**3GPP TSG RAN WG1 Meeting #104-e R1-2101827**

**e-Meeting, January 25 – February 05, 2020**

**Source: Moderator (Intel Corporation)**

**Title: Summary #1 of email discussion on initial access aspect of NR extension up to 71 GHz**

**Agenda item: 8.2.1**

**Document for: Discussion/Decision**

# Introduction

In this contribution, we summarize all issues submitted on initial access aspects for NR extension up to 71 GHz for RAN1 #104-e meeting. Section 2 contain a summary of issues identified from contributions submitted to RAN1 #104-e [1] ~ [27]. The list of issues in Section 2 are **not** ordered in terms of discussion priority. Section 3 contains list of conclusions/agreements proposed by the moderator based on discussions. Section 4 contains list of conclusions and agreements made in RAN1 #104-e. Please note the conclusions and agreements listed in Section 4 may not be the full list as moderator is updating the list as meeting progresses.

# Summary of Issues and Discussions

## 2.1 SSB Aspects

### 2.1.1 DRS Related Aspects (including potential use of Short Signal Exemption for SSB)

* From [1] FUTUREWEI:
  + In 60 GHz shared spectrum, support SS/PBCH across discovery burst transmission windows that are quasi co-located with respect to average gain, QCL-Type A, and QCL-Type D properties.
* From [3] ZTE, Sanechips:
  + More than 64 candidate SSBs can be defined in a half-frame for Rel-17 NR above 52.6 GHz.



* From [4] OPPO:
  + For above 52.6GH unlicensed spectrum, introduce SSB candidate positions to allow more SSB transmission occasions for a given SSB beam or to allow SSB beam repetitions.
* From [5] Huawei, HiSilicon:
  + For unlicensed operation in 52.6GHz to 71GHz, support LBT before SSB transmission and reuse the concept of discovery burst window from Rel-16 NR-U.
* From [8] CATT:
  + For NR operation in unlicensed spectrum in 52.6-71 GHz, the principle of transmission window defined in Rel-16 NR-U is supported.
  + More than 64 SSB transmission opportunities shall be defined within a 5ms SSB burst set to support up to 64 beams for SSB beam sweeping in case of occasional LBT failure. The additional bit(s) for the extension of SSB index need to be further study.
* From [12] Intel:
  + Observation: For 120 kHz SCS SSB, transmission of 64 SSB with 20 msec SSB periodicity exceed 10 msec transmission duration within a 100 msec observation period required for short control signal exemption. For 480 kHz SCS SSB, transmission of 64 SSB and 64 Type0-PDCCH with associated PDSCH with 20 msec SSB periodicity exceed 10 msec transmission duration within a 100 msec observation period required for short control signal exemption. For 960 kHz SCS SSB, transmission of 64 SSB and 64 Type0-PDCCH with associated PDSCH with 20 msec SSB periodicity does not exceed 10 msec transmission duration within a 100 msec observation period required for short control signal exemption.
  + While SSB may be considered as a candidate for short control signal exemption, RAN1 specification shall support operations of SSB transmission with LBT (at the gNB) at least for 120 kHz SSB.
    - For 480 kHz and 960 kHz SSB, also support operations of SSB transmission with LBT (at the gNB) for commonality with 120 kHz SSB
* From [15] Spreadtrum:
  + The initial access mechanisms for R16 NR-U can be further adapted for high frequency, e.g., to support up to 64 SSB beams.
* From [18] NEC:
  + With respect to the 120 kHz SCS SSB pattern for LBT mode operation, CORESET and PDSCH related to SIB1 should be multiplexed with SSB to guarantee the absence of any gaps greater than 16us in the discovery burst set.
* From [20] Samsung:
  + Discovery burst transmission window should be supported for 60 GHz unlicensed band.
* From [22] Ericsson:
  + Consistent with EN 302 567, when operating in LBT mode a node can access the channel without LBT for control signal/channel transmissions, the total duration of which shall not exceed 10ms within an observation period of 100ms. The following signals/channels shall be classified as Short control signaling transmissions:
    - SS/PBCH blocks
    - PRACH
    - FFS: Other control transmissions not multiplexed with user data (subject to gNB configuration)
  + Observation: It is not necessary to optimize the SS/PBCH transmission/reception mechanism by introducing a transmission window, especially since SS/PBCH blocks can be classified as short control signaling transmissions consistent with EN 302 567.
* From [24] Convida:
  + Increasing the number of SSB candidate positions to above 64 to increase transmission opportunities to cope with LBT failure should be considered.

**Summary of Discussions in Tdoc**

* Discussion on DRS window to cope with LBT failure is supported or not. If supported, the details of the DRS.
  + Majority of the companies seems to propose support of DRS like windows and corresponding SSB candidate positions similar to NR-U
    - FUTUREWEI, ZTE, Sanechips, OPPO, Huawei, HiSilicon, CATT, Intel, Spreadtrum, Samsung, Convida
  + Some companies suggested that DRS like operation is not necessary for SSB as short signal exemption (defined in EN 302 567) could be applied.
    - Ericsson

**Discussions #1**

* Please provide further views on whether DRS window (to cope with LBT failure) should be supported. Also provide further comments on related issues to DRS.

|  |  |  |
| --- | --- | --- |
| **Company** | **Support DRS (similar to Rel-16 NR-U)?** | **Discussions/Comments** |
| Samsung | Yes | There is always scenario where short control signal is not applicable, e.g. for the region where regulation doesn’t define short control signal, or for the condition (duty cycle) short control signal is not satisfied. Hence, the SSB transmission subject to LBT always happens, then it’s natural to reuse NR-U DBTW for such cases. |
| NEC | Yes | The DRS window with necessary modification should be supported as a mechanism to improve the SSB transmission performance for LBT mode operation. Discovery burst transmission may not always meet the restrictions of short control signal. |
| ZTE, Sanechips | Yes | Short control signalling has strict usage requirements. No matter for SSB or DRS including SSB and CORESET#0/RMSI, their transmission time in a periodicity of 100 ms may exceed 10 ms. In such cases, LBT could be used. Thus we support to define DRS window and more candidate SSB positions to increase the opportunities for SSB/DRS. |
| DOCOMO | Yes | We agree to support DRS window to cope with LBT failure. We also see the scenario where short control signal is not applicable while LBT is necessary prior to the transmission. For example, regulation in Japan require LBT before transmissions with transmission power larger than a certain threshold. In other words, there is a case where SSB transmission is subject to LBT. Ok to reuse the one specified in Rel-16 NR-U. |
| LG Electronics | Yes | For the scenario whether LBT is required for SSB transmission, it would be beneficial to provide more opportunities for SSB to cope with LBT failure. |
| Spreadtrum | Yes |  |
| vivo | Yes | We agree to support DRS window to cope with possible LBT failure if it is needed. |
| Nokia |  | While we would prefer to apply the short control signaling as much as feasible, it is evident that with 120kHz it may not be always applied if the number of actually transmitted SSBs is large. Hence it would seem relevant to consider LBT mechanism in initial access.  Whether and how to extend the number of potential SSB time locations should be further considered. With 120kHz if the number of locations is increased, the DRS window may extend beyond 5ms. Thus, instead of increasing max number of SSB positions beyond 64, e.g. up to 128 (and use similar cycling mechanism as in Rel. 16 NR-U) it could be considered that max number of SSB positions remains 64 while some of the positions (e.g. last N positions) can be used as a back-up positions for the SSBs which were not transmitted due to LBT failure.  For RMSI and LBT it could be possible to consider SSB and CORESET#0 multiplexing pattern1 and pattern 2/3 separately. |
| Charter Communications |  | Prefer to apply short control signaling as much as possible and avoid elaborate DRS transmission window design for SSB. In regions where there is no short control signaling defined, it is usually the case that LBT is also not mandated. |
| Futurewei | Yes | Support DRS window to cope with LBT failure similar as Rel 16. |
| Ericsson | No | Our view is that contrary to operation in the 5/6 GHz band, a discovery burst transmission window (DBTW) is unjustified for operation in the 60 GHz band for a number of reasons:   * As we and others have shown, when operating with LBT (which is not even required in many regions), deferral due to LBT failure is very rare in the 60 GHz band due to high pathloss and heavy reliance on beamforming. Even if LBT failure occurs in a rare event, it is not disastrous to system operation to drop an SSB transmission on rare occasions. * Furthermore, if there is a serious concern about rare dropping of an SSB, by implementation the gNB can secure access to the channel in advance of an SSB burst, e.g., by one or more attempts to schedule data to a user. * MIB re-design. The current MIB supports indication of only 64 candidate SS/PBCH positions, hence if 64 beams are used, indication of more than 64 positions (plus a larger Q value compared to Rel-16) will require adding additional bits to MIB, thus negatively affecting coverage. * SSB can be classified as short control signaling, thus removing the need for LBT in many scenarios of interest. It does not matter that the 10 ms duration could be exceeded for certain numbers of beams, since LBT can still be performed if the duration is exceeded. This in itself is not a motivation to introduce a transmission window.   Given that a DBTW is not motivated for operation in the 60 GHz band, it unwarranted for RAN1 to spend a lot of time designing such a feature (as was done in Rel-16). |
| Qualcomm | No | We share the same view as Ericsson. Considering the high beam directivity for 60 GHz range compared to FR1, LBT failure rate may be low. Hence, we recommend that DRS window is not used, especially that the SSB can be considered as a short control signal. |
| OPPO | Yes | The concept of DRS window should be reused at least for SSB transmission subject to LBT case. |
| Xiaomi | Yes | For LBT required operation case, it is necessary to support the DRS window as defined in Rel-16. |
| Apple |  | The SSB transmission should be prioritized to leverage the short control signaling rule. Can be discussed in channel access under short control signaling and SSB related subjects |
| Intel | Yes | RAN1 specification should support possibility of SSB transmission with LBT. |
| Huawei, HiSilicon | Yes | In our view, the 10 ms out of 100 ms channel occupancy is only a necessary condition for exemption and not sufficient. Otherwise, virtually any single signal/channel could be designed so that it satisfies the above short duration criteria. 3GPP should interpret short “management and control  Frames” terminology used in 302 567 and decide which signals/channels can be exempted. In particular, we believe that LBT is still necessary before gNB transmits SSB because of a broader energy emission foot-print of SSB burst. Moreover, if default periodicity of 20 ms is assumed, neither Case D nor Case E SSB patterns in 120 and 240 kHz satisfy the necessary 10/100 ms criteria.  Therefore, similar to Rel-16 NR-U, discovery burst transmission window should be supported. Moreover, transmitting RMSI PDCCH/PDSCH together with its associated SSB in discovery burst transmission window should be considered to reduce the initial access latency and required beam switching. |
| Lenovo, Motorola Mobility | Yes | Support of DRS like windows and LBT before SSB transmission. Increasing the number of SSB candidate positions to cope with LBT failure needs to be studied further. |

*Moderator Note: Below are tentative summary and suggested conclusion, please continue to add comments to above until discussion in GTW. Moderator will update the summary and suggested conclusionas further comments are provided.*

**Moderator Summary of Discussions #1**

* Support DRS for NR operating 52.6 ~ 71 GHz, similar to SSB design for NR-U
  + 14 Companies
  + Companies commented 120kHz SSB may not strictly meet the short signal exemption requirements needed to avoid LBT and therefore may need to consider DRS.
* Do not support DRS for NR operating 52.6 ~ 71 GHz
  + 3 Companies
  + Companies commented with use of pre-emptive channel access gain prior to SSB and use of short signal exempt rules, it should be possible to operate the system without LBT for SSB.
* Majority of the companies seems to think DRS support is needed. With that said, suggest to discuss in GTW to at least hear out the companies that do not believe DRS for 60GHz band is needed to explain their logic and motivation.
* Strive to make a conclusion in GTW, discussion could be held starting with following statement:
  + Support DRS for NR operating 52.6 ~ 71 GHz, similar to SSB design for NR-U
* Also, this might be relevant topic for channel access, may need Chairman’s guidance on where to discuss this matter.

### 2.1.2 Supported Numerology

* From [2] Lenovo, Motorola Mobility:
  + For supporting NR from 52.6 GHz to 71 GHz in Rel. 17, support the same numerology of data channel for SSB and PRACH including 480KHz and 960KHz
* From [3] ZTE, Sanechips:
  + The following options can be considered for determining SCSs of SSB and other initial access signals/channels in initial BWP, wherein Option 1 is preferred.
    - Option 1: both SSB and other initial access signals/channels support SCS (120kHz, 480kHz, 960kHz)
    - Option 2: SSB supports SCS (120kHz, 240kHz); Other initial access signals/channels support SCS (120kHz)
* From [4] OPPO:
  + For above 52.6GHz, adopt single numerology for initial access, where the numerology candidates are 120kHz, 480kHz and 960kHz.
  + For above 52.6GHz, 240kHz SSB SCS is not supported.
* From [5] Huawei, HiSilicon:
  + SCS other than 120 kHz are not supported for SSB and other initial access related signals/channels in initial BWP.
* From [6] Nokia, NSB:
  + Support 240 kHz SCS for the SSB transmission in NR bands ranging between 52.6 GHz to 71 GHz.
  + Observation: Supporting 480kHz and 960kHz sub-carrier spacings for SSB can have implications to initial cell search/selection complexity, UE minimum initial RF BW and possibly to synchronisation raster, depending on the minimum carrier BW.
  + Consider and discuss of support of 480kHz and 960kHz kHz SCS for the SSB transmission in NR bands ranging between 52.6 GHz to 71 GHz.
  + Observation: It would appear that 480 and 960 kHz cannot be used for initial access related data and control channels in initial BWP for IDLE and Inactive Mode UEs.
  + Support additional SCS (480 kHz, 960 kHz) for SSB for other use cases than initial cell selection (e.g. for Scell, BM and RRM).
* From [7] CAICT:
  + SSB design with 480 and 960kHz SCS should be considered.
* From [8] CATT:
  + The complexity or performance degradation will be introduced if 960 KHz is used for the SCS of SSB.
* From [9] vivo:
  + Observation: All supported SCS for data/control SCS in FR2 could be used for initial DL BWP.
  + Support SCS 120KHz, 480KHz and 960KHz for initial DL BWP in NR operation from 52.6-71GHz.
  + Support the following SCS pairs for SSB and initial DL BWP in NR operation from 52.6-71GHz：(120K, 120K) + (960K, 480K) + (960K, 960K).
  + Observation: For frequency domain offset estimation during SSB detection, using SSB with low SCS such as 120K/240KHz may increase hardware complexity or cell search latency. For number of buffering samples during SSB detection, using SSB with high SCS such as 960KHz will need larger buffer cost compared to that in FR2 if adopting the same SSB period (20ms).
* From [10] TCL:
  + Introduce groups of SCS in FR2 and all control/data communication will use the SCS from one such group.
* From [11] MediaTek:
  + Support only 120 kHz for SSB SCS in initial access.
* From [12] Intel:
  + Support 480 kHz and 960 kHz SCS for SSB and initial BWP.
* From [13] Fujitsu:
  + Do not support 240kHz for SSB for the new frequency range (52.6~71GHz).
  + In addition to 120kHz, support 480 kHz and 960 kHz for SSB at least for the cases other than initial access.
* From [15] Spreadtrum:
  + Support 120kHz SCS for SSB and initial BWP.
  + Support 240kHz SCS for SSB.
* From [17] LGE:
  + Support 240 kHz SCS for SS/PBCH block in frequency range from 52.6 GHz to 71 GHz.
  + For SS/PBCH block with 480 and/or 960 kHz SCS, the following three alternatives can be taken into account and Alt 3 is preferred considering no specification impact and CSI-RS as an alternative of SS/PBCH block in most use cases.
    - Alt 1: Support SS/PBCH block with 480 and/or 960 kHz SCS for all cases
    - Alt 2: Support SS/PBCH block with 480 and/or 960 kHz SCS for cases other than initial access
    - Alt 3: Do not support SS/PBCH block with 480 and/or 960 kHz SCS for any case
* From [20] Samsung:
  + Support 480 kHz SCS and 960 kHz SCS for SS/PBCH block after initial access.
* From [22] Ericsson:
  + Like in Rel-15/16 FR2, for initial access (PCell), support 240 kHz SCS for SS/PBCH block in an initial BWP (in addition to the already supported 120 kHz) and 120 kHz SCS for initial access related signals/channels in an initial BWP.
  + For cases other than initial access (e.g. for an SCell), support 480 and 960 kHz SCS for SS/PBCH block.
* From [23] Apple:
  + Support 480kHz SCS for SSB and PRACH in addition to 120kHz SCS for initial access in an initial BWP.
* From [24] Convida:
  + The support of SSB and SSB burst design for higher SCS like 480 KHz and above should be studied for NR operation from 52.6 to 71 GHz.
* From [25] Qualcomm:
  + Observation:
    - increasing the SSB SCS will have an effect on the UE initial search complexity which will depend on multiple factors including the number of frequency bins needed and the number of correlations in time. the effect of the initial search timing resolution (for different SSB SCSs) on the performance of channels with high SCS (480 and 960 kHz) needs to be studied
    - larger SSB SCS causes less time domain blockages to other channels
    - explicit beam switching gap between SSBs may be required for larger SSB SCS
    - for NSA mode, increasing the SCS for the SSB may have a different effect on the UE search complexity compared to SA mode
  + for the SSB for NR operation in the frequency between 52.6GHz and 71GHz:
    - Use SCS = 120 kHz and 240 kHz for SA mode
      * FFS for 480 kHz and 960 kHz
    - Use SCS = 120 kHz, 240 kHz, 480 kHz, and 960 kHz for NSA mode
* From [26] NTT Docomo:
  + Observation: For SSB, all the candidate SCSs, i.e., from 120 kHz to 960 kHz, would be available in terms of detection/BLER performance.
    - Lower SCS may be slightly better
  + For SSB SCS, in addition to 120 kHz,
    - 480 and 960 kHz SCS should be supported to achieve single numerology at least for non-initial access cases.
    - FFS: which SSB SCS(s) is assumed for initial access in each band in 52.6 – 71 GHz

**Summary of Discussions in Tdoc**

* Various views on which SCS should be supported for SSB (in addition to 120 kHz)
  + No other SCS:
    - Huawei, HiSilicon, MediaTek
  + 240 kHz:
    - Nokia, Spreadstrum, LGE, Ericsson, Qualcomm
  + 480 kHz:
    - Lenovo, Motorola Mobility, ZTE, Sanechips, OPPO, CAICT, Intel, Fujitsu, Samsung, Ericsson (for SCell only), Apple, Convida(?), Qualcomm (for non-initial access) , NTT Docomo (for non-initial access)
  + 960 kHz
    - Lenovo, Motorola Mobility, ZTE, Sanechips, OPPO, CAICT, vivo, Intel, Fujitsu, Samsung, Ericsson (for SCell only), Qualcomm (for non-initial access), NTT Docomo (for non-initial access)
* Discuss further on the supported SCS and applicable scenarios (e.g. initial access, non-initial access, PCell, SCell)

**Discussions #1**

* Please provide further views on supported SCS for SSB and applicable scenarios (e.g. initial access, non-initial access, SCell only, etc).
* Please directly edit the summary of the views below (if there are any errors or require clarifications)
  + No other SCS:
    - Huawei, HiSilicon, MediaTek
  + 240 kHz:
    - Nokia, Spreadstrum, LGE, Ericsson, Qualcomm
  + 480 kHz:
    - Lenovo, Motorola Mobility, ZTE, Sanechips, OPPO, CAICT, Intel, Fujitsu (for non-initial access, FFS for initial access), Samsung, Ericsson (for SCell only), Apple, Convida(?), Qualcomm (for non-initial access) , NTT Docomo (for non-initial access), AT&T (initial access and non-initial access)
  + 960 kHz
    - Lenovo, Motorola Mobility, ZTE, Sanechips, OPPO, CAICT, vivo, Intel, Fujitsu (for non-initial access, FFS for initial access), Samsung, Ericsson (for SCell only), Qualcomm (for non-initial access), NTT Docomo (for non-initial access), AT&T (initial access and non-initial access)

|  |  |
| --- | --- |
| **Company** | **Additional Discussions/Comments** |
| Samsung | Support for 480/960 kHz for non-initial access case, and open to 240/480/960 for initial access case, if the UE complexity can be limited. The discussion of SCS for initial access should take into account the sync raster design in RAN4. |
| NEC | Support 480 and 960 kHz SCSs for non-initial access case and initial access case. |
| ZTE, Sanechips | Support SCS 480/960 kHz for operating with single numerology, to achievie required time synchronization accuracy and reduced synchronization complexity. |
| DOCOMO | As captured by the moderator above, we support 480/960 kHz for non-initial access case. For initial access, we are also open to 240/480/960 kHz, while we slightly prefer to deprioritize 240 kHz as the advantage seems small and the number of supported SCSs should be minimized in our view. As Samsung mentioned above, we should consider factors related to RAN4, including sync raster design and minimum channel bandwidth. |
| LG Electronics | It is confirmed that our views are correctly captured. From our understanding, the main motivation to introduce new SCS(s) for SSB is to provide a tool for a UE to be operated with single numerology as much as possible. However, as described in our Tdoc [17], CSI-RS having the same numerology with the SCS configured for the active BWP can be considered as an alternative of SSB for most use cases. |
| Spreadtrum | The SSB with 480 and 960kHz SCS could be supported for measurement to reduce UE complexity when UE is receiving data with 480 and 960kHz SCS. For CSI-RS based measurement, in our view, CSI-RS validation is not well supported in NR-U. |
| vivo | Support at least one of 480/960KHz SCS for SSB in non-initial access case and initial access case.  Support for 480/960KHz for non-initial access case is needed due to single numerology, measurement complexity, time synchronization accuracy and complexity, as mentioned above.  For initial access, we need to determine supported numerology for initial DL BWP first as described in 2.1.4. When looking at FR1&FR2, the SCS for data/control in normal BWP is both supported for initial DL BWP, e.g. 60K/120K in FR2. The benefit is to avoid BWP switching for UE operation. Following this, 480K/960K should be supported for initial DL BWP. If this is the case and only allows 120K SSB for initial access, it will occur (120K, 480K) and (120K, 960K) combination with mixed numerology, which will result in problems such as K\_offset indication, time synchronization accuracy and etc. So it is better to support at least 960K SSB to avoid these problems. |
| Nokia | Support for 240kHz for initial cell selection. In order to enable single sub-carrier spacing operation in selected cells (such as Scells) we would support 480/960kHz scs at least for Scells/non-initial access/cell selection case. We are open to support 480/960kHz scs for initial cell selection case as well.  Please note that it would be good to try to clarify what all use cases are considered as non-initial access. E.g. does the initial access cover UE initial cell selection procedure without any assistance information or does it also cover other/all cases when cell is accessed. For example, if SSB center frequency (together with scs) is provided in system information (for IDLE) or via Connected mode signaling, can that considered to be part of non-initial access? E.g. can we differentiate initial cell selection procedure from other cases. |
| Charter Communications | Support 480 and 960 kHz SCSs for non-initial access case and initial access case to facilitate running a cell with a single numerology. We did not observe any performance benefit in terms of PCI detection performance with 240 kHz SCS compared to 120 kHz SCS. |
| Futurewei | Support a single numerology (120 kHz) for initial access (initial cell selection). We are open to discuss the benefits in having larger SCS (480kHz, 960 kHz) for non-initial access. |
| Ericsson | Support 120/240 kHz in an initial BWP.  Support 480/960 kHz for an SCell. |
| Qualcomm | Initial access: 120 and 240 kHz (FFS for 480/960 kHz)  Non-initial access: 120/240/480/960 kHz  Study the feasibility of 480 and 960 kHz wrt UE search complexity for initial access and non-initial access  Study the initial timing resolution based on low SCS (120/240 kHz) and its impact on higher SCS data |
| OPPO | Support 480/960 kHz SSB for both initial access and non-initial access cases. |
| InterDigital | Support 120/240 kHz for initial access (FFS 480/960kHz)  Support 120/240/480/960kHz for non-initial access |
| Fujitsu | Firstly, to clarify initial access case and non-initial access case, in our view, initial access case is referring to SSB locates at a sync raster and is associated with RMSI based on which UE can perform random access to access the cell, and non-initial access case is talking about the other SSBs.  Support 480/960 kHz for non-initial access.  For initial access, as mentioned by other companies e.g. Samsung and DOCOMO, some aspects related to RAN4 need to be considered, e.g. minimum channel bandwidth and maximum mandatory bandwidth of UE. Since the bandwidth issues are under discussion in RAN4, RAN1 can wait for RAN4’s decision or send LS to RAN4 asking about the situation, and then further discuss the SCS of SSB for initial access accordingly. |
| Xiaomi | Support 240 for initial access case for initial access, open for one of 480/960 for initial access as well .Support 480/960 for same numerology operation after initial access. |
| AT&T | One or both of 480 and 960 kHz for both initial access and non-initial access cases. Okay to mandate only 120 kHz for initial access and leave additional SCSs to capability. |
| CATT | Support SSB and all other physical channels in the same numerology 120, 480 and 960 kHz SCS  FFS: 120 kHz SCSfor SSB/initial access channel and 480 kHz, 960 kHz for other physical channel |
| Apple | We support 480kHz for none-initial access case and initial access case. However, we do not see strong justification to support 960kHz for SSB including both initial access and non-initial access case. Note that 480kHz SSB is sufficient to support 960kHz data control from timing accuracy perspective. In addition, TRS with 960kHz SCS can be used if single SCS is pursued. |
| Intel | Support SCS 480 kHz and 960 kHz for SSB and initial BWP. There are some deployments where both gNBs and UEs are fully controlled by the network operator. In these scenarios, the support of single numerology operation can enable efficient transceiver implementation and operation. In order to have an option for single numerology operation across initial access, control and data transmissions, RAN1 specification should support SCS 480 kHz and 960 kHz for SSB and initial BWP. |
| Huawei, HiSilicon | First, we think that the discussion of additional SSB SCS needs to be split into SSB SCS for Initial Access and non-Initial Access from the outset due to the following reasons:   * WID considers two separate objectives for possible additional SCSs for SSBs:  |  | | --- | | * “Study and specify, if needed, additional SCS (240kHz, 480kHz, 960kHz) for SSB, and additional SCS(480kHz, 960kHz) for initial access related signals/channels in initial BWP. * Study and specify, if needed, additional SCS (480kHz, 960kHz) for SSB for cases other than initial access.” |  * Most companies have studied the issues of additional SSB SCS for Initial access and non-initial access scenarios separately as additional SSBs for each scenario has its own challenges and possible applications.   In any case, to provide our view, we do not think any additional SSB SCS is required for either of the initial access and non-initial access scenarios. Moreover, all operations during Initial access can be done using 120 kHz SCS (see our discussions in 2.1.3 for further details).   * Some of the reasons that additional SSB SCSs are not required for initial access:   + Additional SSB SCSs increases UE blind search complexity due to increased number of blind detections.   + Although SSB burst with a higher SCS in general has a shorter length, this does not translate into a smaller initial access latency as, during initial access, UE buffers a 20 ms (default SSB periodicity) of the signal around the synch raster and tries to find the SSB within the buffered duration. Moreover, the initial access latency also includes higher layer latencies that are independent from the used SCS.   + The number of required time samples per unit of time to detect SSB is proportional to the SSB SCS. This results in an added complexity for a UE if a higher SSB SCS is used.   + The achievable DL timing accuracy of SSB with 120 kHz is around 34 ns which is considerably below the CP of 960 kHz SCS that may be used in th connected mode. It is most likely that the timing accuracy obtained using 120 kHz SCS is enough for operation in 960 kHz. Even if the achievable DL timing accuracy is not enough for high data rate operation, fine tuning of timing is readily possible using TRS after initial access.   + SSBs with higher SCSs have a lower coverage as well-documented during SI. As a side effect, if a higher SCS is used, more actually-transmitted SSB beams may be required to provide the same coverage as that of the 120 kHz SSB.   + A 48 PRB CORESET#0 that uses Mux pattern 3 with SSB, requires at least 800 MHz in 960 kHz SCS. 800 MHz Minimum Channel BW is too large and may not be practical. More practical minimum channel BWs restrict the SSB CORESET#0 multiplexing to Pattern 1 only, which does not necessarily translate in faster beam sweeping than using 120 kHz SSB.   + Specification effort associated with designing SSB patterns, CORESET#0 Mux with SSB, and other initial access channels/signals if 480/960 kHz SSBs are agreed do not justify any possible potential gain. * Some of the reasons that additional SSB SCSs are not required for cases other than initial access:   + A main usage of SSB in connected mode is RRM purposes. Even if SSB and data use the same numerology (i.e., both 960 kHz or both 480 kHz), UE still requires to have scheduling restrictions/measurement gap for RRM measurement. Use of single numerology does not avoid scheduling restriction/MG during SMTC. There are scenarios that SSB measurement for RLM also needs scheduling restrictions even if SSB and data have the same SCS.   + Almost all usages of SSB in the connected mode (RRM, RLM, BFD-RS, BFR-RS, CSI) can be done using CSI-RS with the same numerology of the Active BWP. If SSB measurement in a different numerology than that of Active BWP is problematic (which we do not believe it is), CSI-RS with the same numerology as that of the Active BWP is readily available.   + Since SSBs of neighboring cells are measured during RRM, the single-numerology operation cannot be deployed per cell. In practice, the whole network has to operate on a single numerology to make the single numerology operation per UE even possible.   + Switching BWP1 with SCS1 to BWP2 with SCS2 is already supported in Rel-15/16. After RRC configuration, UE can switch its initial BWP with 120 kHz SCS to a configured BWP with 480/960 kHz to increase its maximum achievable data rate if necessary (BWP change can also happen any time during RRC Connected state). The BWP switch delay is provided in Table 4.5.6.1.0.1-1of TS 38.533 as follows:   Table 4.5.6.1.0.1-1: BWP switch delay   |  |  |  |  | | --- | --- | --- | --- | |  | NR Slot length (ms) | BWP switch delay TBWPswitchDelay (slots) | | | Type 1Note 1 | Type 2Note 1 | | 0 | 1 | 1 | 3 | | 1 | 0.5 | 2 | 5 | | 2 | 0.25 | 3 | 9 | | 3 | 0.125 | 6 | 18 | | Note 1: Depends on UE capability.  Note 2: If the BWP switch involves changing of SCS, the BWP switch delay is determined by the smaller SCS between the SCS before BWP switch and the SCS after BWP switch. | | | |   As can be observed, the absolute time of BWP switch delay without changing SCS is the more or less the same for all SCSs (e.g. 1 ms for mu=0 and 0.75 ms for mu=3 for type 1). This trend most likely will continue for higher SCSs. Therefore, the BWP switching latency from 960 kHz BWP to 960 kHz BWP is not considerably smaller, if any, than the BWP switching latency from 120 kHz BWP to 120 kHz BWP. More important, BWP switching delay from a lower SCS to a higher SCS is determined by the BWP switching delay of a higher SCS. In other words, changing BWP from 120 kHz SCS to 960 kHz SCS does not incur a longer delay than changing a BWP from 480/960 kHz SCS to another 960 kHz SCS (Please Note 2 of the above table)  If more accurate DL synchronization is required due to the use of 960 kHz data channel, this can be achieved using configured 960 kHz TRS after initial access. |
| Lenovo, Motorola Mobility | Support 480 kHz and 960 kHz SCS for both initial access and non-initial access cases. We are also open for supporting 480/960 kHz for only non-initial access case. |

*Moderator Note: Below are tentative summary and suggested conclusion, please continue to add comments to above until discussion in GTW. Moderator will update the summary and suggested conclusionas further comments are provided.*

**Moderator Summary of Discussions #1**

* Several companies discussed limiting the applicability of larger SCS based SSB to non-initial access, SCell, cases without assistance information, etc. It would good to clarify the mode of operation in which specific SCS SSB will be limited to (if agreed to be supported and if agreed to be limiting). Moderator has provide a suggested definition that could be use for discussion purposes:
  + “SSB in non-initial access” in this discussion refers to:
    - SSB in SCell, where gNB is able to provide assistance information (e.g. SSB center frequency, SCS, etc)
    - SSB for neighbor cell RRM measurements, where information is provided by gNB).
  + “SSB in initial access” in discussion
    - SSB used for “Cell Selection” defined in TS38.133 Section 4.1, which includes stored information cell selection and initial cell selection.
* The following is summary of company opinion:
  + No other SCS (other than agreed 120kHz):
    - Huawei, HiSilicon, MediaTek
  + Additionally support 240 kHz:
    - For initial access & non-access: Nokia, Spreadstrum, LGE, Ericsson, Qualcomm
  + Additionally support 480 kHz:
    - For both initial & non-initial access: Lenovo, Motorola Mobility, ZTE, Sanechips, OPPO, CAICT, Intel, Samsung Apple, Convida(?), AT&T, Fujitsu (FFS)
    - For non-initial access: Fujitsu, , Ericsson, Qualcomm, NTT Docomo
  + Additionally support 960 kHz
    - For both initial & non-initial access: Lenovo, Motorola Mobility, ZTE, Sanechips, OPPO, CAICT, vivo, Intel, Samsung, AT&T, Fujitsu (FFS)
    - For non-initial access: Fujitsu, Ericsson, Qualcomm, NTT Docomo
* Majority of the companies seems to at least support 480/960kHz for non-initial access cases. With that said, suggest to discuss in GTW to at least hear out the companies that do not believe no other SCS (than 120 kHz) is needed to explain their logic and motivation. Also discuss the support of 240 kHz SCS SSB.
* [Strive to make a conclusion in GTW.] Further discuss on following statement (as a starting point for further discussion):
  + Support 480kHz and 960kHz SCS SSB for non-initial access cases
  + FFS: support 480 kHz and/or 960 kHz SCS SSB for initial access cases
  + FFS: support 240 kHz SCS SSB for initial and non-initial access cases
    - “SSB in non-initial access” here refers to:
      * SSB in SCell, where gNB is able to provide assistance information (e.g. SSB center frequency, SCS, etc)
      * SSB for neighbor cell RRM measurements, where information is provided by gNB).
    - “SSB in initial access” here refers to
      * SSB used for “Cell Selection” defined in TS38.133 Section 4.1, which includes stored information cell selection and initial cell selection.

### 2.1.3 Mixed Numerology between SSB and CORESET#0

* From [1] FUTUREWEI:
  + The SCS for all SS/PBCH blocks and CORESET #0 on a carrier is always the same for operation in 60GHz shared spectrum.
* From [3] ZTE, Sanechips:
  + The following multiplexing patterns and combinations of SCSs of SSB and Type0-PDCCH can be considered for Rel-17 NR above 52.6 GHz.
    - (SSB, Type0-PDCCH): SCS (120 kHz, 120 kHz)
      * Multiplexing patterns: 1, 3
    - (SSB, Type0-PDCCH): SCS (480 kHz, 480 kHz)
      * Multiplexing patterns: 1, 3
    - (SSB, Type0-PDCCH): SCS (960 kHz, 960 kHz)
      * Multiplexing patterns: 1, 3
* From [7] CAICT:
  + In order to match different SCS, different initial BWP should be considered.
* From [9] vivo:
  + Support the following SCS pairs for SSB and initial DL BWP in NR operation from 52.6-71GHz：(120K, 120K) + (960K, 480K) + (960K, 960K).
* From [12] Intel:
  + Observation: Single numerology operation can enable efficient transceiver implementation and operation.
* From [14] AT&T:
  + The same subcarrier spacings are specified for initial access related signals and channels in the initial BWP and cases other than initial access.
* From [25] Qualcomm:
  + consider the following SSB and CORESET0 SCS combinations:
    - SSB SCS = 120 kHz, CORESET0 SCS = 120, 480, 960 kHz
    - SSB SCS = 240 kHz, CORESET0 SCS = 120 kHz
    - SSB SCS = 480/960 kHz, CORESET0 SCS = SSB SCS

Table : Allowed SSB/CORESET0 SCS Combinations

|  |  |  |  |
| --- | --- | --- | --- |
| **SSB SCS (kHz)** | **CORESET0 SCS (kHz)** | | |
| **120** | **480** | **960** |
| **120** | Yes | Yes | Yes |
| **240** | Yes | No | No |
| **480** | No | Yes | No |
| **960** | No | No | Yes |

**Summary of Discussions in Tdoc**

* Various views on which SCS combinations of SSB and CORESET#0 (initial DL BWP)
  + Some companies explicitly listed the SCS combinations for SSB and CORESET#0
    - (SSB 120kHz, CORESET#0 120kHz)
    - (SSB 120kHz, CORESET#0 480kHz)
    - (SSB 120kHz, CORESET#0 960kHz)
    - (SSB 480kHz, CORESET#0 480kHz)
    - (SSB 480kHz, CORESET#0 960kHz)
    - (SSB 960kHz, CORESET#0 480kHz)
    - (SSB 960kHz, CORESET#0 960kHz)
* Suggest to discuss further the supported SCS combination of SSB and CORESET#0 (initial DL BWP)

**Discussions #1**

* Please provide further views on supported SCS combination for SSB and COERSET#0.

|  |  |
| --- | --- |
| **Company** | **Discussions/Comments** |
| Samsung | At least same SCS between SSB and CORESET#0 should be supported and prioritized. Mixed SCS can be evaluated further based on the need. |
| NEC | Support the same SCS for SSB and CORESET#0 as a baseline, and open to the other SCS combination(s). |
| ZTE, Sanechips | Same SCS for SSB and CORESET#0 should be supported to reduce the complexity of multiplexing and indication of the SCS of CORESET#0, etc. The following three SCS pairs for SSB and CORESET#0 can be considered.   * + - (SSB 120kHz, CORESET#0 120kHz)     - (SSB 480kHz, CORESET#0 480kHz)     - (SSB 960kHz, CORESET#0 960kHz) |
| DOCOMO | We agree same SCS between SSB and CORESET#0 should be supported and prioritized. After that, for mixed SCS, (SSB 120kHz, CORESET#0 480/960kHz) should be discussed at first. We do not see the motivation to support (SSB 480kHz, CORESET#0 120kHz) and (SSB 960kHz, CORESET#0 120/480kHz) |
| LG Electronics | Before discussing multiplexing between SSB and CORESET#0, we should first discuss whether new SCS for SSB/CORESET#0 during initial access is supported or not. If new SCS for SSB/CORESET#0 during initial access is not supported, the current specification would suffice. |
| Spreadtrum | Qualcomm’s table could be starting point of discussion. |
| vivo | Down selection of the above combinations is needed. The comparison could be based on complexity, spec impact, synchronization accuracy and etc. |
| Nokia | Like noted above we would also like to consider the support of 240kHz scs for SSB. Hence, would propose following combinations (accounting the support of 480kHz and 960kHz scs) as a first priority (numbers in square brackets gives the considered SSB and CORESET#0 multiplexing patterns):   * + - (SSB 120kHz, CORESET#0 120kHz) [#1,#3]     - (SSB 240kHz, CORESET#0 120kHz) [#1,#2]     - (SSB 480kHz, CORESET#0 480kHz) [#1]     - (SSB 960kHz, CORESET#0 960kHz) [#1]   Afore listed 480kHz and 960kHz SSB and CORESET#0 multiplexing patterns could be considered also in a certain from of non-initial access, e.g. if scenario noted in Section 2.1.2 can be considered as non-initial access.  Depending on RAN4 agreements on support BW options, the SSB and CORESET multiplexing patterns can be further discussed. |
| Charter Communications | Agree with Samsung and NEC |
| Futurewei | Support having the same SCS for SSB and CORESET#0. Mixed numerology should not be considered at this time. |
| Ericsson | Agree with LGE. It should first be discussed if SCS other than 120 kHz for CORESET0 are supported before going into the details of which combinations of SSB/CORESET0 SCS are supported. Otherwise it becomes a hypothetical discussion. We support the following combinations assuming 120 kHz CORESET0:   * + (SSB 120kHz, CORESET#0 120kHz)   + (SSB 240kHz, CORESET#0 120kHz) |
| Qualcomm | SSB SCS = 120 kHz, CORESET0 SCS = 120, 480, 960 kHz  SSB SCS = 240 kHz, CORESET0 SCS = 120 kHz  SSB SCS = 480/960 kHz, CORESET0 SCS = SSB SCS |
| OPPO | We slightly prefer to support single numerology for SSB and CORESET#0 multiplexing. |
| InterDigital | Agree with LGE and Ericsson that supported SCSs for CORESET0 should be discussed before discussing combinations. |
| Fujitsu | Same SCS for SSB and CORESET#0 should be prioritized. In addition, 480kHz and/or 960kHz SCS for CORESET#0 can be supported only if 480kHz and/or 960kHz SCS is supported for SSB for initial access. |
| Xiaomi | Support the combination by QC with a little modification below:  SSB SCS = 120 kHz, CORESET0 SCS = 120, 480/960 kHz |
| AT&T | The important point is that for each SSB SCS we also have the same CORESET0 SCS. Mixed numerology cases can be specified but we don’t see these as important. Same as R15 FR1 and FR2 basically. |
| CATT | Same SCS for SSB and CORESET#0. |
| Apple | We think at least a same numerology between SSB and CORESET should be supported for new SCS if the corresponding SSB SCS would be agreed in earlier question. Support different SCS combination should be justified by strong and clear use cases. |
| Intel | The support of operation with the same SCS for SSB and CORESET#0 should be prioritized in RAN1. For mixed SCS, the combination of (SSB 120/240 kHz, CORESET#0 120 kHz) could be easily accepted as it requires almost zero specification efforts in RAN1. Other scenarios with mixed SCS operation could be de-prioritized. |
| Huawei, HiSilicon | (SSB 120kHz, CORESET#0 120kHz): We don’t see any usage for mixed numerology during Initial Access. Both SSB and CORESET#0 in 120 kHz are sufficient. As discussed in our answer in Section 2.1.2, using a higher numerology does not shorten Initial access procedure anyway. As PDCCH in CORESET#0 is QPSK, the PN effect on 120 kHz is negligible based on observations in SI and there is no need to use a higher SCS to counter the PN effect. |
| Lenovo, Motorola Mobility | If 480/960 kHz SCS are agreed to be supported for both CORESET#0 and SSB, we support prioritizing the option of same SCS for SSB and CORESET#0. Mixed numerology cases need further study on the potential multiplexing complexity. |

*Moderator Note: Below are tentative summary and suggested conclusion, please continue to add comments to above until discussion in GTW. Moderator will update the summary and suggested conclusionas further comments are provided.*

**Moderator Summary of Discussions #1**

* Several companies stated support of same SCS between SSB and CORESET#0 should be the starting point for further discussions, and this mode of operation should be prioritized.
* From moderator’s understanding if initial access is not supported for 480, and 960 kHz SCS, then there is no need for consideration of SSB and CORESET#0 SCS combination when SSB is either 480 or 960 kHz. This is because SSB/CORESET SCS combination is only relevant for Type0-PDCCH search space configured by MIB.

Further discuss on following statement (as a starting point for further discussion):

* For CORESET and Type0-PDCCH search space configured in MIB:
  + Support {SS/PBCH Block, CORESET for Type0-PDCCH} SCS is {120, 120} kHz
    - FFS: SSB and CORESET multiplexing pattern, number of RBs for CORESET, number of symbols (duration of CORESET), SSB to CORESET offset RBs.
  + If 480kHz and 960 kHz SSB SCS are agreed to be supported, and if initial access is also supported for these SSB SCS,
    - Support {SS/PBCH Block, CORESET for Type0-PDCCH} SCS is {480, 960} kHz
    - Support {SS/PBCH Block, CORESET for Type0-PDCCH} SCS is {960, 960} kHz
  + FFS:
    - (If 240kHz SSB SCS is agreed to be supported){SS/PBCH Block, CORESET for Type0-PDCCH} SCS is {240, 120} kHz
    - {SS/PBCH Block, CORESET for Type0-PDCCH} SCS is {120, 480} kHz
    - {SS/PBCH Block, CORESET for Type0-PDCCH} SCS is {120, 960} kHz
    - {SS/PBCH Block, CORESET for Type0-PDCCH} SCS is {480, 960} kHz

### 2.1.4 Initial Access Support for additional Numerologies

* From [2] Lenovo, Motorola Mobility:
  + For supporting NR from 52.6 GHz to 71 GHz in Rel. 17, if higher subcarrier spacings (numerologies) are adopted for initial access, new CORESET0 mapping structures should be investigated
* From [6] Nokia, NSB:
  + Support additional SCS (480 kHz, 960 kHz) for SSB for other use cases than initial cell selection (e.g. for Scell, BM and RRM).
* From [13] Fujitsu:
  + 480kHz and/or 960kHz SCS for initial BWP can be supported only if 480kHz and/or 960kHz SCS is supported for SSB for initial access.
* From [14] AT&T:
  + Specify one additional SCS (either 480kHz or 960kHz) for initial access related signals and channels in the initial BWP
* From [16] InterDigital:
  + Observation: A single numerology operation is beneficial and NR in 52.6 – 71 GHz already supports a single numerology operation with existing SCS. It’s possible to support a single numerology operation with 120 kHz for UE which wants to avoid frequency numerology change and corresponding complex UE implementation while other UE, which is ready to support additional SCSs and numerology changes, achieves performance benefits with relatively complex UE implementation. Designing new SSBs and initial access related signals/channels for additional SCSs may require a lot of evaluations and corresponding discussions under the limited TUs for the WI.
  + Further study necessity of SSBs and initial access related signals/channels for additional SCSs in Rel-17.
* From [20] Samsung:
  + Whether extra SCS can be supported for SS/PBCH block in initial access depends on the synchronization raster interval.
    - If any of 480 kHz or 960 kHz SCS is supported as default SCS of SS/PBCH block in initial access, the CORESET#0 configuration corresponding to the same SCS as SS/PBCH block should be supported.
* From [22] Ericsson:
  + For cases other than initial access (e.g. for an SCell), support 480 and 960 kHz SCS for SS/PBCH block.
  + Observation: For basic SCell operation, two of the spare bits in IE SubcarrierSpacing can be used to indicate either 480 or 960 kHz SCS for a non-initial BWP via dedicated signaling.

**Summary of Discussions in Tdoc**

* Several companies has discussed whether specific SSB SCS could be used for initial access or whether they should be strictly used only for Scell or non-initial cell selection cases. Some examples of expressed views:
  + 480/960 kHz SSB used for other than initial cell selection:
    - Nokia, NSB, Ericsson
  + 480/960 kHz SSB used for initial access:
    - * AT&T, Samsung
* Suggest to discuss together with supported numerology (2.1.2).

**Discussions**

* Please provide further comments in Section 2.1.2

### 2.1.5 SSB Resource Pattern

* From [1] FUTUREWEI:
  + For 60GHz shared spectrum, consider the support of 120kHz SCS for SS/PBCH (Case D) with necessary changes for LBT opportunities between consecutive SS/PBCH blocks.
* From [2] Lenovo, Motorola Mobility:
  + Observation: For supporting NR from 52.6 GHz to 71 GHz in Rel. 17, if higher subcarrier spacings (numerologies) are adopted for SSB, beam switching issue would appear between the contiguous SSB beams since the CP length would not be enough for beam switching, and an extra gap might be needed to prevent performance degradation.
  + For supporting NR from 52.6 GHz to 71 GHz in Rel. 17, if higher subcarrier spacings (numerologies) are adopted for SSB, then to allow the beam switching between contiguous SSBs, a gap (for example a symbol gap or post prefix) should be supported before beam switching.
* From [3] ZTE, Sanechips:
  + For designing SSB patterns with different SCSs for NR operation above 52.6 GHz, it is proposed to reuse the existing design (i.e. Case A/C, Case B/D and Case E) as much as possible, and take different impacts in single/mixed numerology operation into account.
  + The following options can be considered for supporting beam switching for SSB with SCS 480 kHz and 960 kHz.
    - Option 1: In a half-frame, any two candidate SSBs are discontinuous in the time domain
      * Option 1-1: SSB pattern with SCS 480/960 kHz can adopt the existing pattern of Case A and Case C in one or two slots defined in Rel-15 NR
      * Option 1-2: SSB pattern with SCS 480/960 kHz should be re-designed to reserve at least one symbol between any two candidate SSBs, e.g. only defining one candidate SSB per slot
    - Option 2: Multiple adjacent candidate SSBs are defined to have a same SSB index or QCL assumption
* From [5] Huawei, HiSilicon:
  + Reuse SSB pattern case D for 120 kHz SCS without change at least for licensed operation.
* From [7] CAICT:
  + For the SSB design of 120kHz SCS, the distribution of SSB in each slot could be enhanced.
* From [9] vivo:
  + Observation: No additional gap can considered to accommodate beam switching gap if 120 KHz/240 KHz/480KHz SCS s are used for NR operation up to 71GHz.
* From [10] TCL:
  + FR2 existing SCS and new numerologies can provide a large number of potential SS/PBCH candidate positions to combat channel uncertainty issues.
  + It is proposed to investigate how to transmit the indication about additional SS/PBCH candidate positions which can become available with existing FR2 numerologies or future new numerologies.
* From [12] Intel:
  + Same SSB pattern and Type0-PDCCH CSS configuration to be applicable to 480 kHz and 960 kHz with numerology scaling.
  + Consider 480 kHz and 960kHz SCS based SSB positions in a slot with SSB symbols 2, 3, 4, 5 and 9, 10, 11, 12 in a slot.
    - Note: symbols numbers are enumerated from 0.
* From [19] Xiaomi:
  + Observation: For 120k SCS SSB pattern, there is no candidate SSB positions in 5ms window.
  + At least one SCS beyond 120 kHz should be supported for SSB for initial access and its pattern need update.
* From [20] Samsung:
  + Support new SS/PBCH block pattern for 480 kHz and 960 kHz SCSs.
    - At least one symbol should be reserved between neighboring SS/PBCH block for beam sweeping delay.
    - Symbols should be reserved for CORESET and HARQ with same SCS as SS/PBCH block.
* From [21] CEWiT:
  + Observation: At least for 120KHz SCS, existing SSB design can be reused for NR above 52.6GHz
  + Support for a new SSB design to accommodate more number of SSB beams in the 5ms window and also to accommodate beam switching gap.
  + 120KHz and one among 480KHz and 960KHz should be supported for SSB transmission in NR above 52.6GHz
* From [22] Ericsson:
  + Discuss and agree on design principles for defining SSB time domain patterns for 480 and 960 kHz SCS, including whether or not it is needed to include short gaps for beam switching (e.g., 1 OFDM symbol) and/or long gaps (e.g., 2 slots) to allow for UL transmissions.
  + Use SSB time domain patterns for 120 and 240 kHz SCS as defined for FR2 as a starting point for the design.
* From [23] Apple:
  + Extending the current 120kHz SCS SSB pattern for 480KHz SCS such that PUCCH occasion(s) can be reserved after two consecutive SSBs.

****

* From [25] Qualcomm:
  + Observation:
    - to accommodate explicit SSB beam switching gaps, a new SSB pattern may be required for larger SSB SCS (SCS = 480 kHz and 960 kHz)
    - a symbol-level (1 symbol) SSB beam switching gap may be required for larger SSB SCS (SCS = 480 kHz and 960 kHz)
    - for larger SSB SCS (480 kHz and 960 kHz), accommodating UL segments within the SSB burst may require accounting for DL/UL switching delays taking considerable number of symbols (possibly slot-level)
  + for the SSB for NR operation in the frequency between 52.6GHz and 71GHz and SCS = 480 kHz and 960 kHz, consider defining an SSB pattern consisting of multiple “SSB slots” where SSB symbols for one or more beams are contained in the “SSB slot”
    - A beam switching gap of 1 symbol is inserted between SSBs within the “SSB slot”
    - Additional control symbols may be defined in the SSB slots with beam switching gaps between control and SSB symbols of different beams
    - Additional “gap slots” may be inserted between “SSB slots” to account for URLLC and UL traffic





* From [26] NTT Docomo:
  + When new SCSs are supported for SSB, the two alternatives below can be considered for SSB mapping in time domain:
    - Two SSBs per slot, with guard period of at least 1 symbol between the SSBs
    - One SSB per slot
* From [27] WILUS:
  + At least one symbol gap in time domain between SS/PBCH blocks with different SSB indices should be considered for higher subcarrier spacing (e.g., 960kHz) taking into account a beam switching gap due to a RF interruption time of Tx/Rx beams and/or LBT gap in unlicensed spectrum.

**Summary of Discussions in Tdoc**

* For the not yet specified SSB SCS (i.e. 480 and 960 kHz), several companies provided proposals on which OFDM symbols and slots the SSB should be mapped on.
* For 120 kHz SSB SCS, few companies suggested to update the SSB pattern (OFDM symbols and slots SSB is defined for).
* Suggest to discuss first supported SSB numerology. For the agreed SSB numerology, e.g. 120 kHz, suggest to discuss SSB resource patterns (including whether existing pattern should be applicable).

**Discussions #1**

* While moderator suggest to first discuss SSB numerology, companies are encourage to provide additional discussions to SSB pattern for the (potentially) supported SSB SCS, including whether 120 kHz SSB pattern (OFDM symbol, slot placement) could be used as is or further update is needed.
* For issues related to SSB pattern update due to support of DRS, please provide comments in 2.1.1 to keep the relevant discussions in the same section.

|  |  |
| --- | --- |
| **Company** | **Discussions/Comments** |
| Samsung | If 480/960 kHz is supported for SSB, the corresponding SSB pattern should reserve 1 symbol between neighboring SSB for beam sweeping gap. |
| NEC | Support considering the effect of switching time requirement on SSB pattern for 480 and 960kHz SSB SCS. |
| ZTE, Sanechips | We provide several options related to SSB pattern/transmission that can be considered to support beam switching and/or LBT operation.   * Option 1: Any two candidate SSBs are discontinuous in the time domain * Option 1-1: SSB pattern with SCS 480/960 kHz can adopt the existing pattern of Case A and Case C in one or two slots defined in Rel-15 NR * Option 1-2: SSB pattern with SCS 480/960 kHz should be re-designed to reserve at least one symbol between any two candidate SSBs, e.g. only defining one candidate SSB per slot * Option 2: Multiple adjacent candidate SSBs are defined to have a same SSB index or QCL assumption   Among above, we think Option 2 is preferred as it has no limitation on SSB pattern design. With it, Case D SSB pattern for 120 kHz can also be reused for 480kHz/960kHz. |
| DOCOMO | We agree with Samsung that beam sweeping gap with at least 1 symbol should be considered for SSB with 480/960 kHz SCS if supported. We also think that how to utilize resources in a SSB slot efficiently should be considered with beam switching gap. To minimize the overhead due to beam switching gap, a different SSB pattern within a slot for new SCSs, e.g., one SSB per slot, can be considered so that SSB/CORESET#0/SIB1 with same beam can be transmitted within a same slot and only one beam sweeping cycle per period can be achieved. |
| LG Electronics | For 120 kHz SSB which is already agreed to be supported, existing SSB pattern applied for 120 kHz, i.e., Case D, should be reused. |
| vivo | Agree that beam switching gap problem needs to be considered for SSB with 480K/960K SCS. The following alternatives could be considered:   * + - Alt. 1: New SSB pattern introducing gaps between contiguous candidate SSBs;     - Alt. 2: The same QCL assumptions for contiguous candidate SSBs (e.g. case D in TS38.213);     - Alt. 3: Hopping transmission for contiguous candidate SSBs (e.g. case E in TS38.213). |
| Nokia | We consider that assumption for the beam switching time is << 70 ns meaning that normal cyclic prefix length of 960 kHz subcarrier spacing is long enough to handle beam switching and no explicit beam switching gap is needed between successive SSB blocks. Thus, in our understanding it should be possible to do the beam switching within CP for 480kHz and 960kHz scs so that no additional beam switching gap is needed. To conclude it might be best to consider sending a LS to RAN4 to update or confirm the assumed beam switch time duration. |
| Futurewei | Support existing patterns (such Case D for 120kHz). For shared spectrum, the need of LBT and LBT failure prior to a sequence of SSB transmissions should be discussed. |
| Ericsson | It seems that at least two high level design decisions need to be agreed:   1. Whether or not a symbol gap is needed between SSBs within a slot for beam switching purposes 2. Whether or not a slot-level gap is needed in the pattern, e.g., to allow UL transmissions. This discussion should account for the required DL/UL and UL/DL switching times in order to provide sufficient opportunity for UL transmissions (if slot level gaps are agreed).   Then we can decide if the existing patterns (e.g., Case D) can be reused "as is" or require some modifications. |
| Qualcomm | For higher SCS (at least for 960 kHz and possibly 480 kHz):   * consider adding 1 symbol gap between beams * consider adding slot-level gap for UL/DL switching and UL/URLLC traffic within the pattern |
| OPPO | If 480/960 kHz SSB is supported, we agreed with that at least one symbols should be reserved between neighboring SSBs for the corresponding SSB pattern. But the details should be discussed after we agree to introduce the new SCSs for SSB. |
| InterDigital | We agree that adding a time gap for 960 kHz SSB is needed, if supported. For 480 kHz, further study should be needed. |
| Xiaomi | If 480/960 kHz is supported for SSB, the corresponding SSB pattern can be modified, detail can be FFS after the agreement of 2.1.2. |
| Apple | We support Nokia’s proposal to send RAN4 LS about the beam switching time of new SCSs. As discussed in study item phase, the beam switching gap is an absolute time in a range of <100us. With this assumption, it is still within CP length of 480kHz SCS, but it exceeds the CP length of 960KHz SCS. Nevertheless, it is necessary to ask RAN4 for this as inputs of the design. |
| Intel | For SSB with SCS 480 kHz and 960 kHz, RAN1 specification should support an SSB pattern with at least 1-symbol time gap between consecutive SSB/Type0-PDCCH transmissions. However, minimum 1-symbol gap between SSB and CORESET#0 may result in a slightly larger number of OFDM symbols between consecutive SSBs (up to 3 symbols). Therefore, some further discussion on the number of OFDM symbols for the gap would be useful. |
| Huawei, HiSilicon | As discussed in our reply to Section 2.1.2, only 120 kHz SSB needs to be supported in which case the same Pattern D can be reused for the location of SSB indexes at least for licensed band. |
| Lenovo, Motorola Mobility | If 480/960 kHz SCS are supported for SSB, beam switching gap e.g. a symbol gap between SSB candidates needs to be introduced. |

*Moderator Note: Below are tentative summary and suggested conclusion, please continue to add comments to above until discussion in GTW. Moderator will update the summary and suggested conclusionas further comments are provided.*

**Moderator Summary of Discussions #1**

* Several companies commented that with the sub 100ns beam switching time (which was the assumption during Rel-15), minimum 1 symbol could be needed between SSB for beam switching for larger SSB SCS.
* Companies also commented some reserved symbols could be needed to provide slot-level gap between DL and UL for larger SSB SCS.
* This discussion does depend on whether 480 kHz and 960 kHz SSB is supported (at least for non-initial access cases). However, given that there is significant number of companies supportive of 480kHz and 960 kHz SSB SCS at least for non-initial access case, let hypothetically assume they are supported and discuss further.

Further discuss on following statement (as a starting point for further discussion):

* For 480 kHz and 960 kHz SSB SCS (if agreed)
  + consider adding 1 symbol gap between beams
  + consider adding slot-level gap for UL/DL switching within the pattern
    - *Moderator note: may need to clarify what slot-level gap is*
  + Send an LS to RAN4 to get input on gap required for beam switching, e.g. whether 100ns beam switching gap assumed during Rel-15 NR is applicable for NR operating in 52.6 ~ 71 GHz.

### 2.1.6 SSB and CORESET#0 Multiplexing

* From [1] FUTUREWEI:
  + Support a configuration of SS/PBCH and Type-0 PDCCH multiplexed in the same slot using the same QCL.
  + Support SSB and CORESET#0 multiplexing pattern 1 (different slots), and pattern 3 (same slots).
  + Support a configuration where the PDSCH scheduled by Type-0 PDCCH can be rate-matched around the corresponding SSBs.
* From [2] Lenovo, Motorola Mobility:
  + Observation: For supporting NR from 52.6 GHz to 71 GHz in Rel. 17, with higher SCS values such as 480kHz and 960kHz, if existing SSB structures are used, then the minimum bandwidth requirements for UE will increase significantly in order to accommodate the required number of frequency resources within a time-symbol for PBCH/PSS/SSS and only multiplexing pattern 1 could be supported
* From [3] ZTE, Sanechips:
  + The following multiplexing patterns and combinations of SCSs of SSB and Type0-PDCCH can be considered for Rel-17 NR above 52.6 GHz.
    - (SSB, Type0-PDCCH): SCS (120 kHz, 120 kHz)
      * Multiplexing patterns: 1, 3
    - (SSB, Type0-PDCCH): SCS (480 kHz, 480 kHz)
      * Multiplexing patterns: 1, 3
    - (SSB, Type0-PDCCH): SCS (960 kHz, 960 kHz)
      * Multiplexing patterns: 1, 3
* From [7] CAICT:
  + At most two SSB and CORESET#0 multiplexing patterns are used for 480 and 960 kHz SCS.
* From [8] CATT:
  + While 480 kHz and 960 kHz SCS are introduced, the 1bit indication in MIB provides the information ofType0-PDCCH SCS along with the detected SSB SCS in a given band in 52.7 -71 GHz ,
    - Issue on multiplexing pattern type(s) (Pattern 1, 2, and/or 3) for SSB and CORESET#0 multiplexing, and other signals

|  |  |
| --- | --- |
| SCS of SS/PBCH in extended FR2 | Associated Type0-PDCCH SCS in extended FR2 |
| 120KHz | 120KHz |
| 480KHz |
| 480KHz | 480KHz |
| 960KHz |

* + Patterns 2 and 3 of SSB and CORESET for Type0-PDCCH can multiplex with periodic CSI-RS/paging PDCCH&PDSCH in frequency.
* From [9] vivo:
  + The following alternatives could be considered to solve beam switching problem for contiguous candidate SSBs:
    - Alt. 1: New SSB pattern introducing gaps between contiguous candidate SSBs;
    - Alt. 2: The same QCL assumptions for contiguous candidate SSBs (e.g. case D in TS38.213);
    - Alt. 3: Hopping transmission for contiguous candidate SSBs (e.g. case E in TS38.213).
  + The following SSB-Coreset 0 multiplexing patterns are supported for each SCS pair:
    - (120K, 120K): Pattern 1, Pattern 3
    - (960K, 960K): Pattern 1, Pattern 3
    - (960K, 480K): Pattern 1, Pattern 2
* From [12] Intel:
  + Consider only SSB and CORESET#0 multiplexing pattern 1 for 480 and 960 kHz SCS.
  + Type0-PDCCH CSS may utilize symbols {0,1} and {7,8} that correspond to SSB in the first half and second half of the slot.
* From [19] Xiaomi:
  + Configuration of SSB and CORESET0 multiplexing tables need update to support additional SCS other than 120k for NR from 52.6GHz to 71 GHz.
* From [23] Apple:
  + SSB and CORESET 0/RMSI PDSCH multiplexing pattern 1 can be considered to increase the allowable RMSI payload size with reasonable coverage.
* From [25] Qualcomm:
  + consider the following SSB and CORESET0 SCS combinations:
    - SSB SCS = 120 kHz, CORESET0 SCS = 120, 480, 960 kHz
    - SSB SCS = 240 kHz, CORESET0 SCS = 120 kHz
    - SSB SCS = 480/960 kHz, CORESET0 SCS = SSB SCS

Table : Allowed SSB/CORESET0 SCS Combinations

|  |  |  |  |
| --- | --- | --- | --- |
| **SSB SCS (kHz)** | **CORESET0 SCS (kHz)** | | |
| **120** | **480** | **960** |
| **120** | Yes | Yes | Yes |
| **240** | Yes | No | No |
| **480** | No | Yes | No |
| **960** | No | No | Yes |

* + consider ways to have 1 extra bit to indicate the common SCS in the SSB structure or contents in case more than 2 values for the common SCS are allowed
  + NR Rel-16 SSB/CORESET0 multiplexing pattern 1 design may be reused with possibly some changes to the table (e.g., the need for < 2.5 ms options for the start of the CORESET0 wrt frame boundary) which depends on the outcome of the SSB pattern design
  + SSB/CORESET0 multiplexing pattern 2:
    - For the 240 kHz + 120 kHz combination: reuse the same design as in NR Rel-16
    - For the 120 kHz + 480/960 kHz combination: the CORESET0 symbols may be placed in the gap symbols between the SSBs (similar to the existing NR Rel-16 design)



* + NR Rel-16 SSB/CORESET0 multiplexing pattern 3 design may be reused for the valid combinations of 120 + 120 kHz, 480 + 480 kHz, and 960 + 960 kHz.
  + Consider introducing an SSB/CORESET0 multiplexing pattern for higher SCS SSB (480 and 960 kHz), where a time domain fixed location for the CORESET0 and SIB1 is considered





* + consider introducing an SSB/CORESET0 multiplexing pattern for higher SCS SSB (480 and 960 kHz), where TDM grouping of the SSB and the corresponding CORESET0/SIB1 is considered



* From [26] NTT Docomo:
  + When new SCS(s) is supported for SSB and a single numerology is used for both SSB and CORESET#0/SIB1, at least TDM between SSB and CORESET#0/SIB1 can be supported.
  + When lower SCS is used for SSB compared with that used for CORESET#0/SIB1, FDM between SSB and SIB1 PDSCH such as in pattern 2 can be considered.
* From [27] WILUS:
  + We propose that SS/PBCH block and CORESET#0/RMSI can be multiplexed in TDM/FDM within a slot considering multi-beam operation and it can be closely located without the gap between SSB and CORESET#0/RMSI for not allowing any in-between channel access operation in the unlicensed band.

**Summary of Discussions in Tdoc**

* Several companies discuss the applicability of SSB/Type0-PDCCH multiplexing pattern 1/2/3 for specific SSB SCS
* Suggest to discuss further for each supported SSB/CORESET#0 SCS combination, which Type0-PDCCH multiplexing pattern (1, 2, and/or 3) would be supported.

**Discussions #1**

* Please provide comments on which Type0-PDCCH multiplexing pattern should be supported for each SSB/CORESET#0 SCS combination.
* Additionally, please provide comments on supported bandwidth/PRB for CORESET#0 and any other issues related with Type0-PDCCH CSS/CORESET#0 configuration.

|  |  |
| --- | --- |
| **Company** | **Discussions/Comments** |
| Samsung | • If synchronization raster interval is larger than FR2, additional CORESET#0 RB offsets are needed for 120 kHz SS/PBCH block SCS;  • If 480 kHz and/or 960 kHz SS/PBCH block SCS is supported, at least CORESET#0 configuration table with same SCS as SS/PBCH block should be supported;  • If there are reserved configurations, all of multiplexing Pattern 1, Pattern 2 and Pattern 3 can be supported in a CORESET#0 configuration table;  • If there are reserved configurations, 96 RB can be added to the CORESET#0 configuration table for 120 kHz SS/PBCH block SCS. |
| ZTE, Sanechips | As commented in 2.1.3, same SCS for SSB and CORESET#0 should be supported to reduce the complexity of multiplexing and indication of the SCS for CORESET#0, etc. Thus, multiplexing pattern 1 and 3 can be considered. In addition, bandwidth/PRB for CORESET#0 also depends on minimum bandwidth, multiplexing pattern and the SCS of SSB and CORESET#0. |
| DOCOMO | At least TDM like pattern should be supported considering the available resource for CORESET#0/SIB1.  Even for TDM pattern, beam switching gap overhead should be minimized. For example, TDM between SSB and CORESET#0/SIB1 in the same slot should be considered.  FDM like pattern can be considered if mixed numerology between SSB and CORESET#0 is supported, and if minimum channel bandwidth is large enough. |
| LG Electronics | As we commented in Section 2.1.3, before discussing multiplexing between SSB and CORESET#0, we should first discuss whether new SCS for SSB/CORESET#0 during initial access is supported or not. If new SCS for SSB/CORESET#0 during initial access is not supported, the current specification would suffice. |
| vivo | The multiplexing pattern should be discussed after the SCS pair for SSB and CORESER#0 is determined. Current pattern should be the baseline with minimum spec impact. In our view, the following SCS pair could be supported by reusing current multiplexing pattern:   * + The following SSB-Coreset 0 multiplexing patterns are supported for each SCS pair:     - (120K, 120K): Pattern 1, Pattern 3     - (960K, 960K): Pattern 1, Pattern 3     - (960K, 480K): Pattern 1, Pattern 2 |
| Nokia | For (SSB 120kHz, CORESET#0 120kHz) and (SSB 240kHz, CORESET#0 120kHz) we think that it would be important to enable operation with 96 RB CORESET#0 for 120kHz (to enable for L=1151 for RACH). Then for the considered SSB and CORESET#0 scs combinations, we think that following multiplexing patterns could be considered.   * + - (SSB 120kHz, CORESET#0 120kHz) [#1,#3]     - (SSB 240kHz, CORESET#0 120kHz) [#1,#2]     - (SSB 480kHz, CORESET#0 480kHz) [#1]     - (SSB 960kHz, CORESET#0 960kHz) [#1]   Afore listed 480kHz and 960kHz SSB and CORESET#0 multiplexing patterns could be considered also in case of non-initial access, if scenario noted in Section 2.1.2 can be considered.  Pending of course on RAN4 discussions, but with 480kHz and 960kHz scs for CORESET#0, CORESET BW could be restricted only to 48RB and 24RB, respectively. |
| Futurewei | Support Pattern 1 (TDM) and Pattern 3 (FDM, same numerology). We do not think that mixed numerology is necessary. |
| Ericsson | Agree with LGE. Clearly this topic is dependent on whether or not SCS other than 120 kHz is supported for CORESET0, as well as minimum bandwidth which is being discussed in RAN4. This is particularly relevant for multiplexing patterns 2 and 3.  Our view is that at least Pattern 1 (TDM multiplexing between SSB and and CORESET0) should be supported. |
| Qualcomm | * Multiplexing patterns 1, 2 (for 120 kHz + 480/960 kHz), and 3 (for equal SCS SSB and CORESET0) can be considered with scaling to the new SCSs * Consider adding new/replacement designs that may help mitigate some of the issues for higher SCSs, e.g.:   + Time domain fixed location for the CORESET0 and SIB1 is considered     - UE may sleep until the corresponding CORESET0/SIB1, thus achieve some power saving     - Smaller delay between SSB and CORESET0/SIB1 (within the same frame)   + TDM grouping of the SSB and the corresponding CORESET0/SIB1 is considered     - Back-to-back SSB/CORESET0/SIB1 help reduce the beam switching gap overheads in case they are adopted |
| OPPO | For SSB and CORESET#0 multiplexing with single numerology, Patten 1, Pattern 2 and Pattern 3 should be supported. |
| InterDigital | Agree with LGE and Ericsson that SCSs for CORESET0 should be discussed first. |
| Xiaomi | Agree with several companies to discuss the SCSs for CORESET#0 in the first place. |
| CATT | Same SCS for SSB and CORESET 0 with multiplexing Patterns 2 and 3. |
| Apple | We shared LG’s view. If new SCSs target for the non-initial access case, i.e., non-standalone e.g., SCell/non-initial BWP, there is no need to transmit SIB information by CORESET #0, hence SSB itself is sufficient.  The maximum bandwidth of CORESET is upbound by the minimum bandwidth of new SCSs, which was handled by RAN4. So, one LS to RAN4 maybe desirable to include other questions identified in earlier discussions to seek inputs.  Assuming there is needed to support SSB/CORESET 0 multiplexing for new SCSs, our preference is multiplexing pattern 0 with a same numerology for SSB/CORESET 0, which is mainly motivated to ensure the performance of SIB1 delivery (coverage and decoding performance) by avoiding FDMed with SSB. |
| Intel | As we pointed out previously, the support of single numerology operation for NR extension up to 71 GHz should be prioritized. Assuming that, the support of SSB and CORESET#0 multiplexing pattern 1 should be prioritized.  As for number of PRBs for CORESET#0. This will highly depend on minimum channel bandwidth supported. For example, for 120kHz case if the minimum channel bandwidth is 400 MHz, it would be possible to focus on the larger CORESET#0 sizes, such as 96 or even larger values.  For 480kHz and 960 kHz, PRB sizes equal or larger than 48 or 24 PRBs, e.g. 60 or 32, respectively, could be candidates for consideration for minimum 400 MHz bandwidth. |
| Huawei, HiSilicon | As discussed in our views in Section 2.1.2 and 2.1.3, only 120 kHz SSB and CORESET#0 need to be supported in which case both Mux Pattern 1 and Mux Pattern 3 can be reused. For licensed band, both 24 PRB and 48 PRB can be configured for CORESET0 as in Rel15/16. For operation in shared spectrum, CORESET0 with 48 PRB and 96 PRB can be configured to make full use of allowed transmit power.  96 PRB CORESET0 in the shared spectrum is due to FCC regulation for 57-71 GHz which restricts the maximum conducted output power at 27 dBm if the emission bandwidth is at least 100 MHz and the conducted power should be scaled down if the transmission bandwidth is smaller than 100MHz. |
| Lenovo, Motorola Mobility | We support multiplexing pattern 1, and pattern 3 with same SCS for both CORESET#0 and SSB. Also agree with ZTE that the minimum bandwidth may impact the required number of PRBs for both CORESET#0 and SSB. If 480/960 are to be supported for both SSB and CORESET#0 and if the minimum bandwidth is not large enough, then multiplexing pattern 3 with 960KHz SCS for example may require further study on the possible CORESET#0 RB configuration. |

*Moderator Note: Below are tentative summary and suggested conclusion, please continue to add comments to above until discussion in GTW. Moderator will update the summary and suggested conclusionas further comments are provided.*

**Moderator Summary of Discussions #1**

* Several companies commented to prioritize multiplexing pattern 1.
* Given that this discussion is highly dependent on whether larger SSB SCS is supported and whether initial access is also supported for these cases, moderator suggest companies to continue to provide comments but hold off making conclusions for now.

Continue to provide comments on this issue.

### 2.1.7 CORESET#0 Configuration

* From [5] Huawei, HiSilicon:
  + For licensed operation, both 24 PRB and 48 PRB can be configured for CORESET0. For operation in shared spectrum, CORESET0 with 48 PRB and 96 PRB can be configured to make full use of allowed transmit power.
* From [9] vivo:
  + To solve the problem of the limited CORESET and RMSI payload, two solutions can be utilized:
    - Assuming two consecutive SSB beams have QCL relationship
    - Assuming only one SSB is transmitted every two consecutive SSB beams
* From [10] TCL:
  + Observation: The transmission of minimum system information with a large number of active beams makes the system inefficient and imposes beam switching constraints, resulting in reduced scheduler flexibility.
  + Observation: For shared carriers, the transmission of minimum system information with a large number of active beams brings additional issues related to channel ownership, and potential requirements to perform channel access procedures while switching the beams.
  + It is proposed to investigate efficient transmission of MSI including the multiplexing patterns for both licensed and shared carriers.
* From [13] Fujitsu:
  + Further discuss SCS of SSB for initial access at least considering maximum mandatory bandwidth of UE.
    - If the maximum mandatory bandwidth of UE is as for the current FR2 and RedCap UE should be considered for the new frequency range, neither of 480kHz and 960kHz can be supported.
    - If the maximum mandatory bandwidth of UE is as for the current FR2 and RedCap UE should not be considered for the new frequency range, 480kHz can be supported.
    - If the maximum mandatory bandwidth of UE is 400MHz, 480kHz and/or 960kHz can be supported.
* From [19] Xiaomi:
  + Configuration of SSB and CORESET0 multiplexing tables need update to support additional SCS other than 120k for NR from 52.6GHz to 71 GHz.
* From [20] Samsung:
  + For COREST#0,
    - if synchronization raster interval is larger than FR2, additional CORESET#0 RB offsets are needed for 120 kHz SS/PBCH block SCS;
    - if 480 kHz and/or 960 kHz SS/PBCH block SCS is supported, at least CORESET#0 configuration table with same SCS as SS/PBCH block should be supported;
    - if there are reserved configurations, both multiplexing Pattern 2 and Pattern 3 can be supported in a CORESET#0 configuration table;
    - if CORESET#0 bandwidth can be increased, 96 RB can be added to the CORESET#0 configuration table for 120 kHz SS/PBCH block SCS.

**Summary of Discussions in Tdoc**

* Following up discussions on supported SSB/Type0-PDCCH multiplexing pattern, companies have provided further discussion on supported bandwidth (#PRB) and configured Type0-PDCCH CSS resources.
* Suggest to discuss further along with SSB/CORSET#0 multiplexing issue (2.1.6)

**Discussions**

* Moderator suggests to discuss this issue along with SSB/CORESET#0 multiplexing issue.
* Please provide comments in Section 2.1.6.

### 2.1.8 Various other aspects on SSB Design

* From [2] Lenovo, Motorola Mobility:
  + For supporting NR from 52.6 GHz to 71 GHz in Rel. 17, if higher subcarrier spacings (numerologies) are adopted for initial access, new SSB structures should be investigated.
  + For supporting NR from 52.6 GHz to 71 GHz in Rel. 17, if higher subcarrier spacings (numerologies) are adopted for initial access, coverage enhancement of channels and signals used for initial access should be considered for NR beyond 52.6 GHz.
* From [7] CAICT:
  + Initial BWP includes only one LBT bandwidth for unlicensed deployment.
* From [9] vivo:
  + For initial cell search in 52.6-71GHz, a UE may assume that half frames with SSB occur with smaller period than FR2 (e.g. 5ms), or lower RAN4 requirement for the cell search time.
* From [13] Fujitsu:
  + For further study on initial access for the new frequency range (52.6~71GHz), it should be clarified whether to consider RedCap UE.
  + For further study on initial access for the new frequency range (52.6~71GHz), RAN1 can send LS to RAN4 asking about at least the minimum channel BW (50MHz or 400MHz) and the maximum mandatory bandwidth of UE (including RedCap UE if it should be considered), or wait for the progress in RAN4.
* From [14] AT&T:
  + Observation: For both single carrier and intra-band multi-carrier deployments regardless of time or frequency division multiplexing of multiple numerologies a myriad of complexities arise during every step of the system design and operation, from standardization, to implementation, to orchestrating the resources during actual deployment which result in additional and unnecessary costs and performance impairments
* From [15] Spreadtrum:
  + The initial access mechanisms for R16 NR-U can be kept, e.g. candidate SSB index, SSB (beam) index, discovery burst transmission window, ssb-PositionQCL-r16, new interpretation of ssb-PositionInBurst and off-raster SSB for cgi report.
* From [18] NEC:
  + Upon LBT based SSB transmission for initial access, the sensing beam group with multiple concurrent LBT/sensing beams could be used to improve the SSB transmission performance.
  + For LBT based initial access, transmission beam(s) for certain SSB should be covered by corresponding LBT/sensing beam(s) on which the channel is sensed to be idle.
  + The energy detection threshold adaptation procedures for LBT based initial access should take into account the maximum transmission power difference between transmission on a single beam and multiple concurrent beams.
* From [21] CEWiT:
  + For SSB with 120KHz SCS, solutions for mitigating effect of phase noise need to be defined.
* From [24] Convida:
  + SSB coverage enhancement should be studied for higher SCS if it is supported.
  + Introduction of TRS/CSI-RS in idle/inactive mode UE in Rel 17 should be studied for NR operation from 52.6 to 71 GHz.
* From [26] NTT DOCOMO:
  + Wider bandwidth than 50 MHz should be considered as minimum channel bandwidth for a band in 52.6 - 71GHz

**Summary of Discussions in Tdoc**

* Companies have provided discussion on considerations for SSB design. The discussion includes, how to handle the 5 msec SSB periodicity, enhanced SSB (e.g. larger number of symbols for PBCH), applicability of reduced capability UEs and how RedCap UE would be handled, support of TRS/CSI-RS in idle/inactive mode, relationship between initial BWP and LBT bandwidth, and minimum channel bandwidth considered.
* Suggest to discuss these issues further.

**Discussions #1**

* Among the issues discussed, please highlight issues that companies think would benefit from having agreements/conclusions in RAN1 #104-e. Also provide issues that were not captured by the moderator in this document.

|  |  |
| --- | --- |
| **Company** | **Discussions/Comments** |
| Samsung | * No need to change the minimum periodicity of 5 ms. There are examples the SSB burst is much shorter than 5 ms, and there is no issue with that. * We didn’t see an issue with PBCH coverage from the SI, so no need to modify the SSB structure. * We don’t think Rel-17 RedCap is targeted for and applicable to 52.6 GHz to 71 GHz * Support of TRS/CSI-RS in idle/inactive mode is discussed in power saving enhancement * We didn’t see a need for special treatment of LBT bandwidth for initial access * We support the proposal of supporting a minimum carrier bandwidth to be larger than 50 MHz (to allow larger sync raster interval), but the discussion should be made in RAN4. |
| NEC | 1. Considering the SSB transmission for initial access in shared channel, we are open to discuss the SSB periodicity.  2. We support keeping the same SSB structure for higher SCS.  3. Upon the minimum channel bandwidth, we support leaving it to RAN4. |
| ZTE, Sanechips | Similar view with Samsung. Most of the issues above do not need a specific discussion. Among them, some have been excluded from WID above 52.6 GHz e.g. SSB coverage enhancement, some are being discussed in other WI group e.g. TRS/CSI-RS, and some enhancements seem unnecessary e.g. smaller half-frame periodicity. We only need to consider the impact of the minimum channel bandwidth on initial access signals/channels. |
| DOCOMO | If 480/960 kHz is supported for SSB, SSB burst may be much shorter than 5 ms. Then SSB measurement window shorter than 1 ms could be beneficial to reduce UE monitoring burden, as described in [28].  We support the minimum carrier bandwidth should be larger than 50 MHz. Ok to discuss the minimum carrier bandwidth itself in RAN4, but we believe it is related to SSB SCS selection for initial access. |
| vivo | Clarification on the SSB period issue here: In FR2, UE will assume 20ms SSB period for initial cell search. Here we propose to change this default SSB period to be smaller (e.g. 5 or 10ms) considering the increasing SSB synchronization complexity for NR operation from 52.6-71GHz. Another alternative is to relax the time requirement in RAN4 for cell search. To maintain the performance, we prefer to have a smaller default SSB period. |
| Nokia | From the issues listed we feel that the minimum carrier/UE BW support discussion is the highest priority/relevant aspect, but these would also depend on RAN4 discussions. |
| Charter Communications | Retain 5 ms SSB burst periodicity. Minimum channel BW discussions are already on-going in RAN4, so need to coordinate there. |
| Futurewei | Initial access BW, LBT BW should be prioritized. We prefer a 400 MHz carrier BW, but we should consider RAN4 discussions on this subject. FR2 SSB burst periodicity and SSB structure should be reused. |
| Ericsson | * Regarding the moderator's suggestion on whether or not to discuss "how to handle the 5 msec SSB periodicity", it is not clear what the discussion point is. Is it about the default SSB periodicity that the UE assumes on initial access? Or is it about the minimum configured periodicity? * No need to modify SSB structure (coverage enhancements are out of scope in the WID anyway) * No need to discuss TRS/CSI-RS in IDLE mode in this WI * LBT bandwidth is being discussed in Channel Access – no need for special handling for initial access * Minimum channel bandwidth is being discussed in RAN4; however, we share a similar view as Samsung; 50 MHz is not needed. |
| Qualcomm | Consider ways to have 1 extra bit to indicate the common SCS in the SSB structure or contents in case more than 2 values for the common SCS are allowed  This comment was not made by Qualcomm:  “*From [25] Qualcomm:*   * *Wider bandwidth than 50 MHz should be considered as minimum channel bandwidth for a band in 52.6 - 71GHz*” |
| OPPO | * No need to change min periodicity of 5 ms * Open to revisit SSB structure if issues are clarified. * No need to consider R17 RedCap UE. * Relation between BWP in general, LBT bandwidth and channel bandwidth can be discussed in 8.2.6. |
| InterDigital | We don’t see the need for discussion on the above issues. |
| CATT | Those issues should be discussed later |
| Apple | - SSB coverage enhancement is NOT in the WID scope.  - As commented earlier, minimum channel BW should ask RAN4 for inputs. |
| Intel | We believe that SS/PBCH coverage enhancements as well as RedCap UE support is not a part of the current WI as described in the WID:  Note: coverage enhancement for SSB is not pursued. |
| Huawei, HiSilicon | We think the discussion should focus first on supported SSB SCS in initial access as many other discussions in this Email discussion depend on the outcome of this discussion.  As discussed in our reply in 2.1.2, we believe that the discussion of additional SSB SCS in Section 2.1.2 needs to be split into SSB SCS for Initial Access and non-Initial Access from the outset (with the first focus on Initial access) due to the following reasons:   * WID considers two separate objectives for possible additional SCSs for SSBs:  |  | | --- | | * “Study and specify, if needed, additional SCS (240kHz, 480kHz, 960kHz) for SSB, and additional SCS(480kHz, 960kHz) for initial access related signals/channels in initial BWP. * Study and specify, if needed, additional SCS (480kHz, 960kHz) for SSB for cases other than initial access.” |  * Most companies have studied the issues of additional SSB SCS for Initial access and non-initial access scenarios separately as additional SSBs for each scenario has its own challenges and possible applications. |
| Lenovo, Motorola Mobility | In our view if the minimum bandwidth is not large enough, then for the case of 960kHz for example with multiplexing pattern 3, an investigation of the required number of RBs might be required. We agree with keeping the current SSB structure in terms of number PRBs/symbols if it can satisfy this case, and only reducing the CORESET#0 bandwidth if there is no impact on the performance and the size of the information carried by CORESET#0. |

*Moderator Note: Below are tentative summary and suggested conclusion, please continue to add comments to above until discussion in GTW. Moderator will update the summary and suggested conclusionas further comments are provided.*

**Moderator Summary of Discussions #1**

* xxx:

## 2.2 PRACH Aspects

### 2.2.1 PRACH BW and Sequence Length

* From [1] FUTUREWEI:
  + With RAN 1 interpretation the OCB restriction does not imply that each of PRACH possible format transmissions should occupied 70% of the nominal channel bandwidth.
  + For 60 GHz shared spectrum, support 400MHz as the default channel bandwidth for the initial channel access and as the default channel bandwidth for the CCA (LBT) operations.
  + Consider the necessity of interlaced based PRACH mappings to achieve the maximum radiated power as well as at least one PRACH format that satisfies the minimum OCB condition.
* From [3] ZTE, Sanechips:
  + Support sequence length 139, 571 and 1151 for PRACH, and further study the corresponding SCS when channel bandwidth and SCS are determined.
* From [5] Huawei, HiSilicon:
  + PRACH sequence length 571 and 1151 are supported for 120 kHz SCS above 52.6 GHz.
* From [6] Nokia, NSB:
  + Observation: Initial BWP bandwidth options for 120 kHz CORESET#0 in FR2 are 34.56 MHz and 69.12 MHz. PRACH preamble using 120 kHz SCS and sequency length of 1151 would not fit into initial BWP defined by 120 kHz SCS CORESET#0 in FR2.
  + Consider supporting wider initial BWP bandwidth options than supported in FR2, e.g. 96 PRBs with 120 kHz SCS.
  + Support PRACH preamble length 571 and 1151 at least for 120 kHz SCS.
* From [9] vivo:
  + Observation: With the usage of higher SCS, the PRACH sequence capacity is very limited when the preamble sequence length is 139.
  + With the usage of higher SCS, the issue of preamble sequence generation needs to be considered to match the certain coverage area.
* From [11] MediaTek:
  + Support PRACH sequence lengths 139/571/1151 for NR above 52.6GHz.
* From [16] InterDigital:
  + Observation: For 52.6 – 71 GHz, longer PRACH sequences are needed for the case that the transmit power is limited, however, no additional specification enhancements are needed as the existing PRACH sequences with the existing sequence lengths 571 and 1151 can be reused for with existing SCS.
  + For 52.6 – 71 GHz, the existing PRACH sequences with the existing PRACH sequence lengths 571 and 1151 should be reused.
* From [17] LGE:
  + The PRACH sequence lengths (i.e., L=139, L=571 and L=1151) can be supported for 120 kHz considering the regulatory requirements in the unlicensed band but it needs to clarify whether all of these lengths of PRACH sequence are required in the licensed band where regulatory requirements are not defined on PSD limit.
* From [20] Samsung:
  + Support short PRACH format for all PRACH sequence lengths LRA ϵ {139, 571, 1151} and all SCSs µ ϵ {3, 5, 6}, and don’t support long PRACH format.
* From [22] Ericsson:
  + Observation: While L = 139/571/1151 is beneficial for 120 kHz PRACH from a coverage perspective, the longer sequence lengths (L = 571/1151) lead to excessive PRACH bandwidth for 480/960 kHz PRACH, and are not needed in order to maximize PRACH transmission power given regulatory/UE power limits.
  + Specify support for all sequence lengths (139/571/1151) for 120 kHz PRACH. For 480/960 kHz PRACH, specify support for only L = 139.
* From [25] Qualcomm:
  + consider using the following for the PRACH preamble sequence lengths for higher bands:
    - SCS = 120 kHz: 139 and 571
    - SCS = 480/960 kHz: 139 only

**Summary of Discussions in Tdoc**

* Companies have provided views on supported PRACH sequence lengths for each supported SCS
  + Support L=139
    - ZTE, Sanechips, MediaTek, Intel, Interdigital, LGE, Ericsson, Qualcomm (for 120,480,960kHz)
  + L=571, 1151
    - ZTE, Sanechips, Huawei, HiSilicon , Nokia, NSB (at least for 120kHz), MediaTek, Intel, LGE, Interdigital, Ericsson, Qualcomm (for 120kHz only)
* Discuss further supported PRACH sequence lengths for each supported SCS

**Discussions #1**

* Please provide comments on supported PRACH sequence length (e.g. L=139, 571, 1151), PRACH Format (e.g. 0-3, A, B, C), PRACH SCS (and applicable scenarios).

|  |  |
| --- | --- |
| **Company** | **Discussions/Comments** |
| Samsung | Support all PRACH sequence length (L=139, 571, 1151) for short PRACH format (A, B, C)   * Support SCS = 480 kHz and 960 kHz for non-initial access case * Support SCS same as initial BWP SCS for initial access case (depending on the outcome from SSB discussion) |
| ZTE, Sanechips | * Support sequence length 139, 571 and 1151 for PRACH format A, B, C. * Support 120kHz SCS for PRACH, jointly discuss additional SCSs (480kHz and 960kHz) for PRACH and SSB if single subcarrier spacing is supported. |
| DOCOMO | We support PRACH sequency length L=139 and 571. We are open to L=1151. We support all short PRACH format.  We support 480/960 kHz SCS for PRACH for non-initial access case, and the same SCS as initial BWP SCS for initial access case. |
| LG Electronics | For PRACH sequence lengths, the lengths (i.e., L=139, L=571 and L=1151) can be supported for the PRACH format (A, B, C). If 480 or 960 kHz subcarrier spacing is supported for PRACH, the corresponding PRACH sequence length can be L=139 and/or L=571. However, it is necessary to clarify whether all of these lengths of PRACH sequence are required in the licensed band where regulatory requirements are not defined on PSD limit.  Support of 480/960 kHz SCS for PRACH is not preferred considering the specification impact on the RO configuration and RA-RNTI issue for 480/960 kHz SCS. |
| Spreadtrum | The PRACH with 480 and 960kHz for non-initial access could be supported to reduce UE complexity when UE is sending data with 480 and 960kHz SCS. |
| vivo | Support all PRACH sequence length (L=139, 571, 1151) for short PRACH format (A, B, C) and not support PRACH format 0-3.  We support 480K and 960K SCS for PRACH and initial UL BWP with single numerology. |
| Nokia | Support PRACH preamble length 571 and 1151 (in addition to L=139) at least for 120 kHz SCS for short formats (A,B and C). For 480kHz and 960kHz scs PRACH sequence L=139 is supported at least for non-initial access. |
| Futurewei | Support all preambles for SCS 120 kHz (139, 571,1151) and all existing corresponding FR2 PRACH formats. We do not prefer 480kHz/960 kHz for PRACH. |
| Ericsson | * SCS = 120 kHz   + Support L = 139, 571, 1151 for PRACH formats A,B,C * SCS = 480/960 kHz   + Support for non-initial access case only, e.g., SCell   Support L = 139 for PRACH formats A,B,C |
| Qualcomm | Sequence length (LRA):  - SCS = 120 kHz: 139 and 571  - SCS = 480/960 kHz: 139 only  We believe the metric that should be used to get the LRA is the max EIRP of 40 dBm EIRP limit which leads to a required BW of 50 MHz (at 23 dBm/MHz PSD limit). The conducted FCC requirements may not be a good metric choice because, realistically, depending on the UE antenna array gain, a much smaller BW (compared to the “conducted” 100 MHz BW number) may be sufficient to achieve the 40 dBm max EIRP. For example, a 15 dB antenna gain yields a 63 MHz BW where the above SCS/LRA combinations are sufficient to achieve that.  For higher bands consider reusing the PRACH formats defined in NR Rel-16 (with appropriate SCS scaling) |
| OPPO | For spectrum without PSD limit (e.g., licensed spectrum), support L=139 for 120, 480, 960 kHz PRACH sequence; For spectrum with PSD limit (e.g., unlicensed spectrum), support L=571, 1151 for 120 kHz PRACH sequence. For 480kHz and 960kHz SCS, L=139 has already made the PRACH bandwidth greater than 50MHz, which meets the maximum allowed EIRP. In this case, further increasing L to 571 and 1151, does not help to have a better coverage. |
| InterDigital | As clarified in our contribution, we prefer to support L=571, 1151 for 120 kHz. For other SCSs, whether to support 480kHz and/or 960kHz should be discussed before discussing applicable PRACH sequence. |
| Fujitsu | Support all PRACH sequence length and all short PRACH format.  For non-initial access, support 480kHz and 960kHz and all combinations of PRACH sequence length and PRACH SCS can be supported.  For initial access, similar as SSB, some aspects related to RAN4 need to be considered to figure out applicable combinations of PRACH sequence length and PRACH SCS, e.g. minimum channel bandwidth and maximum mandatory bandwidth of UE. Since the bandwidth issues are under discussion in RAN4, RAN1 can wait for RAN4’s decision or send LS to RAN4 asking about the situation, and then further discuss the applicable combinations of PRACH sequence length and PRACH SCS for initial access accordingly. |
| CATT | Support sequence lengths 139, 571 and 1151 for all PRACH format A, B, C. |
| Apple | For 120 kHz, support of length 139,571 and 1151.  For 480kHz and 960kHz SCS, only support L = 139. |
| Intel | Support larger PRACH preamble sequences (571, 1151). Support PRACH formats for L=139, 571, 1151 with SCS 480 kHz and 960 kHz.  As a starting point, RAN1 could agree on L=139 with corresponding PRACH formats and SCS 480 kHz and 960 kHz.  We do not see a need to support Format 0~3. |
| Huawei, HiSilicon | **RACH numerology:** The main usage of RACH is during initial access wherein the cost/benefit compromise for the use of a higher than 120 kHz SCS for any signal/channel is not justifiable. Moreover, RACH use in any case is limited to designated RACH slots. As such, we don’t see any compelling reason to support higher than 120 kHz SCS for RACH transmission.  **RACH sequence length:** Support L=571, L=1151 for operation in shared spectrum so the UE can transmit with the maximum allowed power which requires minimum 50 MHz BW for EU and minimum 100 MHz for US. For licensed band, L=139 can be supported.  **RACH format:** Support all short PRACH formats (A,B,C) in Rel-15/16 in principle at least as a baseline. Reducing guard time or PRACH duration may be further considered. |
| Lenovo, Motorola Mobility | We support PRACH with 480 and 960kHz depending on the agreed SCS for SSB |

*Moderator Note: Below are tentative summary and suggested conclusion, please continue to add comments to above until discussion in GTW. Moderator will update the summary and suggested conclusionas further comments are provided.*

**Moderator Summary of Discussions #1**

* Majority of the companies seems to support L=139, 571, and 1151 for 120kHz PRACH SCS. Note that this is already supported in current specification.
* For 480 and 960 kHz PRACH SCS, there seems to be a general support for at least L =139. L=571, 1151 for these may require further discussion.
* No company seems to be against supporting PRACH formats A, B, and C.
* [Strive to make a conclusion in GTW.] Further discuss on following statement (as a starting point for further discussion):
  + Moderator note: assume no additional agreement is needed to support L=139, 571, and 1151 for 120kHz PRACH SCS.
  + Support at least 480 and 960 kHz PRACH SCS with sequence length L=139 for PRACH Formats A1~A3, B1~B4, C0, and C2.
    - FFS: support of sequence length L = 571, 1151

### 2.2.2 Supported PRACH Numerology

* From [1] FUTUREWEI:
  + Support only 120kHz SCS for PRACH for initial access.
* From [2] Lenovo, Motorola Mobility:
  + For supporting NR from 52.6 GHz to 71 GHz in Rel. 17, support the same numerology of data channel for SSB and PRACH including 480KHz and 960KHz
* From [3] ZTE, Sanechips:
  + Support 120kHz SCS for PRACH, jointly discuss additional SCSs (480kHz and 960kHz) for PRACH and SSB if single subcarrier spacing is supported.
* From [5] Huawei, HiSilicon:
  + For PRACH and Msg3 in initial UL BWP, only 120 kHz should be used in the frequency band from 52.6GHz to 71GHz.
* From [6] Nokia, NSB:
  + Observation: 960 kHz SCS for PRACH can support required range for the indoor scenario. It would be beneficial to support e.g. 960 kHz PRACH for SCell operating with 960 kHz SCS.
* From [9] vivo:
  + Observation: All supported SCS for data/control SCS could be used for initial UL BWP in NR FR2 operation. There are only two applicable SCSs for PRACH format (A, B, C) in NR FR2 operation.
  + Support 120KHz, 480KHz and 960KHz as candidate SCS of initial UL BWP.
* From [11] MediaTek:
  + Support only 120 kHz for PRACH SCS in initial access.
* From [12] Intel:
  + Support 480 kHz and 960 kHz SCS for PRACH in NR extension up to 71 GHz.
* From [13] Fujitsu:
  + In addition to 120kHz, support 480kHz and 960kHz for PRACH at least for the cases other than initial access.
  + Select combinations of SCS and sequence length for PRACH for initial access at least considering maximum mandatory bandwidth of UE.
    - If the maximum mandatory bandwidth of UE is as for the current FR2 and RedCap UE should be considered for the new frequency range, only consider the combinations with BW not larger than 100MHz, i.e. (L=139, SCS=120kHz), (L=139, SCS=480kHz), and (L=571, SCS=120kHz).
    - If the maximum mandatory bandwidth of UE is as for the current FR2 and RedCap UE should not be considered for the new frequency range, only consider the combinations with BW not larger than 200MHz, i.e. (L=139, SCS=120kHz), (L=139, SCS=480kHz), (L=139, SCS=960kHz), (L=571, SCS=120kHz) and (L=1157, SCS=120kHz).
    - If the maximum mandatory bandwidth of UE is 400MHz, only consider the combinations with BW not larger than 400MHz, i.e. (L=139, SCS=120kHz), (L=139, SCS=480kHz), (L=139, SCS=960kHz), (L=571, SCS=120kHz), (L=571, SCS=480kHz), and (L=1157, SCS=120kHz).
* From [16] InterDigital:
  + Observation: PRACH with 120 kHz generally outperforms PRACHs with additional SCSs.
  + Further study necessity of PRACH for additional SCSs in Rel-17.
* From [22] Ericsson:
  + For cases other than initial access (e.g. for an SCell), support 480 and 960 kHz SCS for PRACH
* From [25] Qualcomm:
  + Observation: for the PRACH performance of different numerologies in the high frequency regime,
    - No noticeable difference in the misdetection performance is identified among SCSs.
    - With the same CINR, the false alarm rate increases as the SCS or sequence length (i.e., bandwidth) increases
  + consider using the following for the PRACH preamble sequence lengths for higher bands:
    - SCS = 120 kHz: 139 and 571
    - SCS = 480/960 kHz: 139 only
  + Observation: for higher RACH SCS (480 and 960 kHz), the CP length may not be long enough to absorb the gNB beam switching delay requirement
* From [26] NTT Docomo:
  + For SCS of PRACH preamble, in addition to 120 kHz,
    - 480 and 960 kHz SCS should be supported to achieve single numerology operation

**Summary of Discussions in Tdoc**

* Companies provided proposals on supported SCS for PRACH. Some proposal suggest to limit specific SCS for PRACH to initial access or SCell operation.
  + Support only 120kHz
    - FUTUREWEI (for initial access), Huawei, HiSilicon, MediaTek
  + Support 120, 480, 960 kHz
    - Lenovo, Motorola Mobility, Intel, Fujitisu, Ericsson (non-initial access cases), Qualcomm, NTT Docomo
* Suggest to discuss further on the supported SCS for PRACH along with supported sequence lengths (2.2.1)

**Discussions**

* Moderator suggest to discuss together with supported sequence lengths.
* Please provide comments in Section 2.2.1.

### 2.2.3 PRACH Format

* From [5] Huawei, HiSilicon:
  + For PRACH SCS = 120 kHz, the PRACH formats A1, A2, A3, C2 with reduced guard time or reduced PRACH duration NdurRA should be supported.
* From [8] CATT:
  + Consider supporting the increasing of symbols in time domain to enhance coverage and the extending of frequency domain by repeating and concatenating the RACH preamble sequence in the unlicensed spectrum.
* From [9] vivo:
  + Format 0-3 with special SCS is not supported
  + Support 120KHz and 960KHz SCS for PRACH format (A, B, C) in NR operation from 52.6-71GHz.
* From [25] Qualcomm:
  + for higher bands consider reusing the PRACH formats defined in NR Rel-16 (with appropriate SCS scaling)

**Summary of Discussions in Tdoc**

* Several companies provided proposals on supported PRACH Formats (0~3, A, B, C) for 52.6 ~ 71 GHz band. The discussion includes potential updates to guard time for existing PRACH formats, and increasing number of symbols in time domain.
* Suggest to discuss further supported PRACH Formats and related issues.

**Discussions**

* Moderator suggest to discuss together with supported sequence lengths.
* Please provide comments in Section 2.2.1.

### 2.2.4 RACH Occasion Resources

* From [1] FUTUREWEI:
  + Support non-consecutive RO to reduce possibility of LBT failure.
* From [4] OPPO:
  + set the reference SCS for RACH slot determination as 120kHz.
  + RAN1 should design a unified RO configuration for both licensed and unlicensed spectrums.
  + On top of RO configuration, a mask can be further added for unlicensed spectrum to switch off certain RO from being selected.
* From [5] Huawei, HiSilicon:
  + A gap between two consecutive TDM ROs should be introduced to avoid a LBT failure at the UE due to a RACH transmission from another UE in the previous RO.
* From [6] Nokia, NSB:
  + Observation: If LBT gaps are needed between ROs, it would be better to define fixed LBT gap time between valid ROs that do not depend on the time domain allocation of the PRACH. In that case the LBT gap length would not depend on the used PRACH format.
* From [8] CATT:
  + Observation: The current RO configuration of FR2, based on the 60 KHz slot as the basic unit, which supports two slots configuration when SCS is 120KHz.
  + When the specification supports SCS=/480/960 KHz, 120 KHz configuration is reused for each 8/16 slots within 60 KHz slot.
* From [9] vivo:
  + With the introduction of larger SCS in 52.6-71GHz, such as 480/960kHz, how to configure time domain ROs should be considered.
  + One approach is to reuse FR2 RO slot configuration rule but to define new reference slot and re-interpret RACH slot index for high PRACH SCS in 52.6-71GHz.
* From [11] MediaTek:
  + There is no need to support non-consecutive RACH occasions configuration.
* From [13] Fujitsu:
  + Support RO configuration for non-consecutive ROs in time domain.
* From [16] InterDigital:
  + Observation: In NR-U, introduction of non-consecutive RACH occasions was discussed, but agreements on the specification support weren’t made as it could be handled by gNB implementationn. For 52.6 – 71 GHz, non-consecutive RACH occasions still can be handled by gNB implementation and CCA failure may be a relatively rare event due to a narrower beam.
  + For 52.6 – 71 GHz, supporting non-consecutive RACH occasions is not preferred
* From [17] LGE:
  + If 480 or 960 kHz subcarrier spacing is supported for PRACH, the corresponding PRACH sequence length can be L=139 and/or L=571, and the following FFS points can be considered:
    - How to express slot indexes within the 10ms window for 960 kHz subcarrier spacing PRACH by using existing 16 bits RA-RNTI
    - How to configure RACH slot for 480 or 960 kHz subcarrier spacing PRACH
  + When LBT is used to transmit the PRACH preamble, consider to insert CCA gap between adjacent RACH occasions in time domain (e.g. X usec or Y symbol) to avoid inter-UE LBT blocking due to the propagation delay of PRACH transmitted in an earlier RO.
* From [19] Xiaomi:
  + Inconsecutive RO time domain configuration need be discussed.
* From [20] Samsung:
  + Using the RO pattern for SCS = 120 kHz derived from the PRACH configuration table as the reference for larger SCS cases.
  + For RO configuration, both direction 1 (indication on which one(s) of the 8 eighty-slots) and direction 2 (keep 80slots in total but redesign the RACH period and RACH duration location) can be considered.
  + Support non-consecutive RO configuration to alleviate the RACH LBT failure.
* From [22] Ericsson:
  + For 480/960 kHz PRACH, support PRACH configurations that allow maintaining the same PRACH processing load (operations/unit time) as for 120 kHz PRACH configurations.
  + Observation: The current PRACH configuration table for FR2 which defines PRACH slot positions based on a reference numerology of 60 kHz can be reused as is for 480/960 kHz. What needs to be specified is a rule on which 1 or 2 480/960 kHz slots within the reference 60 kHz slot contain PRACH occasion(s).
  + Support configuration of PRACH occasion(s) in only 1 or 2 480/960 kHz slots within a 60 kHz reference slot.
  + For 480/960 kHz PRACH, reuse the current PRACH configuration table in 38.211 for FR2 "as is." Specify rule for which 1 or 2 480/960 kHz slots within a 60 kHz reference slot are used depending on the value in the existing column "Number of PRACH slots within a 60 kHz slot" in the current PRACH configuration table. The rule should be common for all PRACH configurations in the table.
* From [25] Qualcomm:
  + a maximum of 4 FD multiplexed ROs for SCS = 120 kHz and sequence length = 571. For all other SCS and sequence length combinations, a maximum of 8 FD multiplexed ROs can be used
  + for higher RACH SCS (480 and 960 kHz), consider including a symbol-level gap between ROs to allow for gNB beam switching delay
  + for higher RACH SCS (480 and 960 kHz), consider including a symbol-level gap between POs to allow for gNB beam switching delay

**Summary of Discussions in Tdoc**

* Large number of companies discusses issue of supporting (or not supporting) non-contiguous RO.
* Suggest to discuss further on support of non-contiguous RO.

**Discussions #1**

* Please provide further comments on support of non-contiguous RO to cope with LBT.

|  |  |  |
| --- | --- | --- |
| **Company** | **Is there a need to consider LBT failure in RO design (e.g. by supporting non-contiguous RO configuration)?** | **Discussions/Comments** |
| Samsung | Yes | We observed more severe issue of RO blocking by LBT due to shorter symbol duration for 60 GHz unlicensed band, so we support configuring symbol gaps before RO for LBT purpose. |
| NEC | Yes | Support no-contiguous RO to reduce the impact of failure LBT. |
| ZTE, Sanechips | Neutral | We agree that non-contiguous RO configuration has benefit on LBT, so if LBT is required for RACH transmission, non-contiguous RO can be considered; otherwise, it’s not needed. |
| DOCOMO | Yes | We agree non-contiguous RO could be discussed from both perspective of beam switching gap with 480/960 kHz SCS as well as LBT failure, though the probability of LBT failure may be low. |
| LG Electronics | Yes | Consider to insert CCA gap between adjacent RACH occasions in time domain (e.g. X usec or Y symbol) to avoid inter-UE LBT blocking due to the propagation delay of PRACH transmitted in an earlier RO. |
| Spreadtrum | Neutral |  |
| vivo | Yes | We support non-contiguous RO is needed to avoid LBT blocking. Besides, RO configuration details for new SCS should also be discussed, e.g. reference slot and RO mapping within the slot |
| Nokia | Yes (covering also non-initial access scenarios) | If LBT is needed/supported for RACH, then non-contiguous ROs can be considered. If supported, it would be better to define fixed LBT gap time between valid ROs that does not depend on the time domain allocation of the PRACH. |
| Charter Communications | Neutral | Similar feature was not supported for Rel-16 NR-U which has much longer LBT sensing durations. |
| Futurewei | Neutral | Non-contiguous RO may be considered when LBT is required prior to RACH transmissions. RACH transmissions may also be considered under the short control signal transmissions category (LBT exempt) |
| Ericsson | No | As we discuss in Section 2.1.1 for SSB, LBT failure is rare, and furthermore, PRACH should not require LBT in the first place due to short control signaling exemption. It makes little sense to re-design PRACH configurations to support such gaps. The PRACH configuration table can be used "as is" in the 60 GHz band as we describe in our contribution. It is undesirable to re-design the PRACH configuration tables to support such gaps when they are not warranted in practice. |
| Qualcomm | No to LBT gap (but may need beam switching gap) | Agree with Ericsson on the LBT part. However, there may be a need for gNB beam switching gaps in between ROs/POs depending on SCS |
| OPPO | Yes | We support to configure non-contiguous RO for both licensed and unlicensed spectrum. The gap between ROs can be considered as LBT gap at UE side in unlicensed spectrum as well as beam switching gap at gNB side. |
| InterDigital | No | We believe that LBT failure issue can be handled by gNB implementation. |
| Fujitsu | Yes | We agree that non-contiguous RO should be supported, considering not only LBT but also beam switching. |
| Xiaomi | Yes | We prefer non-contiguous RO configuration for LBT failure case. |
| CATT | Yes | Non-contiguous RO is useful |
| Intel | No | From our analysis, even if we utilize 120 kHz SCS for PRACH, we do not believe the UE could ever exceed total transmission duration of 10 msec within 100 msec observation period. So, it might be possible to always consider utilizing short control signal exemption for PRACH transmissions.  We suggest to further discuss this. |
| Huawei, HiSilicon | Yes | We believe a gap between two consecutive TDM ROs should be introduced to avoid a LBT failure at the UE due to a RACH transmission from another UE in the previous RO. |
| Lenovo, Motorola Mobility | Yes | Support non-contiguous ROs for RACH if LBT based PRACH transmission is supported. |

*Moderator Note: Below are tentative summary and suggested conclusion, please continue to add comments to above until discussion in GTW. Moderator will update the summary and suggested conclusionas further comments are provided.*

**Moderator Summary of Discussions #1**

* Support non-consecutive RO
  + 10 Companies
  + Companies commented non-consecutive RO would be needed to cope for the following reasons:
    - Gap for LBT, gap for gNB Rx beam switching, and/or gap to avoid inter-UE LBT blocking
* No need to support non-consecutive RO
  + 4 Companies
  + Companies commented PRACH can be considered as part of short signal exemption and/or handle LBT by implementation.
* Majority of the companies seems to think non-consecutive RO is needed. With that said, suggest to discuss in GTW to at least hear out the companies that do not believe non-consecutive RO is needed to explain their logic and motivation.
* [Strive to make a conclusion in GTW.] Further discuss on following statement (as a starting point for further discussion):
  + Support non-consecutive RO configuration for PRACH
* Also, this might be relevant topic for channel access, may need Chairman’s guidance on where to discuss this matter.

### 2.2.5 RA Preamble ID calculation

* From [9] vivo:
  + When a larger PRACH SCS is introduced in 52.6-71GHz, the issue of RA-RNTI calculation needs to be investigated.
* From [17] LGE:
  + If 480 or 960 kHz subcarrier spacing is supported for PRACH, the corresponding PRACH sequence length can be L=139 and/or L=571, and the following FFS points can be considered:
    - How to express slot indexes within the 10ms window for 960 kHz subcarrier spacing PRACH by using existing 16 bits RA-RNTI
    - How to configure RACH slot for 480 or 960 kHz subcarrier spacing PRACH
* From [25] Qualcomm:
  + for higher RACH SCS (480 and 960 kHz), consider the following options for the RA-RNTI:
    - Option A: using the following equation for the RA-RNTI calculations µmax is the maximum µ for the FR used) and defining rules in case RA-RNTI conflicts with pre-allocated RNTIs or in case multiple ROs have the same RA-RNTI
      * RA-RNTI = (1 + s\_id + 14×t\_id + 14×max(80,Nslotframe,µmax)×f\_id + 14×max(80,Nslotframe,µmax) × 8 × ul\_carrier\_id) mod 216
    - Option B: reuse the same RA-RNTI equation in NR Rel-16, divide the RAR window into N segments (each segment is 80 slots using the used SCS), and signal the segment index in the DCI that schedules the MSG2/B

**Summary of Discussions in Tdoc**

* Some companies noted that RA-RNTI calculation (RA preamble ID) could overflow for larger PRACH SCS (i.e. 480 and 960 kHz) and suggest some potential modifications of this including methods to avoid issues by RO configuration definition.

**Discussions #1**

* Please provide further comments on RA-RNTI calculation issue identified by companies.

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| **Company** | **Discussions/Comments** |
| Samsung | We agree this issue should be further investigated in the WI. |
| ZTE, Sanechips | We agree to discuss this issue. Among the solutions above, Option B proposed by Qualcomm seems a more straightforward solution. |
| DOCOMO | We agree to discuss this issue further. |
| LG Electronics | If 960 kHz subcarrier spacing is supported for PRACH, further discussions are needed for how to express slot indexes within the 10ms window for 960 kHz subcarrier spacing PRACH by using existing 16 bits RA-RNTI. |
| vivo | We agree to discuss this issue after RO configuration for new SCS is determined. |
| Nokia | We can discuss this once we have concluded on supported scs (for RACH) and RO design. |
| Futurewei | Agree with the vivo and Nokia that we can discuss this topic after RO design and SCS for RACH decision. |
| Ericsson | We are fine to discuss this; however, it is not clear that a change is needed. It depends on the number of RACH occasions that are defined within a 60 kHz reference slot. Following the Rel-15/16 design, if two 480/960 kHz PRACH slots are defined within a 60 kHz reference slot, then changes may not be needed. |
| Qualcomm | Some solution is needed for this issue |
| OPPO | We can further investigate this issue. |
| InterDigital | We are fine to discuss this issue further. |
| Fujitsu | We agree that this issue should be discussed further. |
| CATT | These issue should be discussed after the conclusion of SCS for PRACH. |
| Apple | We agree to discuss this issue in the WI phase.  On Option B, it is unclear for us about the need of indicating segment index, as the potential use case is only when RAR window is overlapped between RO in two consecutive segmented windows |
| Intel | Further investigate this issue in RAN1 |
| Huawei, HiSilicon | This issue may be further investigated after we reach an agreement for the supported RACH SCS(s). This won’t be an issue if only 120 kHz is supported. |
| Lenovo, Motorola Mobility | We agree to discuss this issue further. Also agree with Nokia that the decision on SCS for RACH needs to be made first. |

*Moderator Note: Below are tentative summary and suggested conclusion, please continue to add comments to above until discussion in GTW. Moderator will update the summary and suggested conclusion as further comments are provided.*

**Moderator Summary of Discussions #1**

* There seems to be consensus that RA-RNTI calculation problem needs to be resolved (assuming 480/960kHz PRACH SCS is needed)
* Suggest to conclude the following:
  + If 480 and/or 960 kHZ PRACH SCS is supported, RAN1 observes that current RA-RNTI calculation and PRACH identification in RAR does not correctly provide unique identification of PRACH.
  + Study further on how UE can uniquely identify PRACH in RAR.
    - Some examples for consideration:
      * Modification of RA-RNTI calculation equation
      * Divide RO into N segments, and indicate which segment in RAR

### 2.2.6 Short Signal Exception for PRACH

* From [12] Intel:
  + Observation: For 120 kHz, 480kHz, and 960 kHz PRACH transmission, UE does not exceed total transmission duration of 10 msec for PRACH within a 100 msec observation period.
  + Consider applying short control signal exemption to PRACH transmission by the UE.
* From [22] Ericsson:
  + It is not necessary to optimize PRACH design to allow for gaps between consecutive PRACH occasions within a PRACH slot, especially since SS/PBCH blocks can be classified as short control signaling transmissions consistent with EN 302 567.

**Summary of Discussions in Tdoc**

* Few companies discussed whether short signal exemption defined in EN302 567 can be applied to PRACH.
* Suggest to discuss further on short signal exemption to PRACH.

**Discussions #1**

* Please provide further comments applicability of short signal exemption for PRACH.

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| **Company** | **Discussions/Comments** |
| Samsung | Support including PRACH as short control signal. |
| NEC | Support treat the PRACH as a shot control signal. |
| ZTE, Sanechips | Support including PRACH as short control signal. |
| DOCOMO | Support including PRACH as short control signal |
| LG Electronics | Support transmission of short control signaling without LBT can be considered for transmitting information without any user plane data such as SSB, PRACH considering the updated ETSI EN 302 567. |
| vivo | Support including PRACH as short control signal |
| Nokia | We support treating the PRACH as short control signal. This discussion may relate to general channel access method discussion in agenda 8.2.6. |
| Charter Communications | Support including PRACH as short control signal |
| Futurewei | Support PRACH transmissions as short control signal. |
| Ericsson | Support defining PRACH as short control signal |
| Qualcomm | Support including PRACH as short control signal |
| OPPO | Support including PRACH as short control signal. |
| Xiaomi | Support to include PRACH as short control signal. |
| CATT | Support including PRACH as short control signal |
| Apple | Support including PRACH as short control signal. |
| Intel | Apply short control signal exemption to PRACH transmission by the UE |
| Huawei, HiSilicon | We do not support short signal exemption for PRACH due to the following reasons:   * If all UEs are allowed to transmit RACH without LBT, in fact the total RACH transmission time can be far more than the requirement of maximum 10 ms per every 100 ms. For instance, PRACH configuration Index 28 in Table 6.3.3.2-4 of 38.211 for FR2 allows RACH transmission in symbols (7-13) of all 40 reference subframes of all frames; resulting in the maximum total RACH occupancy of 42% (42 ms out of 100 ms). Although this might be an extreme example, in fact, many other PRACH configuration Indexes don’t meet the maximum 10 ms per every 100 ms requirement. * UL signals including RACH are transmitted using a wider beam and, therefore, have a larger interference foot-print on the network. * In our view, and as discussed in our reply in Section 2.1.1, the 10 ms out of 100 ms channel occupancy is only a necessary condition for exemption and not sufficient. Otherwise, virtually any single signal/channel could be designed so that it satisfies the above short duration criteria. 3GPP should interpret short “management and control Frames” terminology used in 302 567 and decide which signals/channels can be exempted. In particular, we believe that LBT is still necessary before gNB transmits SSB because of a broader energy emission foot-print of SSB burst. Moreover, if default periodicity of 20 ms is assumed, neither Case D nor Case E SSB patterns in 120 and 240 kHz satisfy the necessary 10/100 ms criteria. |
| Lenovo, Motorola Mobility | Support treating PRACH as short control signal. |

*Moderator Note: Below are tentative summary and suggested conclusion, please continue to add comments to above until discussion in GTW. Moderator will update the summary and suggested conclusion as further comments are provided.*

**Moderator Summary of Discussions #1**

* There seems to be majority support on application of short signal exemption to PRACH.
* Moderator suggest further discuss on the following:
  + RAN1 concludes NR PRACH is considered as control/management frames that can be exempt from LBT as described by short signal exception rules in EN 302 567.
* Moderator would like to further ask companies, if above statement is agreed, does this mean RAN1 no longer considers LBT for PRACH, or does the specification still need to support LBT for PRACH as an option?

# Summary of Moderator Proposals and Conclusions

[To be filled by Moderator]

# Summary of Agreements/Conclusion in RAN1 #104e

[To be filled once agreements and conclusions are available]

# Reference

1. R1-2100051, “Considerations on initial access for additional SCS in Beyond 52.6GHz,” FUTUREWEI
2. R1-2100057, “Initial access enhancements for NR from 52.6 GHz to 71GHz,” Lenovo, Motorola Mobility
3. R1-2100073, “Discussion on the initial access aspects for 52.6 to 71GHz,” ZTE, Sanechips
4. R1-2100149, “Discusson on initial access aspects,” OPPO
5. R1-2100200, “Initial access signals and channels for 52-71GHz band,” Huawei, HiSilicon
6. R1-2100257, “Initial access aspects,” Nokia, Nokia Shanghai Bell
7. R1-2100299, “Some views on initial access aspects for 52.6-71GHz,” CAICT
8. R1-2100370, “Initial access aspects for up to 71GHz operation,” CATT
9. R1-2100429, “Discussions on initial access aspects for NR operation from 52.6GHz to 71GHz,” vivo
10. R1-2100541, “Initial access aspects,” TCL Communication Ltd.
11. R1-2100607, “Initial access aspects for NR operations in 52.6-71 GHz,” MediaTek Inc.
12. R1-2100643, “Discussion on initial access aspects for extending NR up to 71 GHz,” Intel Corporation
13. R1-2100740, “Considerations on initial access for NR from 52.6GHz to 71 GHz,” Fujitsu
14. R1-2100781, “Further Discussion of Initial Access Aspects,” AT&T
15. R1-2100825, “Discussion on initial access aspects for NR from 52.6GHz to 71GHz,” Spreadtrum Communications
16. R1-2100836, “Discussions on initial access aspects,” InterDigital, Inc.
17. R1-2100892, “Initial access aspects to support NR above 52.6 GHz,” LG Electronics
18. R1-2100939, “Discussion on initial access aspects supporting NR from 52.6 to 71GHz,” NEC
19. R1-2101109, “On initial access aspects for NR from 52.6GHz to 71GHz,” Xiaomi
20. R1-2101194, “Initial access aspects for NR from 52.6 GHz to 71 GHz,” Samsung
21. R1-2101286, “Discussion on Initial access aspects for NR beyond 52.6 GHz,” CEWiT
22. R1-2101306, “Initial Access Aspects,” Ericsson
23. R1-2101372, “On Initial access signals and channels,” Apple
24. R1-2101417, “Consideration for NR Initial Access from 52.6 GHz to 71 GHz,” Convida Wireless
25. R1-2101453, “Initial access aspects for NR in 52.6 to 71GHz band,” Qualcomm Incorporated
26. R1-2101605, “Initial access aspects for NR from 52.6 to 71 GHz,” NTT DOCOMO, INC.
27. R1-2101672, “Discussion on initial access aspects for NR beyond 52.6GHz,” WILUS Inc.