**3GPP TSG-RAN WG4 Meeting #94-e R4-20xxxxx**

**Electronic Meeting, Feb.24th – Mar.6th 2020**

**Agenda item:** 8.14.1.2

**Source:** Moderator (Apple)

**Title:** Email discussion summary for RAN4#94e\_#21\_NR\_RF\_FR2\_req\_enh\_Part\_2

**Document for:** Information

# Introduction

The beam correspondence topic area includes the following topics:

1. Topic 1: beam correspondence based on SSB
2. Topic 2: beam correspondence based on CSI-RS
3. Topic 3: initial access beam correspondence
4. Topic 4: additional beam correspondence enhancements
5. Topic 5: beam correspondence capability aspects

Each topic consists of sub-topics, as captured in the following sections.

During the first round of email discussions, it is recommended to converge on the following aspects of each topic:

1. Topic 1: side conditions and performance difference aspects (2.2.1, 2.2.2)
2. Topic 2: how to achieve ”CSI-RS only condition” and remaining aspects of side conditions (3.2.1, 3.2.2)
3. Topic 3: whether a feasible solution can be identified (4.2.1)
4. Topic 4: which, if any, beam correspondence enhancements are feasible within the Rel-16 timeframe (5.2.1, 5.2.2, 5.2.3)

During the second round of email discussion, it is recommended to converge further Topics 1 through 4 and to also address the beam correspondence capability aspects (Topic 5).

# Topic #1: Beam correspondence based on SSB

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2000012](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000012.zip) | Apple Inc. | Observation 1: If we consider a beam refinement procedure based on SSB from the perspective of UE functionality under a sub-optimal network configuration which does not include CSI-RS for the P3 procedure, then it may be helpful to consider a requirement on SSB based beam correspondence with the understanding that performance between SSB based and SSB+CSI-RS based beam correspondence are taken into account, as summarized in [10]. |
| [R4-2000077](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000077.zip) | Qualcomm Incorporated | Proposal 1: For SSB-based eBC, P3 CSI-RS is not configured.  Proposal 2: For SSB-based eBC, minimum TR SNR is equal to or greater than minimum SSB SNR.  Proposal 3: PSD of reference signal (RS) used by the UE to achieve beam correspondence shall be the same, regardless of RS type (SSB or CSI-RS) |
| [R4-2000271](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000271.zip) | Samsung | Observation 1: SNR side condition for SSB based BC is limited by testability SNR range, and BC performance is impacted due to less RS available.  Observation 2: From RF test point of view, SSB based BC is not suitable to specify with MOP metric.  Proposal 1: SSB based BC is not specified, or to be specified with other metric instead of MOP metric. |
| [R4-2000394](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000394.zip) | Intel Corporation | Observation 1: CSI-RS is a UE specific reference signal and can only be configured when UE is in RRC connected mode.  Observation 2: When UE is in RRC connected mode, side condition of SSB + tracking CSI-RS can be used for UE to fine tune “narrow beam” for beam correspondence.  Observation 3: A UE is able to finish initial access and establish RRC connection with network without sacrificing the cell coverage with â€˜fatâ€™ beams  Proposal 1: Updated parameter table for SSB based beam correspondence should be as table 1   |  |  | | --- | --- | | **Parameter** | **Value** | | SSB periodicity | 20 ms [1] | | Use P1 CSI-RS configuration? | No | | Use P3 CSI-RS configuration? | ~~Alt. 1: Yes~~  Alt. 2: No | | Use tracking CSI-RS? | Yes | | Tracking CSI-RS QCL info | qcl-TypeD=SSB | | Tracking CSI-RS min SNR | ~~TBD~~  6dB | | Tracking CSI-RS resource sets | 2 NZP CSI-RS resource sets, set0 and set1; each resource set has 4 periodic resources over two consecutive slots | | Tracking CSI-RS resource periodicity | 20 ms | | Tracking CSI-RS resource time domain location and slot offsets | Resource mapping: Set0: l{0,4}, set1: l{0,4};  Slot offset: set0 = 2µ10; set1 = 2µ10 +2; | | Tracking CSI-RS resource frequency domain configuration | = 3; 48RBs for BW=100/200/400MHz, 32RBs for BW=50MHz | | PDCCH/PDSCH DM-RS QCL info | qcl-TypeD=TRS | | SSB min SNR level | Alt. 1: 6 dB [1] [10]  ~~Alt. 2: 13 dB [14]~~ | | (note) | RAN4 didn’t assume more than [1] SSB indices should be transmitted  SSB use configuration for Rel-15 which is specified in 38.508 per agreed in RAN4 #92bis meeting |   Proposal 2: When SSB periodicity =20ms, a UE should meet Rel15 beam correspondence requirements without CSI-RS assistance under the condition 1) SNR = 6dB, 2) For each test grid point, at least 3 SSB bursts should be provided for beam refinements. |
| [R4-2000791](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000791.zip) | Apple Inc. | Observation 1: It is unrealistic to assume the codebook size of Rx beamforming for SSB measurement more than 8. Rx refinement for SSB based L1 and L3 measurement cannot be easily assumed too.  Observation 2: The effective codebook size of Rx beamforming for CSI-RS measurement can be much larger than SSB’s due to Rx refinement and potential relaxed measurement delay requirements.  Observation 3: To be consistant with SNR assumption of Rel-15 BC requirement, 6dB of SSB SNR should be considered.  Observation 4: Up to 4.7 dB EIRP performance degradation are observed for 2x2 array with different RSRP implementation margin.  Observation 5: Up to 5.0 dB EIRP performance degradation are observed for 4x1 array with different RSRP implementation margin.  Proposal: Considering a significant EIRP spherical performance degradation with SSB based BC, there can be two options  Option 1: Introduce a performance relaxation margin for SSB based BC. The exact margin is TBD  Option 2: No specify the requirements for SSB based BC. |
| [R4-2000858](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000858.zip) | NTT DOCOMO | Observation 1: According to Rel-15 test parameter for beam correspondence, both SSB and CSI-RS with repetition are transmitted by the same Tx beam from gNB and UE would assume the same spatial Rx parameters to receive both signals.  Proposal 1: Beam correspondence requirements based on only SSB should be specified in Rel-16.  Proposal 2: There are no technical issues on beam correspondence based on only SSB and the performance can be the same as that in Rel-15. |
| [R4-2001199](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2001199.zip) | LG Electronics | Observation 1: The new EIRP requirements by SSB based enhanced BC could not guarantee the existing EIRP requirements for BC in rel-15.  Observation 2: It is quite burden to specify both SSB based eBC and CSI-RS based eBC in rel-16 since the expected OTA test time will be raised some high cost UE.  Proposal 1: RAN4 only specified CSI-RS resource based enhanced BC requirements to reduce OTA test time and keep the current EIRP (peak and spherical) in rel-15 without any new signaling and measurements. |
| [R4-2001384](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2001384.zip) | Nokia, Nokia Shanghai Bell | Observation 1: While Method 2 (SSB in wide beam and CSI-RS in fine beam from TE) in [2] is best option from the real deployment perspective for ensuring that the UE uses only CSI-RS for beam correspondence, we also see that Method 3 in [2] is viable testing solution.  Observation 2: Potential UE measurement and test requirement enhancements should be discussed and done separately from the ongoing main Rel-16 beam correspondence enhancements.  Proposal 1: Re-use Rel-15 SSB conditions for beam correspondence requirements and test cases based on SSB only |
| [R4-2001490](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2001490.zip) | Sony, Ericsson | Observation 1: There is no inherent difference in terms of beam correspondence performance between SSB and CSI-RS under OTA test environment.  Observation 2: The standard deviation of the RSRP estimates coverges quickly when the number of REs is larger than 20 and the SNR = 6 dB.  Observation 3: Rel-15 BC test is declared automatically passed if a UE passes Rel-16 BC test using the same SSB configuration and SNR as in Rel-15.  Proposal 1: Do not configure CSI-RS in P3 for SSB only BC test.  Proposal 2: SSB min SNR level = 6dB in Rel. 16.  Proposal 3: If the Rel-16 SSB BC test is done with the same SSB configuration and side condition as Rel-15, then the UE is allowed to skip the Rel-15 BC test if it passes the Rel-16 SSB BC test. |
| [R4-2001761](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2001761.zip) | Huawei, HiSilicon | Observation 1: the current SSB configuration for Beam correspondence test have impact on the UL and DL beam match accuracy.  Observation 2: rough or fine beam selection in P1 procedure is compromise between search time and DL beam selection accuracy, whether refinement shall be fulfilled in P1 procedure in up to UE implementation.  Observation 3: rough beam DL beam search will cause 7dB SNR difference which is defined in TS 38.133.  Observation 4: UE using rough beam in P1 procedure cannot fulfill the RF requirement of beam correspondence defined in the current spec even side condition on SNR is increased by 7dB.  Proposal 1: For SSB only based BC, 3dB degeneration for both bit 1 and bit 0 UEs on Beam correspondence requirement shall be provided.  Proposal 2: the side condition for SSB only based beam correspondence shall be SNR≥13dB which comply with TS 38.133. |

## Open issues summary

The open issues related to Topic #1 can be grouped into the following sub-topics: side conditions of BC based on SSB and the performance difference of BC based on SSB only vs. BC based on CSI-RS only configurations.

### Side conditions of BC based on SSB

**Issue 1-1-1: Whether a BC based on SSB requirement is feasible**

* Proposals
  + Option 1: Yes (4 companies)
  + Option 2: No (2 companies)
  + Option 3: Yes, under certain conditions, e.g. relaxation margin, 3 SSB bursts per grid point, higher SSB SNR (3 companies)
* Recommended WF
  + Convergence between Option 1 and Option 3 is needed

**Issue 1-1-2: SSB min SNR level**

* Proposals
  + Option 1: 6 dB (5 companies)
  + Option 2: 13 dB (1 company)
* Recommended WF
  + Option 1

**Issue 1-1-3: Use P3 CSI-RS?**

* Proposals
  + Option 1: no
* Recommended WF
  + Option 1

**Issue 1-1-4: Tracking CSI-RS min SNR**

* Proposals
  + Option 1: 6 dB
* Recommended WF
  + Option 1

**Issue 1-1-5: Tracking CSI-RS configuration**

* Proposals
  + Option 1: See additional tracking CSI-RS configuration parameters in R4-2000394
* Recommended WF
  + TBD

### Performance difference of BC based on SSB only vs. BC based on SSB and CSI-RS

**Issue 1-2-1: Analysis of performance difference**

* Proposals
  + Option 1: 5 dB
  + Option 2: 3 dB
  + Option 3: 0 dB
* Recommended WF
  + TBD

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX | Sub topic 1-1:  Sub topic 1-2:  ….  Others: |

### CRs/TPs comments collection

*Major close-to-finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic#1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

*Recommendations on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #2: Beam correspondence based on CSI-RS

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2000078](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000078.zip) | Qualcomm Incorporated | Observation 1: There is neither a default QCL assumption nor a subsequent UE behaviour in RAN1 when qcl-TypeD of periodic CSI-RS is absent in FR2.  Observation 2: There will be technical implementation issues when P1 CSI-RS is configured with qcl-typeD = ‘none’.  Observation 3: There is no such a test case where a source of qcl-TypeD of periodic CSI-RS is not configured even though it aims to verify UE performances based on configured periodic CSI-RS.  Proposal 1: Parameters for CSI-RS based Beam Correspondence test shall be per Table 1   |  |  |  | | --- | --- | --- | | Parameter | Value | Justification | | P1 CSI-RS periodicity | ~~Alt.1: P1 CSI-RS is configured with [TBD] ms periodicity, the QCL (qcl-TypeD) relation is configured as ‘SSB’~~  Alt.2: P1 CSI-RS is not configured; instead aperiodic P2 CSI-RS can be considered if necessary. If P2 CSI-RS is supported, its qcl-TypeD is ‘SSB’  ~~Alt.3: P1 CSI-RS is configured with [TBD] ms periodicity, the QCL (qcl-TypeD) relation is configured as ‘none’~~ | P1 CSI-RS is not necessary for the test | | P3 CSI-RS repetitions per resource set | Alt. 1: maxNumberRxBeam in UE capability IE of MIMO-ParametersPerBand  ~~Alt. 2: 8~~ | Respect UE capability declaration. Besides, UE is not required to meet L1-RSRP accuracy if it is smaller than *maxNumberRxBeam*, and it should not exceed  *maxNumberAperiodicCSI-RS-Resource* as per TS38.133. | | P3 CSI-RS configuration repetition | On |  | | P3 CSI-RS trigger | ~~Alt.1: once P1 CSI-RS is finished~~  Alt.2: once every SSB cycle (20 ms) if P1 CSI-RS is not configured | P1 CSI-RS is not necessary for the test | | Tracking CSI-RS periodicity | reuse Rel-15  60 kHz SCS: 40 slots for CSI-RS resources 1 and 2  120 kHz SCS: 80 slots for CSI-RS resources 1 and 2 |  | | P3 CSI-RS QCL info | ~~Alt.1: Type D to P1 CSI-RS~~  Alt.2:  If P2 CSI-RS is transmitted;  - Type A to TRS  - Type D to P2 CSI-RS  Otherwise;  - Type C to SSB  - Type D to SSB | P1 CSI-RS is not necessary for the test | | P1 CSI-RS QCL info | ~~Alt.1: P1 CSI-RS is transmitted and the QCL relation is configured as ‘SSB’~~  Alt.2: P1 CSI-RS is not transmitted  ~~Alt.3: P1 CSI-RS is transmitted and the QCL relation is configured as ‘none’~~ | P1 CSI-RS is not necessary for the test |   Proposal 2: RAN4 defines CSI-RS based eBC requirement by Method-3 below.  - Method-3: SSB and CSI-RS are present, but SSB’s PSD is back-off by XdB from CSI-RS  - X is either 3 or 6  - CSI-RS SNR is [6]dB  - EIRP requirement in terms of ∆EIRPBC CDF will be defined in such a way that UE relying on SSB-only for beam refinement cannot meet the requirement but UE using CSI-RS can satisfy the requirement |
| [R4-2000271](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000271.zip) | Samsung | Observation 3: Neither Method-1 nor Method-3 is perfect to achieve “CSI-RS only” condition. Method-1 is not feasible and Method-3 may has too high SSB SNR at many AoAs (measurement grids)  Proposal 2: P2 CSI-RS is not necessary for CSI-RS based BC, and Alt.1 is proposed for most of parameters as shown in the table.   |  |  |  | | --- | --- | --- | | **Parameter** | **Value in WF** | **Our proposal** | | P1 CSI-RS periodicity | Alt.1: P1 CSI-RS is configured with [TBD] ms periodicity, the QCL (qcl-TypeD) relation is configured as ‘SSB’  Alt.2: P1 CSI-RS is not configured; instead aperiodic P2 CSI-RS can be considered if necessary. If P2 CSI-RS is supported, its qcl-TypeD is ‘SSB’ [2]  Alt.3: P1 CSI-RS is configured with [TBD] ms periodicity, the QCL (qcl-TypeD) relation is configured as ‘none’ | Alt.1 | | P3 CSI-RS repetitions per resource set | Alt. 1: *maxNumberRxBeam* in UE capability IE of *MIMO-ParametersPerBand*  Alt. 2: 8 | Alt.1 | | P3 CSI-RS configuration repetition | on | 🡨 | | P3 CSI-RS trigger | Alt.1: once P1 CSI-RS is finished  Alt.2: once every SSB cycle (20 ms) if P1 CSI-RS is not configured  \* The test time for Alt.1 is assumed less than or equal to Alt.2 | Alt.1 | | Tracking CSI-RS periodicity | reuse Rel-15  60 kHz SCS: 40 slots for CSI-RS resources 1 and 2  120 kHz SCS: 80 slots for CSI-RS resources 1 and 2 | 🡨 | | P3 CSI-RS QCL info | Alt.1: Type D to P1 CSI-RS  Alt.2:  If P2 CSI-RS is transmitted;  - Type A to TRS  - Type D to P2 CSI-RS  Otherwise;  - Type C to SSB  - Type D to SSB | Alt.1 | | P1 CSI-RS QCL info | Alt.1: P1 CSI-RS is transmitted and the QCL relation is configured as ‘SSB’ [14]  Alt.2: P1 CSI-RS is not transmitted [2]  Alt.3: P1 CSI-RS is transmitted and the QCL relation is configured as ‘none’ | Alt.1 |   Proposal 3: An optimization to Method-3 is proposed to effectively achieve “CSI-RS only” condition by utilizing UE measurement reporting of SS-SINR. The side condition for CSI-RS is SNR=6dB with fixed PSD for all AoAs, and the side condition for SSB is SNR=-3dB with dynamic PSD for each AoA. |
| [R4-2001199](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2001199.zip) | LG Electronics | Proposal 1: RAN4 only specified CSI-RS resource based enhanced BC requirements to reduce OTA test time and keep the current EIRP (peak and spherical) in rel-15 without any new signaling and measurements. |
| [R4-2001384](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2001384.zip) | Nokia, Nokia Shanghai Bell | Proposal 2: Re-use the Rel-15 CSI-RS conditions for Rel-16 beam correspondence requirements based on CSI-RS only |
| [R4-2001490](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2001490.zip) | Sony, Ericsson | Observation 4: Testing CSI-RS only BC through configuring the UE in a BWP without SSBs may not be representative of common real deployments, and it may fail to implement a true CSI-RS only BC test.  Observation 5: Lowering the SNR of SSB can encourage the UE to use CSI-RS for beam selection.  Proposal 4: RAN4 shall identify the scenario where UE can only use CSI-RS for beam selection and decide the test method according to the desired scenario. |
| [R4-2001761](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2001761.zip) | Huawei, HiSilicon | Proposal 3: CSI-RS P1 shall be configured to ensure UE would not use SSB measurement as P1 procedure. P2 procedure could be skipped.  Proposal 4: P1 CSI-RS QCL relation is configured as ‘none’.  Proposal 5: For CSI-RS only based Beam correspondence, both periodic and aperiodic CSI-RS shall be provided to the UE, the exact configuration is as in Table 1.   |  |  |  | | --- | --- | --- | | Resource Type | periodic | aperiodic | | Resource Set Config |  |  | | repetition | off | on | | aperiodicTriggeringOffset | n/a | Depending on UE capability  Periodic and aperiodic CSI-RS are not configured in the same slot | | **Resource Config** |  |  | | nzp-CSI-RS-ResourceId | 0 for resource #0 | Depending on UE capability | | powerControlOffset | 0 | 0 | | powerControlOffsetSS | db0 | db0 | | nrofPorts | 1 | 1 | | cdm-Type | noCDM | noCDM | | density | 3 | 3 | | nrofRBs | 48 for channel bandwidth ≥ 100MHz  32 for channel bandwidth = 50MHz | 48 for channel bandwidth ≥ 100MHz  32 for channel bandwidth = 50MHz | | qcl-info | none | all AP-CSI-RS resources are TypeD to P-CSI-RS resource#0 | | Periodicity(slots) | Slot80(120kHz) | N/A | | Offset | 8 | N/A |   Proposal 6: the side condition for CSI-RS only based beam correspondence shall be SNR≥ 6dB. |
| [R4-2001777](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2001777.zip) | Huawei, HiSilicon | TP for TR 38.831: beam correspondence based on CSI-RS only |

## Open issues summary

The open issues related to Topic #2 can be grouped into the following sub-topics: how to achieve ”CSI-RS only” condition and side conditions of BC based on CSI-RS.

### How to achieve “CSI-RS only” condition

**Issue 2-1-1: Method to achieve “CSI-RS only” condition**

* Proposals
  + Option 1: Method 3 (SSB and CSI-RS are present, but SSB’s PSD is back-off by XdB from CSI-RS)
  + Option 2: Method 4 (decrease SSB power until UE SSB based SS-SINR measurement reporting is within the threshold ≤-3dB)
* Recommended WF
  + TBA

### Side conditions of BC based on CSI-RS

**Issue 2-2-1: P1 CSI-RS configuration**

* Proposals
  + Option 1: P1 CSI-RS is not configured
  + Option 2: P1 CSI-RS is configured with [TBD] ms periodicity, the QCL (qcl-TypeD) relation is configured as ‘SSB’
  + Option 3: P1 CSI-RS is configured with 80 slot (120 kHz) periodicity, the QCL relation is configured as ‘none’
* Recommended WF
  + TBA

**Issue 2-2-2: P2 CSI-RS configuration**

* Proposals
  + Option 1: Aperiodic P2 CSI-RS can be considered if necessary. If P2 CSI-RS is supported, its qcl-TypeD is ‘SSB’
  + Option 2: P2 CSI-RS is not considered
* Recommended WF
  + TBA

**Issue 2-2-3: P3 CSI-RS configuration**

* Proposals
  + Option 1:
    - maxNumberRxBeam in UE capability IE of MIMO-ParametersPerBand repetitions per resource set
    - Trigger once every SSB cycle (20 ms) if P1 CSI-RS is not configured
    - If P2 CSI-RS is transmitted, QCL Type A to TRS and Type D to P2 CSI-RS
    - If P2 CSI-RS is not transmitted, QCL Type C to SSB and Type D to SSB
  + Option 2:
    - 8 repetitions per resource set
    - Trigger once P1 CSI-RS is finished
    - QCL Type D to P1 CSI-RS
  + Option 3:
    - All AP-CSI-RS resources are TypeD to P-CSI-RS resource#0
* Recommended WF
  + TBA

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX | Sub topic 1-1:  Sub topic 1-2:  ….  Others: |

### CRs/TPs comments collection

*Major close to finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic#1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

*Suggestion on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #3: Initial access beam correspondence

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2000012](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000012.zip) | Apple Inc. | Proposal 1: RAN4 shall not define any requirements on initial access.  Proposal 2: RAN4 shall consider whether a requirement is needed to verify UE beam refinement when CSI-RS for P3 procedure is not present. |
| [R4-2000199](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000199.zip) | Qualcomm Incorporated | Observation 1: TRx beam (mis)alignment characteristics between rough beam and fine beam have not been analysed.  Observation 2: How many beam widths UE supports is up to UE implementation.  Observation 3: Which beam width UE uses at a specific moment and during any procedure cannot be specified unless UE should transmit UL channel/signal with the maximum transmission power.  Observation 4: Msg1 based initial access BC property can be verified by SSB-only based Rel-16 eBC, if introduced, unless one wants to introduce a new test specific UE behaviour that forces UE to use rough beam.  **Conclusion: If a UE satisfies SSB-based Rel-16 eBC requirement in connected mode, if introduced, it is considered to satisfy BC during initial access procedure.** |
| [R4-2000858](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000858.zip) | NTT DOCOMO | Observation 2: Beam correspondence for initial access is the subset of the beam correspondence based on only SSB.  Proposal 3: Introduce the requirements on beam correspondence for initial access in Rel-16. The requirements for this enhancement could be discussed based on the discussion on beam correspondence based on only SSB. |
| [R4-2001325](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2001325.zip) | Ericsson, Sony | Observation 1: the evaluation of Msg2 reception can be made in a sparse grid. The test time required for verifying the beam correspondace is therefore not excessive.  Observation 2: Both OTA test setup 1 (single AoA) and OTA test setip 3 (two AoAs) from 38.133 are feasible for beam correspondace test in intial access.  Proposal 1: beam correpondence for intial access is critical for system performance and is a SSB-only beam correspondence test. Therefore, it shall be completed within the Rel-16 WI “UE RF enhancement for FR2”.  Proposal 2: verify BC during intial access by measuring the relative spherical coverage and the correlation between PRACH power and msg2 detection capability. |
| [R4-2001384](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2001384.zip) | Nokia, Nokia Shanghai Bell | Observation 3: Potential UE requirements for beam correspondence during initial access should be discussed and developed separately from the ongoing main Rel-16 beam correspondence enhancements for BC based on SSB only and BC based on CSI-RS only in RRC\_CONNECTED. |

## Open issues summary

Topic #3 addresses the RAN Plenary guidance and represents a feasibility study of whether a requirement on initial access can be introduced. The open issues consist of the question whether to introduce such a requirement as well as the proposed solutions.

### Feasibility and proposed solutions

**Issue 3-1-1: Whether RAN4 shall introduce a requirement on initial access beam correspondence**

* Proposals
  + Option 1: Yes
  + Option 2: No
  + Option 3: Verify a related “BC property”
* Recommended WF
  + TBA

**Issue 3-1-2: Proposed solutions**

* Proposals
  + Option 1: Verify BC during intial access by measuring the relative spherical coverage and the correlation between PRACH power and msg2 detection capability
  + Option 2: Discuss based on the discussion on beam correspondence based on only SSB
  + Option 3: Msg1 based initial access BC property can be verified by SSB-only based Rel-16 eBC, if introduced, unless one wants to introduce a new test specific UE behaviour that forces UE to use rough beam
  + Option 4: Consider whether a requirement is needed to verify UE beam refinement when CSI-RS for P3 procedure is not present
  + Option 5: Potential UE requirements for beam correspondence during initial access should be discussed and developed separately from the ongoing main Rel-16 beam correspondence enhancements for BC based on SSB only and BC based on CSI-RS only in RRC\_CONNECTED
* Recommended WF
  + TBA

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX | Sub topic 1-1:  Sub topic 1-2:  ….  Others: |

### CRs/TPs comments collection

*Major close to finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
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## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

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| --- | --- |
|  | **Status summary** |
| **Sub-topic#1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

*Suggestion on WF/LS assignment*

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|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

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| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #4: Additional beam correspondence enhancements

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2000012](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000012.zip) | Apple Inc. | Observation 2: With increasing Fs, the phase of CC1 steering vector distorts the array response of CC2, and best beam selection optimized for CC1 degrades CC2 performance.  Proposal 3: The Rel-16 requirement on beam correspondence for CA needs to be enhanced to include scope for UL intra-band non-contiguous CA.  Proposal 4: For UL intra-band non-contiguous CA with Fs ≤ 1400, the Rel-15 requirement can be re-used.  Proposal 5: For UL intra-band non-contiguous CA with 1400 < Fs ≤ 2400 the EIRP spherical coverage requirement is relaxed by 0.3 dB.  Proposal 8: RAN4 should discuss further beam correspondence enhancements, including proposed enhancements based UE measurement including RSRP and/or L1-SINR, in the context of further enhancements in Rel-17. |
| [R4-2000079](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000079.zip) | Qualcomm Incorporated | Conclusion: Further additional performance enhancement especially based on UE measurement reports and the corresponding test configuration enhancements will not be discussed under Beam Correspondence Enhancement agenda |
| [R4-2000271](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000271.zip) | Samsung | Observation 4: After introducing L1-SINR reporting, the Rel-16 BC bit-0 UE can be enhanced in terms of saving network resource, test time and so on.  Proposal 4: Introduce L1-SINR reporting in Rel-16 beam correspondence as enhancement to BC bit-0 UE. |
| [R4-2001065](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2001065.zip) | Fraunhofer HHI | Observation 1: The peak angles of the boresight beam and of beams close to boresight do not show a significant variance in beam peak direction over frequency when fixed-frequency beamforming weights are used.  Observation 2: Beams steered further away from boresight exhibit greater differences in beam peak direction over frequency when fixed-frequency beamforming weights are used.  Observation 3: Fixed-frequency beamforming weights used for different frequencies affect the direction of both the main lobe and the side lobes.  Observation 4: Any variation in the strength or gain of the main lobes has been masked due to normalization.  Proposal 1: A thorough investigation of the impact of beamforming with DL CA on beam correspondence in terms of spherical coverage performance, regarding both the direction and strength of the beam, should be conducted. |
| [R4-2001232](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2001232.zip) | OPPO | Observation 1: Rel-15 beam correspondence is a mandatory feature.  Observation 2: UE can declare support of beam correspondence if it meets RAN4 requirements with or without beam sweeping support.  Observation 3: RAN4 requirements are defined under SINR≥6dB conditions.  Observation 4: UE beam correspondence capability cannot be guaranteed under SINR below 6dB conditions.  Observation 5: Beam sweeping is important to enhance UE beam selection performance in real NW.  Observation 6: The real SINR capability below which beam correspondence is not reliable is UE implementation specific, NW has no knowledge of this.  Observation 7: With the L1-SINR reported, NW could be aware of UE environmental conditions but does not know whether UE beam correspondence capability is reliable or not.  Observation 8: The environmental condition based enhancement can be achieved by UE simply report UL beam sweeping request indication to NW.  Proposal 1: Enhance UE beam selection performance under real NW conditions.  Proposal 2: UE reports the UL beam sweeping request indication when necessary in the NW to realize environmental condition based beam correspondence enhancement. |
| [R4-2001493](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2001493.zip) | Sony | Observation 1: Poor SNR and/or poor SINR in the DL may cause the UE not being capable of fulfilling BC without UL beam sweeping.  Observation 2: A UE may in some cases be capable of BC without UL beam sweeping but in other cases not.  Observation 3: Beam correspondence is a dynamic capability in real networks that depends on the network SNR and DL reference signal configuration. It is not enough for the network to only know UEâ€™s beam correspondence capability, regardless of whether the BC UE capability bit is set to 0 or to 1.  Observation 4: It is necessary to have dynamic reporting/signaling from UE in order to ensure the UE performs beam correspondence based on DL reference signals configured by the network.  Proposal 1: Enhancements to beam correspondence measurement reporting is in the scope of Rel-15 beam correspondence WID, and RAN4 should discuss and define it. |

## Open issues summary

The open issues related to Topic #4 can be grouped into the following sub-topics: utilizing the existing UE measurement including RSRP and/or L1-SINR, impact of carrier aggregation, and UL beam sweeping request indication. It is recommended to first identify which of these aspects can feasibly be addressed within the Rel-16 scope before developing detailed solutions.

### Utilizing the existing UE measurement including RSRP and/or L1-SINR

**Issue 4-1-1: Feasibility of utilizing the existing UE measurement including RSRP and/or L1-SINR**

* Proposals
  + Option 1: Proposed enhancement is feasible for Rel-16
  + Option 2: Proposed enhancement is not feasible for Rel-16
* Recommended WF
  + TBA

### Impact of carrier aggregation

**Issue 4-2-1: Feasibility of CA impact**

* Proposals
  + Option 1: Proposed enhancement is feasible for Rel-16
  + Option 2: Proposed enhancement is not feasible for Rel-16
* Recommended WF
  + TBA

### UL beam sweeping request indication

**Issue 4-2-1: Feasibility of UL beam sweeping request indication**

* Proposals
  + Option 1: Proposed enhancement is feasible for Rel-16
  + Option 2: Proposed enhancement is not feasible for Rel-16
* Recommended WF
  + TBA

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX | Sub topic 1-1:  Sub topic 1-2:  ….  Others: |

### CRs/TPs comments collection

*Major close to finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic#1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

*Suggestion on WF/LS assignment*

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|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #5: Beam correspondence capability aspects

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2000012](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000012.zip) | Apple Inc. | Proposal 6: Rel-16 beam correspondence enhancements can be applicable to both Rel-15 beam correspondence types of UEs (bit-0 and bit-1) and are independent of the Rel-15 beam correspondence capability.  Proposal 7: RAN4 should discuss how to define a new capability related to Rel-16 beam correspondence enhancement. |
| [R4-2000271](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000271.zip) | Samsung | Observation 4: After introducing L1-SINR reporting, the Rel-16 BC bit-0 UE can be enhanced in terms of saving network resource, test time and so on.  Proposal 4: Introduce L1-SINR reporting in Rel-16 beam correspondence as enhancement to BC bit-0 UE. |
| [R4-2000858](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2000858.zip) | NTT DOCOMO | Proposal 4: No need to introduce new UE capability for beam correspondence based on SSB only since the beam correspondence performance based on only SSB would be the same as that in Rel-15 except for the time for trying and deciding Rx beam.  Proposal 5: Rel-16 UE shall support the beam correspondence performance based on only SSB as mandatory if UE can set the bit of UE capability on beam correspondence introduced in Rel-15.  Proposal 6: Test applicability rule between Rel-15 and Rel-16 should be clarified. For example, if Rel-16 UE has the UE capability on beam correspondence introduced in Rel-15, UE only performs the test specified in Rel-16 and can skip the test specified in Rel-15. |
| [R4-2001199](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2001199.zip) | LG Electronics | Proposal 2: Enhanced Beam Correspondence in rel-16 shall be optional. If UE support rel-16, then, the UE need to meet the enhanced BC requirements with updated side conditions. Then the BC requirement in rel-15 will be skipped as mentioned in WF [2]. The UE only satisfy the CSI-RS based BC requirements. |
| [R4-2001493](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_94_e/Docs/R4-2001493.zip) | Sony | Observation 5: It is questionable whether the UE BC capability bit is useful for a real network.  Observation 6: A UE can always meet the spherical coverage requirement if the side conditions are properly selected.  Proposal 2: If a UE supports Rel-16 BC and the UE is Rel-15 BC bit-0 UE, it is an invalid scenario and should not be allowed. |

## Open issues summary

The open issues related to Topic #5 can be grouped into the following sub-topics: aspects related to bit0/bit1 UE formulation from Rel-15, aspects related to enhancements introduced in Rel-16, and test case applicability. It is recommended to first resolve the open issues associated with Topics 1 – 4 during the first round of the email discussion.

### Related to bit0/bit1 UE formulation from Rel-15

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

**Issue 5-1-1: Whether the Rel-15 UE bit0/bit1 BC capability is applicable to Rel-16 enhancements**

* Proposals
  + Option 1: If a UE supports Rel-16 BC and the UE is Rel-15 BC bit-0 UE, it is an invalid scenario and should not be allowed
  + Option 2: Rel-16 beam correspondence enhancements can be applicable to both Rel-15 beam correspondence types of UEs (bit-0 and bit-1) and are independent of the Rel-15 beam correspondence capability
  + Option 3: Introduce L1-SINR reporting in Rel-16 beam correspondence as enhancement to BC bit-0 UE
  + Option 4: Rel-16 UE shall support the beam correspondence performance based on only SSB as mandatory if UE can set the bit of UE capability on beam correspondence introduced in Rel-15
* Recommended WF
  + TBA

### Related to enhancements introduced in Rel-16

**Issue 5-2-1: Whether a new capability for Rel-16 enhanced beam correspondence is needed**

* Proposals
  + Option 1: Yes
  + Option 2: No (mandatory regardless of Rel-15 BC capability)
  + Option 3: No (mandatory if Rel-15 BC capability is bit1)
* Recommended WF
  + TBA

### Test case applicability

**Issue 5-3-1: Test applicability rule**

* Proposals
  + Option 1: Test applicability rule between Rel-15 and Rel-16 should be clarified. For example, if Rel-16 UE has the UE capability on beam correspondence introduced in Rel-15, UE only performs the test specified in Rel-16 and can skip the test specified in Rel-15
  + Option 2: If the Rel-16 SSB BC test is done with the same SSB configuration and side condition as Rel-15, then the UE is allowed to skip the Rel-15 BC test if it passes the Rel-16 SSB BC test
  + Option 3: If UE support rel-16, then, the UE need to meet the enhanced BC requirements with updated side conditions. Then the BC requirement in rel-15 will be skipped as mentioned in WF [2]. The UE only satisfy the CSI-RS based BC requirements
* Recommended WF
  + TBA

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX | Sub topic 1-1:  Sub topic 1-2:  ….  Others: |

### CRs/TPs comments collection

*Major close to finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
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|  | **Status summary** |
| **Sub-topic#1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

*Suggestion on WF/LS assignment*

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|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |