3GPP TSG RAN WG1 #119 R1-24xxxxx

Orlando, US, November 18th – 22nd, 2024

**Agenda item:** 9.11.5

**Source:** Moderator (Qualcomm Incorporated)

**Title:** Feature lead summary #1 on IoT-NTN TDD mode

**Document for:** Discussion and Decision

# Background

In RAN#105, a new work item on Introduction of IoT-NTN TDD mode was approved [1] with the following objective:

The study and work objectives assume the following:

* LEO @600 km and @1200 km orbit respectively, with set-1 satellite parameters as reference scenarios (See 3GPP TR 36.763)
* Target the 1616-1626.5 MHz MSS allocated band
* Standalone deployment with anchor and non-anchor carriers (i.e. operating in carrier(s) used only for NB-IoT)
* Operate with Earth fixed Tracking area, with either Earth fixed cells or Earth moving cells for NGSO
* The new NB-IoT NTN TDD mode allows configuring the usage of radio resources in the targeted MSS allocated band with a periodic subset of the UL and DL subframes in N radio frames. The periodic pattern should consist of non-overlapping set of usable contiguous UL subframes and set of usable contiguous DL subframes, and guard periods, which is periodic every N radio frames, with N=9 as baseline. No blind detection is assumed at the UE side. The value of N and the configuration of the periodic pattern are fixed per band.

This work item includes the following objectives:

* Study the impact due to the periodic pattern, at least on UE downlink synchronization and other aspects (if identified) [RAN1, RAN4]
	+ Checkpoint in RAN#106 for the completion of the study phase. RAN1 start from Oct’24. RAN4 start from Nov’24
* Specify a new NB-IoT TDD NTN mode based on minimum necessary changes to the NB-IoT NTN FDD frame structure and procedures, based on the outcome of the study, including:
	+ Definition, configuration (if needed) and signaling (if needed) of the periodic pattern including confirming the value of N, and associated UE procedures [RAN1, RAN2]
	+ Other necessary impacts on higher layers [RAN2]
	+ RRM and RF core requirements [RAN4]

## 1.1 Previous agreements:

### 1.1.1 RAN1#118b

Agreement

The target operating DL CNR of NB-IoT NTN TDD is obtained following the parameters in TR 36.763 and modifying the carrier frequency to 1.6GHz:

* For LEO-600, the operating DL CNR is 4.91dB (i.e. with 0dBi UE antenna gain).
* For LEO-1200, the operating DL CNR is 5.51dB (i.e. with 0dBi UE antenna gain).
* When reporting link level simulation results, companies are encouraged to report the CNR margin with respect to the above operating DL CNRs.
* Companies may report values for other scenarios (e.g. UE antenna gain of -5.5 dBi, LEO-800) with the corresponding assumptions.

Agreement

For the study phase, RAN1 assumes as a baseline for evaluations (which includes DL synchronization as per the WID) that downlink PHY channels and signals are transmitted on the anchor carrier following subframe index/location and SFN mapping of NB-IoT NTN FDD.

* For the purpose of study, the DL subframes of the Rel-19 TDD pattern may not fully cover all the instances of the PHY channels and signals and eNB will not transmit the corresponding instances.
	+ FFS: What is the TDD pattern

Agreement

RAN1 evaluates via link level simulations the following:

* NPSS/NSSS detection
* NPBCH decoding

Agreement

The impact of the TDD pattern at least on the following channels / signals are evaluated at least qualitatively (e.g. specification impact, number of available instances, etc.):

* SIB1-NB
* Other SIBs needed for basic NB-IoT NTN operation (e.g. SIB2, SIB31)
* Paging
* NPRACH / RAR
* NPSS/NSSS/NPBCH
* NPDCCH, NPUSCH, NPDSCH
* Note: Study for the above channels / signals may continue during the normative phase.
* It is up to companies to perform link level evaluations for some of the aspects above.

Agreement

For link level simulations of NPSS / NSSS / NPBCH, RAN1 uses the following assumptions:

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| Parameter | Value |
| Carrier frequency | 1.6GHz |
| Channel model | NTN TDL-C rural, 30 degrees |
| Frequency error / timing drift (including XO error) | 34 ppm for NPSS / NSSS (24ppm Doppler + 10ppm XO error)0.1ppm for NPBCH |
| Variation of frequency error / variation of timing drift | 0.27ppm/s for NPSS / NSSS0 for NPBCH |
| UE velocity | 3km/h |
| Target performance | For NPSS/NSSS:* 99% detection probability with 0.1% false alarm rate
* FFS: How to define correct detection, including successful timing / frequency estimation / cell ID detection.

For NPBCH:* 1% BLER

For the channels / signals above, acquisition delay shall be reported for the corresponding detection probability |
| Other assumptions (e.g. combining length, frequency error hypothesis, etc.) | To be reported and justified by companies |

Agreement

For the study phase, RAN1 evaluates the following combination of N (in radio frames) and D (D = number of consecutive downlink subframes):

* N = 9:
	+ D = 8
	+ D = 20
	+ D = 30
* N = 8:
	+ D = 20
* Companies to report which subframe indices are included in the set of consecutive downlink subframes.
* Other combinations are not precluded to be reported by companies

NOTE: This does not imply that the above combinations are the only ones to be considered during the normative phase.

Agreement

For the study phase, RAN1 evaluates the following combination of N (in radio frames) and U (U = number of consecutive uplink subframes):

* N = 9:
	+ U = 8
	+ U = 20
	+ U = 30
* N = 8:
	+ U = 20
* Companies to report which subframe indices are included in the set of consecutive uplink subframes.
* Other combinations are not precluded to be reported by companies
* For evaluations including both uplink and downlink (if any), companies are encouraged to prioritize the case of D=U

NOTE: This does not imply that the above combinations are the only ones to be considered during the normative phase.

Agreement

For the study phase, RAN1 assumes as a baseline for evaluations that uplink PHY channels are transmitted on the anchor carrier following subframe index/location and SFN mapping of NB-IoT NTN FDD.

* For the purpose of study, the UL subframes of the Rel-19 TDD pattern may not fully cover all the instances of the PHY channels and eNB will not receive the corresponding instances.
	+ FFS: What is the TDD pattern

## 1.2 Plan for this meeting

From the FL perspective, RAN1 should progress on the following topics in this meeting:

1. Conclude on downlink synchronization performance based on submitted evaluations, in line with RAN checkpoint.
2. Conclude on the value of N, at least for the 1616-1626.5 MHz MSS band.
3. Advance on downselection / prioritization of values of D/U.
4. Initial agreements on:
	1. Set of subframes in D.
	2. How to indicate / derive the GP / location of U.
	3. General aspects on how to handle different uplink/downlink physical channels/signals.

# 2 Evaluation of downlink synchronization

Several contributions have provided evaluation results for NPSS, NSSS and NPBCH in line with the agreed evaluation assumptions in RAN1#118b.

The following xls includes the link level simulation results from multiple companies (note: the numbers of proposal 2-1 are linked to the xls):



The xls has highlighted a couple of results that, in FL’s view, do not follow the agreed simulation assumptions and should be discussed.

The summary of the evaluations is shown below. At least the highlighted text would need discussion, since one of the two sources seems to be from an outlier, having a large impact on the median.

## **[HIGH] Proposal 2-1 (Conclusion): RAN1 makes the following observations on downlink synchronization:**

**Case 1: For N=9, D=8:**

* **For NPSS:**
	+ **For one-shot detection (90ms delay), 9 sources provided simulation results, with a median required SNR of 1.30dB. The link budget margin is (median margin):**
		- **4.21 dB for LEO-1200 (0dBi antenna gain)**
		- **-1.89 dB for LEO-600 (-5.5dBi antenna gain).**
	+ **For two-shot detection (180ms delay), 3 sources provided simulation results , with a median required SNR of -1.20dB. The link budget margin is (median margin):**
		- **6.71dB for LEO 1200 (0dBi antenna gain)**
		- **0.61dB for LEO-600 (-5.5dBi antenna gain).**
	+ **For four-shot detection (360ms delay), 3 sources provided simulation results, with a median required SNR of -3.80dB. The link budget margin is (median margin):**
		- **9.31dB for LEO-1200 (0dBi antenna gain)**
		- **3.21dB for LEO-600 (-5.5dBi antenna gain).**
	+ **NOTE: The assumptions for combining for 2-shot and 3-shot detection are different across companies.**
* **For NSSS:**
	+ **For one-shot detection (180ms delay), 5 sources provided simulation results, with a median required SNR of -2.50dB. The link budget margin is (median margin):**
		- **8.01dB for LEO-1200 (0dBi antenna gain)**
		- **1.91dB for LEO-600 (-5.5dBi antenna gain)**
* **For NPBCH:**
	+ **For 90ms combining, 4 sources provided simulation results, with a median required SNR of 3.48dB. The link budget margin is (median margin):**
		- **2.03dB for LEO-1200 (0dBi antenna gain)**
		- **-4.07dB for LEO-600 (-5.5dBi antenna gain)**
	+ **For 640ms combining, 7 companies provided results, with a median required SNR of -4.00dB. The link budget margin is (median margin):**
		- **9.51dB for LEO-1200 (0dBi antenna gain)**
		- **3.41dB for LEO-600 (-5.5dBi antenna gain)**

**Case 2: For N=9, D=20:**

* **For NPSS:**
	+ **For a combining of 2 consecutive NPSS (100ms delay), 1 source provided simulation results, with a median required SNR of -0.8dB. The link budget margin is (median margin):**
		- **6.31dB for LEO-1200 (0dBi antenna gain)**
		- **0.21dB for LEO-600 (-5.5dBi antenna gain)**
* **For NPBCH:**
	+ **For 640ms combining, 2 sources provided simulation results, with a median required SNR of -0.40dB. The link budget margin is (median margin):**
		- **5.91dB for LEO-1200 (0dBi antenna gain)**
		- **-0.19dB for LEO-600 (-5.5dBi antenna gain)**

**Case 3: For N=9, D=30:**

* **For NPSS:**
	+ **For combining of 3 consecutive NPSS (110ms delay), 1 source provided simulation results, with a median required SNR of -2.4 dB. The link budget margin is (median margin):**
		- **7.91dB for LEO-1200 (0dBi antenna gain)**
		- **1.81dB for LEO-600 (-5.5dBi antenna gain)**
* **For NPBCH:**
	+ **For 640ms combining, 2 sources provided simulation results, with a median required SNR of
	 -2.23dB the link budget margin is (median margin):**
		- **7.74dB for LEO-1200 (0dBi antenna gain)**
		- **1.64dB for LEO-600 (-5.5dBi antenna gain)**

**NOTE: Other evaluated scenarios (LEO-600 with 0dBi antenna gain, LEO-1200 with -5.5dBi antenna gain, LEO-800 with 0dBi antenna gain) have margins in between LEO-1200 (0dBi antenna gain) and LEO-600 (-5.5dBi antenna gain)**

**NOTE: Different companies provided input for different cases. For the companies that evaluated multiple cases, the performance (in terms of acquisition delay) of Case 3 and Case 2 is better than the performance of Case 1.**

## **[HIGH] Proposal 2-2 (Conclusion): In terms of downlink synchronization (NPSS/NSSS/NPBCH), all the following cases meet the link budget requirements for IOT-NTN TDD and are feasible from RAN1 perspective:**

* **Case 1: N=9, D=8**
* **Case 2: N=9, D=20**
* **Case 3: N=9, D=30**

Please provide comments on the two proposals above, especially regarding the following:

1. Any comments about the evaluation results xls, e.g. whether some result is missing or whether some result should be excluded.
2. Any comments about the formatting of writing the observations down (e.g. use of median vs average, whether to include some additional scenarios, etc.)
3. Any comments about the proposed conclusions.

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| Company | Comment |
| OPPO | For the concrete observation details, we may further provide comments later. But for proposal 2-2, do we really need to consider case 1,2,3 for DL sync? or only focus on case 1. I think that there are potential issues to support case 2 and 3. The link level simulation cannot lead us to conclude the feasibility for case 2 and 3 for the moment. At least more detailed discussions are needed for these cases. But do we need to spend time to discuss these two cases? |
| Vivo1 | FL has provided a summary of the link-level results, which is valuable. However, we believe it is also important to consider system-level analysis and draw observations for the overhead of DL broadcast signals/message of initial access from system-level. These perspectives can offer a broader view of the potential impacts on overall system performance and NW scheduling. We have revised our contribution to R1-2410672, corrected some errors and provided additional observations on the overall DL overhead when the repetition time is 8. The updated observations/proposal are also copied to the FL summary. For example, it can be observed that if the number of repetition of SIB1-NB within 2560ms is at least 8: for N=9, D=8, the overhead of DL broadcast signal within 5120ms is 58.8%; the overall overhead of DL broadcast signal and message (NPSS/NSSS/MIB-NB/SIB/MSG2/MSG4) of a UE during IA exceeds 67.5%. There are very limited resources for multi-UE access and unicast data transmission. |

# 3 Downlink

## 3.1 Downlink structure

On the periodicity of the TDD structure, the following input was received:

* [HW], [TH], [Iri], [SS], [Vivo], [CATT], [OPPO], [Eri], [QC], [Len], [CMCC], [LGE] support to specify or focus on N=9
* [NK] proposes to prioritize N=8
* [Eri] proposes N=8 in addition to N=9 for systems not constrained by legacy deployments.
* [Xiaomi] proposes to preclude N=9 D/U=8

The main reason cited by most companies is to keep compatibility with the legacy system deployed in the 1.6GHz MSS band.

### **[HIGH] Proposal 3.1-1: In Rel-19, only N=9 is supported for the 1616-1626.5 MHz MSS band.**

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| Company | Comment |
| Ericsson | Given we are introducing into the technical specification a TDD mode for NB-IoT NTN, we should not design only a tailored made TDD mode framework for a particular system, but also a TDD mode framework that can be generic and future-proof with minimum impact in the 3GPP technical specification. Thus, we can be ok with N = 9 including in parallel an N = 8.  |
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Regarding the value of D, the following input is received:

* [HW]: at least D=30 is supported
* [ZTE], [CATT]: at least 2 consecutive radio frames (D=20).
* [Apple], [TH], [Iri], [SS], [Vivo?], [OPPO], [Eri], [Len], [QC], [Nor]: at least D=8 is supported
* [Xiaomi]: preclude D/U=8

Several companies (e.g. [Len], [QC], [Apple], [TH], [OPPO]) mentioned that D=8 should be supported but additional downlink subframes may be configured, and some companies mentioned explicitly that D=8 could be the assumption during initial access. Other companies, however (e.g. [ZTE]) propose that the pattern is fixed. FL brings forward the following proposal:

### **[HIGH] Proposal 3.1-2: At least D=8 is supported for the 1616-1626.5 MHz MSS band**

* **During initial access, a UE may assume D=8 for the 1616-1626.5 MHz MSS band.**
* **FFS whether larger values of D are specified for usage after initial access.**

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| Company | Comment |
| Ericsson | D = 8 is too restrictive leaving almost no room for user data (which may require repetitions and in principle use up to 10 NPDSCH subframes) when essential PHY-channels and signals (and other information e.g., SIB2-NB, SIB31-NB) are transmitted. Similarly, as in the previous proposal, we can accept D = 8 given the limitation of the system at 1616 – 1626.5 MHz, but since we are introducing a TDD mode for NB-IoT NTN into the specs, we should also have other value(s) e.g., D = 20.Finally, we would not like to condition the longer values for D to post-initial access because we think that the system at 1616 – 1626.5 MHz has a fixed allocation of resources for the services it hosts (including 1 fixed UL and 1 fixed DL slot for NB-IoT services), and therefore there is no possibility to “unlock” more resources for NB-IoT post-initial access. |
| OPPO | If this proposal is agreeable, does it imply that for FL proposal 2-2, we don’t need case 2 and case 3? I would suggest to only focus on case 1 and I certainly agree with proposal 3.1-2. |
| Vivo1 | Based on our analysis, D=8 may not provide sufficient capacity for multi-UE access/dedicated data transmission. The overhead of DL common signals, such as NPSS, NSSS, MIB-NB, and SIB, already account for approximately 58.8% of the available DL resources. And taking the overhead of other DL signals (e.g., msg2/4) during initial access procedure into account, more than 67.5% of the available DL resources would be required for initial access for a single UE. |

On the set of subframe used for the DL structure (assuming D=8), the following input was received:

* [Eri] proposed to use 2 consecutive radio frames, with subframes [3,4,5,6,7,8,9,0] or [4,5,6,7,8,9,0,1].
* [QC] proposed to downselect between $\left[4 5 6 7 8 9 0 1\right],$ $\left[3 4 5 6 7 8 9 0\right],$ $[8 9 0 1 2 3 4 5]$, $[9 0 1 2 3 4 5 6]$
* [TH] proposed to consider an alternative frame structure where the NSSS is moved to subframe 7
	+ NOTE: [TH] proposal says “NPSS is moved to subframe 7”, but the figures are about NSS.
* [Iri] has an example showing frames [8 9 0 1 2 3 4 5].
* [ZTE] proposes an example of [4,5,6,7,8,9,0,1] for D=8, but prefer to have D>=10 and keep alignment with frame boundary.
* [Len] states that a time offset (in subframes) between the TDD structure and the NBIOT frame boundary should be introduced, with an offset of 3-4 subframes (which is equivalent to [3,4,5,6,7,8,9,0] or [4,5,6,7,8,9,0,1])
* [OPPO] present different alternatives for the locations of D=8 (starting in SF 3, 4, 8 or 9). Furthermore, the location is fixed.

FL makes the following proposal:

### **[LOW] Proposal 3.1-3: The downlink subframes within D=8 (at least for initial access) are:**

* **Option 1: [3 4 5 6 7 8 9 0] (across two consecutive radio frames)**
* **Option 2: [4 5 6 7 8 9 0 1] (across two consecutive radio frames)**
* **Option 3: [8 9 0 1 2 3 4 5] (across two consecutive radio frames)**
* **Option 4: [9 0 1 2 3 4 5 6] (across two consecutive radio frames)**
* **Option 5: [0 1 2 3 4 5 6 7] with NSSS mapped to subframe 7 instead of subframe 9**

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| Company | Comment |
| Ericsson | The proposal states “The downlink subframes … are:” but I guess the intention is listing candidates for an eventual down-selection?Similar comment as in previous proposal for “initial access,” so, please remove “at least for initial access”.We should also have a similar proposal for other values of D (e.g., D = 20) for which in principle it would be natural to have two consecutive radio frames each spanning from [0 1 2 3 4 5 6 7 8 9]. |
| OPPO | We think that the importance is the other DL common signal/channel relative location to NPSS. For option 1~4, any option is good to adopt, basically there is not much pros and cons among different options. For ease of UE detecting NSSS, one option could be selected as the assumption for UE performing initial access. Otherwise, UE can make hypothesis on these 4 options, which may increase a bit of the NSSS detection complexity, but network can implement any option it wants. So, I would say option 5 should be the first to rule out, as the change is not necessarily needed. Then RAN1 can assume all the options are possible to implement or just pick one.  |
| Vivo1 | We share similar view with Ericsson that this proposal should be for down selection.The WID requires minimum changes on legacy IoT FDD, we think option5 should be ruled out as it changes the NSSS location. |

On how to determine the offset of the TDD frame structure:

* [ZTE]: Remaining radio frames before SFN wrap are skipped. TDD pattern is the same across H-SFN
* [LGE]: Several options are presented:
	+ Orphan subframes not used for DL or UL (this seems to indicate pattern is the same across H-SFN.
	+ TDD pattern starts at very first SFN0, offset is derived by NBPCH / SIB1-NB
* [OPPO] proposes to reduce the length of the H-SFN by removing the last 16 radio frames
* [QC] proposes that the offset is derived based on sync signals, and may be different across SFN wrap-around.
* [Nordic] indicates that during the last 70ms, only the last part is transmitted

FL would like to clarify that for the alignment to work, we would need to change the number of SFNs in a H-SFN. Skipping transmissions would not make things to be aligned (highlighted cells indicate the start of a TDD pattern):

This would be the pattern if we do not do anything:

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| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | … | 1008 | 1009 | 1010 | 1011 | 1012 | 1013 | 1014 | 1015 | 1016 | 1017 | 1018 | 1019 | 1020 | 1021 | 1022 | 1023 | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
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One way to align the patterns would be to make one SFN 1017 radio frames (so RF 1017 -> RF0):

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| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | … | 1008 | 1009 | 1010 | 1011 | 1012 | 1013 | 1014 | 1015 | 1016 | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** |
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Based on the above, FL makes the following proposal:

### **[LOW] Proposal 3.1-4: The offset between the 90ms TDD structure and the 10240ms H-SFN is:**

* **Option 1: Always the same across H-SFNs. SFN duration is changed to X radio frames, with X a multiple of 9.**
* **Option 2: Different across some H-SFNs.**
	+ **UE is indicated (implicitly or explicitly) the offset between SFN and 90ms TDD structure based on some downlink signal (e.g. one of NPSS/NSSS/NPBCH/SIB1-NB)**

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| Company | Comment |
| Ericsson | More discussion and analysis is needed aiming at minimizing the specification impact, we are not ready to agree on this proposal yet.  |
| OPPO | from our point of view, option 1 is easier for UE downlink synchronization, as the SFN index does not need to be re derived cross H-SFN. This is also more close to what we have in legacy system. Therefore, our preference is option 1.  |

## 3.2 Downlink channels

### 3.2.1 SIB1-NB

For handling of SIB1-NB, the following input is received:

* [HW] states that the performance of SIB1-NB will be impacted due to the reduced number of UL and DL subframes.
* [TH], [Iri] states that the available SIB1-NB subframes are enough at least with 16 repetitions. [Iri] additionally state that 4 or 8 repetitions may also be enough in some cases.
* [SPDR] states that only N=8, D=20 may not receive SIB1 with repetition 16. For other cases, 16 repetition works. For 4 and 8 repetitions, no case can receive SIB1.
* [vivo] analyzes different combinations of N and D. For N=9, larger values of D offer more opportunities of SIB1-NB transmission. For N=8, some frames may be always dropped.
* [ZTE] states that the for N=9, D=8, SIB1-NB will be received at most once every 180ms, with the corresponding performance degradation.
* [LGE] analyzes different number of repetitions for N=9, D=8. For 4 repetitions, not all the TBCC bits may be transmitted. For 8 or 16, the code rate may not be low enough. A set of solutions are proposed to solve this issue, including allowing smaller TBS or additional SIB1-NB transmissions.
* [OPPO] proposes to extend the SIB1-NB transmission window by a factor of N.
* [Nor] observes that at most 14-15 SIB1-NB subframes may be received in 2.56s

#### **[MEDIUM] Proposal 3.2.1-1 (Conclusion): RAN1 concludes that SIB1-NB reception following current specifications is feasible at least when the configured number of repetitions is 16. RAN1 may further consider during the normative phase enhancements to SIB1-NB, including but not limited to:**

* **Allowing smaller TBSs.**
* **Additional SIB1-NB transmissions.**
* **Extending SIB1-NB transmission window.**

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| Company | Comment |
| Ericsson | The WID states “Specify a new NB-IoT TDD NTN mode based on minimum necessary changes to the NB-IoT NTN FDD frame structure and procedures”.Based on the WID, we should aim at specifying TDD mode with minimum spec impact.Moreover, some clarification is needed for the sub-bullets, for example: Is “Allowing smaller TBs” literally a proposal to introduce smaller TBs which would imply e.g., new entries in the TBS/MCS table? or is it meant to propose using for TDD NTN mode the smallest TBs from the TBs available in the legacy TBS/MCS table? |
| Vivo1 | First, it is not clear whether the conclusion is for N=9 or N=8 or both?For N=8, we think there are issues for SIB1-NB reception, as there are always-invalid occasions for SIB1-NB reception, potentially causing the UE to fail in decoding SIB1-NB.For N=9 D=8, we observed that the occasions for transmitting SIB-NB are significantly reduced. Although there may be 15 transmission occasions within 2560ms, but if the SIB1-NB requires multiple subframes for mapping all the code bits, the number of actual repetitions for SIB1-NB will further reduce. E.g., For Case1. N=9 D=8, if the mapping of a complete SIB-NB requires 4 subframes and configured number of repetitions is 16, 1 complete SIB1-NB can be provided within a NPBCH periodicity=640 ms, 3~4 complete SIB1-NBs can be provided within a SIB1-NB periodicity=2560 ms, 7~8 complete SIB1-NBs can be provided within 5120ms. The performance impact on the SIB1-NB due to the reduced transmission occasions is unclear. It can be also observed that in order to have sufficient repetitions for transmission, UE needs to monitor SIB1-NB for a few SIB1-NB periods, which could significantly impact its battery life. Regarding the three options, the first option, which seems to propose new TBS, is not in line with the spirit of the WID: minimum necessary changes to the NB-IoT NTN FDD frame structure and procedures. The 2nd option may work, but as we mentioned before, there would be less resources for data scheduling. The last option leads to higher power consumption. Therefore, we suggest drawing observations of the impact of the cases on SIB1. |

### 3.2.2 General handling of other DL channels

For handling of general DL channels, many different inputs have been received.:

* [TH] proposes that other SI may span multiple downlink transmission periods
* [Iri] proposes to postpone and drop if overlap with next SI repetitions or overflow window length
* [OPPO]: RAN1 considers to align the SI window with period D subframe start, and change the SI window length and period to multiple of 90 ms.
* [QC] proposes to postpone NPDCCH and NPDSCH not carrying SIB1, and to specify a mechanism to monitor NPDCCH in every downlink burst. Also, non-D subframes should be “non NB-IoT DL subframes”
* [Nor] States that current SI configurations can provide enough repetitions within an SI window if properly configured.
* [SPDR] proposes that NPDSCH and NPDCCH may be in different periods.
* [LGE] proposes that RAR window / CR timer are adjusted to align with the TDD pattern.
* [Len] proposes to introduce valid / invalid subframes for DL, and to further study the existing paging / SI.
* [Eri] proposes to limit the usable entries in the MCS / TBS table.

Overall, not all the companies provided their views on these issues. FL proposes to have a high level agreement providing some guidance for future meetings.

#### **[LOW] Proposal 3.2.2-1: RAN1 to further discuss how to handle the collision of NPDCCH and NPDSCH (other than the one carrying SIB1-NB) and its associated parameters (e.g. starting point, windows for SI or RAR, PO, etc.) with non-D subframes, including at least the following potential specification impacts:**

* **Introducing new periodicities to align with the TDD structure.**
* **Postponement of a channel when it collides with non-D subframes.**
* **Specifying restriction of a channel to be fully confined within a single set of D subframes.**
* **Dropping (full of partial) of channels when they collied with non-D subframes.**
* **Specifying that the non-D subframes are not “NB-IoT DL subframes.”**

|  |  |
| --- | --- |
| Company | Comment |
| Ericsson | We prefer to capture the problem to be studied without yet the bullets since e.g., one of them already enunciates e.g., “Introducing …” and we think we are not there yet. Thus, the main sentence is ok until “… with non-D subframes”.  |
| Vivo1 | Similar view as Ericsson |

# Uplink

## 4.1 Uplink structure

Similar to the value of D, several companies provided input on the supported values of U:

* [HW] proposes to support U=30
* [TH] proposes to make this parameter configurable, and a value of 8 shall be supported.
* [SS] proposes to prioritize U=8
* [CATT] proposes to support at least U=20
* [Eri] proposes to support U=8 for compatibility with the legacy system, and U=20 for other cases
* [Len], [QC] proposes that U=8 is the baseline, additional subframes are indicated by SI

In view of the above, FL makes the following proposal.

### **[MEDIUM] Proposal 4.1-1: At least U=8 is supported for the 1616-1626.5 MHz MSS band**

* **FFS whether larger values of U are specified (e.g. U=20, U=30)**

|  |  |
| --- | --- |
| Company | Comment |
| Ericsson | Similar view as for DL. We think that if a TDD mode for NB-IoT NTN is going to be introduced into the technical specifications, it is ok to include the value (U = 8) that the system at “1616 – 1626.5 MHz” requires given its constraints, but also other values (e.g., U = 20) that offer better compatibility with the specification and a future proof solution. |
|  |  |

Several companies brought up the issue of the length of the guard period (GP) and location of uplink subframes:

* [TH] proposed that the GP should be larger than the RTT, which may be different for different deployments. They propose to indicate the “downlink to uplink guard period” for TDD operation.
* [SPDR] proposes that the GP needs to cover RTT between UE and ULSRP
* [Vivo] states that for regenerative, the GP should be at least 12.89ms for LEO-600 and 20.89ms for LEO-1200. Additionally, they propose to consider a single D-U switching point in the periodic pattern.
* [CATT] states that the RTT values are from 12.88ms to 25.77ms and from 20.88ms to 41.77ms, and proposes to have a single GP in the TDD pattern.
* [OPPO] states that the location of the U subframes is signaled by the eNB as an offset with respect to the D subframes.
* [Eri] states that the half duplex gap (1ms) should be taken into account.
* [QC] states that the set of U subframes can be explicitly indicated in logical time by an offset, or implicitly by e.g. common TA.
* [NK] states that RAN1 should study how to allocate the period of active contiguous subframe for UL to cover all the UE with different differential delay.

In addition, FL also observes that, due to the compatibility with the legacy Iridium structure, it may not be possible to always define the TDD pattern as [D G U] at the ULSRP, since this would mean that right after the U there is the start of the D (which is not compatible with their structure in most cases).

### **[MEDIUM] Proposal 4.1-2: For the relative location between D and U subframes and guard period (GP):**

* **The GP between D and U is designed to be larger than the maximum RTT**
	+ **FFS: what is the maximum RTT**
	+ **FFS: whether a half duplex gap (1ms) should be added to the maximum RTT**
* **For indicating the GP(s) location/length:**
	+ **Option 1: The GP(s) is(are) explicitly indicated.**
	+ **Option 2: The location of the U subframes is indicated / derived with respect to the location of the D subframes, and the guard period is derived as the difference between the end of D/U subframes and beginning of next U/D subframes.**

|  |  |
| --- | --- |
| Company | Comment |
| Ericsson | For the system at “1616 – 1626.5 MHz” it has been said that the restriction is that only 1 UL and only 1 DL slot can be assigned to NB-IoT. Since the system at “1616 – 1626.5 MHz” has several DL and UL slots, one question we have is what are the actual UL and DL slots intended to be assigned to NB-IoT from among all the possibilities below?  |
| OPPO | For U subframe, we need to have some high level alignment on the understanding. We would suggest to add two points1. whether the U subframe and D subframe are subframe aligned at the UL sync reference point. This should be clarified, as it may change the legacy definition of ULSRP.
2. what is the reason a gap period should cover the max RTT. This is not clear. We think that the max RTT can already be covered by K offset, no matter how much the GP is. Would it make sense that the GP is only needed to cover the forbidden period in the Iridium’s TDMA structure?
 |

## 4.2 Uplink channels, general handling

Several companies provided initial views on how to handle other channels:

* [LGE] states that NPRACH cannot be transmitted in non-UL subframes, and proposes to modify the periodicity to align with TDD pattern
* [Len] proposes to introduce valid / invalid subframes for UL, and to align NPRACH resources with the TDD pattern.
* [QC] proposes that transmissions of NPUSCH / NPRACH are postponed when they collide with non-U slots. Furthermore, it is proposed to modify the starting point of segmented uplink pre-compensation.
* [Nor] proposes to adjust the interpretation of the NPRACH configuration to adjust to 90ms periodicity.
* [vivo] states that when subcarrier spacing of 3.75kHz is applied to NPRACH, the minimum required continuous UL resource for NPRACH in a UL resource set is 7 ms
* [HW] states that the NPRACH repetitions may be dropped in non-uplink resources.

Similar to the DL case, not all the companies provided their views on these issues. FL proposes to have a high level agreement providing some guidance for future meetings.

### **[LOW] Proposal 4.2-1: RAN1 to further discuss how to handle the collision of NPUSCH and NPRACH and its associated parameters (e.g. NPRACH occasions) with non-U subframes, including at least the following potential specification impacts:**

* **Introducing new periodicities to align with the TDD structure.**
* **Postponement of a channel when it collides with non-U subframes.**
* **Specifying restriction of a channel to be fully confined within a single set of U subframes.**
* **Dropping (full of partial) of channels when they collide with non-U subframes.**
* **Impact on segmented pre-compensation.**

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| --- | --- |
| Company | Comment |
| Ericsson | We prefer to capture the problem to be studied without yet the bullets since e.g., one of them already enunciates e.g., “Introducing …” and we think we are not there yet. Thus, the main sentence is ok until “… with non-U subframes”. |
|  |  |

# Proposals from contributions

|  |  |  |
| --- | --- | --- |
| [R1-2409409](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2409409.zip) | Huawei, HiSilicon [HW] | *Observation 1: For a TDD pattern with N=8, any radio frame in the TDD pattern will eventually have a collision that will result in dropping that radio frame, because of 10 ms shifting occurring every 80 ms with the Iridium frame. It’s impossible to design a system that will work properly with N=8 to coexist with the Iridium satellite system.**Proposal 1：RAN1 should focus on a TDD pattern with N=9 when investigating and designing IoT NTN TDD system in Rel-19.* *Observation 2: The gap from the set of contiguous DL subframes to the set of contiguous UL subframes in a TDD pattern should be at least 21 subframes to accommodate the TX/RX switching at eNB and RTT of service link in LEO600/1200.* *Observation 3: Considering the consecutive DL subframes should contain the basic DL signals and information (NPSS, NSSS, MIB-NB and SIB1-NB), D=8 is not enough to schedule and transmit DL data.**Observation 4: There is no coexistence issue if the total duration of consecutive DL/UL subframes in a IoT NTN TDD pattern does not exceed the total duration of DL/UL slots in a Iridium TDMA frame structure.* *Proposal 2: At least the IoT NTN TDD pattern with D=30 DL consecutive subframes and U=30 consecutive UL subframes per N=9 radio frames should be supported.* *Observation 5: For Set-1 LEO600 and LEO1200 satellite scenario, the single shot NPSS detection can meet the link budget requirement (assume 0dBi antenna gain). The NPSS combination within the same TDD pattern can improve the coverage margin of NPSS.* *Observation 6: If there are only 8 DL subframes per 90ms TDD pattern, UE cannot meet the required CNR of NPSS detection with single shot detection, assuming -5.5dBi antenna gain. It is difficult to combine NPSS across 90ms TDD pattern because the timing drift between 2 NPSSs is 3.06us, exceeding the requirement of timing error +/-2.08us.**Observation 7: For Set-1 LEO600 and LEO1200 satellite scenario, the single shot NPBCH detection can meet the link budget requirement assuming 0dBi antenna gain. If antenna gain of -5.5dBi is assumed, the decoding latency of NPBCH in a TDD pattern with D=30 subframes is only half of that in a TDD pattern with D=8 subframes.* *Observation 8:* *The performance of NPRACH, Paging and SIB1-NB will be impacted due to reduced number of available DL and UL subframes in the TDD pattern, compared with the legacy FDD frame structure.*  |
| [R1-2409440](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2409440.zip) | THALES [TH] | **Parameters defining the NB-IoT NTN TDD pattern****Proposal 1** The TDD-DL-UL-Pattern provides the following parameters for TDD operation:* DL-UL-TransmissionPeriodicity which indicates the periodicity of the DL-UL pattern,
* nrOfDownlinkSubframes which indicates the number of consecutive DL subframes at the beginning of each DL-UL pattern,
* nrOfUplinkSubframes which indicates the number of consecutive UL subframes,
* DownlinkToUplinkGuardPeriod which indicates the downlink to uplink guard period for TDD operation.

**TDD pattern parameters values****Observation 1**Downlink to uplink Guard Period for TDD operation should commensurate at least the round trip delay (RTD). Thereby, to suit different deployments/orbits it should not be fixed per band**.****Proposal 2** In NB-IoT NTN TDD mode, for cell search procedure a UE may assume a predefined value for DL-UL-TransmissionPeriodicity and nrOfDownlinkSubframes. **Proposal 3**The value of DL-UL-TransmissionPeriodicity used for NB-IoT NTN TDD operation is fixed per band.**Proposal 4**The value of DL-UL-TransmissionPeriodicity is equal to 9 radio frames for the 1616-1626.5 MHz MSS allocated band.**Proposal 5**A minimum value of nrOfDownlinkSubframes and nrOfUplinkSubframes equal to 8 subframes is supported.**The start position of DL-UL pattern****Proposal 6** The first subframe of the DL-UL pattern period may not coincide with the start of a radio frame.**Proposal 7** The first subframes of DL-UL periodic pattern should be known to the UE.**Indication of the parameters of NB-IoT NTN TDD pattern****Proposal 8** The following parameters of TDD-DL-UL-Pattern are defined per cell and broadcast in system information* nrOfDownlinkSubframes
* nrOfUplinkSubframes
* DownlinkToUplinkGuardPeriod
* FFS: Their maximum values and bit allocations

**Proposal 9**Introduce an offset to indicate the subframes offset from the start position of a radio frame to the first subframes of DL-UL TDD pattern. **Proposal 10**RAN1 to discuss how the subframes offset from the start position of a radio frame to the first subframe of DL-UL TDD pattern is indicated to the UE. One or more of the following options may be considered:* Option 1: Introducing an offset to be part TDD-DL-UL-Pattern configuration which is explicitly indicated
* Option 2: Leverage existing invalid subframe filed
* Option 3: Implicit indication

**A modified frame structure for the new NB-IoT TDD mode for NTN****Proposal 11**RAN1 to discuss the possibility to support a slightly modified frame structure with:* a duration of 8ms
* NPSS is moved to 7th subframe of every second frame.

**UE downlink synchronization for IoT-NTN TDD mode support****Proposal 12**RAN1 to study the impact due to the periodic pattern, only on UE downlink synchronization.**DL synchronization evaluation results****Observation 2**For a 1% miss detection rate of the NPSS, the min required SNR is equal to:* 3.7 dB for single NPSS received
* -3.8 dB for 4 NPSS received during a 4x9 radio frames period

**Observation 3**For a 1% miss detection rate of the NSSS, the min required SNR is equal to -2.8 dB **Observation 4**For NPBCH decoding with 1% BLER, the min required SNR is equal to:* -6.9 dB for a 640 ms window, with 7 MIB subframes received

**Observation 5**The DL Carrier-to-noise ratio (CNR) for LEO600, LEO1200 and LEO800 is shown in the following table:

|  |  |
| --- | --- |
| Orbit | DL CNR  |
| LEO600 | 4.91dB |
| LEO1200 | 5.51 dB |
| LEO800 | 1.30 dB |

**Observation 6**No tangible negative impact observed due to the periodic pattern with N=9 radio frames on UE downlink synchronization**Observation 7**When operating in the new TDD mode for NB-IoT NTN, successful NPSS/NSSS/NPBCH detection/decoding can be achieved with an adequate coverage margin for the satellite parameter set1 and the LEO600 and LEO1200 orbits considered in 3GPP TR 36.763, and for orbit LEO800 with associated satellite parameter set.**Proposal 12**Adopt the value of 9 radio frames for DL-UL-TransmissionPeriodicity. **SIB1-NB scheduling in IoT NTN TDD mode****Observation 8**With NB-IoT NTN TDD mode of operation with N=9, the number of available instances of SIB1-NB within 256 radio frames period would be enough, at least when SIB1-NB sequence is repeated 16 times.**Observation 9**In NB-IoT NTN TDD mode of operation with N=9 and nrOfDownlinkSubframes=8, a single SIB2-NB may span two consecutive DL transmission period when SIB2-NB is transmitted in 8 consecutive valid subframes. **Observation 10**In NB-IoT NTN TDD mode of operation, the actual DL transmission period may not coincide with the first radio frame for SI message transmission in the SI window indicated by si-RadioFrameOffset. |
| [R1-2409531](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2409531.zip) | CMCC [CMCC] | **Proposal 1:****It is proposed to discuss whether the TDD configuration in the TDD mode can be reused for the new TDD mode.** **Proposal 2:****It should be further discussed whether the current available slots in the legacy system can support the DL synchronization procedure and the initial access procedure.****Proposal 3:****The available slot number from the legacy system (of MSS band) needs to be clarified.****Proposal 4:****N=9 radio frames can be considered for determining the periodicity of the new TDD mode of NTN system. And based on that further feasibility studies can be done based on that.** |
| [R1-2409565](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2409565.zip) | Iridium Satellite LLC [Iri] | **Observation 1:** When operating in NB-IoT NTN TDD mode with half duplex FDD frame structure, successful 99% NPSS detection with single NPSS subframe can be achieved with SNR margin of 5.41 dB and 6.01 dB for satellite parameter Set1 and the LEO600 and LEO1200 orbits respectively, considered in 3GPP TR 36.763, but operating in L-band. **Observation 2:** For LEO-800, even at the lower elevation angle of 8.20 downlink link budget has SNR margin of 1.8 dB to decode NPSSS successfully using single NPSS subframe. NPSS decoding performance can be further enhanced by combining multiple NPSS subframes and using more advanced NPSS detection algorithms.**Observation 3:** When operating in NB-IoT NTN TDD mode with half duplex FDD frame structure, successful 99% NSSS detection can be achieved with SNR margin of 8.31dB and 8.91 dB for satellite parameter Set1 and the LEO600 and LEO1200 orbits respectively, considered in 3GPP TR 36.763, operating in L-band.**Observation 4:** For LEO-800, even at the lower elevation angle of 8.20 downlink link budget has SNR margin of 4.7 dB to decode NSSS successfully using single NSSS subframe. NSSS decoding performance can be further enhanced by combining multiple NSSS subframes.**Observation 5:** When operating in NB-IoT NTN TDD mode with half duplex FDD frame structure, NPBCH can be successfully decoded by receiving up to 4 NPBCH subframes with SNR margin of 7.61 dB and 8.21 dB for satellite parameter Set1 and the LEO600 and LEO1200 orbits respectively, considered in 3GPP TR 36.763, operating in L-band.**Observation 6:** For LEO-800, even at the lower elevation angle of 8.20 downlink link budget has SNR margin of 4.0 dB to decode NPBCH successfully using up to four NPBCH subframes. **Observation 7:** When operating in NB-IoT NTN TDD mode with half duplex FDD frame structure, NPBCH can be successfully decoded by receiving up to 7 NPBCH subframes with SNR margin of 9.41 dB and 10.01 dB for satellite parameter Set1 and the LEO600 and LEO1200 orbits respectively, considered in 3GPP TR 36.763, s operating in L-band.**Observation 8:** For LEO-800, even at the lower elevation angle of 8.20 downlink link budget has SNR margin of 5.8 dB to decode NPBCH successfully using up to seven NPBCH subframes. **Observation 9:** When operating in NB-IoT NTN TDD mode, SIB-1 repetition pattern should be configured as 16 to allow every alternate active downlink opportunity to carry SIB-1 subframes for optimal SIB-1 acquisition time.**Observation 10:** When operating in NB-IoT NTN TDD mode, SIB-1 repetition of 4 and 8 may also be sufficient for successful decoding. Satellite network operators can configure SIB-1 scheduling parameters from the existing parameters set depending on the required SIB-1 acquisition latency time. **Observation 11:** With the IoT-NTN TDD mode frame pattern, it is possible for the SI window start time to fall within the inactive downlink period.**Observation 12:** With IoT-NTN TDD mode frame pattern, it is not possible to transmit all 8 subframes of SI transport blocks when SI TBS is equal to or greater than 208 bits.**Observation 13:** With the IoT-NTN TDD mode frame pattern, postponement of the transmission of SI transport block to the next downlink active time can result in overlap with the transmission of the next SI repetition when N=9 and SI repetition pattern is configured as lower than every 16th radio frame.**Observation 14:** With the IoT-NTN TDD mode frame pattern, postponement of the transmission of SI transport block to the next downlink active time can result in no overlap when N=9 and the SI repetition pattern is configured as every 16th radio frame.**Observation 15:** With IoT-NTN TDD mode frame pattern and postponement of transmission of SI transport block to the next downlink active time can result in in the SI transmission in the subframes outside of the configured SI window.**Proposal 1:** In NB-IoT NTN TDD mode, with value N preset to 9 indicating an active downlink time periodicity of 90ms, a UE can successfully complete downlink synchronization by detecting NPSS, NSSS and NPBCH with sufficient margin. Thus, N=9 to be defined for the L-band (1616 – 1626.5 MHz).**Proposal 2:** When operating in NB-IoT NTN TDD mode, there is no need to update the SIB-1 scheduling mechanism in the existing specifications, except for disabling transmissions during downlink inactive time. **Proposal 3:** In IoT-NTN TDD mode, if start of the SI window falls within the downlink inactive time, it shall be postponed to the next downlink active time.**Proposal 4:** In IoT-NTN TDD mode, SI transmission shall be allowed to be postponed to the next downlink active time opportunity.**Proposal 5:** In IoT-NTN TDD mode, SI transmissions shall be truncated if due to the proposed postponement, it overlaps with the transmission of the next SI repetition.**Proposal 6:** In IoT-NTN TDD mode, SI transmission shall be truncated if due to the proposed SI transmission postponement, it overflows the configured SI window length.**Proposal 7:** In NB-IoT NTN TDD mode, with value N preset to 9 indicating an active downlink time periodicity of 90ms, a UE can successfully complete downlink synchronization including SIB-1 acquisition. By making minor modifications to the SI scheduling mechanism, all SI messages can be scheduled with active downlink time duration of 8ms. Thus, D=8 can work for the IoT-NTN TDD mode for scheduling SI messages.  |
| [R1-2409618](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2409618.zip) | Samsung [SS] | **Proposal 1: RAN1 prioritizes N=9 and D=U=8 for further evaluations.** **Proposal 2: If N=9 and D=U=8 are supported, RAN1 discusses how to align {NPSS, NSSS, NPBCH} transmissions with D=8 with the following options.*** **Option 1: {NPSS, NSSS, NPBCH} are transmitted across consecutive two subframes. NPSS and NSSS are transmitted in the first subframe, and NPBCH is transmitted in the second subframe.**
* **Option 2: {NPSS, NSSS, NPBCH} are transmitted across consecutive two subframes. NSSS is transmitted in the first subframe, and NPBCH and NPSS is transmitted in the second subframe.**
* **Option 3: {NPSS, NSSS, NPBCH} are transmitted in one subframe with re-defining new subframe indexes.**
 |
| [R1-2409654](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2409654.zip) | Spreadtrum, UNISOC [SPDR] | ***Observation 1: In current specification, NPSS is transmitted in every frame and NSSS is transmitted only in even frames.******Observation 2: Among 4 cases, the duration to receive 4 different NSS of Case #1 is largest. For Case#4, UE can’t receive 4 different NSSS.******Observation 3: In IoT NTN TDD mode, the period of NPSS and NSSS will be greatly extended, which may affect DL synchronization.******Observation 4: For Case#1, UE may miss one PBCH block, which causes UE can’t acquire MIB.******Observation 5: Regardless of which case, the number of PBCH block that UE received is decreased which may affect UE to acquire MIB.******Observation 6: If repetition number is 4 and 8, all 4 cases can’t receive entire SIB1.******Observation 7: If repetition number is 16, only Case#4 can’t receive entire SIB1.******Observation 8: For IoT NTN TDD mode, UE spend more time to acquire SI and Case #1 has largest time.****Observation 9: For Case #4, if nB>=T, there could be always-invalid PO/PFs for some UE. If a small value of nB (e.g. one8thT) is provided, all PFs are valid but the paging capacity would be limited.**Observation 10: For Case #1, 2 and 3, the always-invalid PFs can be avoided, but the latency would be much longer and capacity would be much more limited.****Observation 11: DCI and it scheduled NPDSCH may in different periods.******Observation 12: In IoT NTN TDD mode, latency of RACH procedure will increase.******Observation 13: In IoT NTN TDD mode, NPUSCH maybe collision with guard period or DL active subframes of next period.******Observation 14: The guard period need to cover RTT between UE and UL synchronization reference point (i.e., TA pre-compensation value of UE) in NTN.******Proposal 1: RAN1 to discuss whether PBCH block that UE can receive in TDD mode is less than current spec would affect performance.*** |
| [R1-2409702](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2409702.zip),revised to R1-2410672 | Vivo [Vivo] | **Observation 1: In the worst case, the guard period should be no less than 12.89 ms for LEO-600 km and 20.89 ms for LEO-1200 km for the regenerative payload case, no less than 25.77 ms for LEO-600 km and 41.77 ms for LEO-1200 km for transparent payload, to prevent the overlapping between UL and DL considering the potential propagation delay on service link.****Observation 2: According to Clauses 8.12.3.1.1 and 8.12.3.2.1 in 36.101, for LEO-600km, the performance loss on NPBCH detection caused by the periodic pattern must not exceed 6.91dB for single NPBCH TTI or 16.41dB for multiple NPBCH TTIs, respectively; for LEO-1200km, the performance loss on NPBCH detection caused by the periodic pattern must not exceed 7.51dB for single NPBCH TTI or 17.01dB for multiple NPBCH TTIs, respectively.****Observation 3: Performance loss on NPBCH detection due to the restricted resource set of TDD pattern in Case1. N=9 D=8 is larger than the acceptable maximum loss 6.91B for single NPBCH TTI for LEO-600km and 7.51dB for LEO-1200km respectively; performance losses on NPBCH detection due to the restricted resource set of TDD pattern in Case2. N=9 D=20, Case3. N=9 D=30 and Case4. N=8 D=20 are acceptable for single NPBCH TTI for LEO-600km and for LEO-1200km.****Observation 4: Performance losses on NPBCH detection due to the restricted resource set of TDD pattern in Case1. N=9 D=8, Case2. N=9 D=20, Case3. N=9 D=30 and Case4. N=8 D=20 on NPBCH detection are acceptable for multi NPBCH TTI for LEO-600km and for LEO-1200km.****Observation 5: For other DL common channel/signal, to ensure a similar performance as that of the minimum performance requirement defined for NPBCH in 36.101, the TDD pattern may need to provide up to 16 repetitions within multi NPBCH TTI (e.g., 5120 ms) for these DL channels/signal*.*****Observation 6: By assuming that the maximum information bits of SIB-NB1 is around ~385 bits, subframe#4 of at least 4 frames for SIB1-NB mapping are needed.****Observation 7: For Case 4. N=8 D=20, if the mapping of a complete SIB-NB requires 4 subframes, subframe#4 in some frames conveying specific bits of SIB1-NB may never have an opportunity for transmission.****Observation 8: For Case1. N=9 D=8, if the mapping of a complete SIB-NB requires 4 subframes and configured number of repetitions is 16, 1 complete SIB1-NB can be provided within a NPBCH periodicity=640 ms, 3~4 complete SIB1-NBs can be provided within a SIB1-NB periodicity=2560 ms, 7~8 complete SIB1-NBs can be provided within 5120ms.****Observation 9: For Case2. N=9 D=20, if the mapping of a complete SIB-NB requires 4 subframes and configured number of repetitions is 16, 1~2 complete SIB1-NB can be provided within a NPBCH periodicity=640 ms, 7~8 complete SIB1-NBs can be provided within a SIB1-NB periodicity=2560 ms, 14~15 complete SIB1-NBs can be provided within 5120ms.****Observation 10: For Case3. N=9 D=30, if the mapping of a complete SIB-NB requires 4 subframes and configured number of repetitions is 16, 2~3 complete SIB1-NBs can be provided within a NPBCH periodicity=640 ms, 11 complete SIB1-NBs can be provided within a SIB1-NB periodicity=2560 ms, 21~22 complete SIB1-NBs can be provided within 5120ms.****Observation 11: If SIB2-NB and SIB31-NB are transmitted in a single SI, they require 8 DL subframes for resource mapping in one SI repetition, if SIB2-NB and SIB31-NB are transmitted in separate SIs, each of them requires 8 DL subframes for resource mapping in one SI repetition.****Observation 12: For N=8 D=20, at least one SI repetition occasion in each SI window overlaps with the DL resource set in every SI period as long as an appropriate si-RadioFrameOffset is configured. For a SI with a periodicity of 640ms, SI window length=160ms, up to 2 repetitions may be provided within 640ms, and 16 repetitions can be provided within 5120ms.****Observation 13: For N=9, the time to acquire all SI may be longer than N=8. When D=8, for a SI with a periodicity of 640ms and SI window length=160ms, up to 1 repetition may be provided within 640ms, and up to 7 repetitions can be provided within 5120ms; When D=20, for a SI with a periodicity of 640ms and SI window length=160ms, up to 2 repetition may be provided within 640ms, and up to 14 repetitions can be provided within 5120ms; When D=30, for a SI with a periodicity of 640ms and SI window length=160ms, up to 3 repetition may be provided within 640ms, and up to 21 repetitions can be provided within 5120ms****Observation 14: For N=8, if the length of the non-DL portion of the periodic pattern exceeds 10ms and nB-r13>=T, there could be PO/PFs for a specific UE always outside the DL resource set; if an appropriate configuration(e.g.,a small value of nB-r13) is provided to ensure the interval between PFs is times of the period of the pattern, all PFs are valid but the paging capacity would be limited.****Observation 15: For N=9, the always-invalid PFs within non-DL portion can be avoided, but a longer time is needed for mapping each UE to a valid PO/PF in DL resource set at least once, compared with N=8 combined with a small nB-r13.****Observation 16: If the number of repetition of SIB1-NB within 2560ms is at least 16: for N=9, D=8, the overhead of DL broadcast signal(NPSS/NSSS/MIB-NB/SIB) within 5120ms is 86.8%; for N=9, D=20, the overhead of DL broadcast signal(NPSS/NSSS/MIB-NB/SIB) within 5120ms is 47.2%; for N=9, D=30, the overhead of DL broadcast signal within 5120ms is 39.8%; for N=8 D=20, the overhead of DL broadcast signal(NPSS/NSSS/MIB-NB/SIB) within 5120ms is 45%.****Observation 17: If the number of repetition of SIB1-NB within 2560ms is at least 16 and the repetition number of MSG2/MSG4 DCI/NPDSCH is 16: For N=9, D=20, the overhead of DL signal for initial access(NPSS/NSSS/MIB-NB/SIB/MSG2/MSG4) within 5120ms for a UE is 54.2%; For N=9, D=30, the overhead of DL signal for initial access(NPSS/NSSS/MIB-NB/SIB/MSG2/MSG4) within 5120ms for a UE is 44.5%; For N=8 D=20, the overhead of DL signal for initial access(NPSS/NSSS/MIB-NB/SIB/MSG2/MSG4) within 5120ms for a UE is 51.3%.****Observation 18: If the number of repetition of SIB1-NB within 2560ms is at least 16, the repetition number of MSG2/MSG DCI is 32, the repetition number of MSG2/MSG4 NPDSCH is 8: For N=9, D=20, the overhead of DL signal for initial access(NPSS/NSSS/MIB-NB/SIB/MSG2/MSG4) within 5120ms for a UE is 54.9%; For N=9, D=30, the overhead of DL signal for initial access(NPSS/NSSS/MIB-NB/SIB/MSG2/MSG4) within 5120ms for a UE is 45.0%; For N=8 D=20, the overhead of DL signal for initial access(NPSS/NSSS/MIB-NB/SIB/MSG2/MSG4) within 5120ms for a UE is 51.9%.****Observation 19: For N=9 D=8, a UE may not able to finish initial access within 5120ms due to the restricted resource if the number of repetitions of SIB1-NB within 2560ms is at least 16.****Observation 20: If the number of repetition of SIB1-NB within 2560ms is at least 8: for N=9, D=8, the overhead of DL broadcast signal within 5120ms is 58.8%; for N=9, D=20, the overhead of DL broadcast signal within 5120ms is 36.0%; for N=9, D=30, the overhead of DL broadcast signal within 5120ms is 32.3%; for N=8 D=20, the overhead of DL broadcast signal within 5120ms is 35%.****Observation 21: If the number of repetition of SIB1-NB within 2560ms is at least 8 and the repetition number of MSG2/MSG4 DCI/NPDSCH is 8: For N=9, D=8, the overhead of DL signal for initial access(NPSS/NSSS/MIB-NB/SIB/MSG2/MSG4) within 5120ms for a UE is 67.5%; For N=9, D=20, the overhead of DL signal for initial access(NPSS/NSSS/MIB-NB/SIB/MSG2/MSG4) within 5120ms for a UE is 39.5%; For N=9 D=30, the overhead of DL signal for initial access(NPSS/NSSS/MIB-NB/SIB/MSG2/MSG4) within 5120ms for a UE is 34.7%; for N=8 D=20, the overhead of DL broadcast signal within 5120ms is 38.1%.****Observation 22: If the number of repetition of SIB1-NB within 2560ms is at least 8, the repetition number of MSG2/MSG DCI is 32, the repetition number of MSG2/MSG4 NPDSCH is 8: For N=9, D=8, the overhead of DL signal for initial access(NPSS/NSSS/MIB-NB/SIB/MSG2/MSG4) within 5120ms for a UE is 78.1%; For N=9, D=20, the overhead of DL signal for initial access(NPSS/NSSS/MIB-NB/SIB/MSG2/MSG4) within 5120ms for a UE is 43.7%; For N=9 D=30, the overhead of DL signal for initial access(NPSS/NSSS/MIB-NB/SIB/MSG2/MSG4) within 5120ms for a UE is 34.5%; For N=8 D=20, the overhead of DL signal for initial access(NPSS/NSSS/MIB-NB/SIB/MSG2/MSG4) within 5120ms for a UE is 41.9%.****Observation 23: All cases works if the number of repetitions of SIB1-NB within 2560ms is at least 8, but the capacity for Case1 is very limited.****Observation 24: If the number of repetitions of the NPRACH is reduced to 1 in LEO-600km, for N=9, and N = 8, the UL resource set within a period is sufficient to transmit NPRACH; if the number of repetitions of the NPRACH is reduced to 2 in LEO-1200km, for N = 9 with U =8, the resource is not sufficient for NPRACH in a period; for N = 9 with U = 20 or U = 30, and for N = 8 with U = 20, if 14ms resource is available, the UL resource set within a period may be sufficient to transmit NPRACH.****Observation 25: If the number of repetitions of the NPUSCH is reduced to 4 in LEO-600km, if 15kHz with 12 subcarrier is used for NPUSCH, the UL resource set within a period may be sufficient to transmit NPUSCH for N=9, and N = 8; if the number of repetitions of the NPUSCH is reduced to 16 in LEO-1200km, if 15kHz with 12 subcarrier is used for NPUSCH, the UL resource set within a period may be sufficient to transmit NPUSCH for N = 9 with U = 20 or U = 30, and for N = 8 with U = 20, but not sufficient for N = 9 with U =8.****Observation 26: For N = 8, it can be guaranteed that at least one NPRACH resource overlaps with the UL resource set in every NPRACH period (if nprach-Periodicity is equal to or larger than 80ms) as long as an appropriate nprach-StartTime is configured.****Observation 27: For N = 9 U=20, there are less time occasions to transmit NPRACH compared with N=8 U=20, and more uplink resources can be used for NPUSCH transmission.****Observation 28: As the supported DL gap duration can be larger than the duration between two adjacent resource sets for N=8 or 9, interruptions on NPDCCH/NPDSCH due to the N-frame based periodic pattern may be acceptable, the legacy behavior (i.e., postponing the DL transmission until the next DL resource set) can still be applicable when an NPDCCH/NPDSCH transmission cannot be completed before the end of a DL resource set.****Observation 29: The UL gap may not be needed; it can be assumed that UL transmission within a period is always synchronized to the network.****Observation 30: For the periodic pattern with which a NPDSCH is transmitted in the same period as the corresponding NPDCCH or in the next period of the NPDCCH, the legacy NPDSCH scheduling timeline for DCI format N1/N2 can be applied.****Observation 31: For the periodic pattern with which a NPDSCH should be transmitted more than one period later than the corresponding NPDCCH, the NPDSCH scheduling timeline for DCI format N1 is workable, but some further enhancement may be needed to fully utilize all the DL subframes.****Proposal 1: For the normative work of IoT-NTN TDD mode, changes on the potential subframes for NPBCH/NPSS/NSSS/SIB1-NB/Paging transmission should be avoided. Subframes other than 0/4/5/9 are not expected to be used for NPBCH/NPSS/NSSS/SIB1-NB/Paging transmission.****Proposal 2: If IoT-NTN TDD mode is supported, it should be able to accommodate to the legacy system on MSS allocated band.****Proposal 3: If IoT-NTN TDD mode is supported, consider a single D-U switching point in the periodic pattern.****Proposal 4: When subcarrier spacing of 3.75kHz is applied to NPRACH, the minimum required continuous UL resource for NPRACH in a UL resource set is 7 ms.****Proposal 5: The target operating UL CNR of NB-IoT NTN TDD is obtained following the parameters in TR 36.763 and modifying the carrier frequency to 1.6GHz:****• For LEO-600km, the operating UL CNR is 17.93 dB for 3.75kHz, and 1.03dB for 180kHz****• For LEO-1200 km, the operating UL CNR is 12.43 dB for 3.75kHz, and -4.37dB for 180kHz.** |
| [R1-2409730](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2409730.zip) | ZTE Corporation, Sanechips [ZTE] | ***Observation 1:*** *If compatibility to TDD pattern of Iridium’s legacy system should always be considered, configuring DL and UL duration larger than 8 subframes should not be allowed due to the restriction of slot length and gap in legacy system.****Observation 2:*** *If compatibility to TDD pattern of Iridium’s legacy system is not hard restriction, it is not necessary to consider N=9, D=8, and U=8 as a mandatory pattern to be supported.****Proposal 1:*** *RAN1 should discuss and clarify whether compatibility to TDD pattern of Iridium’s legacy system should always be considered when determining configurable values of N, D, and U.****Proposal 2:*** *RAN1 should discuss and clarify what will be restrictions when considering compatibility to TDD pattern of Iridium’s legacy system.****Observation 3:*** *Inter-UE interference may happen if UE-specific periodic pattern is introduced but not properly configured.****Observation 4:*** *Inter-cell interference may happen if cell-specific periodic pattern is introduced but not properly configured.****Proposal 3:*** *A fixed periodic pattern can be considered for IoT-NTN TDD mode without additional configuration signaling.****Proposal 4:*** *The TDD pattern should be aligned with radio frame timing for easier resource determination.****Proposal 5:*** *An offset between start of DL duration and start of TDD pattern is needed to ensure the subframes for common channel and synchronization signals are covered when D<10.****Proposal 6:*** *The start time of first TDD pattern is preferred to be aligned with SFN0 in each hyper frame for easier resource determination of TDD pattern. The remaining radio frames before SFN warp around that cannot carry a complete TDD pattern can be skipped in TDD pattern determination.****Observation 5:*** *The required SNR for 2-NPSS combination detection with 90ms periodicity is -1.2 dB, which is lower than CNRs for LEO-600 and LEO-1200 with -5.5 dBi UE antenna gain. The acquisition delay is 2\*90=180ms if D=8 and 90ms if D=20 or 30.****Proposal 7:*** *The required SNR for NPSS detection can be satisfied and no need of NPSS enhancement.****Observation 6:*** *The required SNR for 1-NSSS detection is -2.5 dB, which is lower than CNRs for LEO-600 and LEO-1200 with -5.5 dBi UE antenna gain. The acquisition delay is 2\*90=180ms if D=8 and 90ms if D=20 or 30.****Proposal 8:*** *The required SNR for NSSS detection can be satisfied and no need of NSSS enhancement.****Proposal 9:*** *At least 2 consecutive radio frames are preferred to be allocated for DL in the periodic pattern, which ensures at least one NSSS can be received within a single TDD pattern.****Observation 7:*** *When D=8 and N=9, the required SNR for NPBCH detection within 640ms time window is -1.8 dB, which is lower than CNRs for LEO-600 and LEO-1200 with -5.5 dBi UE antenna gain but higher than minimum performance requirement in TS 36.101. The acquisition delay is 640ms.****Observation 8:*** *When D=20 and N=9, the required SNR for NPBCH detection within 320ms time window is -2.4 dB, which is lower than CNRs for LEO-600 and LEO-1200 with -5.5 dBi UE antenna gain and minimum performance requirement in TS 36.101. The acquisition delay is 320ms.****Proposal 10:*** *The required SNR for NPBCH detection can be lower than CNR by only receiving available subframes within downlink duration. However, the minimum performance of NPBCH defined in TS 36.101 may not be satisfied for D=8 and N=9.****Proposal 11:*** *At least 2 consecutive radio frames are preferred to be allocated for DL in the periodic pattern, which ensures the required SNR for NPBCH detection can also be lower than the minimum performance of NPBCH defined in TS 36.101.****Observation 9:*** *When D=8 and N=9, UE can only receive SIB1-NB once every 180ms, which is even longer than the SIB1-NB period. That is, the SIB1-NB coverage performance will degrade at least 9dB and UE may miss the reception of some SIB1-NB packet.****Proposal 12:*** *At least 2 consecutive radio frames are preferred to be allocated for DL in the periodic pattern, which ensures UE will not miss SIB1-NB reception.****Observation 10:*** *When introducing TDD pattern, the paging resource will degrade significantly and paging delay will increase significantly.* |
| [R1-2409827](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2409827.zip) | Apple [Apple] | ***Proposal 1:*** *NPBCH/NPSS/NSSS/SIB1-NB are transmitted in 8 continuous subframes in very 90ms periodicity.****Proposal 2:*** *Additional DL subframes and UL subframes are configurable by SIB1-NB.****Observation 1:*** *IoT-NTN TDD mode impacts on DL and UL scheduling.* ***Observation 2:*** *IoT-NTN TDD mode impacts on random access.*  |
| [R1-2409835](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2409835.zip) | LG Electronics [LGE] | ***Observation 1: Synchronization detection window would be increased, and the initial access latency would be prolonged after applying the TDD pattern with N=9 due to the increased NSSS periodicity. Meanwhile, the number of blind decoding for NPBCH to determine the LSB of SFN would be the same.*** ***Observation 2: For SIB1-NB transmission with the TDD pattern with N=9 and D=8, if the repetition number is 4, it is not guaranteed that all the output of TBCC for SIB1-NB is actually transmitted within a single SIB1-NB period.*** ***Observation 3: For SIB1-NB transmission with the TDD pattern with N=9 and D=8, if the repetition number is 8 or 16 without additional SIB1 transmission, it is not guaranteed that the effective coding rate is sufficiently small compared to the NPBCH repetitions.******Observation 4: For SIB1-NB transmission with the TDD pattern with N=9 and D=8, the minimum TBS (i.e., 208 bits) and the repetition number of 16 with additional SIB1 transmission enabled are required for the reliable SIB1-NB transmission. Otherwise, the decoding performance of the SIB1-NB transmission would not be compatible with the NPBCH repetition.*** ***Observation 5: Depending on the TDD pattern period, when SFN wraps around, there could be some orphan subframes or frames. Whether or how to handle these orphan subframes needs to be defined.*** ***Observation 6: Even though the TDD pattern is repeated regardless of the system frame period boundary, the UE can derive the frame offset between the beginning of the 1st TDD pattern period and SFN0 based on the pattern of the received code blocks of NPBCH repetitions and the SFN information.*** ***Observation 7: For indicating the frame offset of the 1st TDD pattern period with respect to the SFN0, it is necessary to check whether the MIB or SIB1-NB has sufficient room or it.*** ***Observation 8: Depending on the TDD pattern, NPRACH cannot be transmitted since the NPRACH resources are mapped on non-UL subframe.*** ***Proposal 1: For IoT-NTN TDD mode, following enhancements can be considered for DL synchronization:*** * ***NSSS is mapped on all or a subset of odd frames on top of even frames.***
	+ ***FFS: How to define cyclic shift for new NSSS occasions.***

***Proposal 2: For IoT-NTN TDD mode, consider one of more of followings for SIB1-NB transmission:*** * ***Option 1: Smaller TBS indicated by the reserved state of the SIB1-NB scheduling information.***
* ***Option 2: TDD pattern always include subframe#3 to ensure additional SIB1 transmission enabled.***
* ***Option 3: Adopt the concept of RV (redundancy version) for SIB1-NB to ensure all the coded symbols are transmitted.***
* ***Option 4: Define additional SIB1-NB transmission occasion on top of subframe #3 and #4.***

***Proposal 3: For SFN wrap-around issue, RAN1 considers one or more of followings:**** ***Option 1: TDD pattern period always (re)start at SFN0, and the orphan subframes or frames within 10240 msec or 1024\*10240msec after applying the TDD pattern are used for neither DL nor UL***
* ***Option 2: TDD pattern period start at very first SFN0 regardless of system frame period boundary.***
	+ ***Option 2-1: The offset between SFN0 and the 1st TDD pattern period is derived by a UE based on the pattern of the received NPBCH code blocks.***
	+ ***Option 2-2: The offset between SFN0 and the 1st TDD pattern period is indicated by MIB or SIB1-NB.***

***Proposal 4: For IoT-NTN TDD mode, one or more of followings can be considered to define UL subframes and their locations for the TDD pattern:*** * ***Modifying NPRACH periodicity and start time considering the TDD pattern with N=9.***

***Proposal 5: For IoT-NTN TDD mode, one or more of followings can be considered for initial access procedure:*** * ***RAR window starts in DL subframe provided by the TDD pattern subject to the existing required time.***
* ***Subframe offset to indicate RAR-to-Msg3 TX timing is prolonged to ensure that Msg3 is mapped on UL subframe provided by the TDD pattern.***
* ***UE (re)starts the contention resolution timer at the DL subframe provided by the TDD pattern subject to the existing required time.***
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| [R1-2409849](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2409849.zip) | Nokia, Nokia Shanghai Bell [NK] | **Observation 1: The set of contiguous UL subframe should cover all UE’s UL transmission with different differential delay.****Observation 2: The use of UL/DL subframe availability every 9 radio frames does not fit legacy specification time elements.** **Observation 3: N=9 may request the number of DL subframes is at least 20 and N=8 will allow the number of contiguous subframes to be less than 20.****Observation 4: The 1:N or k:N active radio frame with contiguous UL subframe and contiguous DL subframe may impact to the DL synchronization and cell search.****Observation 5: maximum number of NPBCH without changing content in TDD carrier should be increased for same coverage of FDD carrier.****Proposal 1: RAN1 should study how to allocate the period of active contiguous subframe for UL to cover all the UE with different differential delay.****Proposal 2: RAN1 to prioritize N=8 as alternative to the N=9 baseline for UL/DL subframe availability.****Proposal 3: RAN1 to discuss whether HARQ feedback is needed between two active radio frames separated according to the periodicity N.****Proposal 4: RAN1 should study how to have accurate DL synchronization and cell search in this IoT NTN TDD mode.****Proposal 5: RAN1 to send LS to RAN4 to study both DL synchronization and cell search issue in this IoT NTN TDD mode.****Proposal 6: RAN1 to discuss if there are restrictions related to a potential DL-UL gap length and start time, when considering the legacy Iridium system.****Proposal 7: RAN1 to discuss if there are restrictions related to active downlink and active uplink lengths and start times, when considering the legacy Iridium system.****Proposal 8: RAN1 to discuss the impact on the achievable link budget if the number of repetitions and resource unit length are restricted due to the use of every Nth radio frame and a limited number of DL/UL subframes.** **Proposal 9: RAN1 to evaluate the cell capacity when accounting for at least NPSS, NSSS, NRS, MIB and relevant System Information Blocks (at least SIB1-5 and SIB31).****Proposal 10: RAN1 should evaluate the UL capacity for NPRACH and NPUSCH considering the active radio frame per N radio frame.** |
| [R1-2409887](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2409887.zip) | Xiaomi [Xiaomi] | **Observation 1: Based on one-shot NPSS detection, the required SNR@1% miss detection rate with 0.1% false alarm rate for the coarse synchronization and fine synchronization are ~0.5dB and ~1.3dB, respectively.****Observation 2: When reaching the fine synchronization based on the one-shot NPSS detection, there is around 3.6 dB and 4.2 dB margin compared to the target DL budget of 4.91 dB and 5.51 dB for LEO-600km and LEO-1200km with 30 degrees elevation, respectively.** **Observation 3: Fine synchronization can be obtained by one-shot NPSS reception while meeting with the DL coverage target.****Observation 4: Based on the TDD frame structure assumption of N=9 and D=8, maximum DL sync acquisition delay is 90ms.****Observation 5: Based on the TDD frame structure assumption of N=9 and D=8, the cell detection delay is about 720ms even if the cell detection with the DL coverage target is successful by one-shot NSSS reception.****Observation 6: With the assumption of N=9 and D=8, there are at most 7 different sub-blocks of NPBCH could be transmitted in the 640ms period of NPBCH, which may result in noticeable performance degradation for NPBCH decoding.****Observation 7: It is quite changeable for the resource availability of various of channels, if N=9 and D/U=8 is utilized for the IoT-NTN TDD frame structure.** **Proposal 1: Preclude N=9 and D/U=8 for the IoT-NTN TDD frame structure design.** |
| [R1-2409982](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2409982.zip) | CATT [CATT] | **Observation 1:** **For LEO@600km and LEO@1200km, the RTT ranges are from 12.88ms to 25.77ms and from 20.88ms to 41.77ms.****Observation 2:** **The maximum gap between the downlink and uplink is 5 radio frames’ length (50ms).****Observation 3: For LEO@600km and LEO@1200km with 0dBi UE antenna gain, the CNR margin of single NPBCH is 1.95 and 2.55dB, respectively.****Observation 4: For case 1, there may have a risk due to limited DL resources.****Observation 5:** **Case 3 and Case 4 only support regenerative payload scenarios, i.e. TDD pattern with a gap of 3 radio frames.****Observation 6:** **Case 2 is feasible in both regenerative payload and transparent forwarding scenarios.****Proposal 1: The guard period is configured with once in a TDD pattern.****Proposal 2:** **When working in NTN NB-IoT TDD mode, to ensure downlink synchronization performance with 0dBi UE antenna gain, receiving single NPBCH subframe can meet the demodulation performance requirement.****Proposal 3:** **When working in NTN NB-IoT TDD mode, to ensure downlink synchronization performance with -5.5dBi UE antenna gain**, **it is necessary to receive 4 repeated NPBCH subframes in order to successfully decode NPBCH.****Proposal 4:** **For the periodic TDD pattern of IoT-NTN TDD mode, at least case 2 is supported.** |
| [R1-2410083](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2410083.zip) | OPPO [OPPO] | **Observation 1: the WID scope does not explicitly mention the requirement of the coexistence, more clarification of WID scope is needed from RAN plenary.****Observation 2: according to Iridium’s clarification, for coexistence with Iridium’s existing service, the design restriction for IoT NTN TDD is as follows:**1. **TDMA period is 90 ms**
2. **IoT NTN uplink transmissions can only be restricted in the UL slot of Iridium TDMA structure, where the UL slot has a duration of 8.28 ms**
3. **IoT NTN downlink transmissions can only be restricted in the DL slot of Iridium TDMA structure, where the DL slot has a duration of 8.28 ms**
4. **No transmission is allowed within any of the guard period of the Iridium TDMA structure, where the duration of each of the guard period is not disclosed to 3GPP.**

Observation 3: The of N=9 is intended for the co-exsitence case, according to above mentioned design restriction (3), the consecutive downlink subframes should be within a DL slot, which is 8.28 ms. Thus, for D=20 and D=30 cases, not all the DL subframes are available for IoT NTN transmission.Observation 4: Due to the design restriction (4), the concrete guard period duration is transparent to 3GPP. Therefore, for UE performing initial DL synchronization, the UE should assume that D=8. The eNB should be responsible to ensure that the D subframes are within a Iridium DL slot. Observation 5: If D=8 and N=9 are assumed for the initial DL synchronization, the D location with respect to SFN framing can be of 4 possible choices. One option is to assume a default D location, or the other option is that not to assume default D location and leave for eNB implementation. But for NSSS detection, option 2 may lead to increased UE blind detection power consumption. Observation 6: I**f only set-1 satellite is considered for future deployment, the NPBCH coverage seems good enough even without any repetition. Thus, NPBCH does not need further enhancement.** Observation 7: In order to fully accomplish DL synchronization, it is expected that the periodic TDD pattern remains the same cross different H-SFN. Thus, we can reuse the legacy interpretation of SFN index indication/H-SFN index indication in MIB. **Observation 8: In legacy system, the SIB1-NB transmission period is 2560 ms, where one SIB1-NB is transmitted over 160 ms (i.e., 16 radio frames). Over the 160 ms, the actual SIB1-NB transmission is over 8 alternate radio frames. This SIB1-NB transmission may not compatible with periodic pattern and would lead to a shortage of SIB1-NB resources.** **Observation 9: In legacy NB-IoT system, the SI window length, and period is defined under power of 2 (2^n) constraint, which is co-prime of 90 ms. In this case, the legacy design will result in issue that the UE may not get SIB within periodic D subframe.****Observation 10: When the UE receives SIB1-NB, eNB can configure larger value of D for better system throughput. However, due to the actual guard period of Iridium’s TDMA structure is transparent to 3GPP, the network can configure a guard period in D subframes that separates it into multiple sets of consecutive subframes (D subframe sets). The guard period location and length can be provided by SIB1-NB and the eNB ensures that the guard period is conform to Iridium TDMA structure.****Observation 11: The DL sync can be performed only in default D subframe, in which no guard period is assumed. Moreover, in D subframe set, it is not assumed to transmit NPSS/NSSS/NPBCH/SIB1-NB, so that eNB can have more degree of freedom to configure the guard period, which does not impact the DL synchronization.** **Observation 12: For NPSS/NSSS detection, the required SNR to achieve 99% successful detection probability with 0.1% false alarm rate is -0.2 dB.****Observation 13: For NPBCH decoding, the required SNR to achieve 1% BLER is 1.4 dB.****Proposal 1: RAN1 could continue discussing the design details for IoT NTN TDD to achieve the coexistence with Iridium’s existing service in 1616-1626.5 MHz MSS allocated band. But RAN1 draws a recommendation to RAN plenary to clarify the WID scope during the checkpoint in RAN#106.****Proposal 2: For initial DL synchronization, UE assumes D=8, N=9 and a default D location respect to SFN framing.** **Proposal 3: Consider to shorten H-SFN length by cutting off 16 radio frames.** **Proposal 4: RAN1 considers to extend the SIB1-NB transmission period as well as the one SIB1-NB transmission duration by a factor of N=9.** **Proposal 5: RAN1 considers to align the SI window with period D subframe start, and change the SI window length and period to multiple of 90 ms.** **Proposal 6: DL synchronization is performed only in default D subframe.****Proposal 7: eNB can configure larger number of subframes for D in SIB1-NB and guard period in D, so that the system can benefit from enhanced throughput.****Proposal 8: No guard period is expected in default D subframe, and NPSS/NSSS/NPBCH/SIB1-NB are not expected outside default D subframe.****Proposal 9: The definition of uplink time synchronization reference point remains the same, i.e., DL and UL are at least subframe aligned at reference point.** **Proposal 10: eNB configures an offset to determine the starting U subframe based on the location of the D subframe.** |
| [R1-2410307](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2410307.zip) | Ericsson [Eri] | Observation 1 The NB-IoT TDD NTN design compatible with the “legacy system deployed in the 1616-1626.5 MHz band,” has the following restrictions associated to it [2]: “N = 9”: That is, a period consisting of N = 9 (90 ms) “D = 8”: That is, from among “DL1 to DL4” located within a period consisting of N = 90 ms, one DL slot will allocate D = 8 ms for NB-IoT DL transmissions. “U = 8: That is, from among “UL1 to UL4” located within a period consisting of N = 90 ms, one UL slot will allocate U = 8 ms for NB-IoT UL transmissions.Observation 2 For “the legacy system deployed in the 1616-1626.5 MHz band” with inherent DL constrains N = 9 ms and D = 8 ms, it is required to keep the location of PHY-channels and signals as per legacy NB-IoT NTN in FDD mode.Observation 3 In relation with the previous observation, aiming at fitting within D = 8 ms all essential PHY-channels and signals and their locations as per legacy NB-IoT NTN in FDD mode, it should be possible using as reference two adjacent NB-IoT radio frames (i.e., two adjacent 3GPP SFNs) keeping unmuted a set of subframes in the middle of the two radio frames as to encompass the essential PHY-channels and signals, for example: Across two adjacent NB-IoT radio frames, subframe #3 to subframe #0 are kept unmuted as to fit within D = 8 ms. Across two adjacent NB-IoT radio frames, subframe #4 to subframe #1 are kept unmuted as to fit within D = 8 ms.Observation 4 In terms of UL, the “legacy system deployed in the 1616-1626.5 MHz band” is subject to same constrains of N = 9 ms and U = 8 ms. Thus, UL PHY-channels and signals as per legacy NB-IoT NTN in FDD mode should fit within U = 8 ms.Observation 5 For “the legacy system deployed in the 1616-1626.5 MHz band,” an UL slot and a DL slot used for NB-IoT services cannot be adjacent to each other since what is in between them (i.e., 0.36 + guardband, see Figure 5) has a duration of less than a “half-duplex guard subframe” (i.e., 1 ms).Observation 6 For “the legacy system deployed in the 1616-1626.5 MHz band,” the UL PHY-channels and signals as per legacy NB-IoT NTN in FDD mode should fit within U = 8 ms, and as stated in previous observations the presence of a “half-duplex guard subframe” between an UL slot and a DL slot should be considered. In addition, having settled the location of the NB-IoT radio frames with respect to the unmuted DL slot, will in turn condition the location of adjacent NB-IoT radio frames with respect to the unmuted UL slot.Observation 7 When operating NB-IoT NTN TDD mode into the “legacy system deployed in the 1616-1626.5 MHz band” we foresee the following impacts or aspect to be studied: How to align the boundaries of the subframes within 3GPP SFNs that are intended to be unmuted with respect to the slot boundaries of the unmuted UL and DL slots of the “legacy system deployed in the 1616-1626.5 MHz band”. The achievable data rates are foreseen to be very low, and it does not seem to be possible using all entries in the TBS/MCS table, thus it might be considered using a subset of entries in the TBS/MCS table. A frequent postponement of the user data (e.g., NPUSCH Format 1) is expected to happen given the limited amount resources, the consequences of that need to be studied. For single-tone with 3.75 kHz SCS one RU spans 32 ms, since there are only 8 ms available for UL every 90 ms, then 360 ms will be required to transmit the entire RU. Thus, RAN1 needs to discuss if both 3.75 kHz SCS and 15 kHz should be supported or if only the latter one (single-tone with 15 kHz SCS) is to be supported.Observation 8 Based on the analysis performed on DL aspects, the anchor carrier must reserve DL subframes to accommodate at least NPBCH, NPSS, NSSS, SIB1-NB, SIB2-NB, and SIB31-NB, leaving the rest of the subframes usable for control information and data traffic, where the latter can span from one up to 10 NPDSCH subframes.Observation 9 In relation the previous observation, as a minimum assigning 2 DL radio frames out of N radio frames is foreseen to be needed, and aiming at minimizing the specification impact, the selection of N can be either equal to the transmission duration of one self-decodable CSB (i.e., 8 radio frames) or a multiple of such a duration.**Observation 10 The guard period between DL and UL can be discussed once the periodic pattern for DL and UL have become stable. When the time comes, “half-duplex FDD operation for Frame structure type 1” and “half-duplex guard subframe” for Type-B half-duplex FDD operation” should be part of the discussion.**Proposal 1 For “the legacy system deployed in the 1616-1626.5 MHz band” with N = 9 ms and D = 8 ms, aiming at fitting within D = 8 ms all essential DL PHY-channels and signals and their locations as per legacy NB-IoT NTN in FDD mode, RAN1 considers: Across two adjacent NB-IoT radio frames (i.e., two adjacent 3GPP SFNs), subframe #3 to subframe #0 are kept unmuted as to fit within D = 8 ms. Across two adjacent NB-IoT radio frames (i.e., two adjacent 3GPP SFNs), subframe #4 to subframe #1 are kept unmuted as to fit within D = 8 ms.Proposal 2 For “the legacy system deployed in the 1616-1626.5 MHz band” with N = 9 ms and U = 8 ms, aiming at fitting within U = 8 ms all essential UL PHY-channels and signals and their locations as per legacy NB-IoT NTN in FDD mode, RAN1 considers: That the gap between an UL slot and a DL slot used for NB-IoT services shall be of at least one “half-duplex guard subframe” as defined for NB-IoT NTN in FDD mode. That across two adjacent NB-IoT radio frames (i.e., two adjacent 3GPP SFNs), 8 contiguous subframes are kept unmuted as to fit essential UL PHY-channels and signals within U = 8 ms. That given 3GPP SFNs are sequential and used for both UL and DL, the NB-IoT radio frames (3GPP SFNs) containing the 8 contiguous subframes fitting essential UL PHY-channels and signals within U = 8 ms, depend on the NB-IoT radio frames (3GPP SFNs) containing the 8 contiguous subframes fitting essential DL PHY-channels and signals within D = 8 ms.Proposal 3 For the support of “TDD mode NB-IoT NTN” on the anchor carrier in DL: At least 2 consecutive DL radio frames within a period composed by N radio frames are used to carry at least NPBCH, NPSS, NSSS, SIB1-NB, SIB2-NB, and SIB31-NB, leaving the rest of the subframes usable for NPDCCH and NPDSCH. Aiming at minimizing the spec impact, MIB-NB is used as design reference where N can be either equal to the transmission duration of one self-decodable CSB (i.e., 8 radio frames) or a multiple of such transmission duration.Proposal 4 For the support of “TDD mode NB-IoT NTN” on the anchor carrier in UL: At least 2 consecutive UL radio frames within a period composed by N radio frames are used to carry NPRACH and NPUSCH. Aiming at minimizing the spec impact, N can be equal to the one selected for DL. The UL period pattern design consisting of “Y UL subframes out of N radio frames” can be symmetrical to the DL period pattern design consisting of “X DL subframes out of N radio frames,” where Y = X. |
| [R1-2410366](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2410366.zip) | Lenovo [Len] | ***Proposal 1: RAN1 should focus on the frame structure with N=9 for the 1616-1626.5 MHz band for the study and specification work.******Proposal 2: The number of consecutive DL subframes of 8 in TDD pattern is the baseline and is assumed by UE in initial access.******Proposal 3: A time offset between the TDD pattern and the NBIoT frame boundary should be introduced, the time offset can be fixed as 3 or 4 subframes.******Proposal 4: The number of consecutive DL subframes in TDD pattern is further indicated by system information.******Proposal 5: The number of consecutive UL subframes of 8 in TDD pattern is the baseline and can be further indicated by system information.******Proposal 6: TDD pattern in IoT NTN can introduce the valid/invalid subframe for DL and UL with bitmap manner separately, the bit length is determined by the consecutive DL/UL subframe in TDD pattern.******Proposal 7: The existing pre-configured resources for SI/paging need to further study.******Proposal 8: New NRACH resources configuration need to further study, at least to align with the new TDD pattern.*** |
| [R1-2410499](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2410499.zip) | Qualcomm Incorporated [QC] | **Observation 1: Under a TDD pattern of D=8, N=9, downlink synchronization is feasible with a link margin greater than 8dB in LEO-600.****Proposal 1: RAN1 concludes that for N=9, D=8 downlink synchronization is feasible.****Proposal 2: RAN1 supports N=9 for the 1616-1626.5 MHz MSS band. This value is fixed in the specifications for the 1616-1626.5 MHz band.****Proposal 3: RAN1 supports** $D=$**8 For the 1616-1626.5 MHz MSS band*** **At least during initial access, the UE assumes** $D=8$
* **The downlink subframes in the downlink burst include subframes {0, 4, 5, 9}. Downselect the set of subframes in a DL burst between the following alternatives:**
	+ **Option 1:** $[4 5 6 7 8 9 0 1]$
	+ **Option 2:**$\left[3 4 5 6 7 8 9 0\right]$
	+ **Option 3:**$[8 9 0 1 2 3 4 5]$
	+ **Option 4:**$[9 0 1 2 3 4 5 6]$
* **FFS: Support of other values beyond** $D=8$ **for higher peak DL peak throughput**
	+ **Values of** $7\leq D\leq 19$ **would result in similar specification impact as** $D=8$ **as long as there is a single NPSS in each downlink burst.**
	+ **Values of** $D\geq 20$ **would result in multiple NPSS in a single downlink burst, which would require the UE to perform some degree of “blind decoding”, modify basic sync signals, or introduce some signaling to indicate the offset between the TDD frame structure and the NB-IoT frame structure.**

**Observation 2: For a periodicity N (in radio frames) that is not a power of 2, it is not possible to consistently express the TDD pattern in terms of radio frames / subframe numbers.****Proposal 4: As a baseline, the offset between the TDD pattern and the 3GPP frame structure is derived by the UE based on the detection of NPSS.****Proposal 5: RAN1 supports U=8 for the 1616-1626.5 MHz MSS band*** **RAN1 should further consider specifying values larger than 8, which can be supported with limited specification effort.**

**Proposal 6: The UE determines the set of contiguous uplink slots based at least on detection of NPSS. For determining the offset, at least the following options are considered:*** **Option 1: The set of UL “subframes” is the same as the set of DL subframes at the ULSRP, with the offset at the satellite controlled by common TA (no additional signaling required)**
* **Option 2: The set of UL “subframes” is the set of DL subframes minus an offset at the ULSRP**
	+ **Option 2.1: The offset is indicated in system information (additional signaling required)**
	+ **Option 2.2: The offset is fixed in specifications**

**Proposal 7: DL subframes not contained within the downlink burst are not NB-IoT DL subframes.*** **NPDCCH and NPDSCH not carrying SIB1 are postponed until the next NB-IoT DL subframe in case of collision with non-NB-IoT DL subframes.**

**Proposal 8: RAN1 specifies a mechanism to enable NPDCCH monitoring in every downlink burst.****Proposal 9: The UE may assume that NRS is available in every DL subframe not including sync signals.****Proposal 10: Transmissions of NPUSCH / NPRACH that collide with non-U slots are postponed until the next U-slot.*** **FFS: details, including unit of postponement.**

**Proposal 11: For segmented uplink pre-compensation, and for a transmission that spans multiple uplink bursts, a new segment is started at the beginning of each uplink burst.*** **A UE is not required to maintain phase continuity across multiple uplink bursts.**
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| [R1-2410570](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_119/Docs/R1-2410570.zip) | Nordic Semiconductor ASA [Nor] | ***Observation-1****: NPSS averaging over large number of 90ms periods impose unnecessary power consumption and cell search delay compared to legacy.* ***Proposal-1****: Do not introduce additional NSSS locations in the HD-FDD frame structure.****Proposal-2****: Agree on the following observation: For TDD NTN-IoT D=8 and N=9 cell acquisition, cell acquisition is feasible at least at 0dB SNR or more.****Observation-2:*** *With 90ms pattern D=9 and N=9,**a R19 TDD UE may at best obtain 14-15 NPDSCH subframes containing SIB-1 once 2.56s.****Observation-3:*** *Legacy SI configuration parameters can provide enough repetitions within SI window, if configured correctly.****Proposal-3****: Consider adjustments in how current NPRACH configurations are interpreted. This to match N=9. Such NPRACH periodicity would range 90ms and 2610ms.****Proposal-4****: Consider adjustments in how current NPDCCH configurations are interpreted. This to match N=9. Maximum supported* $R\_{max}=8$*.****Proposal-5:***  *Transmission/reception gaps for NPUSCH/NPDSCH as well as delaying start of reception/transmission are existing mechanisms in legacy NB-IoT. Potential issue(s) due to increased gap sizes should be further studied.* ***Proposal-6:***  *On the last 70ms orphan period within a hyper-frame, only DL part is transmitted. 90ms periods start always from frame number 0.* |

# References

[1] [RP-242415](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_105/Docs/RP-242415.zip), New WID on introduction of IoT-NTN TDD mode