**3GPP TSG RAN meeting #106 Draft-RP-xxx**

**Madrid, Spain, December 9-12, 2024**

**Agenda Item: 10.4.5**

**Source: IRDM**

**Title: Proposed way forward on the introduction of IoT-NTN TDD mode**

# Introduction

A new work item on introduction of IoT-NTN TDD mode was approved in RAN plenary #105. The detailed scope of this WI can be found in RP-242415 [1]. According this WID [1], there is a checkpoint at RAN #106 as follows:

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| The work item aims to specify enhancements for NB-IoT NTN to enable NTN operation with a NB-IoT TDD mode leveraging commonalities with half-duplex NB-IoT FDD NTN, by defining a new NB-IoT TDD mode for NTN based on minimum necessary changes to the NB-IoT NTN FDD frame structure and procedures for the NB-IoT operation in the targeted unpaired MSS allocated band (TN deployment is not expected in this band). The feature is not intended to be applicable to existing 3GPP bands.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
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We invite companies to comment on the proposed way forward on the introduction of IoT-NTN TDD mode.

# Discussion

The TDD-DL-UL-Pattern can be defined with the following parameters:

* **DL-UL-TransmissionPeriodicity** (referred to as N in the WID) which indicates the periodicity of the DL-UL pattern. It can be provided in number of radio frames.
* **nrOfDownlinkSubframes (D)** corresponding to the number of consecutive/ contiguous DL subframes at the beginning of each DL-UL pattern.
* **nrOfUplinkSubframes (U)** which provides the number of consecutive/ contiguous UL subframes
* **DownlinkToUplinkGuardPeriod** which indicates the Downlink to uplink Guard Period for TDD operation. This parameter in provided in number of subframes.

These parameters are illustrated in Figure 1.



Figure Definition of the periodic TDD-DL-UL-Pattern

**Observation 1:**

When defining the **DownlinkToUplinkGuardPeriod** in Non-Terrestrial networks, as outlined in clause 7.3.6 of [2, 38.811] this guard time directly depends on the propagation delay between UE and Base Station. Thereby, it should commensurate at least the round trip delay (RTD). The RTD could take different values depending on satellite orbit (LEO600km, LEO1200km or GEO) and the position of the reference point for uplink synchronization. For example:

* Minimum Downlink to Uplink Guard time for TDD operation for LEO at 600 km would range from 12.88 ms to 25.77 ms
* Minimum Downlink to Uplink Guard time for TDD operation for LEO at 1200 km would range from 20.88 ms to 41.77 ms.

**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.**

**Observation 2:**

Legacy frame structure limitations



**The DL slot/UL slot pairs (e.g**. **DL1/UL1 and DL4/UL4) in existing system have different transmission gap and thereby different Downlink to uplink Guard Period should be supported.**

Based on the above discussion, we have the following two proposals:

**Proposal 1:**

Revise the WID paragraph to specify N=9, D=U=8 for this MSS band.

**Proposal 2:**

With N=9, D=U=8, specify the Guard Period to be configurable per cell, to accommodate the legacy frame structure limitations and to allow for multiple orbits’ RTDs (as per Observations 1 and 2 above.)

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| Company | Comment |
| Iridium | Support Proposal 1Support Proposal 2 |
| ZTE | For proposal-1: We are supportive to specify it in band level and no additional configurability, per UE state or cell, is needed;For proposal-2: Not support. Let’s follow the traditionally TDD pattern design with fixed pattern. The configurability of GP is additional optimization and will lead to other issues, e.g., definition of the whole pattern since D+U+G may be smaller than N = 9. BTW, the motivation is not justfied since the orbit of iridium system is also fixed. |
| Huawei/HiSilicon | Support proposal 1 in general. For “No blind detection is assumed at the UE side” Surely there is still some blind detection (e.g. to decode PDCCH). So what is meant should be clarified, i.e. no blind detection of the value of N. But that should be obvious after fixing N to 9, so maybe this part could be deleted. ~~No blind detection is assumed at the UE side~~For Proposal 2, configuration of GP seems be to optimization. According to RAN chair guideline, it should not be included. |
| OPPO | For proposal 1, we are OK.For proposal 2, The motivation related to observation 1 is not clear. If we target coexistence with Iridium system, then the configurability of GP between D and U is not needed as the D and U relative location is pre-defined by Iridium’s TDMA structure. We agree with ZTE that the orbit of Iridium system is fixed. But on the other hand, the motivation related to observation 2 is meaningful. if the guard period for different (D, U) pairing is different, e.g., the guard period between (D1, U1) is different from guard period between (D4, U4), it indeed motivates the configuration of different guard periods. Therefore, we think proposal 2 needs a revision of motivation.**Suggested revised proposal 2**With N=9, D=U=8, specify the Guard Period to be configurable per cell, to accommodate the legacy frame structure limitations ~~and to allow for multiple orbits’ RTDs (~~as per Observation~~s 1 and~~ 2 above.) |
| Ericsson | **On Proposal 1:**We suggest to update the proposal 1 as the following. The motivations are as the following. The WID explicitly states "*including confirming the value of N*". In our view the current proposal brings too much work is the set of parameters needed for (N = 9 (i.e., 90 ms), U = D = 8 ms) which are not so specification friendly. The point is that if we are touching the technical specification to add a TDD mode operation, then we should allow for other values like the ones we propose (N = 8 (80 ms), U = D = 20 ms) including as well values that other Companies propose (e.g., U = D = 30 ms), because if we stick to the set of values proposed in Proposal 1, the achievable data rate is foreseen to be very limiting, basically the essential PHY-channels and signals that need to be transmitted leave very limited room for control information and user data. It is not clear to us why to inherit those limitations. We can rather add another set of values for a more generic TDD mode operation that will perform better.**Proposal 1 (revised):**Revise the WID paragraph to specify N=9, D=U= {8, 20\*, 30\*} for this MSS band and specify N = 8, D = U = {20, 30, 40} for bands other than the MSS band.* Alternatively, multiples of 8.

**On Proposal 2:**Observation 2 states that “**The DL slot/UL slot pairs (e.g**. **DL1/UL1 and DL4/UL4) in existing system have different transmission gap**”. In relation with it, we think that is important knowing what the duration of those gaps is in terms of ms, which will facilitate the design. We think that is a technical aspect that should be discussed in RAN1. |
| Samsung | We support Proposal 1 but not for proposal 2. These observations are not based on RAN1 and no discussion for such justification. We should left this for WG-level discussion. |
| MTK | Proposal 1: supportProposal 2: support with limited scope to accommodate the legacy frame structure limitations |
| Thales | We support both proposalsIn our view, the **DownlinkToUplinkGuardPeriod** should be configurable for different reasons:In the WID we target different orbits: 600km and 1200km orbits. 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.Further, by considering the existing system constraints, the value of DownlinkToUplinkGuardPeriod is different for each DL/UL pair. (i.e. the DL/UL gaps for DL1/UL1, DL2/UL2, DL3/UL3, DL4/UL4 are all different).Regarding the comments from ZTE, we would like to clarify that the existing specs support already configurable TDD pattern. And the issue related to the fact D+U+G is a real problem: Indeed, by simply adding the yellow text in the definition of consecutive/ contiguous UL subframes (=8 subframes), the behavior of the UE is clear. * **nrOfUplinkSubframes (U)** which provides the number of consecutive/ contiguous UL subframes. To suit the existing system deployed at targeted band the minimum of **U** should be equal to 8. And these consecutive/ contiguous UL subframes should not be necessary placed at the end of the TDD pattern window.

Also, we may modify the **Proposal 2** asfollows**:****Proposal 2**With N=9, D=U=8, specify the Guard Period ~~to be~~ may be configurable ~~per cell~~, to accommodate the legacy frame structure limitations and to allow for multiple orbits’ RTDs (as per Observations 1 and 2 above.) |

**Way Forward-2:**

We are discussing a controversial paragraph about if to have parameters fixed or configurable.

This is complete 4.1 section of revision of the WID, altered with inputs of round #1 of WF.

### 4.1 Objective of SI or Core part WI or Testing part WI

*The work item aims to specify enhancements for NB-IoT NTN to enable NTN operation with a NB-IoT TDD mode leveraging commonalities with half-duplex NB-IoT FDD NTN, by defining a new NB-IoT TDD mode for NTN based on minimum necessary changes to the NB-IoT NTN FDD frame structure and procedures for the NB-IoT operation in the targeted unpaired MSS allocated band (TN deployment is not expected in this band). The feature is not intended to be applicable to existing 3GPP bands.*

*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 (U) and set of usable contiguous DL subframes (D), and guard periods, which is periodic every N radio frames, with N=9. ~~No blind detection is assumed at the UE side~~. The value of N is fixed per band. For other parameters of the configuration of the periodic pattern (downlink to uplink guard period for TDD operation and the number of consecutive/contiguous DL and UL subframes)*
	+ *For this target band, support N=9, D=U=8, with the guard period configurable (to meet legacy system frame constraints ~~and accommodate different orbits~~).*

*This work item includes the following objectives:*

* *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, necessary adaptation and associated UE procedures [RAN1, RAN2]*
	+ *Other necessary impacts on higher layers [RAN2]*
	+ *RRM and RF core requirements [RAN4]
	Note: RAN4 work to be aligned with RAN1 assumptions.*
* *Specify a new NB-IoT TDD operating NTN band for the MSS allocation spanning 1616-1626.5 MHz for DL and UL, based on the outcome of the study, to be used as example band for this WI [RAN4].*
	+ *Specify band numbering*
	+ *Specify SAN and UE RF characteristics*
	+ *Specify DL and UL channelization.*
	+ *Specify channel bandwidth as 200 kHz*
	+ *Note1: No NTN-NTN coexistence study needed.*
	+ *Note2: Leverage existing work as much as possible for TN-NTN coexistence of adjacent bands*

*Note3: Reuse the existing RAN4 requirements as much as possible (no intention to have any relaxation of the RF emissions requirements)*

**Observation 2.1:**

When defining the **DownlinkToUplinkGuardPeriod** in Non-Terrestrial networks, as outlined in clause 7.3.6 of [2, 38.811] this guard time directly depends on the propagation delay between UE and Base Station. Thereby, it should commensurate at least the round trip delay (RTD). The RTD could take different values even in the same orbit~~. depending on satellite orbit (LEO600km, LEO1200km) and the position of the reference point for uplink synchronization.~~ For example:

* Ex1: Minimum Downlink to Uplink Guard time for TDD operation for LEO at 600 km would range from 12.88 ms to 25.77 ms
* Ex2: Minimum Downlink to Uplink Guard time for TDD operation for LEO at 1200 km would range from 20.88 ms to 41.77 ms.
* **Iridium orbit is @ 780 km, and also has variable RTD, with its min and max value.**

**Downlink to uplink Guard Period for TDD operation should commensurate at least the round trip delay (RTD). Thereby, Guard Period ~~to suit different deployments/orbits~~ should not be fixed per band.**

**Observation 2.2:**

Legacy frame structure limitations



**The DL slot/UL slot pairs (e.g**. **DL1/UL1 and DL4/UL4) in existing system have different transmission gap and thereby different Downlink to uplink Guard Period should be supported.**

Based on the above discussion, we have the following two proposals to discuss as basis for refining the WID:

**Proposal 2.1:**

Revise the WID to specify N=9 for this MSS band and specify D=U=8 for the initial search.

**Proposal 2.2-A:**

After initial search, D, U and Guard Periodmay be configurable.

**OR**

**Proposal 2.2-B:**

With fixed N=9, D=U=8, specify the Guard Period to be configurable ~~per cell~~, to accommodate the legacy frame structure limitations and to allow for ~~multiple orbits’~~ RTDs variation even within the same orbit (as per Observations 2.1 and 2.2 above.)

**Proposal 3:**

If the time and scope allow, as a second priority, consider Other N, U, D as per Ericsson’s input above, for other bands and operators use.

(We think the guidance from Chair in the first online session was clear not to expand the scope, but we are also cognizant that Ericsson proposal would allow more broadly applicable solution.)

Please provide inputs on the proposals above or join offline-offline @18h on Tuesday, III-floor coffee room:

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| Company | Comment |
| Iridium | Proposal 2.1: supportProposal 2.2-A: preferred to Proposal 2.2-B.Proposal 3: in ideal world, support, but worried will be considered scope expansion and jeopardize the WID prospects. |
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