3GPP TSG RAN WG1 #118bis R1-240xxxx

Hefei, China, October 14th – 18th, 2024

**Agenda item:** 9.11.5

**Source:** Moderator (Qualcomm Incorporated)

**Title:** Feature lead summary #2 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 Plan for this meeting

From FL perspective, RAN1 should progress on the following issues:

1. Agree on the details of the TDD frame structure to be studied. Ideally, a single TDD frame structure should be taken as baseline. This includes deciding on the following aspects:
	1. Constraints introduced by the legacy system in the 1616-1626.5 MHz MSS band.
	2. Periodicity of the frame structure (N)
	3. Number of consecutive DL subframes (D)
	4. Number of consecutive UL subframes (U). This may be lower priority since there is no mandate in the WID to consider uplink during the study phase.
2. Agree on the evaluations to be performed during the study phase. This includes deciding on the following:
	1. Which channels / signals / requirements to evaluate.
	2. Operating SNR / link budget / simulation assumptions.
3. If time allows topics marked as [LOW PRIORITY] in the FLS can be discussed.

# [CLOSED] TDD frame structure

## 2.1 Overall framework & compatibility with legacy system in the 1.6GHz MSS TDD band

In the justification part of the work item document [1] there is the following statement:

*This Work Item Description proposes the introduction of a new feature that allows the operator to use the radio resources in a periodic subset of the UL and DL subframes in N radio frames to achieve TDD operation in the SAN (Satellite Access Node) and IoT NTN UE, thus limiting power consumption.* ***This feature allows extending 3GPP NB-IoT NTN operation with support for additional NGSO satellite system.***

It is feature lead’s understanding that the main objective of this Work Item is to make necessary modifications to the NB-IoT NTN specifications to enable operation in the existing satellites deployed in the 1.6GHz MSS TDD band in a manner that is compatible with the existing system deployed in those satellites. This is the main reason behind the baseline of N=9 in [1].

Some references for this existing system, and provided in contributions in this meeting (e.g. [TH, QC]), are:

* Public document describing the system deployed in the 1616-1626.5 MHz band [2], with a TDD frame structure as shown below:



Figure 2.1-1: Iridium TDMA structure (from [2])

* Previous contribution to RAN4 describing design constraints [3], consistent with [2], with the following statement:
	+ *Iridium believes that our system can comply with its design constraints if the* ***DL system frame is limited to no longer than 8msec****. […] However, Iridium’s constellation is TDD and we use the same frequencies for UL and DL. By using the appropriate timing offsets between the UL and DL selective availability,* ***we can align the UL and DL with the Iridium TDD constraints*** *while using the FDD procedures*

As we will explore further in sections 2.2 and 2.3, based on the input from companies, there seems to be a fundamental misalignment at this stage on whether coexisting with the system in [2] is a must, and what are the consequences of this coexistence. Feature lead puts forward the following proposal to discuss the necessity of aligning with the TDD frame structure of the system deployed in the 1616-1626.5 MHz band.

### **Proposal 2.1-1: The study and specification work for NB-IoT NTN TDD focuses on necessary modifications to NB-IoT NTN to enable coexistence with the TDD frame structure of the legacy system deployed in the 1616-1626.5 MHz band, with the following constraints:**

* **At the satellite, downlink NB-IoT transmissions shall be confined within downlink slot(s) in the TDD frame structure of the legacy system.**
* **At the satellite, uplink NB-IoT transmissions shall be confined within uplink slot(s) in the TDD frame structure of the legacy system.**
* **FFS: Whether and how transmissions can span multiple uplink slots, downlink slots and/or guard periods in the TDD frame structure of the legacy system.**

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| Company | Comment |
| Ericsson | In Proposal 2.1-1 it is unclear what should be understood by “legacy system” to which NB-IoT TDD operation should be aligned with. Is it the one in Figure 2.1-1? If so, it is not included in the WID, and its components (e.g., SIMPLEX TIME SLOT, etc) are terminologies outside 3GPP which make them difficult to use as a design reference.Overall, we should not design a tailored made TDD mode framework for a particular system, but rather a TDD mode framework that can be generic and future-proof with minimum impact in the 3GPP technical specification.  |
| Nordic  | The study and specification work for NB-IoT NTN TDD **any modifications to NB-IoT NTN shall ensure at least** coexistence with the TDD frame structure of the legacy system deployed in the 1616-1626.5 MHz band, with the following constraints: |
| LGE | It would be better to understand the details of the legacy TDD frame. According to the reference, it is difficult to find the details of the guard period in terms of their sizes and the exact locations. Otherwise, it would be very difficult to determine whether NB-IoT DL or UL transmissions are really confined within DL slots or UL slots of the legacy TDD frame, respectively. On the usage of guard period, it is understood that the gap between DL and UL will be used neither DL nor UL to avoid DL-UL interference. On the other hand, in term of DL-UL interference, we can allow that NB-IoT DL transmission on the gap between two DL slots and NB-IoT UL transmission on the gap between UL slots.  |
| Iridium | Agree with Ericsson, on making the framework more generic and with minimum impact. We propose using IRDM legacy frame structure (Figure 2.1-1 above) as *a guideline to IRDM system constraints only, rather than designing for it.* Thus, the limitation is the number of contiguous UL sf to less or equal 8 sf and number of contiguous DL sf to less or equal 8 sf, both configurable for flexibility.Also, as proposed by several companies, the UL-DL-offset in subframes also configurable.Then, if we focus and count subframes (for the three parameters mentioned), then we do not need to worry about IRDM legacy frame structure, and guard periods. Guard periods will be honoured by having <= usable sf in each direction. |
| Thales | From the WID, the objective is to introduce a new TDD mode for NB-IoT NTN. The target in Rel-19 is unpaired MSS allocated band (1616-1626.5 MHz MSS). So we need to adapt to the in-orbit satellite system constraints.In this MSS band, we know that there is already in-orbit satellite system. From our understanding, this is already considered in the WID by setting a value of N (the period of TDD pattern) to 9 (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).In our view, we need only to agree on the parameters defining the TDD pattern with the following consideration:1. Define a TDD pattern more generic and flexible enough, which can be deployed in other TDD bands (if any), and systems
2. 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
3. We need to set N=9 (this is already a baseline according to the WID).
4. The number of consecutive/ contiguous DL subframes at the beginning of each DL-UL pattern. For flexibility can take different values. However, to support in-orbit system, We should support a minimum of 8 subframes for DL consecutives subframes
5. The number of consecutive/ contiguous UL subframes should be flexible with a minimum of 8 UL subframes to support in-orbit system.

To enable coexistence with the TDD frame structure (see Figure below), we need (3), (4) and (5).(3) is already in the WID. For (4) and (5) we can discuss directly a proposal abut the configuration od the TDD pattern including the minimum values for DL and UL consecutive/ contiguous subframes. |
| Lenovo | Please clarify why do we add “At the satellite” in the first and second sub-bullet? And suggest adding a note or “e.g.., in each frame cycle, consecutive 4 downlink slots with each of 8.28ms duration” to explain the terminology of “downlink slot(s) in the TDD frame structure of the legacy system”.Our further concern is the how strong the motivation is to follow the legacy Iridium TDD frame structure. |
| Vivo1 | ‘legacy system’ in the proposal is not clear to us. Either we capture the Figure 2.1-1 as part of the proposal to illustrate the legacy system, or we first agree on some principles of length/locations of TDD IoT pattern by considering structure of the figure.e.g., **The study and specification work for NB-IoT NTN TDD focuses on necessary modifications to NB-IoT NTN ~~to enable coexistence with the TDD frame structure of the legacy system deployed in the 1616-1626.5 MHz band,~~ with the following constraints:*** **The time duration of the DL or UL resource set should be no longer than 8.28\*4=33.12ms**
* **The time gap between a DL resource set and a UL resource set should be no less than 20.32ms (which is the length of the SIMPLEX TIME SLOT)**
	+ **FFS if the DL resource set and the UL resource set are from the same period or different periods**
* **FFS the location of the DL and UL resource set**

With the two principles, the pattern can be aligned with the IRDM legacy frame structure if an offset is defined.Since we have not agreed how the pattern would be like, e.g., DSU or SDU, we may need the 1st FFS for further discussion. Because if in the end we agree that TDD pattern is DSU, then the time between a DL resource set and a UL resource set in a same TDD pattern period should be no less than 20.32ms to align with Figure 2.1-1, and a time offset is needed. If TDD pattern is agreed to be SUD, the time between DL resource set in a period and the UL resource set in the next period should be no less than 20.32ms for alignment. |
| ZTE | “Coexistence” seems not a proper description of study here. The study should focus on how to implement the NB-IoT NTN structure with constraints of the legacy TDD frame structure applied in 1616-1626.5 MHz band. Moreover, it should also be clarified what will be the constraints and whether they can be revised. Then the following study will be easier. |
| Nokia, NSB | Our understanding is this WI is to study whether and how to design a IoT NTN TDD mode that can work in “1616-1626.5 MHz MSS allocated band”. Then a generic TDD mode should be discussed so that it can also be used in other TDD band with some minor update for that band.The “legacy system” is not clear to 3GPP. Some more legacy system information is needed, e.g. what is the subframe length, frame length, whether 3GPP need to have aligned TDD pattern of the frame/subframe to coexist with legacy system on that band. Additionally, the word “within” means alignment or just within?For the coexistence, it should also be discussed in detail, in which domain, only time domain or both time and frequency domain? |
| OPPO | In the WID justification, we understand that the design is to support periodic frame structure for power consumption limitation, but it does not seem to target a coexistence with legacy deployement assuming the legacy framing is unchangable and 3GPP frame structure has to be tailored to it. Moreover, according to Iridium’s comment, it seems that the legacy frame is quite flexible, and can be adapted to be compatible with 3GPP’s frame structure. This is indeed very helpful and give us more space to conduct the design work.  |
| CATT | We support Nokia view. This WI is not intended to design one dedicated TDD system, so one generic TDD mode should be considered.  |
| Huawei, HiSilicon | General fine with proposal. It should be clear that the DL/UL slots should be slot in legacy system.  |

## 2.2 Periodicity of the TDD frame structure (N)

The work item objective states the following:

*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****.*

The input for this topic is highly dependent on the issue discussed in Section 2.1. Several contributions have provided input on the value of N (in radio frames), with some contributions (e.g. [vivo, LGE]) mentioning both options:

* N = power of 2:
	+ Multiple of 8: [CATT]
	+ N=8 or N=16: [Eri]
	+ N=4 or N=8: [OPPO]
		- NOTE: [OPPO] seems to use N-1 instead of N in their contribution, but Fig.1 shows a periodicity of 40 and 80ms for “N”=3 and 7.
	+ Power of 2 [LGE]
	+ N=8 [NK, vivo]
* N=9: [HW], [TH], [ZTE] (assumed), [Xiaomi] (assumed), [Iri], [SS] (assumed), [QC], [Nor], [vivo], [LGE]
* N=10 [NK]
* Needs clarification: [CMCC]

Most inputs (including others than the above, e.g. [Apple]) mention the difficulty of aligning the NB-IoT timing (powers of 2 radio frames) to a periodicity of 90ms. For instance, it is mentioned in several contributions that N=9 would result in different subframes being in the pattern after an SFN wrap around, since 9 does not divide 1024. We discuss this issue in section 2.4

Feature lead proposes to select among one of the following two options:

### **Proposal 2.2-1: The study and specification work assumes a value of periodicity of TDD pattern (N, in radio frames) of:**

* **Option 1: N=2k**
* **Option 2: N=9.**
	+ **FFS: Whether and how to handle alignment between the TDD frame structure and the NB-IoT frame structure (e.g. SFN wrap-around).**

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| Company | Comment |
| Ericsson | We suggest removing the following wording “and specification work” since it is too early for it.What is the intention of Option 1 and Option 2? Is it performing a down-selection? Or to consider both?To make things clear and aligned with the main sentence, we suggest the following update: “**FFS: Whether and how to handle alignment between the periodicity of the TDD ~~frame structure~~ pattern and the legacy FDD NB-IoT frame structure (e.g. SFN wrap-around)**”The impact on other working groups (e.g., RAN2 and RAN4) from the selection of the value of N should be studied. |
| Nordic  | **The study and specification work assumes a value of periodicity of TDD pattern (N, in radio frames) of at least N=9:*** **FFS N=2^K**
 |
| Iridium | The way WID was approved was to tie it to IRDM’s used MSS band. For IRDM system, we need N=9, and we agree that other values for N could be other operators’ N of choice and should not be precluded. We are just mindful of time spent on this, since it was clearly stated in the WID: N=9 as a baseline; and the agreement RAN1 should conclude the studying in only 1 more meeting.In our paper R1-2408400, at the end in the Section 3, we proposed one way to solve for SFN wrap-around (depicted in R1-2408400, Table 3); We propose to define the offset from the start time of the SIB-1 periodicity time window, which is 2560 ms in which the SIB-1 is received; Rather than (SFN, sf) = (0,0). |
| Thales | We do not support this Proposal.Indeed, in the WID it is clearly stated that N=9 is a baseline.**RP-242415:*** 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.

Proposal 2.2-1 can be revised as:**Proposal 2.2-1: The study and specification work assumes a value of periodicity of TDD pattern (N, in radio frames) of at least equal to 9.*** **Option 1: N=2k**
* **Option 2: N=9.**
	+ **FFS: Whether and how to handle alignment between the TDD frame structure and the NB-IoT frame structure (e.g. SFN wrap-around).**
 |
| Vivo1 | We are ok to study both, but we think N=9 should be the baseline |
| ZTE | Regarding option 2, we do not think it is necessary to consider the issue of SFN wrap-around, etc. In our understanding, we only need to align the TDD frame structure and NB-IoT frame structure from SFN0. When the remaining time of a period cannot cover a TDD pattern, it can just be skipped instead of introducing more complex mechanism. |
| Nokia, NSB | We think it is too early to decide on the number of N, as for now 3GPP has not clear understanding how this N will impact to the current specifications (at least RAN1/2/4). If N=9, then RAN1 need to study the impact to the procedure/parameters that current 3GPP specification has defined and discuss whether these impacts are acceptable. |
| CATT | Generally it is ok for us. We need to further check what is impact to current specification if N=9.  |
| Huawei, HiSilicon  | Support. |

## 2.3 Number of downlink subframes in the TDD frame structure

The work item description in [1] includes the following:

*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.***

For simplicity, we will denote by D the “number of contiguous DL subframes” as in [HW].

There is a clear dependency of this topic with respect to the issues described in the previous sections. Here are some inputs on this issue, depending on the assumption for N:

* Assuming N=9:
	+ [HW] proposes a set of TDD patterns to further discuss during the study phase, including D={10 30 40 45 50}
	+ [QC], [TH] propose to take D=8 as baseline due to constraints of the frame structure of legacy system deployed in the 1616-1626.5 MHz band, with other values FFS.
	+ [ZTE] proposes to allocate at least 2 consecutive radio frames D>=20
	+ [LGE], [SPDR] have examples with D=10
	+ [Iri] D=Single digit or double digit integer
* Assuming N=2k:
	+ [CATT]: Example of D=42
	+ [E///]: At least two consecutive radio frames (D>=20)
* Other considerations:
	+ [QC] states that D>=7 for the system to work without remapping, and D=8 to fit within an Iridium slot
	+ [vivo] proposed that D should be enough to transmit NPDCCH/NPDSCH with a certain number of repetitions.

Although the WID states that “*The value of N and the configuration of the periodic pattern are fixed per band*”, companies seem to have a different understanding of this statement given the following input (note that many companies seem to assume the pattern is fixed in their contributions without mentioning it explicitly):

* [ZTE], [HW], [ZTE] state that the pattern is fixed.
* [TH], [Iri], [CATT], [SRAN] state that the pattern is configurable. [TH] states that for initial search the UE can assume a default value.

In case the pattern is configurable, RAN1 would need to study the UE assumption for initial search before that configuration is received (e.g. in SIB).

### **Proposal 2.3-1: The number of consecutive downlink subframes in the TDD frame structure (D) is:**

* **Option 1: fixed in specifications for a given band.**
* **Option 2: configurable.**
	+ **FFS: Assumption of the UE for initial search before acquiring the configuration.**

### **Proposal 2.3-2: D is one (if fixed) or more (if configurable) of the following for the 1.6GHz MSS TDD band: {8 10 30 20 40 42 45 50 [others TBD]}**

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| Company | Comment |
| Ericsson | We should use a common wording across proposals, therefore we suggest the following updated on Proposal 2.3-1:**Proposal 2.3-1: The number of consecutive downlink subframes (D) within the periodicity of the TDD pattern ~~frame structure (D)~~ is:*** **Option 1: fixed in specifications for a given band.**
* **Option 2: configurable.**
	+ **FFS: Assumption of the UE for initial search before acquiring the configuration.**

We think that Proposal 2.3-2 could be merged with Proposal 2.3-1, or at least simplified as follows:**Proposal 2.3-2: D is one (if fixed) or more (if configurable) of the following ~~for the 1.6GHz MSS TDD band~~: {8 10 30 20 40 42 45 50 [others TBD]}** |
| Nordic  | **Proposal 2.3-1 OK****Proposal 2.3-2: any complexity issues to support all values from 8 to 64?** |
| Iridium | **Proposal 2.3-1 : Configurable**FFS: Assumption of the UE for initial search before acquiring the configuration.**Proposal 2.3-2** Agree with Nordic, configurable, and the range is fine. |
| Thales | **Proposal 2.3-1** We support option 2 with modification: **Option 2: D is configurable with a minimum of 8 subframes can be configured****FFS: Assumption of the UE for initial search before acquiring the configuration**Regarding **Proposal 2.3-2**, we think at this stage what is needed is to define the minimum value of D. We do not support to fix its value er band. Instead, UE assumption for initial search before acquiring the configuration could be discussed during the normative work. |
| Lenovo | We are OK with the update from E///. I am wondering whether the configuration should be based on the granularity of subframe or others (e.g., half-frame, frame) since the PSS/SSS/PBCH/SIB1 is transmitted with the period of 5ms. (e.g., half-frame, frame) |
| Vivo1 | For Proposal 2.3-1: Option1 is the baseline considering that during the cell search phase there is no any prior information about the pattern. Anyway, we need to define a fixed value for idle UE. Option2 can be FFS under option1.For Proposal 2.3-2: we would like to make sure that this proposal is for study the feasibility of the value and we think the proposal can be refined as **Proposal 2.3-2: for number of consecutive downlink subframes in the TDD frame structure (D), study the feasibility of one or more values of the following for the 1.6GHz MSS TDD band: {8 10 30 20 40 42 45 50 [others TBD]}** |
| ZTE | A fixed pattern is preferred to enable the function, which is simple and can also avoid potential collision. Further optimization with increased complexity seems not necessary for NB-IoT NTN. Regarding the duration, we think 20 subframes can be considered to provide enough resource for transmission of synchronization signals and system information. |
| Nokia, NSB | We think firstly, it should be studied the options and values but not just make decision in the first meeting of the SI phase.We support to study of both issues but we propose to add “study” in the proposals.**Proposal 2.3-1: The number of consecutive downlink subframes in the TDD frame structure (D) is studied:*** **Option 1: fixed in specifications for a given band.**
* **Option 2: configurable.**
	+ **FFS: Assumption of the UE for initial search before acquiring the configuration.**

**Proposal 2.3-2: RAN1 to study that D is one (if fixed) or more (if configurable) of the following for the 1.6GHz MSS TDD band: {8 10 30 20 40 42 45 50 [others TBD]}** |
| CATT | **Proposal 2.3-1 OK****Proposal 2.3-2: current value proposed is for only evaluation.**  |
| Huawei, HiSilicon | **Proposal 2.3-1,** we assume the intention of the proposal is trying to down select between option 1 or 2. Our reading of WID is only one fixed pattern is supported per band.**Proposal 2.3-2: support** |

## 2.4 [LOW PRIORITY] Signaling aspects related to downlink

For the case of N=9, several companies highlighted the issues on signaling the TDD pattern offset vs the NB-IoT frame structure:

* [Iri] proposed to indicate the offset taking as reference the start of the SIB1 window.
* [QC] proposed to derive the TDD pattern implicitly based on the detection of sync signals
* [LGE] proposed introduce “orphan subframes” to align the NB-IoT frame structure and TDD frame structure after an SFN wrap-around.

An illustration of this issue is shown below, from [LGE] (the 70ms offset comes from 1020 mod 90 = 70):



Given this is the first meeting for this work item and not all companies presented their views on the issue, the option “Other options are not precluded” is added in case a better method is found.

### **Proposal 2.4-1 (assuming N=9): RAN1 to consider the following options for solving the issue of aligning the 90ms TDD structure with the 10240ms NB-IoT SFN structure:**

* **Option 1: SI indicates the offset with respect to a reference point, which will change across multiple SI instances.**
* **Option 2: The UE derives the offset based on the observation of sync signals.**
* **Option 3: “Orphan subframes” (e.g. 70ms) are introduced after an SFN (or HSFN) wrap-around to align both structures**
* **Other options are not precluded.**

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| Company | Comment |
| Ericsson | Earlier proposals need to be discussed first. The potential impacts in other Working Groups from using N = 9 need to be studied first as to have a better understanding on what are the potential issues to be solved.Please perform the following up to align the terminology across the proposals: “…**aligning the 90ms periodicity of TDD pattern ~~structure~~**…”  |
| Nordic  | Option 3 is our preference, assuming HSFN wrap-around |
| LGE | We may need to consider it together with how the legacy system works in the same band. On Option 2, from our perspective, since NPSS is always the same across all the frames, it is unclear how the UE knows the offset. To be specific, by using only NPSS, the UE only knows the subframe boundary, and does not distinguish frame index, SFN index, and H-SFN index. Considering the chicken-egg problem, the UE may need to know SFN and H-SFN, then the UE may apply the offset to derive TDD pattern starting point. According to our analysis, the UE could derive the offset based on the detected pattern of the NBPCH. To be specific, since the TDD pattern period is not aligned with the period where the part of NPBCH is changed (as we know, NPBCH’s coded bits are partitioned into 8 parts), some puncturing of the coded bit part would be different across different H-SFN. With this, the UE can derive the offset. In short, in option 2, we need to add NPBCH on top of the sync signals. |
| Vivo1 | We are fine to study. For option3, we need some clarification, “Orphan subframes” means there are no any DL/UL resource in the “Orphan subframes” due the wrap around issue, right?  |
| ZTE | We think it is enough to align the 90ms TDD structure with the start of 10240ms NB-IoT SFN structure. The orphan subframes at the end of SFN structure can be skipped. No need to introduce additional offset or structure, which makes the system more complex. |
| Nokia, NSB | Fine to study this. Better to update to “**Proposal 2.4-1 (assuming N=9): RAN1 to ~~consider~~ study**” |
| CATT | The reference point is unclear to us.  |

## 2.5 [LOW PRIORITY] Number of uplink subframes in the TDD frame structure

Similar to the downlink case, the work item description in [1] includes the following:

*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.***

For simplicity, we will denote by U the “number of contiguous U subframes” as in [HW].

As in the downlink case there are different views among companies on the number of subframes for the uplink. Note that since the WID does not explicitly state that RAN1 analyze the impact on uplink during the study phase, the number of companies that provided input on this issue is smaller than for downlink:

* N=9:
	+ [HW]: U={10, 30, 15, 20,10}
	+ [TH] Minimum value of U=8
	+ [vivo] U should be enough to transmit an NPRACH with a certain number of repetitions
	+ [Iri] U is single or double digit integer
	+ [QC] U=8 as baseline
* N=2k:
	+ [vivo] U should be enough to transmit an NPRACH with a certain number of repetitions
	+ [Eri] U >=20

Unlike the downlink case, and as explained in [TH], the UE will acquire at least basic information before attempting uplink transmission and, therefore, the need for a predefined set of uplink subframes may be reduced. Similarly to the downlink case, the WID states *“[...] and the configuration of the periodic pattern are fixed per band”*. Regarding the configuration of the value of U and the relative location of the U vs D, the following input was received.

* N=9:
	+ [TH] Configurable, at least U=8
	+ [Iri] Configurable, U is single- or double-digit integer.
	+ [QC] The location of the uplink subframes may be controlled by an offset or by common TA.

### **Proposal 2.5-1: The number of consecutive uplink subframes in the TDD frame structure (U) is:**

* **Option 1: fixed in specifications for a given band.**
* **Option 2: configurable.**

### **Proposal 2.5-2: The location of consecutive uplink subframes in the TDD frame structure with respect to the downlink subframes in the TDD frame structure is:**

* **Option 1: fixed in specifications for a given band.**
* **Option 2: configurable.**

|  |  |
| --- | --- |
| Company | Comment |
| Ericsson | In Proposal 2.5-1, we propose the follow update to align terminology across proposals:“**The number of consecutive uplink subframes (U) within the periodic TDD pattern ~~frame structure (U)~~ is**”In Proposal 2.5-2, we propose the follow update to align terminology across proposals:**“The location of consecutive uplink subframes in the UL periodic TDD pattern ~~frame structure~~ with respect to the downlink subframes in the DL periodic TDD pattern ~~frame structure~~ is”** |
| Nordic  | we prefer to have those configurable. |
| LGE | UL information could be provided by SIB like other features.  |
| Thales | For Proposal 2.5-1, we support option 2 with a minimum of 8 subframes can be configured.We propose the following revision for Proposal 2.5-2 **Proposal 2.5-2** **U indicates the number of consecutive UL subframes which is not necessary placed at the end of the TDD pattern.**Indeed, the position (as shown in Figure below) of U is given by **DownlinkToUplinkGuardPeriod** which indicates the Downlink to uplink Guard Period for TDD operation. This parameter in provided in number of subframes.We think for the definition of the TDD pattern we need to introduce **DownlinkToUplinkGuardPeriod.** This parameter should be configurable to support different orbits including and deplyement scnerios (at least up to 1200km orbits as per the WID) including the targeted MSS/L band of the WID,  |
| Lenovo | 1.the uplink transmission duration should be large enough to cover the RACH. 2.the uplink subframe in the proposal is based on the subcarrier spacing of 15kHz?3.75kHz? |
| ZTE | We would prefer a fixed pattern for simplicity and avoid potential interference caused by variant patterns. |
| Nokia, NSB | We think it should be firstly studied. For legacy TDD system, it utilized fixed TDD pattern for both initial access and RRC CONNECTED mode. We think whether to introduce configurable TDD pattern should be studied, e.g. impact to UL/DL procedures, UE implementation, hardware, etc. |
| CATT | The proposal is fine for us. |

# [CLOSED] Impact on downlink synchronization

## 3.1 High level framework

When conducting the study on the impact of the TDD pattern on downlink synchronization, one of the key issues is whether the mapping and periodicity of the signals / channels used for initial acquisition is the same as for NB-IoT NTN FDD. Given that the WID states that the specification work is “based on minimum necessary changes to the NB-IoT NTN FDD frame structure”, most companies assumed that the baseline is to keep the same mapping and periodicity as in NB-IoT NTN FDD. The following input has been received regarding changes in mapping / periodicity:

* [TH] proposes to map the NSSS to subframe 7 instead of subframe 9.
* [SPDR] proposes to consider enhancements to NPBCH to reduce the acquisition of MIB-NB.
* [OPPO] proposes to have the NSSS available every active downlink radio frame and NPBCH to be repeated within 320ms.
* [LGE] proposes to have NSSS mapped to some even radio frames and to modify MIB-NB periodicity.
* [Apple] proposes to reconsider the periodicity of NPSS/NSSS/NPBCH/SIB1-NB
* [SS] proposes to extend NPSS/NSSS/NPBCH transmission periodicities.

In view of the above, FL makes the following proposal for further discussion

### **Proposal 3.1-1: RAN1 strives to reuse the NB-IoT FDD subframe / SFN mapping and periodicities for NPSS/NSSS/NPBCH/SIB1-NB**

* **If RAN1 studies conclude that the above is not feasible, new mappings and periodicities will be considered.**

|  |  |
| --- | --- |
| Company | Comment |
| Ericsson | Since this work is supposed to be based on FDD frame structure type, then we need to add to the proposal the location of the PHY-channels and signals within the radio frame on the anchor carrier and mention other SIBs. We suggest the following update:“**Proposal 3.1-1: RAN1 strives to reuse the location of PHY-channels and signals transmitted on the anchor carrier as per FDD frame structure type 1, NB-IoT FDD subframe / SFN mapping and periodicities for NPSS/NSSS/NPBCH/SIB1-NB/Other SIBs-NB (e.g., SIB2-NB, SIB31-NB)*** **If RAN1 studies conclude that the above is not feasible, new mappings and periodicities will be considered.**”
 |
| Nordic | Not clear how this agreement makes us go forward. For any change to FDD protocol stack we need consensus. |
| LGE | Actually, we see some critical problem on SIB1-NB transmission. According to the specification, SIB1-NB can be transmitted in every other frames within 160msec, and repetitions could be evenly distributed over 2560msec periods. Moreover, the start frame is determined based on the PCID. Depending on the repetition number, its value can be 16 frames, 32 frames, 48 frames. In this case, the eNB may not transmit some coded bits due to the lack of DL subframes, and some cell may not transmit SIB1-NB. If the UE does not receive SIB1-NB, the subsequent communication including data communication would not be possible. Followings are relevant captures of the specifications:

|  |
| --- |
| 36.331For FDD, SIB1-NB transmission occurs in subframe #4 of every other frame in 16 continuous frames. The starting frame for the first transmission of the SIB1-NB is derived from the cell PCID and the number of repetitions within the 2560 ms period and repetitions are made, equally spaced, within the 2560 ms period (see TS 36.213 [23]).36.213 |

 |
| Vivo1 | We support the main bullet with inclusion of paging(to make sure the Paging subframes is modified to other subframes other than subframe 0/4/5/9).**Proposal 3.1-1: RAN1 strives to reuse the NB-IoT FDD subframe / SFN mapping and periodicities for NPSS/NSSS/NPBCH/SIB1-NB/Paging** |
| ZTE | Support to further study the impact of TDD patterns on NPSS/NSSS/NPBCH/SIBs needed for NTN access/paging. Regarding whether to consider new mappings or periodicities, can be discussed after the study. |
| Nokia, NSB | We think reuse legacy as much as possible should be a good start. While if modify, then the impact to spec/implementation should be studied.For the proposal, we think it should be updated as“**Proposal 3.1-1: RAN1 strives to reuse the NB-IoT FDD subframe / SFN mapping and location/periodicities for NPSS/NSSS/NPBCH/SIB~~1-NB~~**” |
| CATT | Legacy configuration is always important to follow, and we don’t expect too many changes to introduce new pattern. |
| Huawei, HiSilicon | We think the current FDD design can not be directly reuse because some of the transmission may be either punctured or postponed due to gap or uplink. To me this proposal is not urgent. We just need to list channels and signals to be investigated. |

## 3.2 Performance evaluations

From the contributions submitted to this meeting, and in line with the following WID statement:

*Study the impact due to the periodic pattern, at least on UE downlink synchronization and other aspects (if identified)*

There seems to be consensus that the performance of NPSS/NSSS should be verified, in line with the WID statement above. Several other companies also mention studying the performance of NPBCH and SIB1-NB, although some of the inputs are not explicit on whether this study should be performed during the study phase or work item phase:

* NPBCH: [Eri], [LGE], [QC], [OPPO], [LGE], [TH], [Iri]
* SIB1-NB: [Eri], [LGE] [QC], [OPPO], [LGE]

On which working group should conduct this study, there are multiple contributions with different views, with a clear majority leaning towards RAN1 evaluating these channels (although it is understood that RAN4 may need to adjust their tests during the RAN4 study phase):

* [HW], [TH], [ZTE], [Xiaomi], [NK] propose RAN1 should conduct the evaluations.
* [QC], [NK] propose RAN4 should conduct the evaluations.

### **Proposal 3.2-1: RAN1 evaluates the impact of the TDD frame structure on at least the following:**

* **NPSS/NSSS detection**
* **NPBCH decoding**
* **FFS: SIB1-NB decoding**

|  |  |
| --- | --- |
| Company | Comment |
| Ericsson | We propose the follow update to align terminology across proposals:**Proposal 3.2-1: RAN1 evaluates the impact of the periodic TDD pattern ~~frame structure~~ on at least the following:*** **NPSS/NSSS detection**
* **NPBCH decoding**
* **FFS: SIB1-NB decoding**
 |
| Nordic  | Essential SIB1, SIB2 and SIB31 should be included in study |
| LGE | We also think that the SIB1 should be included.  |
| Thales | According to the WID, there is a check point to conclude RAN1 study:* + Checkpoint in RAN#106 for the completion of the study phase. RAN1 start from Oct’24. RAN4 start from Nov’24

Therefore, to limit the RAN1 effort before the checkpoint (only one meeting left) we ‘d better to focus the study on DL synchronization. Other aspects including SIB1-NB decoding may be further examined during the normative work (starting from February meeting)We therefore propose the following revision:**Proposal 3.2-1: RAN1 evaluates the impact of the TDD pattern ~~TDD frame~~ structure on ~~at least~~ the following:*** **NPSS/NSSS detection**
* **NPBCH decoding**
* **~~FFS: SIB1-NB decoding~~**
 |
| ZTE | OK to also include SIBs needed for NTN access into study. |
| Nokia, NSB | We think both RAN1 and RAN4 need to evaluate. We propose to update**Proposal 3.2-1: RAN1 evaluates the impact of the TDD frame structure on at least the following and send LS to RAN4 to evaluate:*** **NPSS/NSSS detection**
* **NPBCH decoding**
* **FFS: SIB1-NB decoding**
 |
| Huawei, HiSilicon | Support in general |

It seems to be common understanding across companies that the performance of the channels / signals above will be impaired by the introduction of the TDD pattern. The Rel-19 study should assess the performance versus the expected operating SNR of the system. The WID states that both LEO 600 and 1200 are to be considered, which can be used to derive the downlink SNR:

*LEO @600 km and @1200 km orbit respectively, with set-1 satellite parameters as reference scenarios (See 3GPP TR 36.763)*

On this issue, two distinct sets of inputs have been received on how to calculate the downlink link budget:

* [Iri] and [TH] provide very similar parameters, with a resulting DL SNR of 4.91dB and 5.51dB for LEO 600 and 1200, respectively. Both inputs also mention LEO-800
* [vivo], [ZTE], [Xiaomi] refer to TR 36.763 Table 6.2.2.1.1, which includes a DL SNR of 3.0dB and 3.6dB for LEO 600 and 1200, respectively.

The major difference between TR 36.763 and the input from [Iri] and [TH] is the target frequency band, which is 1.6GHz in [Iri] and [TH] instead of 2GHz. The difference between these two frequencies (assuming the rest of the parameters in TR 36.763 remain the same) is , which is the same as the difference between both sets of results up to the 1st decimal point. There is some 2nd order difference in e.g. the decimal digits in the target elevation angle, but these are minor.

Given that the WID states that the target frequency of this work item is 1616-1626.5MHz, FL proposes to agree to the target SNR brought forward by [TH] and [Iri]. In order to verify the performance of the NB-IoT TDD frame structure, companies should report the margin with respect to the operating SNR:

### **Proposal 3.2-2: The target operating DL SNR 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 SNR is 4.91dB**
* **For LEO-1200, the operating SNR is 5.51dB**
* **When reporting link level simulation results, companies are encouraged to report the SNR margin with respect to the above operating DL SNRs.**
* **FFS: Whether LEO-800 is studied**

|  |  |
| --- | --- |
| Company | Comment |
| Nordic  | Agree |
| Thales | Ok. We would prefer to include also LEO-800 |
| OPPO | In the WID justification, we understand that the design is to support periodic frame structure for power consumption limitation, but it does not seem to target a coexistence with legacy deployement assuming the legacy framing is unchangable and 3GPP frame structure has to be tailored to it. Moreover, according to Iridium’s comment, it seems that the legacy frame is quite flexible, and can be adapted to be compatible with 3GPP’s frame structure. This is indeed very helpful and give us more space to conduct the design work.  |
| Huawei, HiSilicon | Generally fine with the methodology. We need to double check the value of SNR value.For LEO800, it seems not in the scope of WID |

On the assumptions for LLS, the inputs from different companies (e.g. [ZTE], [HW], [TH]) are roughly aligned except on a couple of points:

* On the channel model, [TH] proposes to use AWGN, while [HW] and [ZTE] propose to use NTN TDL-C
* On the frequency error, [ZTE] proposes to use 24ppm for frequency error, but it is Feature Lead’s understanding that this value does not include the XO error (while [HW] and [TH] include this value). Therefore, the frequency error should be 34ppm accounting for a 10ppm XO error.
* On the timing drift, [HW] and [TH] propose to use the same value as frequency error, while [ZTE] proposes a larger value (which is probably due to feeder link / common TA drift). Given the system under study in this work item is regenerative, Feature Lead has the opinion that the feeder link drift can be neglected.

### **Proposal 3.2-3: For link level simulations of NPSS / NSSS / NPBCH / [SIB1-NB], RAN1 uses the following assumptions:**

|  |  |
| --- | --- |
| Parameter | Value |
| Carrier frequency | 1.6GHz |
| Elevation angle | 30 degrees |
| Channel model | AWGN or NTN TDL-C |
| Frequency error / timing drift (including XO error) | 34 ppm for NPSS / NSSS0.1ppm for NPBCH |
| Variation of frequency error / timing drift | [0.24ppm for NPSS / NSSS]0 for NPBCH |
| UE velocity | 3km/h |
| Target performance | For NPSS/NSSS:* 99% detection probability with 0.1% false alarm rate

For NPBCH:* 1% error rate

For SIB1-NB (if evaluated):* 1% error rate
 |
| Other assumptions (e.g. combining length) | To be reported and justified by companies |

|  |  |
| --- | --- |
| Company | Comment |
| Nordic  | 24ppm value doppler should be sufficient |
| Thales | ok |
| Vivo1 | We suggest considering NTN-TDL-C only.For the column for Variation of frequency error / timing drift, just to make sure. variation of frequency error is 0.24ppm/s, and variation of timing error is 0.24ppm |
| ZTE | Only NTN-TDL-C should be considered similar to evaluations for other NTN topics. |
| Huawei, HiSilicon | We support TDL-C only.How to determine the success of detection should be clarified at least for NPSS and NSSS. |

# [CLOSED] [LOW PRIORITY] Other impacts

On top of the impacts mentioned in the previous sections, some other issues that were brought up, mainly on the topic of aligning current NB-IoT channels with the TDD pattern:

* How to handle system information messages: [SPDR]
* How to handle NPRACH occasions and RAR: [Nor], [HW],[vivo],[LGE],[E///]
* How to handle paging: [HW], [vivo]
* How to handle NPDCCH monitoring occasion: [Nor]
* Half duplex retuning gaps: [E///]

### **Proposal 4-1: RAN1 to consider impact of the TDD pattern on the following:**

* **System information messages**
* **NPRACH occasions and RAR**
* **Paging**
* **NPDCCH monitoring occasion**
* **Half duplex retuning gaps**

|  |  |
| --- | --- |
| Company | Comment |
| Ericsson | Please add NPUSCH and NPDSCH since as we explained earlier a TB can be mapped on one or more than RU and NPDSCH subframe respectively. |
| Nordic  | OK |
| Thales | Yes, but only during the normative phase. Focus only on the DL sync during this study phase following the guidance from the WID |
| ZTE | Support to further consider and study the impacts. |
| Nokia, NSB | We propose also at least to add link budget and system capacity of UL/DL control and data channel.**Proposal 4-1: RAN1 to consider impact of the TDD pattern on the following:*** **System information messages**
* **NPRACH occasions and RAR**
* **Paging**
* **NPDCCH monitoring occasion**
* **Half duplex retuning gaps**
* **Link budget of NPRACH/NPUSCH/NPDCCH/NPDSCH**
* **System capacity of NPRACH/NPUSCH/NPDCCH/NPDSCH**
 |

# Round 2 discussions:

## 5.1 Uplink TDD pattern

Similar to the case of downlink, some of the analysis of the study phase would require knowing what is the number of consecutive uplink subframes. In line with the proposal with offline consensus, FL proposes the following:

### **Proposal 5.1-1: For the study phase, RAN1 evaluates the following combination of N (in radio frames) and U (U = number of consecutive downlink 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**

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

|  |  |
| --- | --- |
| Company | Comment |
| Lenovo | After check the spec, uplink subframe in TDD NBIoT is specified, so we are OK for the proposal except the following typo:U (U = number of consecutive downlink subframes) |
| Ericsson | We are ok with studying it. Please correct the following typo: “**U = number of consecutive uplink ~~downlink~~ subframes**” |
| Vivo3 | We are ok with study. One question for clarification, when companies are doing evaluation, D can be assumed to be different from U, e.g., D=30 but U=20, is this correct understanding? Or they must be the same? |

## 5.2 Continuation from offline

The following issues may need follow up from the offline (proposals in Section 6):

* Issue#1: Confirm the SNR values for the downlink link budget (4.91dB and 5.51dB for LEO-600 and LEO-1200, respectively).
* Issue#2: 0.24ppm/s as frequency error variation / time drift variation.
* Issue #3: How to define correct NPSS detection (e.g. timing or frequency error).

Companies are encouraged to provide feedback on the issues above:

|  |  |
| --- | --- |
| Company | Comment |
| Vivo2/vivo3 | Regarding issue#2, we are not sure why 0.24 ppm/s is assumed. If this assumption comes from TR 38.821, the value should be 0.27ppm/s for LEO 600km, 0.13ppm/s for 1200kmLEO. |

## 5.3 Compatibility with legacy system operating in the 1.6GHz MSS TDD band

This proposal is a continuation of the discussion in Section 2.1, taking into account the input from several companies.

**Proposal 5.3-1: The study and specification work for NB-IoT NTN TDD shall ensure at least operation compatible with the TDD pattern of the legacy system deployed in the 1616-1626.5 MHz band (shown below), with the following constraints:**

* **N = 9.**
* **D = 8, with the set of consecutive downlink subframes being confined within one downlink slot in the TDD pattern below.**
* **U = 8, with the set of consecutive uplink subframes being confined within one uplink slot in the TDD pattern below.**
* **FFS: Details**
* **NOTE: The figure below represents the TDD pattern at the satellite node.**

~~~~

Companies are encouraged to provide feedback on the issues above:

|  |  |
| --- | --- |
| Company | Comment |
| Lenovo | The proposal can be discussed after the evaluation in next meeting. I am not sure whether 8ms in each 90ms period can load all necessary DL channel/signals and RACH channel. |
| Ericsson | We do not have enough understanding about the figure above as to be ready to accept this proposal.We would like to understand the following aspects:* What is the length of the guard periods between UL slots, between DL slots, and between UL and DL slots?
* In our understanding the “SIMPLEX TIME SLOT” refers to DL, and thus we would like to understand why the guard period between “DL4” and “SIMPLEX TIME SLOT” is lengthier in comparison to the guard periods used between other downlink slots.
* What is the length of the guard periods located at both sides of the “SIMPLEX TIME SLOT”?
* In earlier proposals it has been proposed to use D = 8 because of structure above, however we can see that there are several downlink slots available and that the length of each of them is beyond 8 ms. So, what is the reason behind D = 8?

Overall, we need to get a better understanding of the structure depicted in the figure associated to this proposal. |
| Vivo3 | In Proposal 5.1-1: and offline discussion, D/U with some values other than 8 are expected to be evaluated, but this proposal only consider D/U=8. They contradictory to each other. |

# Proposals for online:

Offline consensus (with some details to be solved in online marked in yellow)

**Proposal: The target operating DL SNR 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 SNR is [4.91dB]**
* **For LEO-1200, the operating DL SNR is [5.51dB]**
* **When reporting link level simulation results, companies are encouraged to report the SNR margin with respect to the above operating DL SNRs.**
* **Companies may report values for other scenarios (e.g. antenna gain, LEO-800) with the corresponding assumptions.**

**Proposal: 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**
* **FFS: which channels are evaluated (e.g. NPSS/NSSS/NPBCH/SIB1-NB/Other SIBs-NB/Paging)**
* **FFS: Assumptions for uplink, if needed**

**Proposal: RAN1 evaluates via link level simulations the following:**

* **NPSS/NSSS detection**
* **NPBCH decoding**

**Proposal: 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**

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

|  |  |
| --- | --- |
| 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 | [0.24ppm/s for NPSS / NSSS]0 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.

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 |

**Proposal: 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.**

# Summary of contributions (proposals only)

|  |  |  |
| --- | --- | --- |
| [R1-2407689](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407689.zip%22%20%5Ct%20%22_parent) | Huawei, HiSilicon [HW] | Proposal 1: The TDD pattern for NB IoT NTN should be defined by a number of contiguous DL subframes, followed by a number of contiguous subframes for guard period and followed by a number of contiguous UL subframes, i.e., by the triplet of (D, G, U). The sum of D, G and U should be 90 subframes.Proposal 2: The timing reference point of TDD frame structure should be defined at the TDD duplexer, i.e., at satellite, no matter for regenerative payload or transparent payload. Proposal 3: The following TDD pattern (D, G, U) can be further investigated in the study phase* Pattern 1: (10, 70, 10)
* Pattern 2: (30, 30, 30)
* Pattern 3: (45, 30, 15)
* Pattern 4: (40, 30, 20)
* Pattern 5: (50, 30, 10)

Observation 2: If the existing NPSS and NSSS pattern is reused and eNB skips the NPSS/NSSS on the subframes corresponding to GP and UL, the number of NPSS/NSSS in consecutive radio frames is reduced. Proposal 4: RAN1 evaluate the DL synchronization performance of NPSS/NSSS based on the simulation assumptions in Table 1.Proposal 5: The impacts on the following DL/UL transmissions should be further analysed when the new TDD pattern are introduced. * NPRACH
* Paging
* MIB-NB transmission
* SIB1-NB transmission
 |
| [R1-2407725](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407725.zip) | Spreadtrum Communications [SPDR] | Proposal 1: For IOT NTN TDD mode, enhancements on reducing the delay of MIB-NB reception should be considered.Proposal 2: For IOT NTN TDD mode, enhancements on reducing the delay of SIB1-NB reception should be considered.Proposal 3: For other system information acquisition, the SI periodicity, SI window length and SI repetition pattern need to be modified to adapt the IOT NTN TDD mode pattern. |
| [R1-2407772](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407772.zip) | THALES [TH] | **Proposal 1** The TDD-DL-UL-Pattern provides at least 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.

**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.**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.**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

**Proposal 11**RAN1 to discuss the possibility to support a slightly modified frame structure with:* a duration of 8ms
* NPSSS is moved to 7th subframe of every second frame.

**Proposal 12**RAN1 to study the impact due to the periodic pattern, only on UE downlink synchronization.**Proposal 13**The impact due to the periodic pattern, on UE downlink synchronization in IoT-NTN TDD is evaluated for LEO-600km, LEO1200km and LEO800km orbits. **Proposal 14**Set-1 satellite parameters as in table 6.2-4 of TR 36.763 are reused for the study on UE downlink synchronization in IoT-NTN TDD. **Proposal 15**The following satellite parameters defined for LEO800km are used for the study on UE downlink synchronization in IoT-NTN TDD*<table omitted>***Proposal 16**For the performance evaluation of UE downlink synchronization in IoT-NTN TDD, the following NB-IoT channel and signals can be evaluated:* NPSSS
* NSSS
* NPBCH

**Proposal 17**For the performance evaluation of UE downlink synchronization in IoT-NTN TDD, the following assumptions are considered:*<table omitted>*Note: time drift (48 ppm) caused by Doppler frequency offset should be considered for cell search in the LLS assumption for NPSS detection.**Proposal 18**For the performance evaluation of UE downlink synchronization in IoT-NTN TDD, AWGN channel model is assumed for IoT-NTN link level simulations.**Proposal 19**For link budget calculation, parameters in the following table are assumed:*<table omitted>***Proposal 20**For link budget calculation, the target elevation angle assumed for each deployment scenario is as follow:*<table omitted>***Proposal 21**Adopt the value of 9 radio frames for DL-UL-TransmissionPeriodicity.  |
| [R1-2407882](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407882.zip) | Vivo [Vivo] | Proposal 1: Changes on the subframes for NPBCH/NPSS/NSSS/SIB1-NB/Paging transmission should be avoided, e.g., the set of DL resources of the periodic pattern within one or multiple periods should include at least one set of subframes used for NPBCH/NPSS/NSSS/SIB1-NB/Paging transmissions.Proposal 2: The number of DL subframes in a DL resource set should be large enough to convey at least a NPDCCH or a NPDSCH with a certain number of repetitions.Proposal 3: When subcarrier spacing of 3.75kHz is applied to NPRACH, the minimum required continuous UL resource for NPRACH in a UL resource set is 6 subframes.Proposal 4: The number of continuous UL subframes in a UL resource set should be large enough to convey at least a NPRACH with a certain number of repetitions. |
| [R1-2407924](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407924.zip) | CMCC [CMCC] | **Proposal 1:****For the DL synchronization evaluation, both 600km and 1200km LEO system can be considered with the set 1 parameters from TR36.763.****Proposal 2:****It is proposed to discuss whether the TDD configuration in the TDD mode can be reused for the new TDD mode.** **Proposal 3:****The periodic subset of DL and UL subframes contain the procedure DL synchronization, initial access and the related transmissions.****Proposal 4:****The motivation or the assumption of the N radio frame and baseline value of 9 needs more clarification.** |
| [R1-2407937](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407937.zip) | ZTE Corporation, Sanechips [ZTE] | ***Proposal 1:*** *A fixed periodic pattern can be considered for IoT-NTN TDD mode without additional configuration signaling.****Proposal 2:*** *The required SNR for NPSS detection can be satisfied and no need of DL synchronization enhancement.****Proposal 3:*** *At least 2 consecutive radio frames are preferred to be allocated for DL in the periodic pattern, which avoids NPSS combination detection across different periodic patterns.****Proposal 4:*** *The UL synchronization is not impacted by sparser NPSS when NPSS periodicity is shorter than 256ms.* |
| [R1-2407960](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407960.zip) | Xiaomi [Xiaomi] | Proposal 1: For the TDD frame structure design, consider the guard period to cover the RTT time. Proposal 2: Conduct the LLS simulation for the NPSS and NSSS detection with 90ms periodicity @1% miss detection rate with 0.1% false alarm rate.Proposal 3: For the simulation of NPSS and NSSS detection, at least take the frequency offset and timing drift into consideration. Proposal 4: Determine the number of combinations for the evaluation of NPSS and NSSS detection. |
| [R1-2408037](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408037.zip) | CATT [CATT] | **Proposal 1: For NB-IoT NTN mode, the Guard period in the TDD frame pattern should cover the maximum RTT between UE and eNB for the deployed LEO scenario with transparent payload or regenerative payload, and the guard period is configured with once in a TDD pattern.** **Proposal 2: For NB-IoT NTN mode, TDD frame pattern should be cell specific and the pattern configuration is indicated in system information.** **Proposal 3: Within one TDD period, multiple NPBCHs can be transmitted with 10ms periodicity for sake of MIB transmission.****Proposal 4: In each TDD pattern period, the NPRACH resource should be configured to allow UE to access the network.** **Proposal 5: The Guard period can be configured with subframe granularity to reduce the overhead.****Proposal 6: The N value of the length of TDD frame period can be configured as 8 or 16 depending on application scenarios to match common channel transmission.** |
| [R1-2408078](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408078.zip) | SageRAN [SRAN] | **Proposal 1: TDD frame structure, including TDD period and duration for DL/UL transmission, is defined based on the Uu propagation delay range of NTN beam(s) .****Proposal 2: The duration of TDD period is defined as continuous q subframes with ; The duration of DL/UL transmission are defined as continuous p subframes with .****Proposal 3: At gNB side, the assignment in a TDD period is DL, UL and GP in sequence, among which the duration of GP is .****Proposal 4: For transparent NTN payload, the RP (reference point) shall be at the site of gNB if proposed TDD frame structure is applied, i.e. the k-Mac shall be 0 and the common TA shall be expressed for the delay of the entire feeder link.****Observation 3: With the timing advance setting aligned to RTD at UE side, the duration of UL transmission and DL reception would not overlap in the proposed TDD frame structure.** **Observation 4: The proposed TDD frame structure is much more efficient than the legacy TDD frame structure because of the shorter length of GP.****Proposal 5: To be compliant with the duplex switching overhead, a number of OFDM symbols at the end of DL/UL subframe set shall be reserved for DL-UL switching. The number of reserved symbols is FFS.****Proposal 6: The proposed TDD frame structure configuration, including the TDD period, the DL/UL duration and the number of reserved symbols, can be broadcast via system information.****Proposal 7: The alignment between SFN and TDD period is FFS.** |
| [R1-2408139](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408139.zip) | OPPO [OPPO] | **Proposal 1: Design a periodic pattern such that the NSSS can be detected at every available radio frame.** **Proposal 2: For non-consecutive available radio frame with periodic pattern, consider NPBCH repetition within wider time range, e.g. 320 ms.** **Proposal 3: Consider to expand SIB1-NB transmission period as well as one SIB1-NB transmission duration.**  |
| [R1-2408273](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408273.zip) | Iridium Satellite LLC [IriWP] | <Work plan> |
| [R1-2408302](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408302.zip) | LG Electronics [LGE] | ***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.***
* ***TDD pattern includes a large number of contiguous DL subframes at the expense of the increased value for N.***

***Proposal 2: For IoT-NTN TDD mode, one or more of followings can be considered to define DL subframes and their locations for the TDD pattern:*** * ***Set the value of N, TDD pattern periodicity, to be a form of powers of 2.***
* ***DL subframe locations can be different across different TDD pattern periods based on:***
	+ ***MIB signaling periodicity.***
	+ ***SIB1-NB transmission occasions.***
* ***Modifying MIB periodicity, SIB1-NB mapping.***
* ***Introduce separate TDD pattern for orphan subframes or frames within 10240 msec or 1024\*10240msec.***

***Proposal 3: For IoT-NTN TDD mode, one or more of followings can be considered to define UL subframes and their locations for the TDD pattern:*** * ***Set the value of N, TDD pattern periodicity, to be a form of powers of 2.***
* ***UL subframe locations can be different across different TDD pattern periods based on:***
	+ ***NPRACH transmission occasions.***
* ***Modifying NPRACH periodicity and start time.***

***Proposal 4: 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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| [R1-2408347](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408347.zip) | Nokia, Nokia Shanghai Bell [NK] | **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 study N=8 and N=10 as alternatives 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 the impact on the achievable link budget if the number of repetitions is restricted due to the use of every Nth radio frame.** **Proposal 7: 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 8: RAN1 should evaluate the UL capacity for NPRACH and NPUSCH considering the active radio frame per N radio frame.** |
| [R1-2408400](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408400.zip) | Iridium Satellite LLC [Iri] | **Proposal 1:** In NB-IoT NTN TDD mode, with value N set 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 shall be defined for the L-band (1616 – 1626.5 MHz).**Proposal 2:** In NB-IoT NTN TDD mode, SIB-1 shall broadcast active downlink duration and start offset time in subframes.**Proposal 3:** In NB-IoT NTN TDD mode, SIB-1 shall broadcast active downlink start offset time from the start of 2560 ms SIB-1 periodicity window in which SIB-1 is received.**Proposal 4:** In NB-IoT NTN TDD mode, SIB-1 or SIB-2 shall broadcast active uplink time duration and downlink to uplink time gap in subframes. |
| [R1-2408491](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408491.zip) | Apple [Apple] | ***Proposal 1:*** *RAN1 to determine the transmission pattern for DL synchronization considering the NPSS/NSSS/NPBCH/SIB1-NB transmission periodicity.****Proposal 2:*** *RAN1 to study the IoT-NTN TDD mode impacts on DL and UL scheduling.* ***Proposal 3:*** *RAN1 to study the IoT-NTN TDD mode impacts on random access.*  |
| [R1-2408667](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408667.zip) | Samsung [SS] | **Proposal 1: Support to extend NPSS/NSSS/NPBCH transmission periodicities in the consideration of the following additional aspects.*** **How long DL subframes are available during N radio frames.**
* **Which subframe index(ex) are used for NPSS/NSSS/NPBCH transmissions.**
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| [R1-2408736](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408736.zip) | Ericsson [E///] | [Proposal 1 For the support of “TDD mode NB-IoT NTN” on the anchor carrier, the location within a radio frame of the following PHY-channels and signals remains as in FDD mode:](#_Toc178884682)[ NPBCH is transmitted in subframe # 0 in every unmuted radio frame.](#_Toc178884683)[ NPSS is transmitted in subframe # 5 in every unmuted radio frame.](#_Toc178884684)[ NSS is transmitted in subframe # 9 in every other unmuted radio frame.](#_Toc178884685)[ SIB1-NB is transmitted in subframe #4 in every other unmuted radio frame.](#_Toc178884686)[Proposal 2 For the support of “TDD mode NB-IoT NTN” on the anchor carrier in DL:](#_Toc178884687)[ 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.](#_Toc178884688)[ 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.](#_Toc178884689)[Proposal 3 For the support of “TDD mode NB-IoT NTN” on the anchor carrier in UL:](#_Toc178884690)[ At least 2 consecutive UL radio frames within a period composed by N radio frames are used to carry NPRACH and NPUSCH.](#_Toc178884691)[ Aiming at minimizing the spec impact, N can be equal to the one selected for DL.](#_Toc178884692)[ 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.](#_Toc178884693) |
| [R1-2408871](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408871.zip) | Qualcomm Incorporated [QC] | **Proposal 1: RAN1 prioritizes the case of 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 2: The downlink pattern shall ensure that all of PBCH/PSS/SSS/SIB1 are available (across multiple DL periods) and assuming no remapping of PBCH/PSS/SSS/SIB1.** **Proposal 3: , where is the number of usable contiguous DL subframes in the pattern.****Proposal 4: The offset between the TDD pattern and the 3GPP frame structure is derived by the UE based on the observation of sync signals.*** **As a baseline, RAN1 should design the system such that the UE can determine the offset between the TDD pattern and the 3GPP frame structure based on NPSS detection.**

**Proposal 5: RAN1 takes =8 as baseline for further study:*** **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:**
	+ **Option 2:**
	+ **Option 3:**
	+ **Option 4:**
* **RAN1 to further study how to extend beyond for higher peak DL peak throughput**
	+ **Values of would result in similar specification impact as as long as there is a single NPSS in each downlink burst.**
	+ **Values of would result in multiple NPSS in a single downlink burst, which would require the UE to perform some degree of “blind decoding” or modify basic sync signals.**

**Proposal 6: (Conclusion) From RAN1 perspective, downlink synchronization and acquisition are feasible under a TDD pattern as described above.****Proposal 7: The following mandatory requirements may be impacted by reduced downlink signals due to TDD operation. RAN4 to confirm feasibility and change requirements (e.g. time or SNR requirements) if applicable:*** **Cell re-selection**
* **RRC re-establishment**
* **Radio link monitoring**

**Proposal 8: The following features with impact to RAN4 requirements are down prioritized during the study phase:*** **WUS**
* **PUR**
* **DL channel quality reporting**

**Proposal 9: RAN1 takes as the baseline for further study, where is the number of usable contiguous DL subframes in the pattern.*** **RAN1 should further consider specifying values larger than 8, which can be supported with limited specification effort.**

**Proposal 10: 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 11: RAN1 should strive to minimize the specification changes required for UE procedures in the presence of a TDD pattern, focusing on the following modifications when feasible:*** **Postponement / dropping of channels.**
* **Definition of new values for existing parameters.**
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| [R1-2408874](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408874.zip) | SageRAN [SRAN2] | **Proposal 1: The feasible of TDD frame structure for transparent payload is FFS.****Proposal 2: The design of TDD frame structure for regenerative payload should be discussed.****Proposal 3: For regenerative NTN payload, TDD frame structure including TDD period and duration for DL/UL transmission, shall be defined based on the Uu propagation delay range of NTN beam(s) .****Proposal 4: For regenerative NTN payload, the duration of TDD period is defined as continuous q subframes with ; The duration of DL/UL transmission are defined as continuous p subframes with .****Proposal 5: For regenerative NTN payload, the assignment in a TDD period is DL, UL and GP in sequence, among which the duration of GP is .****Proposal 6: For regenerative NTN payload, to be compliant with the duplex switching overhead, a number of OFDM symbols at the end of DL/UL subframe set shall be reserved for DL-UL switching. The number of reserved symbols is FFS.** |
| [R1-2408919](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408919.zip) | Nordic Semiconductor ASA [Nor] | ***Proposal-1****: RAN1 to discuss whether UE can assume that locations (for blind detection) for NSSS are located in the frame X where NPSS was found and frame X+9.* |

# 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

[2] ICAO TECHNICAL MANUAL FOR IRIDIUM AERONAUTICAL MOBILE SATELLITE (ROUTE) SERVICE (available [here](https://www.icao.int/safety/acp/inactive%20working%20groups%20library/acp-wg-m-iridium-4/ird-swg04-wp04-iridium%20tech%20manual%20-%20051706.pdf))

[3] [R4-2404267](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404267), Motivation for Iridium NB-IoT