3GPP TSG RAN WG2 Meeting #112e R2-200XXXX

November 2nd– November 13th, 2020

Agenda Item: 9.2.1

Source: Eutelsat

Title: Summary #1 of 9.2.1 IoT NTN Scenarios

Document for: Discussion and Decision

# Introduction

This document contains a summary of the contributions under AI 9.2.1 at RAN2#112e. During RAN Plenary session #89e it was decided to start email discussions for RAN2 Study on Narrow-Band Internet of Things (NB-IoT) / enhanced Machine Type Communication (eMTC) support for Non-Terrestrial Networks (NTN) activities in November 2020 to proceed with the Study Item. The main assumptions from the SID [1] are as follows:

* *FDD is assumed for this study*
* *Devices with GNSS capabilities are assumed.*
* *Transparent payload is assumed*
* *Frequency band below 6 GHz*

The main objective for AI 9.2.1 IoT NTN scenarios is to define reference scenarios. It is desirable to re-use the approach used in NR NTN TR 38.821 [2] to maximum synergies between IoT NTN and NR NTN.

In this document, companies’ views are summarized with corresponding observations/proposals on following aspects with detailed proposals from each company listed in appendix.

# IoT NTN Scenarios

## Background

Rapporteur’s summary on IoT NTN Scenarios:

Reminder on the main assumption approved in the SID [1]:

*- FDD is assumed for this study*

*-Devices with GNSS capabilities are assumed.*

*-Transparent payload is assumed*

*-Frequency band below 6 GHz*

A Satellite access network based on satellite with transparent payload is shown in Figure 1. It typically includes the following elements:

- A Ground (or ‘Earth’) Station consisting of a Sat-gateway and a Telemetry, Tracking, Command and Monitoring unit (TTC). TTC link is out of the scope of the Study Item and of the 3GPP realm.

- One or several Sat-gateways attached to a Base Station Base Band Unit (BBU) that connects the Non-Terrestrial Network to a Core Network/ Application Server. Node BBUs are close to Sat-gateways either co-located or at a few kilometers, antenna diversity may be required depending on geographical location and feeder-link frequency band.

- The satellite may be GEO or Non-GEO, and the satellite may be part of a Satellite Constellation to ensure service continuity and is served successively by one or several Sat-gateways. A Satellite Constellation Controller provides each base station with satellite system data (ephemeris, satellite position and velocity,..). This controller could be linked to the TTC unit at least to retrieve the relevant satellite information, but the link (in green) to the TTC unit is implementation dependent and out of scope of 3GPP.

- A Feeder link, which is a radio link conveying information for a satellite mobile service between a sat-gateway and the satellite.

- A service link or radio link between the C-IOT device and the satellite.

- A satellite, which implements a **transparent payload**. A transparent payload performs: Radio Frequency filtering, Frequency conversion and amplification; Hence, the waveform signal repeated by the payload is un-changed except for Frequency translation and Transmit Power, which is set-up according to the reference scenario (GEO, LEO satellite) and associated link budget.

The satellite typically generates several Spot-beams over a given service area bounded by its Field of View (FoV) or Footprint. The footprints of the Spot-beams are typically of elliptic shape. The Field of view of a satellite depends on the on-board antenna design /configuration and the minimum elevation angle. The beamforming may be performed on board the satellite or on the ground.

- C-IoT devices are served by the satellite within the targeted service area and are **GNSS reception capable.**

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Figure 1: A Satellite access network based on satellite with transparent payload

Connected mobility is not supported in the legacy specification for NB-IoT. NB-IoT supports idle mobility where the device reselects a satellite cell (a Spot-beam in the satellite jargon) after a Radio Link Failure.

From all the contributions submitted at **RAN2#112e** RAN on IoT NTN Scenarios:

* A majority of companies propose to focus on LEO and GEO orbital scenarios as approved in the SID [?], except one company which propose to prioritize GEO orbital scenario.
* A majority of companies propose to further divided LEO reference scenarios to earth-fixed beams or earth-moving beams except one company which propose to focus on earth fixed beam
* In Rel-17 IoT NTN SID [1], a NOTE 3 was added to clarify that “*GNSS capability in the UE is taken as a working assumption in this study for both NB-IoT and eMTC devices. With this assumption, UE can estimate and pre-compensate timing and frequency offset with sufficient accuracy for UL transmission. Simultaneous GNSS and NTN NB-IoT/eMTC operation is not assumed”.*

Companies’ proposals related to IoT NTN scenarios in RAN1#103e

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| Company | **Related Proposals & Observations** |
| Eutelsat  Eutelsat, Mediatek, Vodafone, Thales, Hughes/EchoStar, ESA, Inmarsat, Ligado, Sateliot  [3] | **Proposal 1**: We propose to have as reference scenarios for IoT NTN, the ones described in table 1.  It is proposed to consider the 3 scenarios in Table 1 below.   |  |  | | --- | --- | | **NTN Configurations** | **Transparent satellite (NOTE 1)** | | **GEO based non-terrestrial access network** | Scenario A | | **LEO based non-terrestrial access network generating Earth moving beams which move with the satellite (altitude at Nadir 1200 km and 600km)** | Scenario B | | **LEO based non-terrestrial access network generating Earth moving beams which move with the satellite (altitude at Nadir 1200 km and 600km)** | Scenario C |   Table 1: IOT NTN reference scenarios    **Proposal 2**: We propose to use the figures shown in table 4 to estimate NTN IoT Device Densities with NOTE 4 included.   |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **Usage scenarios** | **Experience data rate (note 2)** | | **Overall UE density per km2**  **(note 4)** | **Activity factor (note 3)** | **Max UE speed** | **Environment** | **UE categories** | **Sources** | | DL | UL | | IoT connectivity (low power wide area service capability) | 2 kbps | 10 kbps | 400 | 1,00% | 0 km/h | Extreme coverage | IoT | Device density => Vodafone R2-1901404  Data rate and activity factor => derived from rel-13 TR 45.820 annex E.2 "Traffic models for Cellular IoT" |   **Table 4 - Non-Terrestrial network target performances per usage scenarios [source: TR38.821]**  NOTE 2: As defined in TS 22.261 [3]  NOTE 3: As defined in TS 22.261 [3]  NOTE 4: The Overall UE density per km2 represents a peak value over a 40 km cell diameter. The actual value that can be achieved with a satellite will depend on the beam diameter. |
| ZTE Corporation, Sanechips  [4] | Observation 1: It is difficult for UE with power class 6 to support transmission over NTN.  Observation 2: If one satellite is mapped to one cell, the network capacity will be limited; if one satellite beam is mapped to one cell, the UE mobility performance and access performance will be impacted.  Observation 3: Cell beam (e.g. NR SSB) can deal with the mobility issue and cell capacity issue.  Proposal 1: RAN2 confirms that the eMTC/NB-IoT UEs with power class 3 and 5 can be considered for IoT over NTN.  Proposal 2: RAN2 confirms that both GEO and LEO can be supported for eMTC/NB-IoT over NTN.  Proposal 3: RAN2 confirms that the eMTC/NB-IoT UEs over NTN have the GNSS capability, but simultaneous GNSS and NTN NB-IoT/eMTC operation is not supported.  Proposal 4: RAN2 confirms that only transparent payload is supported for eMTC/NB-IoT over NTN.  Proposal 5: RAN2 confirms that both steerable satellite beams and beams moving with the satellite for LEO can be supported for NB-IoT/eMTC over LEO NTN.  Proposal 6: RAN2 assumes that the maximal cell bandwidth does not exceed 20Mhz for NB-IoT/eMTC over NTN.  Proposal 7: RAN2 considers to support Cell beam (e.g. similar NR SSB) for NB-IoT/eMTC over NTN.  Proposal 8: RAN2 confirms that standalone mode is studied firstly for NB-IoT over NTN.  Proposal 8a: If the frequency bands of TN NB-IoT can be reused for NB-IoT over NTN, in-band and guard-band should also be supported for NB-IoT over NTN.  Proposal 9: RAN2 discuss the maximal CE level that can be supported for NB-IoT/eMTC over NTN.  Proposal 10: The NB-IoT/eMTC multiple TBs scheduling mechanism can be supported for NB-IoT/eMTC over NTN.  Proposal 11: RAN2 needs to identify the TN NB-IoT/eMTC features that are not applicable to NTN NB-IoT/eMTC, and considers the possible impacts on NB-IoT/eMTC specifications |
| OPPO  [5] | Based on the discussion in section 2 we have following proposals:  [Proposal 1: GNSS capability is not assumed for NB-IoT and eMTC UEs in NTN.](#_Toc54186459)  [Proposal 2: GEO scenario is prioritized in Rel-17 for NB-IoT and eMTC in NTN.](#_Toc54186460) |
| Nokia, Nokia Shanghai Bell  [6] | Proposal 1: RAN2 to discuss and agree upon the NTN-IoT scenarios that forms the basis of study item in Rel-17.  Proposal 2 :Performance Requirements of IoT-NTN system in terms of battery life time, coverage enhancements and system capacity should be analysed and concluded as basis for further study on the functional requirements.  Proposal 3 :Dependency of GNSS based pre-compensation for NB-IoT/eMTC operations such as uplink transmission and eDRX operations needs to be concluded as part of the study.  Proposal 4: Battery life time analysis needs to include the power consumption of GNSS operation prior to IoT operation.  Proposal 5: Minimum throughput requirements of IoT-NTN should be identified as basis for further study on applicability of features relevant for throughput enhancements.  Proposal 6 : Latency requirements corresponds to exception reporting from idle mode UE in deep sleep condition also needs to revisted for IoT-NTN scenario.  Proposal 7: The maximum supported repetition number for different channels in IoT-NTN should be identified as basis for timers relevant enhancements.  Proposal 8: RAN2 discuss and agree upon minimum UE capability set needed for basic IoT-NTN operation.  Proposal 9 :RAN2 to discuss on the support for idle mode mobility between NTN and TN system in Rel-17 considering the additional study needed related to system information changes to support this functionality.  Proposal 10: EPC connectivity shall be considered as basis for IoT-over-NTN study. |
| Qualcomm Incorporated  [7] | Proposal 1 : For NB-IoT and eMTC NTN study item, following assumption and scenarios are considered:  (1) UE with GNSS capability,  (2) Fixed tracking area,  (3) GEO based NTN with transparent satellite (scenario A),  (4) LEO-based NTN with earth fixed cell and transparent satellite (scenario C1),  (5) LEO based NTN with earth moving cells and transparent satellite (scenario C2),  (6) HAPS-based NTN,  (7) IDLE mode and CONNECTED mode mobility within same satellite, between different satellites, between LEO and GEO, and between TN and NTN. |
| Xiaomi  [8] | The following reference scenarios can be considered for NB-IoT/eMTC.  Table 2 Reference scenarios for NB-IoT/eMTC NTN   |  |  | | --- | --- | |  | **Transparent satellite** | | GEO based non-terrestrial access network | Scenario A | | LEO based non-terrestrial access network:  steerable beams | Scenario B | | LEO based non-terrestrial access network:  the beams move with the satellite | Scenario C |   Based on the reference scenarios parameters for NR NTN in TR 38.821, we have the following parameters table for NB-IoT and eMTC.  Table 3 Reference scenario parameters for NB-IoT/eMTC NTN   |  |  |  | | --- | --- | --- | | Scenarios | GEO based non-terrestrial access network Scenario A | LEO based non-terrestrial access network (Scenario B & C) | | Orbit type | notional station keeping position fixed in terms of elevation/azimuth with respect to a given earth point | circular orbiting around the earth | | Altitude | 35,786 km | 600 km  1,200 km | | Spectrum (service link) | <6 GHz (e.g. 2 GHz) | | | Max channel bandwidth capability (service link) | 200KHz for NB-IOT;  1.4MHz for eMTC | | | Payload | Transparent | | | Inter-Satellite link | No | | | Earth-fixed beams | Yes | Scenario B: Yes (steerable beams),  Scenario C: No (the beams move with the satellite) | | Max beam foot print size (edge to edge) regardless of the elevation angle | 3500 km (Note 5) | 1000 km | | Min Elevation angle for both sat-gateway and user equipment | 10° for service link and 10° for feeder link | 10° for service link and 10° for feeder link | | Max distance between satellite and user equipment at min elevation angle | 40,581 km | 1,932 km (600 km altitude)  3,131 km (1,200 km altitude) | | Max Round Trip Delay (propagation delay only) | 541.46 ms (service and feeder links) | Scenario B&C: (transparent payload: service and feeder links)  25.77 ms (600km)  41.77 ms (1200km) | | Max differential delay within a cell | 10.3 ms | 3.12 ms and 3.18 ms for respectively 600km and 1200km | | Max Doppler shift (earth fixed user equipment) | 0.93 ppm | 24 ppm (600km)  21ppm(1200km) | | Max Doppler shift variation (earth fixed user equipment) | 0.000 045 ppm/s | 0.27ppm/s (600km)  0.13ppm/s(1200km) | | User equipment motion on the earth | 500 km/h | 500 km/h | | User equipment antenna types | Omnidirectional antenna (linear polarisation), assuming 0 dBi | | | User equipment Tx power | Omnidirectional antenna: UE power class 3 with up to 200 mW | | | User equipment Noise figure | Omnidirectional antenna: 9 dB (refer to TR36.802) | | | Service link | 3GPP defined NB-IoT and eMTC | | | Feeder link | 3GPP Radio interface | |   **Proposal 1: The above types of NTN platforms, reference scenarios and parameters for NB-IoT/eMTC NTN should be supported.** |
| Ericsson  [9] | [Observation 1: NB-IoT supports ultra-low complexity devices with very narrow bandwidth, while eMTC can achieve higher data rates, more accurate device positioning, and supports voice calls and connected mode mobility](#_Toc54184048)  [Observation 2 : eMTC and NB-IoT are complementary technologies that can address different types of IoT use cases based on their unique capabilities.](#_Toc54184049)  [Observation 3 The approved Rel-17 IoT NTN SID is dedicated to LEO and GEO satellite communication, while HAPS/HIBS and A2G are not in the scope.](#_Toc54184050)  [Observation 4 Rel-17 IoT NTN study should equally treat eMTC and NB-IoT. The study item cannot be considered complete, if one of them is not properly studied for feasibility for NTN.](#_Toc54184051)  [Observation 5 As transparent payload is assumed in Rel-17, both feeder link and service link use the Uu interface.](#_Toc54184052)  Based on the discussion in the previous sections we propose the following:  [Proposal 1: IoT NTN study should focus on essential adaptations for NTN, while generic enhancements motivated by non-NTN are outside the scope.](#_Toc54184053)  [Proposal 2: Rel-17 IoT NTN should support connectivity to EPC as the baseline.](#_Toc54184054)  [Proposal 3: In Rel-17 IOT NTN SI, limit the focus to earth fixed beam.](#_Toc54184055) |
| Huawei, HiSilicon | Proposal 1: The deployment scenarios to be supported in NTN NB-IoT needs discussion. .  Proposal 2: The service link for NTN NB-IoT is based on E-UTRA NB-IoT air interface.  Proposal 3: Consider only FDD mode for NTN NB-IoT. |

## Company Views

Eutelsat, Mediatek, Vodafone, Thales, Hughes/EchoStar, ESA, Inmarsat, Ligado, Sateliot summarized the assumptions and satellite scenarios for Rel-17 IoT NTN SI and propose to include these in TR 36.763. ZTE, Qualcomm, Xiaomi, Ericsson, Huawei discussed assumption and satellite scenarios IoT NTN.

Eutelsat, Mediatek, Vodafone, Thales, Hughes/EchoStar, ESA, Inmarsat, Ligado, Sateliot propose to re-use user density targets for IoT NTN as captured in TR 38.821.

Xiaomi proposed parameters table for NB-IoT and eMTC based on the reference scenarios parameters for NR NTN in TR 38.821. IoT parameters are discussed in IoT NTN email discussions in RAN1.

OPPO proposed to re-discuss the IoT NTN assumption for GNSS capability and want to prioritize GEO. This would require a revision of the Rel-17 IoT NTN SID and is RAN Plenary discussion.

Ericsson discuss eMTC should equally treat eMTC and NB-IoT. The study item cannot be considered complete, if one of them is not properly studied for feasibility for NTN. IoT NTN study should focus on essential adaptations for NTN, while generic enhancements motivated by non-NTN are outside the scope. Rel-17 IoT NTN should support connectivity to EPC as the baseline.

Ericsson proposed in Rel-17 IOT NTN SI, limit the focus to earth fixed beam. The assumption in NR NTN is that both types earth-fixed beams and earth-moving beams are supported. This discussion on type of beams can be discussed in the other agenda item track AI 9.2.2. Applicability of TR 38.821.

Nokia proposed to study performance requirements battery life time, coverage enhancements and system capacity, dependency of GNSS based pre-compensation, minimum throughput requirements of IoT-NTN, Latency requirements, maximum supported repetition number, minimum UE capability, support for idle mode mobility between NTN and TN. ZTE also discussed some aspects related to coverage and capacity for NB-IoT and eMTC and proposed standalone mode is studied firstly for NB-IoT over NTN. Some of these aspects within the SID RAN2 objectives may be discussed in the other agenda item track AI 9.2.2 applicability of TR 38.821.

IoT NTN Scenarios

We summarize below the assumptions of the SID [?]:

*- FDD is assumed for this study*

*-Devices with GNSS capabilities are assumed.*

*-Transparent payload is assumed*

*-Frequency band below 6 GHz*

*-UE Power Class 3 and 5*

-Satellite constellation orbit LEO and GEO

*-Link budget for identified scenarios*

**Question 2.2-1: Do companies agree to include the following assumption in the TR36.763?**

*- FDD is assumed for this study*

*-Devices with GNSS capabilities are assumed.*

*-Transparent payload is assumed*

*-Frequency band below 6 GHz*

*-UE Power Class 3 and 5*

-Satellite constellation orbit LEO and GEO

-Link budget for identified scenarios

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| **Company** | **Agree / Disagree** | **Additional comments** |
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**Question 2.2-2**: Do companies agree to include the table 1 as reference scenarios for IoT NTN in TR 36.763 ?

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| **NTN Configurations** | **Transparent satellite (NOTE 1)** |
| **GEO based non-terrestrial access network** | Scenario A |
| **LEO based non-terrestrial access network generating Earth fixed beams (satellite steerable beams) altitude at Nadir 1200 km and 600km** | Scenario B |
| **LEO based non-terrestrial access network generating Earth moving beams which move with the satellite (altitude at Nadir 1200 km and 600km)** | Scenario C |
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| **Company** | **Agree / Disagree** | **Additional comments** |
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**Question 2.2-3**: Do companies agree to include table 4 to estimate NTN IoT Device Densities with NOTE 4 included, in TR36.763?

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| **Usage scenarios** | **Experience data rate (note 2)** | | **Overall UE density per km2**  **(note 4)** | **Activity factor (note 3)** | **Max UE speed** | **Environment** | **UE categories** | **Sources** |
| DL | UL |
| IoT connectivity (low power wide area service capability) | 2 kbps | 10 kbps | 400 | 1,00% | 0 km/h | Extreme coverage | IoT | Device density => Vodafone R2-1901404  Data rate and activity factor => derived from rel-13 TR 45.820 annex E.2 "Traffic models for Cellular IoT" |

**Table 4 - Non-Terrestrial network target performances per usage scenarios [source: TR38.821]**

NOTE 2:               As defined in TS 22.261 [3]

NOTE 3:               As defined in TS 22.261 [3]

NOTE 4: The Overall UE density per km2 represents a peak value over a 40 km cell diameter. The actual value that can be achieved with a satellite will depend on the beam diameter.

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| **Company** | **Agree / Disagree** | **Additional comments** |
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**Question 2.2-4**: Do companies agree that EPC connectivity shall be assumed as basis?

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| **Company** | **Agree / Disagree** | **Additional comments** |
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**Question 2.2-5**: Do companies agree that standalone mode is studied firstly for NB-IoT over NTN.

## Updated proposal based on company views

### IoT NTN Scenarios

TBA based on companies’ contributions captured in summary #1 for initial round of e-mail discussions

## Company Views (2nd round of email discussions)

### IoT NTN Scenarios

TBA based on companies’ comments on updated proposals for IoT NTN scenarios during 1st round of email discussions

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| **Company** | **Agree / Disagree** | **Additional comments** |
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## Updated proposal based on company views (2nd round of email discussion)

TBA based on companies’ comments on updated proposals for IoT NTN scenarios during 2nd round of email discussions

## GTW Agreement / Conclusion

TBA

# References

1. RP-193235, “New Study WID on NB-IoT/eTMC support for NTN”, [MediaTek]
2. 3GPP TR 38.821-g00, “Solutions for NR to support non-terrestrial networks”, Technical Report, (Release 16)
3. R2-2008883, IoT NTN scenarios and UE density, [Eutelsat]
4. R2- 2009071, Consideration on the scenarios for IoT over NTN, [ZTE Corporation, Sanechips]
5. R2- 2009114, Discussion on scenarios for NB-IoT and eMTC in NTN, [OPPO]
6. R2-2009267, On NB-IoT/eMTC for NTN scenarios and Performance requirements, [Nokia, Nokia Shanghai Bell]
7. R2-2009449, Scenarios and assumption for IoT NTN, [Qualcomm Inc]
8. R2-2009589, Discussion on scenarios for NB-IoT and eMTC NTN, [Xiaomi]
9. R2-2010237, NTN IoT scope, scenarios, architecture, and requirements,[Ericsson]
10. R2-2010287, Discussion on NTN scenarios for NB-IoT,[ Huawei, HiSilicon]