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

**e-Meeting, August 16th – 27th, 2021**

Agenda Item: 8.4.4

Source: Moderator (OPPO)

Title: Summary#2 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#106e. 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*

# NR-NTN beam management issues

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

## Background

In RAN1#105-e meeting, we have collected the views on the following issues and the moreover extensive discussions were conducted in the last meeting on issue #1, 5 and 7.

* 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.
* Issue 8: BWP configuration enhancement
* 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.
* 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.

In the last meeting, after 3 rounds of the discussions, we came up with the following FL proposal, which suggests two directions: Alt-1 targets a gNB dominant beam switching for one or a group of UE based on gNB side prediction. Alt-2 targets a UE dominant beam switching based on assistance information.

**FL proposal DP1-1-v5**

For beam management in NR-NTN, support at least one of the following enhancements

* Alt-1: UE BWP/beam switching is triggered by gNB~~relying on prediction~~for one or a group of UE ~~on gNB side~~**to reduce UE measurement effort and/or signaling overhead** .
  + FFS: ~~whether~~ Details on BWP/beam switching ~~can be done~~for a group of UE.
* Alt-2: UE BWP/beam switching is performed by UE ~~automonously~~ autonomously relying on assistance information
  + FSS: details on assistance information

**FL proposal DP3-1:**

For the deployment scenario with multiple beam per cell and frequency reuse >1, NR-NTN should support the following cases for beam measurement performed by a UE:

Alt-1: support beam measurement on multiple RS associated with different beams within a same active BWP.

Alt-2: support beam measurement on multiple RS associated with different beams within across BWPs.

In this meeting, we continue receiving companies’ views on the above issues. The views are summarized in the following table.

Company’s contributions on issue analysis

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| --- | --- | --- |
| Issue 1 | Spreadtrum | ***Proposal 1: Additional association to map SSB index and BWP index is not needed.*** |
| CATT | **Proposal 1: Support the scenario of initial BWP and active BWP associated with different beams mapping to different geographic areas in NTN.**  **Proposal 2: Supporting beam and BWP switching simultaneously for NTN UE should be clearly defined in UE capability.** |
| QC | **Proposal 1: Support satellite beam specific initial BWPs.**  **Proposal 2: 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 3: 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.** |
| Panasonic | **Proposal 1: RAN1 conclude that no enhancement on the association between BWP and beam for NTN will be introduced.** |
| Ericsson | **Observation 2 Using BWP-BM association to enable a frequency reuse can already be supported by existing NR specification. It is a choice of network configuration and implementation.** |
| Xiaomi | ***Proposal 3: The association between BWP and beam can be supported at least for earth moving case.*** |
| Issue 2 | Spreadcom | ***Proposal 2: BWP switching of UL and DL simultaneously in NTN FRF>1 FDD scenario should be supported.*** |
| Baicells | ***Observation 2: Enhancement on joint trigger of NR BWP switching in UL and DL for FDD is beneficial but not essential.***  ***Proposal 2: Further study on the scheme and benefits of joint trigger of NR BWP switching in UL and DL for FDD.*** |
| Issue 3 | Spreadcom | ***Proposal 3: BWP switching without data scheduling should be supported in NTN FRF>1 FDD scenario.*** |
| Baicells | ***Observation 3: BWP switching without data scheduling can be done only if the resources occupied by the UE in the original BWP are not occupied in the target BWP.***  ***Proposal 3：In NTN, support BWP switching triggering with and without data scheduling.*** |
| Issue 4 | Baicells | ***Observation 4: For BWP switching, time re-synchronization can be avoided by using the same clock source for different beams. Frequency re-synchronization may be necessary.***  ***Proposal 3：In NTN, support BWP switching triggering with and without data scheduling.*** |
| Issue 5 & Issue 7 &  **FL proposal DP1-1-v5** | vivo | ***Proposal 3: Further study the necessity and mechanism of indicating beam switching by group common DCI.***  ***Proposal 4: Both Alt-1 and Alt-2 should be supported for predication based beam switch***  ***Proposal 5: The same signalling framework of beam/BWP switching as NR can be reused in NTN.*** |
| Baicells | ***Observation 5-1: In earth-moving scenario, we acknowledge that beam switching can be frequent and often highly predictable. In earth-fixed scenario, we do not think that beam switching can be frequent and often highly predictable. Meanwhile, we believe earth-fixed mode is more suitable for dedicated beam.***  ***Observation 7-1: In earth-moving scenario, we may need a common BWP/beam switching mechanism (for set of UEs) to save the signaling overhead. In earth-fixed scenario, we may not need a common BWP/beam switching mechanism (for set of UEs). Meanwhile, we believe earth-fixed mode is more suitable for dedicated beam.***  ***Proposal 5-1：Need clarification on earth-moving/ earth-fixed scenario before utilizing mechanisms of configured BWP switching.***  ***Proposal 7-1：Need clarification on earth-moving/ earth-fixed scenario before utilizing mechanisms of common BWP/beam switching (for set of UEs).*** |
| 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: Location-based beam switching can achieve the same results as measurement based at 900 elevation angle.**  **Observation 4: RSRP-based beam switching is better than location based at 70 – 80 degree elevation angles Observation 5: Introducing a fixed linkage between BWP and satellite beam is unnecessary.** |
| CATT | **Proposal 3: Not support UE BWP/beam switching autonomously from RAN1 perspective.**  **Proposal 4: No need to support the configuration of group UEs to do beam switching.** |
| CMCC | ***Proposal 1:*** For beam management in NR-NTN, the motivation of Alt-1 (UE BWP/beam switching is triggered by gNB relying on prediction on gNB side) needs more clarification. |
| Panasonic | **Proposal 2: Further discuss the following prediction-based enhancements of beam management to reduce UE measurement effort and/or signaling overhead.**   * **Enhancement 1: Beam switching according to a sequence of beams configured by RRC** * **Enhancement 2: Information on how ground beam/cell area is defined is broadcast by system information** |
| Ericsson | **Observation 5 According to the current specification, gNB side predictions can already be used to facilitate beam management procedure.**  **Observation 6 BWP switching is not necessarily predictable. BWP/beam switching should be performed dynamically with respect to UE position, interference level, channel condition, etc.**  **Observation 8 No clear scenario or evaluation has been provided to motivate the need for simultaneous beam switching of group of UEs.**  **Observation 9 Complete autonomous UE based beam switching is against the level of control that network should have over the UE behavior.**  **Observation 10 Providing assistance information to UE for the UE autonomous beam/BWP switching imposes signaling overhead and introduces delay.**  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.  Proposal 2 A first satellite providing coverage before a service link switch should assist UEs in RRC connected with signaling of the ephemeris of the second satellite providing coverage after the switch.  Proposal 3 The NR network should be able to indicate the timing of the service link switch to UEs in RRC idle and RRC inactive modes.  Proposal 4 RAN1 to conclude that there is no specification change needed to support same beam layout in BWP#0 and BWP#x (Option 1) and hierarchical beam for BWP#0 (Option 2).  Proposal 5 Regarding Alt-1 in FL proposal DP1-1, the following aspects need to be studied first:  a. Whether any specification work is required for prediction-based beam switching at the gNB side.  b. Clarification of enhancements that address L1 beam switching compared to the enhancements of service link switching.  c. Detailed scenarios that prove the specific issues regarding the predictability of NTN beam switching that requires specification work.  d. Clear scenarios and evaluations (including agreed simulation assumptions) that support the need for simultaneous switching of group of UEs.  Proposal 6 Regarding Alt-2 in FL proposal DP1-1, the following aspects need to be studied first:  a. Investigation of the needed assistance information and assessment of the amount of specification effort.  b. The signaling overhead introduced by providing assistance information versus that of the current switching methods.  c. The signaling delay introduced by providing assistance information versus that of the current switching methods. |
| Huawei | ***Proposal 1****: 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 2:*** *Consider the possibility of broadcasting satellite beam information in system information for UE dominant beam/BWP switching to reduce beam measurement.* |
| Apple | ***Proposal 2:*** *Support a common BWP/beam switching mechanism for a group of UEs to save signaling overhead.* |
| ZTE | ***Proposal 5:*** *Group-specific beam/BWP switching should be supported to optimize the signalling overhead and performance.*  ***Proposal 6:*** *A common DCI can be considered to carry out beam switching for a group of UEs with low signaling cost.*  ***Proposal 7:*** *Prediction based solution can be considered at least in the implementation to optimize the efficiency for switching.* |
| Xiaomi | ***Proposal 4: Configured BWP switch can be supported.*** |
| InterDigital | ***Proposal 1:*** *UE BWP/beam switching is triggered by gNB (i.e., reuse existing specification).*  ***Proposal 2:*** *no group common BWP/beam switching indication is supported for NTN.* |
| NEC | ***Proposal 1:*** *To reduce measurement effort and retain some control of gNB over beam selection, it is proposed to support:*  ***Proposal 3:*** *Support the L1 filtered measurement report as a notification to gNB for UE initiated configured BWP switching.* |
| Issue 6 | Huawei | ***Proposal 3:*** *The function of bwp\_InactivityTimer should be reconsidered in NR NTN.* |
| NEC | ***Proposal 2:*** *Support the UE initiated timer-based BWP switching to a new default BWP* out of *a sequence of BWPs. UE may be configured with a set of default BWPs and autonomously switch to the next BWP in the set of BWP#0 or next default BWP Id in defaultDLBWPIdSet for fallback.* |
| Issue 8 | Baicells | ***Proposal 7-1：Need clarification on earth-moving/ earth-fixed scenario before utilizing mechanisms of common BWP/beam switching (for set of UEs).***  ***Proposal 8: Support extending the number of supported BWPs per cell and cell-specific BWP common configuration.*** |
| Qualcomm | **Proposal 4: 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 5: Support BWP frequency shift through DCI and/or configuration.** |
| Issue 9 | Ericsson | 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.  Proposal 2 A first satellite providing coverage before a service link switch should assist UEs in RRC connected with signaling of the ephemeris of the second satellite providing coverage after the switch.  Proposal 3The NR network should be able to indicate the timing of the service link switch to UEs in RRC idle and RRC inactive modes. |
| Issue 10 & **FL proposal DP3-1:** | vivo | *Proposal 2: Support to enhance beam measurement and reporting mechanism for NTN.* |
| Spreadtrum | ***Proposal 6: Beam measurement on multiple RS associated with different beams within a same active BWP and within across BWPs should be supported.*** |
| Baicells | ***Proposal 10: Reduce the dependency of beam management on CSI-RS transmissions and corresponding reporting in NTN.*** |
| CATT | **Proposal 5: Additional enhancement for beam measurement should be justified with clear benefit and motivation.** |
| NEC | ***Proposal 3:*** *Support the L1 filtered measurement report as a notification to gNB for UE initiated configured BWP switching.* |
| OPPO | **Observation 1: In NTN frequency reuse factor greater than 1, legacy L1 CSI-RS based beam management cannot work properly which involves a BWP switching.**  **Proposal 1: support L1 CSI-RS beam measurement enhancement for NTN frequency reuse factor greater than 1.** |
| QC | **Proposal 7: Consider enhancements on radio link monitoring to support efficient reference resource configuration and measurement outside the active BWP.** |
| CMCC | ***Proposal 2:*** For the deployment scenario with multiple beam per cell and frequency reuse >1, at least support beam measurement on multiple RS associated with different beams within a same active BWP (Alt-1).  ***Proposal 3:*** For the deployment scenario with multiple beam per cell and frequency reuse >1, beam measurement on multiple RS associated with different beams within across BWPs (Alt-2) can be further studied. |
| Ericsson | **Observation 12 The “beam measurement on multiple RS associated with different beams within across BWPs” without BWP switching is not supported in the specifications.**  **Observation 13 The feature of “beam measurement on multiple RS associated with different beams within across BWPs”, if introduced, mostly likely would be an optional UE capability. The network cannot rely on the feature for deployment of multiple beams per cell with FRF>1, as network would need to tailor the deployment to the least capable UEs.**  Proposal 7 Regarding DP3-1, the following aspects need to be studied first:  a. The extent of specification impact that is required to introduce measurement gaps for L1 measurements should be evaluated.  b. Comparison between introducing measurement gaps for L1 measurements and utilizing BWP switching to perform the measurements.  c. UE capability for supporting L1 measurements outside active BWP |
| Apple | ***Proposal 1:*** *Consider performing beam measurement either in initial BWP or in different BWPs with BWP switching.* |
| Lenovo | ***Proposal 1: Support both Alt 1 and Alt2. I.e. Multiple RS associated with different beam can be in a same active BWP or across BWPs.***  ***Proposal 2: A trigger state can trigger NZP CSI-RS measurement on multiple BWPs. NZP CSI-RS in different BWPs can be associated with different triggering offset.***  ***Proposal 3: Study how to indexing NZP CSI-RS when multiple NZP CSI-RS are located at different BWPs.***  ***Observation 1: For NTN, current NR 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.*** |
| InterDigital | ***Proposal 3:*** *beam measurement of multiple RS across BWPs is not needed unless additional beam layout is agreed in Rel-17.* |

Summary:

Issue 1 (beam/BWP association) : 6 companies contributed to this issue. The views are diverged and opposing companies believe that the association is not needed. This topic has not received majority support already in the last meeting, so FL invites the proposing companies to have offline discussion with others. This issue will not be further discussed any more in this meeting.

Issue 2 (BWP switch for UL/DL), Issue 3 (BWP switch without data scheduling), Issue 4(BWP switch with re-sync): for each issue, at most 2 companies contributed to these issues. The issues were discussed in previous meetings already. No contributions from other companies in this meeting. Clearly majority companies don’t think it is an issue. Although there are small amount of companies still think that these issues should be addressed. So FL thinks that there is very small chance that any agreement can be reached. So issue 2,3,4 will not be further considered in this meeting.

Issue 5 (BWP switch relying on prediction), Issue 7 (BWP switch triggering for a set of UE): 13 contributions collected towards these issues. The majority companies think the beam switching is predictable according to the satellite moving trajectory. Thus, a prediction-based beam switch should be considered. The advantage is to reduce the UE measurement and reporting effort. The prediction-based beam switch may lead to two directions as captured in FL proposal DP1-1 of the last meeting, i.e. gNB dominant beam switch and UE dominant beam switch.

For gNB dominant beam switch: the opposing companies think that if the beam switch is triggered by gNB, the gNB can always choose to use the prediction to trigger beam switch. Thus, it is a gNB implementation issue, which does not require further spec enhancement. While proposing companies think that thanks to prediction, the gNB may configure a sequence of beam which follows the trajectory of the satellite movement. Based on the collected views, FL suggests that in this meeting at least to conclude: whether spec enhancement, e.g. gNB configures a sequence of beams based on prediction for the UE to perform beam switch is supported? What are the pros and cons?

For UE dominant beam switch: the opposing companies raised two issues, 1) it will impose signalling overhead and introduce delay; 2) the network will lose the control of the UE behaviour. While the proposing companies propose that the network should provide assistance information, e.g. topology of the surrounding beams, so that the UE can rely on these information to decide which beam should switch to. The advantages are 1) reducing UE measurement effort; 2) avoid beam ambiguity when UE is approchig to multiple footprints and RSRP of multiple beams may varying quickly due to the satellite movement, leading to beam switching hopping between multiple beams. FL suggests that in this meeting to conclude if UE dominant beam swtich based on assistance information is supported, taking into account the argements from both sides.

For BWP switch triggering for a set of UEs: most of the companies think that legacy UE-specific triggering should be reused. Moreover, CMCC points out that the area for a group UE switch is quite limited. FL sees little change to get consensus on this proposal. Thus suggests that BWP triggering for a group of UE is not further considered in this meeting.

Issue 6 (*bwp\_InactivityTimer* functionality): two companies contributed to this issue. This issue was not sufficiently discussed in the last meeting. The function of the *bwp\_InactivityTimer* in the legacy system requires the UE to swtich from the active BWP to default BWP. The comtributing companies point out that this functionality is broken in NTN system. Therefore, FL suggests to discuss this issue to conclude whether there is a problem with *bwp\_InactivityTimer* functionalilty and if so there are the enhancements.

Issue 8 (BWP configuration): 2 companies contributed to this issue. The pointed problems are 1) the number of configured BWPs is to be extended; 2) a common BWP configuration should be introduced in particular for the case where only frequency interval is changed from one BWP configuration to the other. With common BWP configuration, signalling overhead can be saved. FL didn’t see any other contributions against this issue, thus, FL suggests that in this meeting we can discuss and try to conclude whether the issue 8 needs further enhancement.

Issue 9 (BM for inter-satellite): 1 company suggests to discuss the extension of the BM framework for inter-satellite case. Moreover it suggests to indicate an idle UE about the service link switch ahead the RACH procedure. This issue was not sufficiently discussed in the last meeting, thus, FL suggest that in this meeting we discuss and try to conclude whether further enhancement is needed.

Issue 10 (beam measurement): 12 companies contributed to this issue. From the collected views, it seems that for L1-RSRP measurement, current spec only supports target beams to be measured are within the active BWP. The current does not support target beams to be measured outside active BWP. From proposing companies, the target beams are not always in the same active BWP due to FRF>1 deployment. However opposing companies think it is up to gNB implementation, e.g. the gNB may choose to transmit multiple target beams in the same active BWP. On the other hand, one company think L3 RSRP measurement can be used. FL suggests that in this meeting we clarify the following 1) whether L1-RSRP measurement within active BWP and outside active BWP can be supported via gNB implementation; 2) if not, whether both cases should be supported in NTN or whether using L3 RSRP measurement is enough.

## First round discussion

### BWP switch relying on prediction

FL suggests that in this meeting at least to conclude: whether spec enhancement is supported, e.g. gNB configures a sequence of beams based on prediction for the UE to perform beam switch? What are the pros and cons?

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| company | Views and comments |
| Ericsson | Configuring a sequence of beams is easier said than done. There are many complications, such as how to determine the sequence of the switching times among the beams.  It is much simpler, robust, and technically sound that the network just sends a DCI to switch the beam when the network considers the swiching necessary (which can be based on prediction if the network would like to).  Using DCI to swich beams is well supported in existing specification. There is no need for specification enhancement. |
| FGI | Share the same view with Ericsson. If RRC configures a sequence of beams, it is complicated how UE triggers each beam switch autonomously. Prefer deprioritizing L1 mobility for Rel-17. |
| ZTE | In our view, existing DCI based solution is able to meet the needs for beams switching and the prediction related behaviour can be done at gNB side as implemeantion. The reason behind is that in NTN case, the footprint of beam of satellite is much larger and the coverage can be further extended with consideration of sidelobe and impacts of terrain. Then, the configuration of measurement can be optimized by gNB to ensure the proper overhead.  However, for the signalign of switching, there is clear need to reduce the overhead from system perspective. Then, the group-DCI based beam switching is preferred with less spec impacts and clear benefits. |
| Nokia, Nokia Shanghai Bell | As Ericsson points out, such a procedure sounds easier said than done. Performing NR beam switching based on UE prediction would introduce some uncertainty as to the exact swithing time, and normally the control of the actual NR beam switch has been the responsibility of the gNB. We do not see any reasons to introduce this functionality. DCI based NR beam switching provides the needed functionality with sufficiently low overhead. |
| Panasonic | We think it is useful for the spec to support RRC configured beam switching pattern consisting of a sequence of beams with potentially associated timing for each beam. The target application scenario could be LEO earth moving cell with LOS. Then UE can perform beam switching based on such configured pattern, without relying on MAC CE or DCI indication which could otherwise cause very high overhead. The UE measurement and reporting effort can also be reduced as well. |
| Baicells | Beam switching prediction can be utilized in the scenario of earth-moving beams. But it is not applicable for earth-fixed beams. Need clarification whether earth-moving beams are used to serve RRC-connected UEs, and why. |
| Sony | As satellite beam switching can be frequent and often highly predictable, we belive it is beneficial to reduce the signaling overhead and latency by preconfiguring the target beam(s) and switching condition(s) to the UE.  In our contribution R1-2106808, we have shown that the location-based beam switching can achieve the similar results as RSRP measurement. Therefore, we think it is feasible to support that gNB preconfigure the UE beam switch based on timer and/or location-information in NTN. |
| Apple | Actually, issue 5 and issue 7 could be discussed separately. For Issue 5, gNB could configure a sequence of beam based on prediction. This could save the signaling overhead. On the other hand, the prediction error may occur, probably due to UE mobility. We are open to further discuss along this line.  For Issue 7, gNB could scheduled the beam switch for a group of UEs simultaneously. This could save the signaling overhead. We are supportive of enhancing for this issue. |
| Lenovo/MM | We think beam sequence configuration can make use of the satellite trajectory and save siganling overhead. |
| vivo | We support gNB dominant beam/BWP switching. In our understanding, spec enhancement is needed, e.g. gNB could configure a sequence of beams for the UE to perform beam switch, based on ephemeris information of satellites and UE positions. This enhancement could reduce the interaction between gNB and UE, which reduces the latency and UE measurement behaviour. |
| NTT DOCOMO | We understand benefit of the beam switching based on prediction. But at the same time, prediction error may occur due to UE mobility. In addition, many discussions are needed for e.g. switching timing determination, beam sequence definition/determination, etc. We are OK to discuss further, while we have doubts about whether the ehnahcement can be completed by end of Rel-17. |
| Xiaomi | Spec. enhancement is needed to support configuring a sequence of beam which follows the trajectory of the satellite movement.  The pros could be reduling the beam indication signalling overhead and latency. Based on the current spec., the UE would perform the beam switching after HARQ-ACK feedback for the DCI/MAC CE carring beam indication information. Considering the large RTT in NTN, this mechnisim would introduce more latency compared to beam sequence indication.  The cons could be the beam selection/indication accuracy and spec. impact. Considering the maximum speed of UE is up to 1200 km/h, it might be hard for the gNB to predict a beam sequence for a long time based on satellite trajectory and UE location. The UE behaviors would be quiet different with current beam indication mechanisim which requires more spec. effort.  We share similar view with FGI, prefer deprioritzing L1 mobility in Rel.17. |
| QC | Configured sequence beam switching has many benefits. It should be supported. |
| Huawei, HiSilicon | We are supportive of this direction. Beam/BWP switching can be based on maximum sevice time to reduce the complexity at the UE side. It is undesirable for a UE to select a cell with good RSRP but with very short sevice duration. So, it is benefitial that gNB can configure a sequence of beams and the corresponding timers for the UE to perform beam switch based on satellite ephemeris and UE position. |
| LG | We share the view with Ericsson. Using current switching mechanism is flexible enough. |
| CMCC | If UE’s location is reported to the gNB, configuring a sequence of beams seems workable. Nevertheless, it requires a lot of spec error, e.g., switching timing determination, beam sequence definition/determination, etc.  However, if UE’s location is unknown to the gNB, the feasibility seems challengable.  Thus, more discussion on the feasibility of this solution is needed. |
| NEC | We support gNB controlled beam switching and prefer a solution which can reduce UE measurement effort and signalling overhead. However, different solutions have been proposed by companies and pre-configured sequence of beams is not the only solution to achieve this. Whether spec impact is needed or not depends on the details of the final supported solution. |
| Moderator summary | Here is a quick summary: the claimed pros and cons for gNB dominant beam switching enhancement based on prediction, e.g. a sequence of beams configuration, triggering a group of UE, are  Pros: signalling saving and reduce UE measurement effort  Cons: the enhancement is not easy to be implemented.  Now we should discuss more detailed technical concerns raised by the opposing companies.  **Concern 1** (raised by Ericsson): how to determine the time for a sequence of beam switching.  FL comment: according to the companies views, for a given UE, the gNB may configure a sequence of beams based on the satellite trajectory and the UE location, so FL understands that the gNB determines the beams as well as the times for the switching among these beams based on these two factors. The algorithm for beam and time determination is up to gNB implementation.  **Concern 2** (raised by Nokia): beam switching based on UE prediction may introduce uncertainty  FL comment: @Nokia, this discussion item is related to Gnb prediction based beam switching instead of UE prediction. With this clarification, do you still hold this concern? |

FL suggests that in this meeting to conclude if UE dominant beam swtich based on assistance information is supported, taking into account the argements from opposing and proposing companies.

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| company | Views and comments |
| Ericsson | There is also much signaling imposed by providing the extra assistance information to the UE. Also, providing this information is not one time job but requires continuous updates, resulting in some delay to the procedure. Therefore, a thorough study needs to be done to assess whether the new delay and signaling overhead introduced by providing assistance information to the UE justifies introducing UE dominant beam switching enhancement or not.  In short, beam swich has been, and should continue to be, network dominant. |
| FGI | Prefer deprioritizing L1 mobility for Rel-17. |
| ZTE | The UE dominant solution requires a lot of spec error and can be depriortized. |
| Nokia, Nokia Shanghai Bell | We do not see any reasons to introduce UE dominant NR beam switching. The gNB should be in control of the UE behaviour based on information provided by the UE. No need to change the overall framework for the NR beam management. |
| Panasonic | We are supportive for UE dominant beam switching based on assistance information such as broadcast beam coverage information in the system information. Then at least idle UE can make use of such information to determine the serving beam/cell to reduce the measurement effort. Since the cell/beam selection for idle UE is not supposed to be under the control of gNB, there should be no concern on the synchronizsed decision between NW and UE. For the connected mode UE, if UE dominant beam switching is supported, there should be additional mechanism to ensure the same understanding between NW and UE. |
| Baicells | Not support UE to dominant beam switch. Nevertheless, UE can trigger beam failure recovery. |
| Sony | We are fine to depriortize the UE dominant solution for Rel-17. |
| Apple | Considering the large spec. impact, we do not support the UE dominant beam switch in Rel-17. |
| Lenovo/MM | We think UE dominat beam switching based on assistance information can be supported as gNB and UE have common understanding on the swithing times. It seems similar some event triggered mechanisms introduced in legacy release which is dominated by UE. |
| vivo | Not support UE dominant beam switching.  If the UE can trigger beam switching autonomously, gNB would be unaware of that behaviour until the UE sends a beam switching report. Due to the long prepagation delay in NTN, there would be always misalignment on beam information between gNB and UE. |
| NTT DOCOMO | UE dominant solution can be deprioritized in rel-17. |
| QC | Can be deprioritized for rel-17 |
| Huawei, HiSilicon | We are also supportive of UE dominant beam switching even though we prefer to have a conclusion for gNB dominant beam switching first given the limit time in Rel-17. For UE dominant beam switching, the beam layout information at the satellite can be indicated to the UE to facilitate the beam /cell swith with reduced complexity of beam measurement. |
| LG | UE dominant solution can be deprioritized in Rel-17 NTN. |
| Spreadtrum | Depriortize the UE dominant solution for Rel-17. |
| Moderator | Majority view: deprioritize UE dominant beam switching |
| CMCC | Agree to deprioritize UE dominant beam switching in Rel-17 NTN. |
| NEC | Ok to deprioritize UE dominant solution. |

### bwp\_InactivityTimer functionality

FL suggests to discuss this issue to conclude whether there is a problem with *bwp\_InactivityTimer* functionalilty and if so there are the enhancements.

|  |  |
| --- | --- |
| company | Views and comments |
| Ericsson | The *bwp\_InactivityTimer* functionalilty works well. We do not see any problem and thus there is no need for any enhancement. |
| FGI | Prefer deprioritizing L1 mobility for Rel-17. |
| ZTE | Share the views as Ericsson. |
| Nokia, Nokia Shanghai Bell | We do not see any strong need for enhancements in this area. |
| Panasonic | To avoid undesired BWP switching due to *bwp\_InactivityTimer*, gNB can configure the timer value to very large that in practice disables the timer switching functionality. Or alternatively, if the hierarchical beam layout is configured for FRF>1, the default BWP can be the umbrella beam. Therefore, no spec enhancement seems needed. |
| Baicells | In NTN, there might be a problem with the legacy *bwp\_InactivityTimer* functionalilty if the UE is out of the coverage when fall back to default BWP. |
| Sony | We share a similar view as Ericsson, and there is no need for enhancement on the *bwp\_InactivityTimer* . |
| Apple | It is possible to address this issue by simply including an infinite value for bwp\_InactivityTimer. This ensures UE does not autonomously switch to default BWP. |
| Lenovo/MM | We think existing *bwp\_InactivityTimer* functionalilty can work by swith to the default BWP#0, no matterh BWP#0 has same beam or different beam from BWP#x. |
| vivo | The motivation or problem is unclear, requiring further clarification. |
| NTT DOCOMO | We feel that current spec can work without any enhancement on *bwp\_InactivityTimer*. |
| Huawei, HiSilicon | A NTN UE will switch BWP/beam due to the satellite movement in a predicable way. From this perspective, some additional timers may be needed to trigger a BWP switch in the future. This may make the UE procedure complicated if the functionalilty of *bwp\_InactivityTimer* is still kept. One simple way to disable the the functionalilty of *bwp\_InactivityTimer* for an NTN UE. |
| LG | Regarding this issue, enhancement on bwp-InactivityTimer including value range extension and (re)start timing can be considered. |
| Moderator | Majority view: no enhancement is needed.  Reason: gNB can simply disable this function by either providing a large value of timer duration or not providing the timer. |
| CMCC | Agree to no enhancement is needed.  As agreed in RAN1 #105-e, “same beam layout in BWP#0 and BWP#x (Option 1) and hierarchical beam for BWP#0 (Option 2) should be supported by the specifications for NR-NTN”.  For the above two layout options, BWP#0 is always there. Thus, the *bwp\_InactivityTimer* functionalilty works well. |
| NEC | In LEO scenario with earth-moving beams, due to the large propagation delay, it may no longer be feasible for the UE to fall back to the original BWP upon timer expiry. Furthermore, the common initial BWP can become congested or blocked in Option#2 if the number of users is large. If the functionality of this timer has to be disabled to make the spec work, surely there is a problem. |

### BWP configuration

The pointed problems are 1) the number of configured BWPs is to be extended; 2) a common BWP configuration should be introduced in particular for the case where only frequency interval is changed from one BWP configuration to the other. With common BWP configuration, signalling overhead can be saved. FL didn’t see any other contributions against this issue, thus, FL suggests that in this meeting we can discuss and try to conclude whether the issue 8 needs further enhancement.

|  |  |
| --- | --- |
| company | Views and comments |
| Ericsson | 1. Supporting higher number of configured BWPs, if introduced in Rel-17, will most likely will be an optional UE capability. Therefore, there would be some UEs that support this feature and some that do not support it. Then network cannot rely on the feature for deployment of multiple beams per cell with FRF>1, as network would need to tailor the deployment to the least capable UEs. Therefore, extending the number of configured BWPs is of little use. 2. This dramatically changes the existing BWP signaling framework. It is an excessive over optimization with significant specification impact, which is not needed. |
| FGI | Prefer deprioritizing L1 mobility for Rel-17. |
| ZTE | 1. We are negative to extend the supported number of BWP. In our view, the deployment based on existing BWP configuration is already feasible. 2. No clear about the intention of this proposal since the configuration is mainly done by RRC, the overhead is not the issue. |
| Nokia, Nokia Shanghai Bell | As Ericsson points out, this functionality would only bring benefit for the network for the case where such functionality is mandatory for all UE. If there is consensus that such feature should be mandatory for all UE, we are open to discus further. If this functionality is expected to be a UE feature or capability, there is no use for this. |
| Panasonic | For problem 1), we still think it is good to decouple the BWP switching from the beam switching as the current design in TN. Therefore, it seems no need to extend number of configured BWPs.  For problem 2), we are supportive for the “almost identical” BWPs with only difference in frequence location and BW. This is also beneficial for the fast BWP switching. |
| Baicells | Support 1) the number of configured BWPs is to be extended.  For 2), the intention of the proposal needs clarifications. |
| Lenovo/MM | For (1), we think it may be necessary depending on the beam and bandwidth configuration of satellite.  For (2), we think it is a kind of optimization. |
| vivo | Not necessary to extend the number of BWPs. |
| NTT DOCOMO | We have same view with Ericcson. Both enhancements would be unnecessary. |
| QC | Both 1 and 2 can be considered. |
| Huawei, HiSilicon | It is not essential to increase the number of BWPs. |
| LG | We are negative for both enhancements. |
| Spreadtrum | Both enhancements are unnecessary. |
| Moderator | For BWP number extension: majority view is not to support. Reason: this would be an optional feature for a UE, thus, the network cannot benefit from this feature for the network deployment.  For common BWP configuration: majority view is not to support. Reason:   1. it requires large spec effort 2. the RRC signalling overhead is not important. |
| CMCC | 1. It is not essential to increase the number of BWPs. 2. It can be further studied. In NTN scenarios, the channel condition may be bad. Thus, reduce RRC signalling overhead may be beneficial. |

### BM for inter-satellite

Issue 9 (BM for inter-satellite): 1 company suggests to discuss the extension of the BM framework for inter-satellite case. Moreover it suggests to indicate an idle UE about the service link switch ahead the RACH procedure. This issue was not sufficiently discussed in the last meeting, thus, FL suggest that in this meeting we discuss and try to conclude whether further enhancement is needed.

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| Company | Views and comments |
| Ericsson | Our intention is to clarify the scope, as we have observed that more often that not in the discussions, inter-satellite case and intra-satellite case have been mixed up, leading to confusing discussions. |
| FGI | Prefer deprioritizing L1 mobility for Rel-17. To our understanding, soft and hard feeder link switches are supported via inter-cell handover. |
| ZTE | For the inter-satellite issue, it’s up to the assumption whether the inter-satellite operation can be done in transparent way to UE as the case within same satellite. In my view, how the handle the inter-satellite handover is still pending in RAN2, e.g., as cell switching or not, we prefer to deprioritize the inter-satellite case. |
| Nokia, Nokia Shanghai Bell | We do not see any need for introducing beam management enhancements between different satellites. We would expect one satellite to serve multiple satellite beams, and for each satellite beam there may be multiple NR beams. We do not see a need for introducing NR beam management or beam management coordination between satellites. Further, L3 mobility is likely more robust for inter-satellige mobility (and is an existing functionality). |
| Panasonic | We are open for further discussion on potential enhancmenet considering the fact that the inter-satellite beam switching can happen quite often in LEO earth moving cell. |
| Baicells | Further enhancement is needed. |
| Sony | We are fine to deprioritize the inter satellite case. |
| Lenovo/MM | We don’t think indicating UE beam/BWP related parameters in RRC idle state is necessary. We think acceesing to another satellite can be perfomed by random access procedure, otherwise, there will be much ignalling overhead in idle state. |
| Vivo | In our understanding, inter-satellite case can be left to handover procedure. RAN1 can only focus on intra-satellite case. |
| NTT DOCOMO | What is required enhancement is unclear for us. |
| Xiaomi | We think the benefit and issues of such scenario should be clarified before discussing and concluding any enhancement is needed. |
| QC | Scope of enhancement for inter-satellite case is unclear. |
| Huawei, HiSilicon | Inter-satellite case relates to handover. Beam/BWP switching within one satellite should be the scope of RAN1. |
| Spreadtrum | We prefer deprioritizing the inter satellite case. |
| Moderator | Majority view: deprioritze this from the RAN1 scope.  Reason: gNB can make it transparent to UE, where a switching between inter-satellite can be a beam switching or handover. |
| CMCC | We are fine to deprioritze the inter satellite case. |

### beam measurement

FL suggests that in this meeting we clarify the following 1) whether L1-RSRP measurement within active BWP and outside active BWP can be supported via gNB implementation; 2) if not, whether both cases should be supported in NTN or whether using L3 RSRP measurement is enough and why.

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| --- | --- |
| company | Views and comments |
| Ericsson | 1. Yes. Within active BWP is existing behavior. Outside active BWP can be done via BWP switching. Besides, as observed by some companies, the gNB may choose to transmit multiple target beams in the same active BWP. 2. Per our response to 1), answer to 2) is not necessary. |
| FGI | Prefer deprioritizing L1 mobility for Rel-17. |
| ZTE | 1. Yes, for Q1, all behaviour can be done by implementation. 2. For Q2: No further enhancement |
| Nokia, Nokia Shanghai Bell | For aspect (1), the current standards supports and assumes that any action happens within the active BWP. If measurements outside the active BWP are needed, a BWP switch may be used. Changing the measurement framework to allow for measurements outside the active BWP would be a substantial change compared to existing framework. Are the proponents suggesting to make this a general change such that it applies to any L1-RSRP measurement?  For aspect (2), we think that the existing RSRP measurement configurations are sufficient. |
| Panasonic | L1-RSRP measurement for different beams within active BWP can be supported by gNB implementation, e.g. transmitting RS corresponding different beams within UE active BWP. On the other hand, L1-RSRP measurement for different beams outside active BWP (without BWP switching) is not supported by existing spec. But it can be realized by performing BWP switching. Therefore, we think the issue is not essential here. |
| Baicells | At least, support L1-RSRP measurement within active BWP via gNB implementation. |
| Apple | We think L1-RSRP measurement outside active BWP is not supported via gNB implementation. We think this case should be enhanced.  We do not agree to use L3 RSRP measurement as it is not instantaneous. |
| Lenovo/MM | For (1), we don’t think gNB implementation is an efficient way.  For the case when BWP#0 and BWP#x have different beam width, to perform RSRP measurement in a single active BWP, e.g. BWP#1, then there will be additional SSB/CSI-RS transmission in BWP#1, and the additional SSB/CSI-RS are for other beams not associated with BWP#1. There will be large signailng overhead in the single active BWP to perform RSRP measurement of multiple beams.  For (2), we think both cases should be supported, as they are corresponding to different beam width of BWP#0. We don’t think R3-RSRP measurement is enough, as beam measurement/reporting is based on L1-RSRP, L1-RSRQ, LI-SINR in legacy releases, and we prefer similar metrics to avoid performance reduction. |
| vivo | 1) Yes. |
| NTT DOCOMO | Q1: Yes, it can be done by BWP switching.  Q2: If measurement without BWP switching is needed, enhancement would be necessary. But necessity of measurement without BWP switching is unclear for us. |
| Xiaomi | For 1), the L1-RSRP measurement within active BWP and outside BWP cannot be done simultaneously, it can be achieved by BWP switching.  For 2), we suggest to deprioritizing L1 mobility for Rel-17. |
| QC | For 1), we don’t think outside BWP measurement by gNB is always possible. This highly depends on satellite implementation. |
| Huawei, HiSilicon | L1-RSRP measurement within active BWP and outside active BWP can be supported via gNB implementation. L1-RSRP measurement outside active BWP is needed for beam/BWP switch. |
| LG | Yes, it can be upto gNB implementation. |
| Spreadtrum | 1): Yes.  2): No further enhancement. |
| Moderator | Majority view: current spec can support L1-RSRP beam measurement inside and outside an active BWP.  Reason: the gNB can control a UE to perform L1-RSRP beam measurement in active BWP or outside BWP (by triggering a BWP switching) |
| CMCC | 1. In our view, UE can perform SSB based beam measurement in BWP#0, thus Alt-1 (beam measurement on multiple RS associated with different beams within a same active BWP) seems workable at least for the basic functionality of beam switching. Hence, Alt-1 should at least be supported for less spec impact.   Nevertheless, Alt-2 (beam measurement on multiple RS associated with different beams within across BWPs) seems beneficial for interference management and throughput enhancement. Thus, Alt-2 can be further studied.   1. No further enhancement. |
| NEC | Agree that L1-RSRP measurement within active BWP and outside active BWP can be supported via gNB implementation. |

### Summary of first round

**gNB dominant Beam switching replying on prediction on gNB side:**

the claimed pros and cons for gNB dominant beam switching enhancement based on prediction, e.g. a sequence of beams configuration, triggering a group of UE, are

Pros: signalling saving and reduce UE measurement effort

Cons: the enhancement is not easy to be implemented.

Now we should discuss more detailed technical concerns raised by the opposing companies.

**Concern 1** (raised by Ericsson): how to determine the time for a sequence of beam switching.

FL comment: according to the companies views, for a given UE, the gNB may configure a sequence of beams based on the satellite trajectory and the UE location, so FL understands that the gNB determines the beams as well as the times for the switching among these beams based on these two factors. The algorithm for beam and time determination is up to gNB implementation.

**Concern 2** (raised by Nokia): beam switching based on UE prediction may introduce uncertainty

FL comment: @Nokia, this discussion item is related to Gnb prediction based beam switching instead of UE prediction. With this clarification, do you still hold this concern?

**UE dominant Beam switching replying on prediction on UE side:**

Deprioritize

**Bwp\_InactivityTimer functionality**

Majority view: no enhancement is needed.

Reason: gNB can simply disable this function by either providing a large value of timer duration or not providing the timer.

**BWP configuration**

For BWP number extension: majority view is not to support. Reason: this would be an optional feature for a UE, thus, the network cannot benefit from this feature for the network deployment.

For common BWP configuration: majority view is not to have enhancement.

Reason: it requires large spec effort and the RRC signalling overhead is not important.

**Beam management for inter-satellite**

Majority view: deprioritze this from the RAN1 scope.

Reason: gNB can make it transparent to UE, where a switching between inter-satellite can be a beam switching or handover.

**Beam measurement**

Majority view: current spec can support L1-RSRP beam measurement inside and outside an active BWP.

Reason: the gNB can control a UE to perform L1-RSRP beam measurement in active BWP or outside BWP (by triggering a BWP switching)

## Second round discussion

**gNB dominant Beam switching replying on prediction on gNB side:**

the claimed pros and cons for gNB dominant beam switching enhancement based on prediction, e.g. a sequence of beams configuration, triggering a group of UE, are

Pros: signalling saving and reduce UE measurement effort

Cons: the enhancement is not easy to be implemented.

Now we should discuss more detailed technical concerns raised by the opposing companies.

**Concern 1** (raised by Ericsson): how to determine the time for a sequence of beam switching.

FL comment: according to the companies views, for a given UE, the gNB may configure a sequence of beams based on the satellite trajectory and the UE location, so FL understands that the gNB determines the beams as well as the times for the switching among these beams based on these two factors. The algorithm for beam and time determination is up to gNB implementation.

**Concern 2** (raised by Nokia): beam switching based on UE prediction may introduce uncertainty

FL comment: @Nokia, this discussion item is related to Gnb prediction based beam switching instead of UE prediction. With this clarification, do you still hold this concern?

2 round discussion: continue the discussion on the gNB dominant beam switching based on gNB prediction and try to conclude if R17 should support it. The high-level design target is to allow gNB configure a sequence of beams based on satellite trajectory and the UE location.

Potential spec impact:

* a sequence of beam configuration
* switching time for the sequence of beams
* UE location reporting

|  |  |
| --- | --- |
| company | Views and comments |
| Ericsson | We are puzzled by the claimed signaling overhead in using DCI to swich beams. The switching field is anyway present in the DCI. And network anyways need to send DCI to UE when there is data. (On the other hand, why would network swich the beam if the network does not need to communitate with the UE?)  Also, the claim of reducing UE measurement does not hold. The network can use prediction (if the network would like to) and send DCI to swich beam. Thus, there is no need for network to configure heavy UE measurement effort.  As we commented in the first round, it is much simpler, robust, and technically sound that the network just sends a DCI to switch the beam when the network considers the swiching necessary (which can be based on prediction if the network would like to).  In short, the proponents should present solid analysis and concrete results to prove the pros, instead of hand-waving claims, which are highly questionable. |
| Lenovo/MM | We think there will be signaling overhead reduction by a sequence of beam configuration. And if accurate UE location is available at gNB side, the switching time for a corresponding beam can be determined. We agree with Ericsson that a data scheduled by a DCI will have corresponding beam indication field in the DCI, however, there are SPS PDSCH, and also other channel/RS, e.g. PDCCH/PUCCH/PRACH/CSI-RS/SRS, we think all other channels can benefit from the beam sequence indication.  We think the main issue for this mechamism is details on UE locationg reporting and update of beam sequence indication. We want to know whether the UE location reporting is explicity by coordinates or implicitly by uplink signal transmission. |
| Panasonic | We support to introduce beam switching based on a sequence of beams with associated timings by RRC in Rel-17 for NTN.  Regarding the comments from Ericsson for the beam switching overhead, we should keep in mind that beam switching is not just for PDSCH using DCI, but also for example for CORESET (PDCCH), which is performed by MAC CE. By using the proposal, such overhead can be reduced.  Regarding the concern of determining the beam switching timing raised in the previous round, in our view, for non-geostationary Earth moving cell/beam scenarios, the beam switching is actually caused by the satellite movement itself. For example, for the LEO satellite reference deployments according to Table 4.2-2 and Table 7.1-1 in TR 38.821, the ground speed of moving cells is 27,216 km/h which is much higher than maximum possible UE speed (500-1000 km/h). Therefore, UE speed can be ignored in typical cases when determining the beam switching timing. Instead, based on satellite trajectory and (infrequent) UE location report, gNB can calculate the beam switching timing for the UE.  Regarding the spec impact, note that gNB can obtain a GNSS-based location information from the UE using existing signalling method as supported by majority in RAN2 discussion, i.e., by configuring includeCommonLocationInfo in the corresponding reportConfig. This is also addressing the question from Lenovo/MM above. So the spec impact can be limited to introducing RRC parameters for beam sequence configuration and the corresponding UE behavior. |
| ZTE | We are negative on the main bullet that gNB is allowed to cofnigrue a sequence of beams based on UE location. In our view, the reporting of UE’s location is sensitive due to the security issue, and should not be used for L1 or triggered by RAN’s needs.  Moreover, it seems that the FL try to push the time based solution in our view, with DCI based solution, the needs for a sequence of beam switching over time is limited and which can be done by DCI signalling.  We still believe that the simple enhancement with less spec impact should be prioritized if the BM is needed. We can focus on the common DCI based solution. |
| Baicells | View1: gNB dominant beam switching itself should be supported. It can be done simply based on UE’s measurements. It also can be done based on UE’s location ( if UE agree to report it’s location), satellite ephemeris and current coverage of beam footprints.  View2: gNB dominant beam switching with a sequence of beam configuration is optional. For earth-fixed beams, it is not necessary. For earth-moving beams, it may be beneficial and can be discussed further. |
| NTT DOCOMO | We have a question. If this prediction mechanism is supported, UE location reporting is needed at the same time, right? UE location information is used to determine at gNB which beam sequence is valid for the UE. Without this, gNB cannot know UE location and thus cannot predict beam sequence.  Then, if this thinking is correct, why is this direction preferred while TA for service link is compensated by UE...? UE location reporting is possible, then the TA drift for sevice link can be indicated by gNB. But such a mechanism has not been agreed. I think “consistency” should be considered. |
| Sony | We think gNB dominant beam switching based on UE location should be supported in Rel-17. We agree with the potential sepc impact summaired by the FL and think those information need to be specified. In addition, satellite ephemeris information may also need to be known by UEs for the gNB to pre-configure a sequence of beams for the UE to perform beam switch. |

### summary of second round

## Third rond discussion

# 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 ignalling 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 ignalling, DCI.
* FFS: Whether separate ignalling 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.

In RAN1#105e meeting, the following agreement was reached.

Agreement:

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

* FFS: Signaling details for indication in SIB

Agreement:

* Polarization information for UL may be indicated in SIB by the network
* UE assumes a same polarization for UL and DL, when the UL polarization information is absent.
* FFS: Signaling details for indication in SIB

In this meeting, we should focus on the signalling design trying to resolve the FFS points from the latest RAN1 agreements.

Company’s contribution

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| vivo | ***Proposal 4: Not support to report UE polarization capability.***  *Proposal 5: Support indicate the polarization information in the following alternatives,*   * *Alt 1: SIB1, for explicit indication* * *Alt 2: SSB transmission, for implicit indication* * ***support to associate SSB transmission with LHCP and RHCP in TDM way.*** |
| NEC | ***Proposal 4:*** *Do not support dynamic polarization indication in Rel-17.*  ***Proposal 5****: Support UE polarization capability indication to gNB.* |
| Spreadtrum Communications | ***Proposal 7: UE reporting polarization capability is not needed.***  ***Proposal 8: Beam specific indication of polarization information for DL by the network should be supported.*** |
| CATT | **Proposal 6: Reporting UE polarization capability is not necessary.** |
| CMCC |  |
| Qualcomm Incorporated | **Proposal 10: Consider at least signalling of polarization per BWP.** |
| OPPO | **Proposal 2: SIB includes DL\_Pol and UL\_Pol parameters which separately select one polarization mode among linear, RHCP, and LHCP.**  **Proposal 3: DL and UL polarization mode is also indicated in UE dedicated RRC.** |
| Samsung |  |
| Ericsson | **Observation 14 In some cases, a UE cannot be expected to reliably detect the used DL polarization.**  [Proposal 8 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.](#_Toc79162826)  [Proposal 9 NTN UE should report its polarization capability (RHCP, LHCP, Linear) to the network.](#_Toc79162827) |
| Nokia, Nokia Shanghai Bell | **Proposal 4: The explicit indication of polarization information for DL is carried in an NTN-specific SIB that is broadcast frequently (SIB1 kind of signaling).**  **Proposal 5: The explicit indication of polarization information for UL is carried in an NTN-specific SIB that is broadcast frequently (SIB1 kind of signaling) and which is assumed to be read by the UE prior to performing UL access attempts.** |
| Apple | ***Proposal 3:*** *The downlink polarization per SSB is indicated in SIB.*  ***Proposal 4:*** *UE polarization capability reporting is not supported.* |
| 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: Support indication of polarization information per beam in SIB.**  **Proposal 5: In addition to polarization indication in SIB, the following signaling design should be discussed for operation with polarization reuse:**   * **Polarization indication for beam management** * **Polarization indication for SSB/CSI-RS measurement** * **Polarization indication of target cell/beam for handover**   **Proposal 6: For operation with polarization multiplexing, information on the polarization should be indicated in DCI for scheduling PDSCH/PUSCH.**  **Proposal 7: 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 6: Depends on the form factor and complexity of the RF implementation, the supported polarization can vary between UE to UE.**  **Observation 7: To support various types of devices with different polarizations, it is necessary for the network to know the UE polarization capability to ensure a robust link between satellites and UEs.**  **Observation 8: 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 9: The UE awareness of gNB polarization of reference signal, e.g., SSB, can improve the beam management performance.**  **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.**  **Proposal 5: 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.**  **Proposal 6: Multi-user multiplexing on the polarization domain based on UE capability is supported.**  **Proposal 7: Support polarization indication per SSB in SIB.** |
| ZTE | ***Proposal 1:*** *The polarization indication can be associated with BWP or SSB using a mapping rule via SIB to save signaling cost.*  ***Proposal 2:*** *The polarization indication for each channel/RS can be supported based on the QCL association with SSB.*  ***Observation 1:*** *The polarization indication per dedicated BWP should be included in UE-specific RRC message if the mapping rule is not defined in SIB.*  ***Proposal 3:*** *The UE polarization capability report can bring benefits to the network scheduling.* |
| FGI, Asia Pacific Telecom, III, ITRI | [Proposal 2For signaling of polarization, a polarization indication carried in SIB1 or DCI format 1\_0 scheduling SIB1 by re-using one bit in another field of the DCI shall be considered.](#_Toc79066461)  [Proposal 3Polarization information shall be divided into serving cell’s polarization and neighbor cell’s polarization.](#_Toc79066462)  [Proposal 4For mobility enhancement, UE shall report whether it is capable of differentiating RHCP and LHCP with circularly or linearly polarized antennas if signaling of polarization is provided.](#_Toc79066463)  [Proposal 5Clarify the UL polarization assumption if the DL polarization information is absent.](#_Toc79066464) |
| 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: UE polarization capabilities can be indicated explicitly or implicitly 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 | Proposal 1. The explicit indication of polarization is per SSB(s) and/or per CSI-RS(s) in SIB. |
| Huawei, HiSilicon | ***Proposal 4:*** *If polarization is used for multiplexing, the UE should report its polarization capability. Otherwise, there is no need to report such information.*  ***Proposal 5:*** *Beam-level or UE-level polarization indication should be supported.* |
| Xiaomi | ***Proposal 1: Dynamic indication of polarization is not supported.***  ***Proposal 2: UE polarization capability reporting is supported.*** |
| InterDigital, Inc. |  |

Following the last RAN1 agreement, in this meeting we should continue discussing the polarization signalling design in SIB for DL and UL. According to companies’ contributions, at least the polarization types: RHCP, LHCP and linear should be included in the signalling. Moreover, there are companies propose to indicate the polarization per beam or per BWP. From FL point of view, the polarization signalling in SIB is hard to be associated with BWP. Therefore, a more meaningful follow-up question to discuss is whether the polarization signalling in SIB is associated with beam, e.g. SSB. Thus, FL suggests that in this meeting we discuss the following:

1. For polarization signalling in SIB for DL
   1. the indicated polarizaiton types include RHCP, LHCP and linear
   2. whether the signalling is per cell or per beam, e.g. per SSB index
2. For polarization signalling in SIB for UL
   1. the indicated polarizaiton types include RHCP, LHCP and linear
   2. whether the signalling is per cell or per beam, e.g. per SSB index

In addition to signalling in SIB, there are also proposals suggest that the UE-specific RRC signalling should also be considered for polariziation indication. Moreover, there are proposals to indicate the polarization per channel/RS/BWP. In this meeting, FL suggests that the following can be further discussed:

1. Whether support polariziation signalling in UE-specific RRC
2. If supported, whether the polarizioation signalling is per BWP or per channel/RS.
3. If supported, whether polarization signalling includes other non-serving cell.

From the collected contributions, there are still diverged views on whether polarization multiplexing is to be supported, which links to a follow-up question whether UE polarization capability should be reported to the network. The opposing arguments question about the polariziation multiplexing scenario and believe that it is not feasible or envisagable in practice. However, the proposing views think that the scenario is valid and important for proliferate the system performance. Thus, FL suggest that in this meeting at least we should conclude that if the polarization multiplexing scenario is supported or not. The proposing companies should explain whether it is practically envisagable.

## First round discussion

#### Polarization signalling in SIB

1. For polarization signalling in SIB for DL
   1. the indicated polarizaiton types include RHCP, LHCP and linear
   2. whether the signalling is per cell or per beam, e.g. per SSB index
2. For polarization signalling in SIB for UL
   1. the indicated polarizaiton types include RHCP, LHCP and linear
   2. whether the signalling is per cell or per beam, e.g. per SSB index

|  |  |
| --- | --- |
| company | Views and comments |
| Ericsson | 1 – a): support  1 – b): per cell should be baseline  2 – a): support  2 – b): per cell should be baseline |
| FGI | 1-a: support  1-b: per cell  2-a: support  2-b: per cell |
| ZTE | 1-a: support  1-b: per beam (e.g., SSB) should be the baseline. The case with one beam per cell can be supported as specific implementation.  2-a: support  2-b: per beam (e.g., SSB) should be the baseline. The case with one beam per cell can be supported as specific implementation. And actually, there is no need to indicate the information for UL since all relationship can be derived based legacy memchanism. |
| Nokia, Nokia Shanghai Bell | 1-a: Support  1-b: Per satellite beam would be sufficient – that is, per cell.  2-a: Support  2-b: Per satellite beam would be sufficient – that is, per cell. |
| Panasonic | For both DL and UL, we think the polarization configuration should be per beam. Each satellite beam has different polarization configuration in case of polarization reuse. If multiple satellite beams are used within a cell, information on the polarization for each SSB should be included in the SIB or implicitly derived from the SSB index to save the signaling overhead. |
| Sony | 1-a) Support.  1-b) we support the polarization indication per beam, e.g. SSB index  2-a) support  2-b) we support the polarization indication per beam, e.g. SSB index |
| Apple | For 1-a) and 2-a), we are fine with them.  For 1-b) and 2-b) we think the polarization signaling in SIB is per SSB. |
| Lenovo/MM | 1-a: Support.  1-b: We prefer per SSB index as different satellite beams may be corresponding to different coverage areas.  2-1: Support  2-2: We prefer per SSB index for the same reason as DL case. |
| vivo | Support 1-a and 2-a.  No matter UL or DL, the polarization information per beam should be supported. |
| NTT DOCOMO | 1-a: Support  1-b: Per cell is baseline and per beam needs further discussion  2-a: Support  2-b: Per cell is baseline and per beam needs further discussion |
| Xiaomi | 1)a), support  1)b), if per beam supported, does it require different SIBs for different beams?  2)a), suppot  2)b), if per beam supported, does it require different SIBs for different beams? |
| QC | If polarization is per cell, we don’t see the need of signaling. A UE is either capable of only one polarization or can find the polarization during initial access. |
| Huawei, HiSilicon | 1-a: Linear polarization indication is not needed.  1-b: Polization can be per cell or per beam  2-a: Linear polarization indication is not needed  2-b: Polization can be per cell or per beam |
| LG | 1-a: support, but we are not sure on the linear polarization indication.  1-b: per beam (e.g., SSB) is preferred.  2-a: support , but we are not sure on the linear polarization indication.  2-b: per beam (e.g., SSB) is preferred. |
| Spreadtrum | 1-a: Support.  1-b: per cell or per beam  2-a: Support  2-b: per cell or per beam |
| Moderator | Majority view: the proposal is agreeable in general. While diverged views on if the indication is per cell or per beam. In addition, some companies think linear polarization is not needed to be indicated.  Revised proposal for GTW  For polarization signalling in SIB   * SIB may indicate DL polarization using a DL polarization type parameter   + Alt1: the DL polarization type parameter indicates: RHCP or LHCP or linear   + Alt2: the DL polarization type parameter indicates: RHCP or LHCP * SIB may indicate UL polarization using a UL polarization type parameter, where UL polarization type parameter indicates: RHCP or LHCP or linear   FFS: whether polarization signalling is per beam |

#### Polarization signalling in UE-specific RRC

1. Whether support polariziation signalling in UE-specific RRC
2. If supported, whether the polarizioation signalling is per BWP or per channel/RS.
3. If supported, whether polarization signalling includes other non-serving cell.

|  |  |
| --- | --- |
| company | Views and comments |
| Ericsson | The key is that there should be a signaling mechanism 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.  This signaling can be UE-specific RRC, by which the gNB can 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.  Once the group reaches the first-step consensus, it can be further discussed if the signaling should be per BWP/channel/RS, include non-serving cell, etc. |
| FGI | 1. Support UE-specific RRC for measurement report 2. Per cell 3. Include neighboring cells’ polarization (similar to how to signal ephemeris)   Agreement in RAN2#113-e  The NTN ephemeris is divided into serving cell’s ephemeris and neighbour’s ephemeris. |
| ZTE | In my view, whether to support the UE specific signalling is up to the design of whole mechanism. In our view, the indication of polarization is just one assistance information to improve the receive/transmission quliaty at UE side and whether to apply it or not is also up to UE’s implemeantion.  According to the discussion in 3.2.1.1, if the signalling of polarization information can be done per SSB via SIB, no additional to define any UE specific signal and the polarization information of all channels for each UE can be delivered by legacy QCL information |
| Nokia, Nokia Shanghai Bell | We have a preference for the polarization operating on a per satellite beam (on a per NR cell) basis. Hence, broadcast information would be sufficient, and we do not need to support polarization signaling via UE-specific RRC configuration. |
| Panasonic | We do not think it is needed |
| Sony | 1. We share similar view as Ericsson that it is neccesery for the network can configure the UE polarization, especially for UEs that can support more than one polarization mode. This can potentially facilitate polarization multiplexing over single or multipe users. Therefoer, a UE specific signalling is needed, and it can be RRC signalling. 2. Can be further discussed once 1) is resolved. 3. Can be further discussed once 1) is resolved. |
| Apple | We do not support the polarization signaling in UE-specific RRC. This is mainly for polarization multiplexing use cases, which may increase UE implementation complexity. If the polarization is per beam or per cell, then we do not need to support polarization signaling in UE-specific RRC. |
| Lenovo/MM | We think this issue may be related to section 3.2.1.2 on the supporting of polarization multiple scenario. If polarization multiplexing is supported, then it means that the polarization mode of a satellite/beam may be changed from time to time, so signailng from gNB is necessary. The signaling can be by UE-specific RRC. If it is associated with a channel/RS, the signaling can also be MAC CE/DCI.  Regarding whether the polarization signaling is per BWP, we think per BWP is necessary as neighboring coverate areas may be associated with different beam, and different beam may be associated with different BWPs, so per BWP polarization is necessary, either explicit or implicitly.  Regarding the polarization signaling of non-serving cells, we think if there is CA between serving cell and non-serving cell, and different cells are associated with different polarization mode, then polarization signaling of non-serving cells is necessary. |
| vivo | We do not see the necessity for the support of UE specific polarization signalling. First, if gNB could transmit signal with LHCP and RHCP in TDM manner or other way, gNB could schedule UE to transmit in corresponding resource for LHCP or RHCP. There is no need for gNB to configure UE specific polarization mode, which results in unnecessary signalling overhead and scheduling complexity. |
| NTT DOCOMO | Polarization operation is per cell or per beam, not per UE in our understanding. In this sense, this feature would be unnecessary. |
| Xiaomi | UE specific RRC signalling is not necessary as the polarzaition is per beam or per cell. |
| QC | UE specific RRC signaling is not necessary for rel-17. |
| Huawei, HiSilicon | We support polariziation signalling in UE-specific RRC.  In general, polarization can be used to reduce the interference among different beams as well as to enhance the throughput via polarization multiplexing. The signaling can be per BWP or per channel RS.  As different serving cell may have different polarization, polarization signalling includes adjacent non-serving cell for cell switching can reduce the measurement complexity at the UE side, otherwise UE have to do the measurement on both polarizaitons. |
| LG | We don’t see the necessity of UE specific RRC signalling. |
| Moderator | According to the company feedback, the views are diverged.  However FL would like to rasie an issue: if polarization signalling by UE-specific RRC is not supported, it means that the UE will only rely on SIB reading, which may lead to a new UE behaviour for RRM and handover.  With this clarification, please continue providing your views. |

#### Polarization multiplexing

FL suggest that in this meeting at least we should conclude that if the polarization multiplexing scenario is supported or not. The proposing companies should explain whether it is practically envisagable.

|  |  |
| --- | --- |
| company | Views and comments |
| Ericsson | Polarization multiplexing should be supported. This is a practical scenario, which has been in use in existing satellite communication systems. |
| FGI | If polarization multiplexing is supported, RHCP and LHCP may carry different information in a serving cell. It seems confusing for UE that cannot support circular polarization. |
| ZTE | The concept for polarization multiplexing is not clear w.r.t the spec impact and it will also have significant requirement on the UE capability. |
| Nokia, Nokia Shanghai Bell | We do not see per-slot polarization as a feasible feature for transparent satellites.  Polarization is a property that is associated to the transmit configuration of the satellite. Is the intention to overlay the payload signals for the satellite with further information for satellite operation for the specific transmissions, thereby making the operation less “transparent”, but rather going towards the regenerative mode? |
| Panasonic | For polarization multiplexing, satellite needs to transmit different streams with different polarizations in the same satellite beam. This function might not be largely supported by the existing satellite, but future satellite and/or HAPS may support the multiplexing function because polarization multiplexing has potential to doubling the user throughput as MIMO multiplexing did in terrestrial networks. Therefore, it would be worth to consider polarization multiplexing as Rel.17 specification.  Similar to the MIMO capability in terrestrial network, it would be necessary to report UE’s multiplexing capability of receiving dual polarization signals as separate streams. |
| Sony | Polarization multiplexing should be supported. The satellite can configure the UE with proper polarization multiplexing scheme based on UE reported poalrization capability to avoid any confusion here. |
| Apple | We do not support polarization multiplexing. |
| Lenovo/MM | We support polarization multiplexing scenario. We think it can improve the spectral efficiency by SU-MIMO or MU-MIMO by different polarizations. We think it can also improve the coverage by supporting UEs with different capabilities at different time instances. We think it is practically envisagable based on satellite implementation, as different polarization modes can be implemented by two separate loops with different weightin values. |
| vivo | In our opinion, polarization multiplexing can be considered with a lower priority in Rel-17 NTN. First, in NTN scenarios, coverage should be the key KPI other than throughput. Intra-UE multiplexing or multi-layer transmission should not be essential to support, but should be considered with a lower priority. Then, considering large beam footprint size and sparse user distribution, inter-UE multiplexing should not be a typical usecase in NTN. Furthermore, polarization multiplexing would lead to the increased scheduling complexity and signalling overhead of interaction between gNB and UE. |
| NTT DOCOMO | Firstly we would like to ask accurate definition of polarization multiplexing. |
| Xiaomi | We don’t support polarization multiplexing. The gNB can set TDM based polarization to support UEs with different polarization capability. |
| Huawei, HiSilicon | Polarization multiplexing can be considered as one potential enhancement. The benefits of polarization multiplexing for UE is clear 1) Boost the throughput; 2) For UEs with poor link conditions, polarization multiplexing can also improve the coverage. As a UE with linear polarization cannot support polarization multiplexing, it is necessary for UE to report its capability of supporting different kinds of polarization, at least whether it is liner or circular. |
| LG | As commented by ZTE and NTT, it is unclear that the meaning of polarization multiplexing and its potential specification impact. |
| Moderator | It seems that some companies are not clear about the polarization multiplexing definition. It means that a network may transmit/receive multiple streams in a time-frequency resource with different polarization types, where the multiple streams may target/from a same UE (intra-UE polarization multiplexing) or different UEs (inter-UE polarization multiplexing).  With the above definition, FL invites ZTE, NTT, LG to further provide their views.  Moreover, one company (Ericsson) has commented that polarization multiplexing scenario has already been supported in existing satellite commnications. Thus, if it is already supported, we need to clarify the reasoning why NTN-NR should not support it.  Please provide your further comments, if any. |

#### Summary of first round

**Polarization signalling in SIB**

Majority view: the proposal is agreeable in general. While diverged views on if the indication is per cell or per beam. In addition, some companies think linear polarization is not needed to be indicated. With this, FL suggests to discuss the proposal 1 in the GTW to check if it is agreeable.

Proposal 1:

For polarization signalling in SIB

* SIB may indicate DL polarization information using a DL polarization type parameter
  + The DL polarization type parameter indicates (select one from Alt1 and Alt2)
  + Alt1: RHCP or LHCP or linear
  + Alt2: RHCP or LHCP (when DL polarization type parameter is not provided, linear polarization is assumed for DL)
* SIB may indicate UL polarization information using a UL polarization type parameter, where UL polarization type parameter indicates: RHCP or LHCP or linear
* FFS: whether polarization signalling is per beam

Proposal 1-v1

For polarization signalling in SIB

* SIB may indicate DL and/or UL polarization information using respective polarization type parameters to indicate: RHCP or LHCP or linear
* FFS: whether polarization signalling is per beam

**Polarization signalling in UE-specific RRC**

According to the company feedback, the views are diverged.

However FL would like to rasie an issue: if polarization signalling by UE-specific RRC is not supported, it means that the UE will only rely on SIB reading, which may lead to a new UE behaviour for RRM and handover. Moreover, the UE measurement complexity might also be problematic in particular for RRM.

**Polarization multiplexing**

It seems that some companies are not clear about the polarization multiplexing definition. It means that a network may transmit/receive multiple streams in a time-frequency resource with different polarization types, where the multiple streams may target/from a same UE (intra-UE polarization multiplexing) or different UEs (inter-UE polarization multiplexing).

With the above definition, FL invites ZTE, NTT, LG to further provide their views.

Moreover, one company (Ericsson) has commented that polarization multiplexing scenario has already been supported in existing satellite commnications. Thus, if it is already supported, we need to clarify the reasoning why NTN-NR should not support it.

## Second round discussion

**Polarization signalling in SIB**

Agreement:

When polarization signalling is present in SIB

* SIB indicates DL and/or UL polarization information using respective polarization type parameters to indicate: RHCP or LHCP or linear
* FFS: whether polarization signalling is per SSB

With the above agreement made in GTW August 20, we should continue discussing the FFS point, i.e. whether SSB shall provide polarization signalling for each SSB index. According to the companies’ views, the per SSB polarization indication addresses the case where multiple beams correspond to a same cell and diverse polarization is used for different beams. With this motivation, FL suggests to discuss and check if the following proposal can be acceptable.

Proposal 1:

Support per SSB index polarization signalling in SIB for DL and UL.

|  |  |
| --- | --- |
| company | Views and comments |
| Ericsson | SSB is DL transmission. It’s unclear what it means to support per SSB signaling for UL. |
| Lenovo/MM | Our understanding is that each SSB index is associated with a polarization type, and the association between SSB index to DL/UL is based on existing QCL procedure. E.g. CORESET#0 polarization type same as corresponding polarization type for corresponding SSB, and PRACH polarization type same as corresponding polarization type for associated SSB.  We are generally fine with the intention. And we want to ask whether the it is explicit signaling in SIB to indicate polarization type for each SSB or a group of SSBs or there will be some implicit way to associate polarization type with SSB index? |
| Apple | Support the proposal of DL only. For UL, some clarification may be needed. |
| Panasonic | We support the proposal 1.  We think the polarization configuration should be per beam (SSB). From previous round of discussion, it seems the majority companies also are positive on this regard. One concern raised is, if per beam supported, does it require different SIBs for different beams? To our understanding, it does not require that. One SIB can contain all polarization configurations for different SSBs explicitly, or implicitly derived from the SSB index to save the signaling overhead. |
| Baicells | Support FL’s Proposal 1.  Polarization signaling per SSB is necessary if polarization multiplexing is applied.  Our understanding is that the SIB is better to be per SSB too. |
| NTT DOCOMO | Same question as Ericsson/Apple. |
| Sony | We support the proposal. |

**Polarization signalling in UE-specific RRC**

If polarization signalling by UE-specific RRC is not supported, it means that the UE will only rely on SIB reading, which may lead to a new UE behaviour for RRM and handover. Moreover, the UE measurement complexity might also be problematic in particular for RRM. FL suggests to further discuss for non-serving cell polarization, whether UE-specific RRC siganling shall be supported? This leads to the proposal 2 below.

Proposal 2:

Support polarization information indication for non-serving cell in UE-specific RRC.

|  |  |
| --- | --- |
| company | Views and comments |
| Ericsson | Support. Note that system information for serving cell can also be sent in UE-specific RRC. Therefore, the proposal should include both serving and non-serving cell. |
| Lenovo/MM | Support. |
| Apple | Do not support. The new UE behaviour for RRM and handover, when non-serving cell polarization information is not indicated, is unclear to us. |
| Panasonic | The proposal 2 is generally ok to us. But to make the intention of the proposal 2 clear, we suggest to add a constraint for such UE-specific RRC indication, saying that polarization information indicated by UE-specific RRC should be the same as that is broadcast by SIB. |
| Baicells | Basically support FL’s Proposal 2.  Polarization information indication for non-serving cell is necessary for handover.  It should be noted that if polarization signaling is per SSB, then the polarization information indication for non-serving cell should be for one beam or some beams in the non-serving cell.  We think maybe a little modification is needed as below:  Support polarization information indication for **one or multiple beams in** a non-serving cell in UE-specific RRC. |
| NTT DOCOMO | Support. In addition, we are supportive of Panasonic’s note. |
| Sony | We support the proposal . |

**Polarization multiplexing**

It seems that some companies are not clear about the polarization multiplexing definition. It means that a network may transmit/receive multiple streams in a time-frequency resource with different polarization types, where the multiple streams may target/from a same UE (intra-UE polarization multiplexing) or different UEs (inter-UE polarization multiplexing).

Moreover, one company (Ericsson) has commented that polarization multiplexing scenario has already been supported in existing satellite commnications. Thus, if it is already supported, we need to clarify the reasoning why NTN-NR should not support it.

Please further discuss the support of polarization multiplexing, if case we shall support this scenario, we can take proposal 3 for the potential agreement.

Proposal 3

Support polarization multiplexing scenario

Note: polarization multiplexing means that a network may transmit/receive multiple streams in a time-frequency resource with different polarization types, where the multiple streams may target/from a same UE (intra-UE polarization multiplexing) or different UEs (inter-UE polarization multiplexing).

|  |  |
| --- | --- |
| company | Views and comments |
| Ericsson | Agree. Not supporting this would be perceived as a significant, unnecssary disadvantage for NR NTN, limiting the use of NR NTN in practice.  Otherwise, as FL mentioned, RAN1 needs to provide a reason why it cannot be supported in 3GPP NR NTN. |
| Lenovo/MM | We support this proposal. And we think supporting this can make NR NTN system more adjustable for different application scenarios for performance improvement. |
| Apple | We do not support polarization multiplexing scenario. This is against the agreement that polarization is broadcasted in SIB. Also, it may involve UE’s dynamic switching of polarization. |
| Panasonic | Support the proposal 3. |
| ZTE | Based on the definition “polarization multiplexing means that a network may transmit/receive multiple streams in a time-frequency resource with different polarization types”, it’s clear that such behaviour is pure gNB’s implemeantation without additional needs on the spec changes. If the intention is to introduce any other impacts except for the previous discussion/agreement, we can start with corresponding proposal directly. |
| Baicells | Support FL’s Proposal 3.  Our understanding is the polarization multiplexing stated in Proposal 3 is related to polarization per beam (or per SSB). |
| NTT DOCOMO | We understand the motivation. Then has this feature been studied well in SI? It seems that 38.821 does not capture this... At least what is spec impact should be clarified first before agreeing this proposal. |
| Sony | We support the proposal. This is a useful feature for NTN to improve the channel capability and link robustness. The performance of polarization based multiplexing can also be optimized through network configured DL/UL polarizations. For example, assign two UEs in orthogonal polarizations though UE specified RRC signalling. |

## Third round discussion

# Additional Aspects

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

## Background

### 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.

Baicells proposes to increase the SCS of the preamble to resolve the issue of residual frequency offset. Moreover, extended CP is proposed to absorb the timing error.

Nok suggests to add SCS scaling factors for all formats defined in TS 38.211 table 6.3.3.1-2. Also support restrited set type A for

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:**

According to the WID, the PRACH enhancement should be supported if the PRACH issue has been identified. Since the start of the WI, we have not concluded any firm agreement on the PRACH issue. FL invites the companies to provide their views on the pointed PRACH issue and the proposed enhancements.

### Reliance on GNSS system

**Nokia expressed their concern of the stability of the NTN function relying on a third part system.**

**Observation 1: 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).**

**Observation 2: The precision and availability provided by different systems may vary significantly.**

**Observation 3: Full reliance on third part GNSS applications leave the 3GPP systems exposed to vulnerabilities that cannot be subject to enhancements or modifications by 3GPP standards or service provider will.**

**Proposal 3: NTN systems must contain a fall-back conservative solution that allows UE to access the network in case of faulty or malfunctioning GNSS systems.**

FL is not sure if the issue is in the scope of the WI as we may assume that the non-GNSS solution is not discussed in R17. But in any case, FL thinks that this topic is highly related to AI 8.4.2. Thus, if there would be any back-up solution, they should be discussed in 8.4.2. So FL invites Nokia to submit their contribution to 8.4.2.

### 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 and RAN1#105-e meeting, DL synchronization issues should be discussed in AI 8.4.2 to check if it is in the WID scope. Thus this topic is not further discussed in this agenda item.

### 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 on the issue listed in section 4.1.4.

### HAPS related

CMCC presented the following observations and concluded that HAPS and ATG scenarios are supported by the up to date agreements and no further enhancements are needed.

***Observation 2:*** In order to support HAPS and ATG scenario, the following enhancements should be supported which are essential for ATG and HAPS, and they are also beneficial for satellite application.

* 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.

***Observation 3:*** Extend the value range of K1 (Issue 1) has been agreed in RAN1#104-e meeting.

***Observation 4:*** Extend the maximal supported HARQ process number (Issue 2) has been agreed in RAN1#102-e meeting.

***Observation 5:*** Support satellite ephemeris based on satellite position and velocity state vectors (Issue 3) has been agreed in RAN1#105-e meeting.

***Observation 6:*** At least from RAN1 perspective, Rel-17 NTN specification can support ATG scenarios.

Softbank presented some views on potential R18 SI scope in R1-2107381. Regarding this contribution, FL thinks that it is out of the WI scope and invites Softbank to have offline discussions with interested companies and the R18 oriented issues are not further discussed in this meeting.

### Channel model

GDCNI presented some issues on the current channel model for NTN in R1-2106999.

***Proposal 1****: Definition of marine and inland river scenes.*

***Proposal 2****: Update Pathloss models for maritime environment.*

***Proposal 3****: Update Pathloss models for inland river environment.*

***Proposal 4:*** *Discuss fast fading models for inland river scenario.*

According to FL’s knowledge, RAN4 is currently working on NTN simulation for calibration phase. The chanel model is based on TR 38.811 and if there is any important issue, RAN4 should be the right place to be informed and be discussed there. For this reason, FL suggests GDCNI to submit there contribution to RAN4 for their information. While discussion on channel model corrections is out of the scope of this agenda item.

## First round discussion

Companies are invited to comment on Additional aspects.

**FL suggestions:**

According to the WID, the PRACH enhancement should be supported if the PRACH issue has been identified. Since the start of the WI, we have not concluded any firm agreement on the PRACH issue. FL invites the companies to provide their views on the pointed PRACH issue and the proposed enhancements.

|  |  |
| --- | --- |
| company | Views and comments |
| Ericsson | With UE precompensation on timing and frequency, there is no issue in PRACH and accordingly there is no need for any PRACH enhancement. |
| FGI | Share the same view with Ericsson. |
| ZTE | For the PRACH related enahcnement, with basic assumption on the pre-compensation, there is no need to enhance it. |
| Baicells | ***Observation 11：A natural way to make initial access preambles more robust against residual frequency offsets is to allow higher SCS.***  ***Observation 12：After pre-compensation, the residual UL timing error of some terminals may exceed the CP length of the legacy preamble format. In this case, the legacy preamble format is not applicable. This problem can be solved to some extent by increasing the CP length.***  ***Observation 13：The limit CP length is one OFDM symbol. When the residual UL timing error exceeds the length of one symbol, the problem cannot be solved by increasing the CP length. In this case, it is necessary to use an enhanced PRACH format that is not restricted by the CP length.***  ***Observation 14: If UEs with different preamble formats share PRACH resources，then mutual interference will occur.***  ***Proposal 11：Support increasing SCS to combat the Doppler effect.***  ***Proposal 12: Support an enhanced preamble format, which uses longer CP and GT to solve the problem that the residual UL timing error exceeds the CP length of the legacy preamble format but is less than one symbol length.***  ***Proposal 13：Support an enhanced preamble format, which uses a single Zadoff-Chu sequence with combination of scrambling sequence.***  ***Proposal 14: Allocate different time-frequency resources for different preamble formats.*** |
| Moderator | FL needs more company views to make summary |

**FL suggestion:** companies are encouraged to provide views on the issue listed in section 4.1.4.

|  |  |
| --- | --- |
| company | Views and comments |
| Nokia, Nokia Shanghai Bell | We would not be supportive of disabling closed loop through specifications.  We do not support UE autonomous reduction of MCS for power limited UEs. |
| vivo | The coverage enhancement related techniques for NTN should be considered to broaden the application scenarios of commercial UE. |
| QC | Given the coverage enhancement WI, PRACH coverage can be an issue. This the the motivation of our proposed enhancement for PRACH format 2. |
| Moderator | FL needs more company views to make summary |

## Second round discussion

## Third round discussion

# GTW Agreement / Conclusion

# References

[R1-2106594](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106594.zip) Discussion on other aspects for NR-NTN vivo

[R1-2106704](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106704.zip) Discussion on beam management and other aspects for NTN Spreadtrum Communications

[R1-2106757](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106757.zip) Discussion on beam management and other consideration for NTN Baicells

[R1-2106808](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106808.zip) Discussion on beam management and polarization for NTN Sony

[R1-2106887](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106887.zip) Remaining issues for NTN Samsung Samsung

[R1-2106970](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106970.zip) Beam management and other aspects for NTN CATT

[R1-2106999](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106999.zip) Discussion on channel models for marine and inland river scenes GDCNI

[R1-2107016](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107016.zip) Remaining issues for NR NTN NEC

[R1-2107246](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107246.zip) Discusson on beam management OPPO

[R1-2107290](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107290.zip) Other aspects of NR-NTN FGI, Asia Pacific Telecom, III, ITRI

[R1-2107344](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107344.zip) BWP operation and other issues for NTN Qualcomm Incorporated

[R1-2107381](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107381.zip) Problems of Rel-17 NTN WI from HAPS point of view SoftBank Corp.

[R1-2107402](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107402.zip) Other Aspects for NTN CMCC

[R1-2107463](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107463.zip) Beam management and polarization signaling for NTN Panasonic

[R1-2107541](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107541.zip) Discussions on other aspects of NTN LG Electronics

[R1-2107644](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107644.zip) On other enhancements for NTN Ericsson

[R1-2107675](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107675.zip) Discussion on other design aspects for NTN Huawei, HiSilicon

[R1-2107739](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107739.zip) On Other Aspects of NR NTN Apple

[R1-2107778](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107778.zip) Discussion on additional enhancement for NR-NTN ZTE

[R1-2107921](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107921.zip) Discussion on other design aspects for NTN Xiaomi

[R1-2107946](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107946.zip) Discussion on other aspects for NTN Lenovo, Motorola Mobility

[R1-2108034](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2108034.zip) On beam management for NTN InterDigital, Inc.

[R1-2108093](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2108093.zip) Further discussion of other aspects for NR over NTN Nokia, Nokia Shanghai Bell