on the motivations and advantages. However, similar to above issues, we can deprioritize compared to the essential issues. |
| Lenovo/MM | We agree with moderator that measurement gap is necessary when the measurement is cross different BWPs. We also agree with ZTE that RS/reporting configuration enhancement is necessary especially considering the time domain offset for different aperiodic NZP CSI-RS located at different BWPs.  We also support to define mechanism for power saving and signaling reduction for measurement/reporting in NTN. |
| LG | As pointed by Ericsson, this issue is related to issue 1 and 7. So, we can further discuss after we make some consensus on it. |
| Nokia, Nokia Shanghai Bell | According to our understanding the introduction of measurement gaps for performing beam related measurements is counter-intuitive. Is the intention here to make an attempt of recreating existing inter-cell measurement framework within the beam management framework? If so, we would strongly oppose to this, as this will (a) introduce duplicate functionality, (b) complicate specifications, and (c) create further fragmentation of the market unless the functionality is made mandatory. |
| Sony | Support this proposal.  As we commented in Discussion Point 1, we think this beam measurement and reporting issue should be discussed with high priority. |
| Huawei, HiSilicon | We don’t think it is essential to consider SSB and CSI-RS based measurement for NTN.  Our view is that in NTN BWP/beam switching merely based on measurement is not efficient as the UE may select adjacent BWP/beam with smaller serving time duration and the complexity for measurement outside active BWP is large. It is beneficial to introduce geometry or timer based BWP switch to reduce the power consumption and increase the BWP switching efficiency at the UE side. |
| Apple | We are supportive to the proposals.  Since different satellite beams in NTN may be associated with different BWPs, BWP may be either switched or extended in order to measure CSI-RS in different beams. The former approach requires additional gap between beam measurement, while the latter approach has a large specification impact. We prefer the approach for BWP switching for CSI measurement in a different beam. |
| vivo | We agree with Ericsson’s view, it is pre-mature to discuss enhancements of the SSB/CSI-RS measurements before the essential issues are identified. |

### Summary of first round

### Company view second round

### Summary of second round

### Final conclusion

## NR-NTN beam and BWP association

### Background

Two companies provided solutions for beam and BWP association.

Xiaomi: For one-beam per cell, handover mechanism can be used to indicate beam switching. While for multiple-beam per cell, intra-cell beam switching should be considered. In order to reduce the interference between adjacent beam footprints, BWP operation for NTN with frequency reuse will be discussed, as illustrated in Figure 1. In this case, it is beneficial to define a association between BWP and beam, or to define a parameter set ID which linking to a BWP ID and a beam ID. In this case, it can switch both the BWP and the beam by indicating a parameter set ID. With this method, the DCI size can be reduced.

Apple: If in a TCI state configuration, the associated DL or UL BWP is configured, then the satellite beam switching via DCI or MAC CE results in the corresponding DL BWP or UL BWP switching. In other words, the DL BWP or UL BWP switching follows the satellite beam switching autonomously, if a TCI state configuration includes the associated DL BWP or UL BWP.

### Discussion point 4

**FL suggestion:**

Conclude the discussion point 1 first before discussing the beam and BWP association.

### Company view first round

|  |  |
| --- | --- |
| company | Views and comments |
| APT | Agree |
| ZTE | No need to discuss the association between beam and BWP explicitly and it’s up to implementation. |
| Panasonic | Support FL suggestion. |
| Ericsson | It is not necessary to directly associate a BWP with a beam. |
| CMCC | Agree. |
| Samsung | OK |
| Lenovo/MM | Agree with moderator’s view. Agree that there are association between BWP and beam, and we prefer that the relationship between bwp and beam explicitly configured. |
| LG | OK with FL suggestion. |
| Nokia, Nokia Shanghai Bell | No need to discuss this at this meeting. |
| Sony | Support |
| Huawei, HiSilicon | We agree with the moderator’s suggestion. |
| Apple | Agree |
| vivo | Support FL suggestion. |

### Summary of first round

### Company view second round

### Summary of second round

### Final conclusion

## NR-NTN SSB transmission in BWP#0 and sync raster

### Background

|  |  |
| --- | --- |
| CATT | 1. **SSB configuration in one BWP follows NR Rel-15 framework, no enhancement needed.** |
| Qualcomm | **Proposal 1: Support satellite beam specific initial BWPs.**  **Proposal 3: Support the following SSB arrangements**   * **Alt 1: SSBs of all satellite beams in a same cell are transmitted within a same frequency interval and do not overlap in time** * **Alt 2: SSBs of a cell are transmitted in different frequency interval, i.e., within their respective BWPs.**   **Proposal 4: Support signalling of the following configurations in SIB1**   * **initial BWPs of other satellite beams,** * **CORSET#0 of other satellite beams if different from that of the serving beam.** |
| Sony | **Proposal 1: SSBs of satellite beams in the same cell are transmitted in the same BWP, e.g., BWP#0.** |
|  |  |

Regarding SSB transmission in BWP#0 (initial BWP), companies’ views are split. There are mainly two directions to pursuit.

Alt-1: SSBs of a same cell are transmitted in a same frequency interval or in one BWP#0.

Alt-2: SSBs of a same cell are transmitted in different frequency intervals or introduce multiple BWP#0.



This topic has been discussed several meetings and there does not seem to have more support for alt-2. In this case, the FL suspects that the company’s views will be changed in this meeting. Thus, to save our time, FL proposes the proposing companies to have offline discussions with other companies.

**FL suggestion:**

For Alt-2, the supporting companies are encouraged to have offline discussions to convince other companies by the benefits of Alt-2. **It means that there is not a dedicated discussion point in this meeting.**

### Company view

|  |  |
| --- | --- |
| company | Views and comments |
| APT | Agree |
| ZTE | No need to introduce additional mechanism |
| Panasonic | Support FL suggestion. |
| Ericsson | Support FL suggestion. |
| CMCC | Agree. |
| Samsung | Agree |
| Lenovo/MM | Support FL suggestion. |
| LG | Agree |
| Nokia, Nokia Shanghai Bell | The SSB configuration should follow the existing NR REl-15 framework to ensure that we focus on basic functionality to enable NR over NTN. |
| Huawei, HiSilicon | We agree with the moderator’s suggestion. |
| Apple | Agree with FL suggestion. |
| vivo | Support FL suggestion. |

# Signalling of Polarization

## Background

The following agreements were made in RAN1#102e and RAN1#103e, respectively:

Agreement:

Potential enhancements for support of polarisation signalling in NR NTN can consider at least the following:

* Configuration of DL and UL transmit polarization including Right hand and Left hand circular polarizations (RHCP, LHCP)
* Network broadcast DL and UL transmit polarization configuration
* UE polarization capability (RHCP, LHCP, Linear)
* Dependence of polarisation signaling on deployment scenarios. For example,
  + Resource reuse mode with/without polarization for the beam management enhancement
  + Fixed polarization per cell/beam for polarization reuse and circular polarisation with intra-UE and inter-UE multiplexing (intra-UE and inter-UE) signalling

Agreement:

Indication of polarization information for DL and UL by the network is supported.

* FFS: Signalling details

In RAN1#104-e meeting, we have further achieved the following agreement that at least explicit indication for DL by the network is supported. Moreover, the details of the signalling is to be discussed in this meeting.

Agreement:

Support at least explicit indication of polarization information for DL by the network

* FFS: whether the indication is done by SIB, other RRC signaling, DCI.
* FFS: Whether separate signaling is needed for the UL and if so, whether or not a same polarization is indicated for DL and UL

Conclusion:

Discuss the necessity of reporting UE polarization capability considering at least following aspects,

* Deployment scenarios.
* UE implementation aspects with respect to polarization.
* Satellite implementation aspects for switching between polarization states.

Satellite implementation aspects for realizing multiplexing of UEs having different polarization capabilities.

Company’s contribution

|  |  |
| --- | --- |
| THALES | **Proposal 1 To increase the per-beam bandwidth while ensuring excellent interference isolation between beams, other frequency separation techniques such as polarization re-use scheme should be considered**  **Observation 3 Circular polarization can be used to double the cell capacity** |
| vivo | ***Observation 6:*** ***The motivation of reporting polarization capability is unclear.***  ***Observation 7: The polarization configuration of beams can be left to the network implementation.***  ***Observation 8: The reporting of UE polarization capability shows no benefit for the polarization configuration of beams.***  ***Observation 9: The reporting of polarization capability could not provide any significant benefit for the multiplexing of UEs having different polarization capabilities.***  ***Observation 10: SSB transmission is suitable to indicate the beam-specific polarization.***  ***Proposal 5:* *Not support to dynamically indicate polarization configuration of beams.***  ***Proposal 6: The reporting of UE polarization capability should not be supported.***  ***Proposal 7: Not support to separately indicate the polarization of UL.***  ***Proposal 8: Enhancements on SSB transmission to support UEs the unmatched polarization to camp in NTN beams could be considered.***  ***Proposal 9: For downlink synchronization, support the polarization indication to be associated with SSB transmission.***  *Proposal 10: Support to associat SSB transmission with LHCP and RHCP in TDM way.*  *Proposal 11: For idle/inactive state UEs, the polarization indication in SIB or SI is not supported.*  *Proposal 12: For connected state UEs, the polarization indication in SIB or DCI, or other RRC signaling could be used to update the polarization indication in SSB transmission.* |
| Spreadtrum Communications | ***Proposal 4: UE reporting polarization capability is not needed.***  ***Proposal 5: Polarization indication can be signalled by gNB.*** |
| CATT | 1. **Network informs UE the polarization indication per beam by SIB, and polarization mode of DL and UL should be same.** 2. **Reporting UE polarization capability is not necessary.** |
| CMCC | ***Proposal 5:*** At least support explicit indication of polarization information for DL by SIB.  ***Proposal 6:*** Further discuss on explicit indication of polarization information for DL by other RRC signaling or DCI, if needed. |
| Qualcomm Incorporated | **Proposal 12: Consider at least signalling of polarization per BWP.** |
| OPPO |  |
| Samsung |  |
| Ericsson | [Proposal 5 Support broadcast signaling in SIB that allows a gNB to indicate the gNB’s DL transmit polarization mode and UL receive polarizations mode to UE.](#_Toc71640619)  [Proposal 6 Support signaling that allows the gNB to configure a UE’s polarization modes including the UE’s receive polarization mode in the DL and the UE’s transmit polarization mode in the UL.](#_Toc71640620)  [Proposal 7 NTN UE should report its polarization capability (RHCP, LHCP, Linear) to the network.](#_Toc71640621) |
| Nokia, Nokia Shanghai Bell | **Proposal 4: Use SIB based broadcast transmission to provide the default polarisation indication for DL and UL.**  **Proposal 5: Define a network configured basic or default polarization mode for DL and UL operation which is used for initial access.**  **Proposal 6: Clarify if signalling of polarization mode using RRC signalling for RRC\_CONNECTED mode UEs can really be supported in the transparent paylod scenarios.**  **Proposal 7: The UE supports the default polarization mode offered by the gNB/satellite.**  **Proposal 8: The UE may report a preference for a polarization mode from its supported polarization modes.** |
| Apple | ***Proposal 4:*** *Regarding the usage of polarization, prioritize the support of inter-beam interference mitigation scenario.*  ***Proposal 5:*** *For inter-beam interference mitigation, the polarization information is configured in a beam specific manner and is signaled via SIB.*  ***Proposal 6:*** *UE polarization capability reporting is not supported for inter-beam interference mitigation.* |
| Panasonic | **Proposal 3: Signaling for the following two usages of circular polarization should be supported.**   * **Polarization reuse for inter-cell/beam interference mitigation** * **Polarization multiplexing for throughput improvement**   **Proposal 4: For operation with polarization reuse, the following signaling design should be discussed:**   * **Polarization for initial access** * **Polarization for beam management** * **Polarization for SSB/CSI-RS measurement** * **Polarization of target cell/beam for handover**   **Proposal 5: For operation with polarization multiplexing, information on the polarization should be indicated in DCI for scheduling PDSCH/PUSCH.**  **Proposal 6: Support the following UE polarization capability report**   * **Transmission capability of circular polarization (explicitly or implicitly by UE type)**   **Reception capability of dual polarization signals as separate streams** |
| Sony | **Observation 4: Depends on the form factor and complexity of the RF implementation, the supported polarization can vary between UE to UE.**  **Observation 5: Understanding the UE capability on the supported polarization mode is critical for NTN network deployment. It is also necessary for the NTN network to use the polarization domain, e.g., The gNB can configure multi-user multiplexing on the polarization domain based on UE capability.**  **Observation 6: The UE awareness of gNB polarization of reference signal, e.g., SSB, can improve the beam management performance.**  **Proposal 6: Multi-user multiplexing on the polarization domain based on UE capability is supported.**  **Proposal 7: Beam management, e.g., spatial relation, in the NTN network can include the polarization aspect.**  **Proposal 8: Support UE polarization capability reporting, it can be either reported explicitly by the UE or implicitly through the UE measurement and reporting of the DL RS on two orthogonal polarizations.** |
| ZTE | ***Proposal 1:*** *The beam/cell level allocation of polarization information for DL/UL in both semi-static and dynamic way can be considered.*  ***Proposal 2:*** *W.r.t the polarization information for one serving cell, the SIB based indication for SSB and RRC based configuration for CSI-RS should be supported. The corresponding information for other channels/RS will be derived based on associated QCL information.*  ***Proposal 3:*** *The explicit indication of polarization information via common DCI can be considered to further optimize the signalling overhead.*  ***Proposal 4:*** *UE polarization reporting should be supported.* |
| Fraunhofer IIS, Fraunhofer HHI |  |
| Lenovo, Motorola Mobility | ***Proposal 5: UE reporting of its polarization capability is supported.***  ***Observation 2: Defining only a single polarization type for all frequency bands may result in reduced spectrum sharing capabilities, whereas defining multiple polarization types may result in erroneous polarization detection.***  ***Proposal 6: In order to facilitate initial access procedure, one or multiple basic polarization types can be defined for different frequency bands.***  ***Proposal 7: DL Polarization information can be indicated in SSBs to avoid degradation of initial cell search.***  ***Proposal 8: UL Polarization information can be indicated in PRACH during initial access.***  ***Proposal 9: Indication of polarization multiplexing is supported where DCI or TCI state signalling may be used for polarization-based multi-user multiplexing and single-user higher rank transmission.***  ***Proposal 10: Measurement and reporting signaling for polarization is needed for efficient beam switching and handover. CSI-RS may be used for polarization measurements.*** |
| ETRI |  |
| LG Electronics | **Observation 1. DL polarization indication seems sufficient.**  **Observation 2. Without UE polarization capability reporting, UE can properly work.**  **Proposal 1. Indication of polarization mode (RHCP, LHCP) can be broadcasted via SIB.** |
| Huawei, HiSilicon | ***Proposal 5:*** *At least cell-level and beam-level polarization indication for NTN should be supported.*  ***Proposal 6:*** *The necessity to report the UE polarization capability is not clear in case that the polarization state of network does not change dynamically.* |
| Xiaomi | ***Proposal 1: The DL polarization information is explicitly indicated in system information.***  ***Proposal 2: Dynamic indication of polarization is not supported.***  ***Proposal 3: UE polarization capability reporting is supported.*** |
| InterDigital, Inc. |  |

There are 16 companies that have provided contributions in this topic. Majority of the companies think that the polarization indication for DL can be provided in SIB.

Companies supporting DL polarization indication in SIB: vivo (for connected UE), CATT, CMCC, Ericsson, Apple, ZTE, LG, Huawei, Xiaomi

Furthermore, there are also companies suggesting to have beam-level polarization indication.

Companies supporting beam-level polarization indication: ZTE, Huawei, vivo, CATT

In addition, CMCC and ZTE also suggest to support polarization indication in UE-specific RRC. ZTE also proposes to support common-DCI based polarization signalling.

Qualcomm proposes to have BWP-wise polarization indication.

Regarding UL polarization indication, Vivo, spreadtrum and CATT think that separate UL indication is not needed. While Ericsson supports a separate DL and UL polarization indication.

Regarding UE polarization capability reporting, there are splitting views with comparable number of the supporting companies.

Support reporting: Ericsson, sony, Xiaomi, ZTE, Lenovo

No reporting: CATT, Apple, LG, HW, spreadtrum

## Discussion point 5

**FL initial proposal-DP5-1**

For explicit indication of polarization information for DL by the network, support indication in SIB

* FFS: indication by UE dedicated RRC.

**FL initial proposal-DP5-2**

No separate indication for UL polarization, UE assumes a same polarization for DL and UL.

**FL suggestion**

Further discuss the necessity of UE polarization capability reporting in this meeting.

### Company view first round

|  |  |
| --- | --- |
| company | Views and comments |
| APT | Agree FL initial proposal-DP5-1 (Good side info for UE to enhance SNR)  For FL initial proposal-DP5-2, not sure why a limit is needed for a satellite to use the same polarization for DL and UL. |
| ZTE | Before we conclude the detailed signalling, we need to firstly conclude the target entity for polarization indication or configuration, e.g., per beam, per BWP or SSB/RS or channel. Otherwise, it’s not clear how to associate the signalling to further DL/UL transmission. Then, w.r.t the 1st bullet, updates as below is proposed:  **FL initial proposal-DP5-1**  For explicit indication of polarization information for DL by the network, support at least one of following indication:   * Option-1: The indication of polarization is per BWP(s) * Option-2: The indication of polarization is per SSB(s) * Option-3: The indication of polarization is per CSI-RS(s) * Option-4: The indication of polarization is per channel(s)   For **FL initial proposal-DP5-2,** we are supportive on it.  W.r.t the UE report, it’s necessary to be supported and further discussion is needed. |
| Panasonic | Support FL initial proposal-DP5-1. We think at least for initial access, information on the polarization should be broadcasted via SIB. For operation with polarization multiplexing, information on the polarization should be indicated in DCI for scheduling PDSCH/PUSCH.  Not supportive on DP5-2. We think different polarization for DL and UL could be useful in certain scenarios, and therefore it is too early to rule it out. For example, for DL, polarization multiplexing is used to muliplex different UEs, but for UL, polariaztion multiplexing is not used. In this case, DL and UL could have different polarization from one UE perspective. Furthermore, it would be necessary to discuss how to handle the case where the UE does not support transmission with the same polarization as DL. For example, UE with linear polarization antenna can receive circular polarization signal, but it may not support transmission of circular polarization.  For UE report of polarization capability, we think the following can be supported:  • Transmission capability of circular polarization (explicitly or implicitly by UE type)  • Reception capability of dual polarization signals as separate streams |
| Ericssson | **Support FL initial proposal-DP5-1**.  **Not Ok with FL initial proposal-DP5-2:** this is counter-productive, imposing unnecessary restriction on the deployment.  **Fine with FL suggestion:** It is expected that a mega NGSO constellation will be utilized to serve multiple types of devices such as reduced capability devices, normal handhelds, vehicular devices, fixed devices, among others. Some of these devices will use linear polarization, some will use circular polarization, and others may support both. For optimal performance, it will be necessary for network to know the polarization capability of these devices or at least the UE type. |
| CMCC | Support FL initial proposal-DP5-1. |
| Samsung | Support DP5-1.  Further discuss DP5-2, especially with motivation and use cases. |
| Lenovo/MM | Regarding DP 5-1, we agree with ZTE that the relationship between polarization and SSB/beam/BWP/RS should be discussed first, and we think a polarization type can be associated with a SSB index.  Regarding DP 5-2, we think no restriction on same polarization type between DL and UL depending on different UE implemenatation.  Regarding DP 5-3, we think polarization type reporting is beneficial for gNB scheduling. |
| LG | Support proposal 5-1 and 5-2. |
| Nokia, Nokia Shanghai Bell | Supportive of FL initial proposal-DP5-1  Supportive of FL initial proposal-DP5-2  Ok to further discuss the need for UE reporting its capabilities regarding polarization. |
| Sony | Support DP5-1.  Not support DP5-2. This is unnecessary limitation as commented other companies. DL and UL may have different scenarios, where DL need to consider multiuser multiplexing while UL may need to maximize the transmit power through different polarization schemes.  It is also necessary to have the UE capability reporting of polarization due to the limitations on the implementation. |
| Huawei, HiSilicon | **FL initial proposal-DP5-1:** Fine with the proposal. Besides the signalling part, it will be good discuss further on how the beam-level or cell level polarization can be achieved as suggested by ZTE.  **FL initial proposal-DP5-2:** Agree, not necessary to introduce a different polarization for UL at least from interference coordination point of view even though it is possible from signalling point of view.  **FL suggestion:** Fine to discuss this further. But we don’t see the necessity to report UE polarization. |
| Apple | We support proposal DP5-1. We can further discuss DP5-2.  For inter-beam interference mitigation, the necessity of UE reporting its polarization capability is unclear, since network polarization configuration is per satellite beam via SIB and does not change with UEs’ polarization capability. |
| vivo | W.r.t the polarization indication, we prefer to first discuss the usage of the polarization, because the dynamic indication of polarization should be necessary if the polarization applies to the multiplexing. If we only support the polarization to apply to the frequency reuse, dynamic indication is unnecessary and semi-statically configured polarization of beams is preferred. Thus, a proposal on the usage as below is proposed:  **Suggested proposal for the usage of polarization:**  **For the usage of polarization, support at least one of following options:**   * **Option-1: The polarization is used for frequency reuse** * **Option-2: The polarization is used for inter-UE/intra-UE multiplexing**   And from the contributions, most of companies have consensus on the polarization used for frequency reuse. Thus, we can first at least support the polarization used for frequency resue in Rel-17.  Then, w.r.t the DL polarization indication, the polarization can also be derived from the SSB transmission and the benefits are listed in our contribution. Thus, we propose the SSB as a candidate option of the indication.  W.r.t the UL polarization indication, the motivation or benefit is unclear and the difference between UL polarization indication and UE capability reporting needs further discussion, which can achieve the same functionality in some cases.  W.r.t the polarization capability reporting, from the contributions, we observed that the supporting companies mainly consider the polarization used for the multiplexing, and with the polarization capability reporting, NW can properly schedule these UEs with different polarization. Thus, the suggested proposal as below is proposed:  **Suggested proposal for the UE polarization capability reporting:**  **For the polarization used for frequency reuse, not support UE polarization capability reporting.**  **For the polarization used for multiplexing, if supported, UE should report the polarization capability to gNB.** |

### Summary of first round

### Company view second round

### Summary of second round

### Final conclusion

# Additional Aspects

Aspects on NTN discussed by one or two companies are discussed in this section.

## RACH Enhancements

Nokia proposed to enable additional SCS scaling factors for all formats defined in TS 38.211 table 6.3.3.1-2 and add one new format (C1) and support restricted set type A for formats defined in TS 38.211 table 6.3.3.1-2. Nokia observed that as GNSS is external to 3GPP, the standard cannot dictate how the UE implements its GNSS solution nor the system chosen (GPS, GLONASS,Galileo, Others). The precision and availability provided by different systems may vary significantly. The full-reliance on GNSS for synchornization and Random Access procedures leaves the 3GPP system implementation dependent on third part systems. Nokia proposed that NTN systems must contain a fall-back conservative solution that allows UE to access the network in case of faulty or malfunctioning GNSS systems.

Samsung observed that a GNSS-aware UE can determine the time and frequency pre-compensation that it should apply when transmitting a PRACH preamble, which improves preamble detection performance for all GNSS-aware UEs. The PRACH guard time for GNSS-aware UEs can be smaller than the PRACH guard time for GNSS-challenged UEs. If PRACH preamble transmissions from GNSS-aware UEs do not interfere with PRACH preamble transmissions from GNSS-challenged UEs, preamble detection performance for all GNSS-challenged UEs improves. Samsung propose that gNB can assign separate PRACH resources to GNSS-aware UEs and GNSS-challenged UEs.

LG propose that if enhanced PRACH formats and/or preamble sequences are necessary and supported in Rel-17 NTN, the option with simple modification, such as a single Zadoff-Chu sequence based on larger SCS and repetition number, is preferred.

Qualcomm proposes transmit diversity for PRACH transmission with format 2, where the antenna switching is applied for the first half and the second half of the PRACH. The simulation shows about 2 dB gain at 1% miss detection rate.

Switching Point

CP/2

**FL suggestions:**

Compared to RAN1#104-e meeting, there seems no new contributors to this aspect, the consensus on the PRACH enhancement is suspected. FL encourages companies to have offline discussions on this topic.

## Feeder link related

Nokia propose that RAN1 define the feeder and service link type of amplification for gNB interpretation of measurement reports and configuration of UE uplink transmit power control with three options considered:

* Constant gain: The combined receive and transmit gain is a constant, independent of the received signal.
* Constant Emitted Isotropic Radiated Power (EIRP): The satellite will adjust the combined receive and transmit gain based on the received signal and a target EIRP to make the feeder link gain equal to one.
* Constant power at receiver: The satellite will attempt to compensate for the radio channel.

Nokia observes that transparent satellite can be analogue RF repeater or sample and forward a digital version of the analogue transmissions. The gNB may in principle compensate for the timing advance and Doppler on the NTN-GW – satellite link, which implies the UE only needs to handle the service link. Nokia propose that RAN1 clarifies that the satellite does not terminate the Uu interface. The gNB location relative to the NTN-GW may impact the NTN user experience and propose RAN1 defines an assumption of the maximum tolerable gNB – NTN-GW delay.

**FL suggestion:** companies are encouraged to provide views.

## DL Synchronisation, System Information Acquisition

Qualcomm proposes different SIBs design based on the system information updating rate.

Samsung observed that for a spot beam size that exceeds 250 km, a BS may need to perform a multi-valued Doppler pre-compensation; e.g. it may need to group distinct sets of SSBs using distinct Doppler values for pre-compensation. Indication for multi-Doppler pre-compensation pattern on DL benefits idle UE cell reselection, connected UE handover and connected UE data channel reception. The gNB/satellite can apply different values of Doppler pre-compensation to different SSBs. Samsung proposes that the BWP configuration is extended to indicate the amount of frequency offset to adjust the PRB grid with respect to the default BWP, as the experienced Doppler shifts at different spot beams are different.

|  |  |  |
| --- | --- | --- |
| fc (GHz) | spot beam size (km) | maximum Doppler difference between UEs (kHz) |
| 2 | 50 | 4.185 |
| 2 | 200 | 15.87 |
| 2 | 250 | 19.25 |
| 2 | 300 | 22.33 |
| 2 | ~ 600 | ~ 45 |



 

As suggested in RAN1#104-e meeting, DL synchronization issues should be discussed in AI 8.4.2 to check if it is in the WID scope.

## Power Control and PUSCH coverage

Samsung proposed that open loop power control, UE should be allowed to predict its own transmission power not only based on DL measurement, e.g., pathloss measurement but also other available information, such as gNB ephemeris and UE trajectory. Samsung proposed closed loop power control should be supported in NTN and a mechanism to disable closed loop power control should be considered.

Qualcomm proposed to support autonomous reduction of MCS for PUSCH at least for cases when UE is power limited and to study the exact triggering condition and indication of the reduced MCS

**FL suggestion:** companies are encouraged to provide views.

## Air To Ground

CMCC proposed “implicit compatibility to support HAPS and ATG scenarios” in the WID means the enhancements for NTN can also be applicable for HAPS and ATG, although we do not need to discuss the enhancements specifically for HAPS and ATG. In principle,

* If there are several potential solutions for NTN, and some of them are more essential / important / applicable for ATG / HAPS, then these solutions should be prioritized.

CMCC identified three issues for application of HAPS and ATG:

* Issue 1: Extend the value range of K1.
* Issue 2: Extend the maximal supported HARQ process number.
* Issue 3: Support satellite ephemeris based on satellite position and velocity state vectors.

CMCC proposals

***Proposal 8:*** Support both ephemeris formats based on satellite position and velocity state vectors (Set 1) and based on orbital elements (Set 2), if possible.

***Proposal 9:*** If down-selection is needed, ephemeris format based on satellite position and velocity state vectors (Set 1) should be supported for implicit compatibility to support HAPS and ATG scenarios.

**FL question**: are proposal 8 and proposal 9 from CMCC already being discussed in AI 8.4.2? and is there necessary to discuss these in AI 8.4.4?

Companies are encouraged to provide views.

## Companies views (1st round discussions )

Companies are invited to comment on Additional aspects.

|  |  |
| --- | --- |
| **Company** | **Comments and Views additional aspects** |
|  |  |
|  |  |

## Summary 1st round discussions

## Companies views (2nd round discussions)

## Summary 2nd round discussion

## GTW Agreement / Conclusion

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