GPP TSG RAN meeting #91e **RP-210434**
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Agenda Item: 10.6.1
Source: Sateliot
Title: Sateliot view, urgent need for NB-IoT NTN normative phase in Rel-17
Document for: Discussion

1. Introduction

The urgency to have an IoT NTN global standard was already explicitly expressed to 3GPP TSG RAN#86 in Sitges in December 2019 [1]. Key points raised in that contribution were:

- *Significant addressable market opportunity:*
  - *Market potential for billions of NB-IoT objects*
  - *Use cases representing ~30% of objects can strongly benefit from global coverage (in logistics, agriculture, energy, maritime, etc.)*
  - *~20% of objects for these use cases could be connected by satellite*
  - *Direct potential of x100's million NB-IoT objects connected directly by satellite. And indirectly, true global coverage could be a requirement for LPWA IoT technology selection*
- *Non-3GPP satellite LPWA solutions starting to be introduced to address this market:*
  - *Unlicensed LPWAN IoT (Sigfox, LoRa) already adapted to satellite (e.g. Lacuna, Eutelsat ELO)*
  - *Proprietary satellite solutions (e.g Myriota, Astrocast, Hiber, Globalstar)*
  - *An addressable market does exist & will be captured by non-3GPP solutions if 3GPP does not act*
- *Satellite NB-IoT can enable new market opportunities for MNOs to develop new hybrid offers where the satellite infrastructure is seamlessly integrated to and complements terrestrial IoT networks*

In the same meeting, the study item of "Study on NB-Io/eMTC support for Non-Terrestrial Network" was approved for Rel-17 [2].

Work on the NTN-IoT SI commenced in November 2020 via WG meetings conducted as official email discussions. The recent RAN1#104-e and RAN2#113-e WG meetings in January-February 2021 marked the first in-meeting discussion in RAN 1 and RAN 2. Good progress was achieved, with outcomes and findings being compiled in 3GPP TR 36.763. The SI work is structured to leverage the outcomes of the NTN-NR study in Rel-16. Studies are planned to be completed in RAN1#105-e and RAN2#114-e in May 2021 [3], with the goal of starting normative phase in the 3rd quarter in order to develop an early/minimum IoT NTN specification in Rel-17.

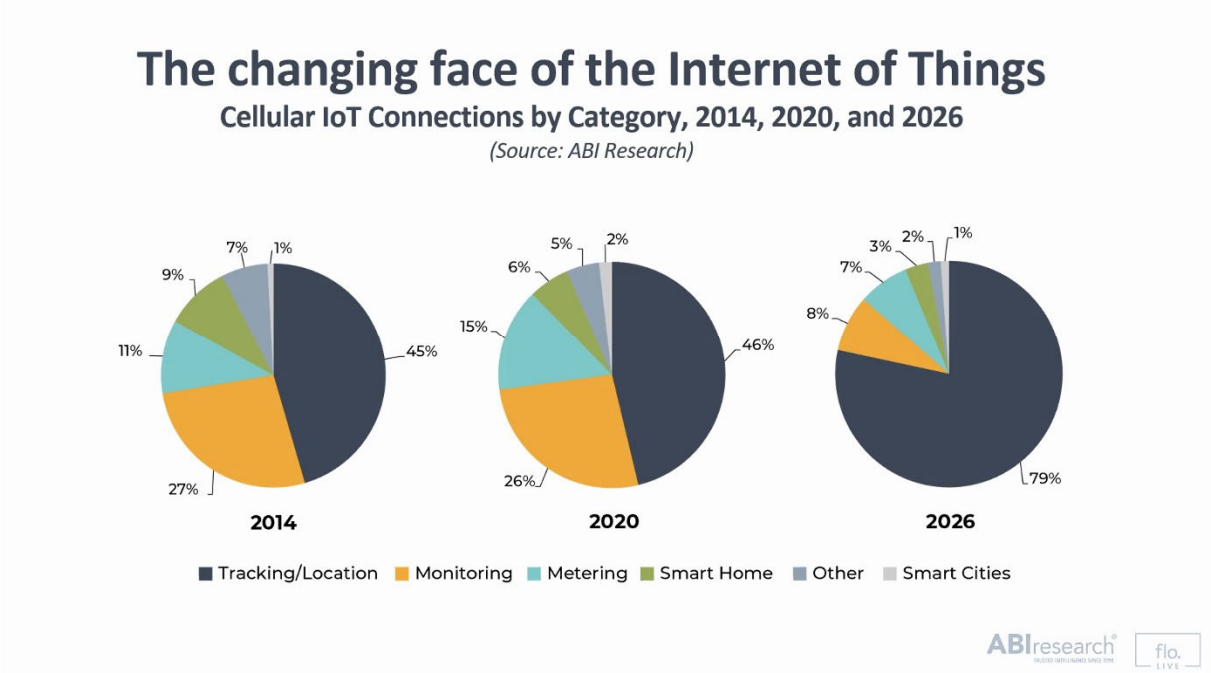
To keep expectations and ensure that 3GPP could deliver this early/minimum NB-IoT NTN solution under Rel-17, it is important to start delineating the scope of the subsequent Rel-17 normative phase for IoT NTN. This document advocates in this respect.

2. Need and urgency for 3GPP IoT NTN in Release 17

2.1. Market opportunity for a global, integrated terrestrial/NTN IoT solution

Different estimates and projections exist for the cellular IoT market. According to Berg Insight, the global number of cellular IoT subscribers increased by 40 percent during 2019 to reach 1.56 billion at the end of the year – corresponding to around 16 percent of all mobile subscribers. Until 2024, the number of cellular IoT subscribers is forecasted to grow at a compound annual growth rate (CAGR) of 21.6 percent to reach 4.15 billion at the end of the period. During the same period, cellular IoT connectivity revenues are forecasted to grow at a compound annual growth rate (CAGR) of 16.1 percent from € 7.0 billion in 2019 to approximately € 14.8 billion in 2024.

Within this market, ABI Research estimates cellular IoT connections by category, as illustrated in the figure below. It can be seen that a 46% of Cellular IoT connections in 2020 are associated with Tracking and Location applications, which are expected to represent a 79% of the total connections in 2026.



In this context, the timely availability of a global terrestrial and satellite cellular IoT solution is key to handle and further contribute to the growth of the massive IoT market without the risk of technology fragmentation, allowing IoT service providers to:

- seamlessly extend IoT connectivity service reach to areas where terrestrial network coverage is not possible or cost-efficient (e.g. environmental monitoring applications in remote areas, not well served by terrestrial networks)
- offer an integrated redundancy layer at critical sites or IoT applications (e.g. IoT devices could still be reached through satellite when terrestrial coverage becomes not available for whatever reasons)
- deliver IoT solutions for which global/ubiquitous coverage is a requirement for technology selection (e.g. a global IoT solution can definitely add value and spur new market demand within the Tracking and Location IoT category as well as other categories such as agriculture, energy, maritime, etc.).

The potential benefits achievable through an integrated satellite/terrestrial IoT solution have been already acknowledged by some mobile network operators. Based on our conversations with some MNOs, hereafter some clear messages:

- *Non-terrestrial IoT as a complement to Terrestrial IoT beneficial where TN not available.*
- *Re-use of existing NB-IoT/eMTC for IoT over NTN would drive economies of scale in devices; and re-use of 3GPP security solutions, roaming capabilities and O&M infrastructure.*
- *Reuse 5G terrestrial specification and NTN WI design as much as possible*
- *Promote NTN related specification progress for a unified solution and early launching for the industry*

Observation#1 - There is a growing market for cellular IoT connections, especially in the massive IoT segment. The addition of NTN features with low marginal costs for cellular IoT devices can only contribute to further expand this market beyond current projections by exploiting the benefits of global / ubiquitous coverage and redundancy.

Observation#2 - The addition of NTN features into the cellular IoT standards is a necessary message to the industry that the 3GPP community is committed to deliver global solutions for the massive IoT market and help mitigate technology selection risk and fragmentation.

2.2. Economically viable satellite solutions to support early IoT NTN deployments

Small satellites solutions based on the so-called New Space approach can allow for low TCO, orders of magnitude lower than those achievable in classic space industry, which makes feasible to implement affordable, cost effective satellite NB-IoT networks.

Reduction of the time and cost of satellite development is being achieved within the New Space sector by using much smaller satellites and assuming higher levels of risk. Specifically, small satellites, and more in particular, satellite platforms compliant with the CubeSat industrial form factor, have become the ideal platforms to balance the performance and capabilities of satellites with the cost of production, launch and maintenance. The New Space sector is a growing sector that is expected to enter its maturity phase in the coming years. It is estimated that in the period 2020-2025 there will be around 3,500 new launches of CubeSats[1]. These figures show a growth of more than 600% compared to the launches that have been carried out in the last four years. Satellite IoT solutions based on this New Space approach are seen as a game changer for new service providers, building new constellations and bringing new services for new uncovered markets.

Unlike NR NTN solutions in LEO orbits for eMBB services, which likely require dense constellations (e.g. in the order of hundreds or more) of high capacity satellites in order to be able to provide high data rates and service continuity, NB-IoT solutions with sparse LEO constellations (e.g. in the order of tens of satellites) of CubeSats or similar platforms are anticipated to be a compelling approach to address the needs of many IoT and M2M applications. In particular, there is a wide range of delay-tolerant IoT/M2M applications that do not require continuous service coverage and that generate short, infrequent messages, that can be properly addressed with such solutions. For example, in smart agriculture applications, small messages, few messages per day, large delays are not a service problem and can be perfectly achieved by a satellite network not offering continuous coverage. More examples are maritime use cases for non-critical asset tracking where today a data logger is already used, livestock monitoring during pasture in rural areas, and in general any non- critical asset tracking in landline, environmental monitoring, wildlife monitoring and so on.

Observation#3 - There are economically viable solutions ready to support early NB-IoT NTN service deployment in the 2022/2023 timeframe and so start harnessing and promoting this market. Among

[1] lxt:33{ { { 2mig2gex3ir3gsrxirx39<3ri{ w3hixmp3<;<3ri{ wtegi1wxwexik}1sj1gexepsrme1e1ri{ 1wxit1xs{ evhw1xli1hiq sgvexm-exmsr1sj1wtegi

them, solutions based on sparse LEO constellations of nanosatellites are poised to address a wide-range of delay-tolerant IoT applications

2.3. Risk of losing market advantage in front of competing technologies

Sateliot started analyzing the space sector of CubeSat and smallsat satellites to find a solution to one of the most important problems of wireless technologies for outdoor IoT: a cost effective coverage solution in underserved areas or where terrestrial infrastructures are not available.

We found out that there is an important quantity of different start-up and more consolidated companies that plan to offer a proprietary IoT coverage solution from space based on small satellites, normally CubeSat. All these implementations share a common approach: develop the best vertical proprietary IoT solution.

These solutions include:

- Development of the protocol wave-form and stack
- Development of the ASIC and RF module for IoT devices
- Development of the Satellite and constellation in Store & Forward

The value chain involves one company for everything and creates a lock-in vendor in each customer.

At the moment, keeping aside classical space companies like Orbcomm, Iridium, Inmarsat and many others GEO satellite providers, we can identify some New-Space companies that are moving in that direction and take advantages of all the previous mentioned TCO low barriers:

- Astrocast, Switzerland: Proprietary protocol, 2 satellites for In Orbit Demonstration already launched. 5 more in process to be launched this year. They have developed their ASIC, secured access to the license spectrum in L-Band by a contract with Thuraya. Mission Control Center already in Operation.
- Myriota, Australia: Proprietary protocol, 5 satellites in process to be launched this year. They have developed their ASIC. They bought old ExactEarth satellites and Mission Control Center.
- Hiber, Netherlands: Proprietary protocol based on E-SSA, 2 satellites for In Orbit Demonstration (IOD) already launched. 1 more in process to be launched this year. They have developed their ASIC.
- Swarm, USA: the first commercial pico-sat constellation, more than 80 satellites already in orbit from January 2021. Public information shows costs of 119$ for the RF module and 5$ monthly fee.

Then, we can put over the table more than 20 other New-Space companies approaching the satellite IoT with support from public administrations and local space agencies to develop low density constellations of small satellites in Store & Forward architectures for delay tolerant services.

It is worth noting two projects that are approaching the IoT outdoor global coverage using terrestrial protocols that already have an industrial ecosystem of chips, devices, applications and operators. One is the LoRa adaptation for space supported by Semtech (owner of LoRa PHY). In November 2020, Semtech introduced LoRa-FHSS to encourage adoption of this solution by satellite operators. There are already satellites in orbit, and early commercial service (Swarm, Lacuna) using LoRa. Other companies have taken steps in adopting LoRa (Kepler). The other project is the adaptation of Sigfox to satellite communications. In this respect, SigFox seeks also to capitalize on hybrid satellite/terrestrial approach with Admiral LEO.

Other initiatives worth mentioning that rely on the use of proprietary protocol adaptations are:

- AST & Science, USA: they promise global phone and IoT connectivity based on their constellation of macro satellites without any modification of the user terminal either software or hardware using mobile terrestrial spectrum from Space (something not allowed by the ITU normative). It seems a proprietary solution.
- Lynks, USA: in the same way as AST & Science, they promise global coverage to 3GPP compliant devices without any modification in the user terminal, same approach for spectrum.

- SkyLo, Israel: an IoT solution with a terminal connected to Inmarsat GEO satellites that use an NB-IoT adaptation considered proprietary.

Indeed, many players in asset tracking and asset monitoring are already investing or are expected to invest massively in satellite IoT to complement their terrestrial IoT in the next 2 to 3 years and such investments in the technologies to be supported by the end devices are made for 5 to 10 years [4]. Therefore, if a first 3GPP IoT over NTN standard is not available before release 18, it is likely to be too late for many verticals who will have to adopt other solutions than 3GPP.

Observation#4 - Non-3GPP satellite IoT solutions, some already capitalizing on the advantages of the New Space industry and the adaptation of terrestrial LPWA protocols for satellite access, start to be introduced to address the massive satellite IoT market opportunity. Urgent need for 3GPP to act in order to avoid 3GPP cellular IoT standards to lose competitive advantage in front of early movers.

3. Sateliot approach and roadmap towards NB-IoT NTN service delivery

It is publicly known that Sateliot started three years ago an important plan to find a solution for outdoor IoT wireless coverage from space based on micro satellites. The key element in this project is the selection of the right air interface to reach economy of scale and avoid vendor lock-in for the end user.

Sateliot commercial strategy is based on a wholesale B2B approach to Mobile Network Operators to extend their coverage in underserved areas or where terrestrial networks are not available like oceans, seas, poles, forest, desert and in general low density populated area where make sense to have IoT solutions. The digital transformation of society is requiring massive IoT solutions to bring the physical reality to the virtual world where Big Data, Machine Learning and Deep Learning are used to take value of this massive amount of new data never seen before.

From the beginning, to give an answer to these needs, Sateliot decided to find-out a solution for the air interface to offer a seamless integration between terrestrial networks and space networks. Potential candidates were Sigfox, LoRaWAN and 3GPP cellular IoT protocols.

Among them, Sateliot decided to focus its business on finding a solution to extend MNO NB-IoT coverage and offer a seamless experience from LEO constellation of microsatellites. For the microsatellites itself, Sateliot decided to take into consideration the CubeSat industry form factor.

And in contrast to constellations for broadband connectivity services, IoT constellation can start offering service to delay tolerant applications where continuous coverage is not needed at the beginning of the business, then, as the business grow, new satellites can be added, more ground stations can be added, Inter Satellite Links can be added and a near real time service can be offered.

From that moment we have worked to focus all our projects to bring our decisions to reality. During 2020 Sateliot has invested more than 5 million euros for NB-IoT technology development for CubeSats. A first satellite will be launched in March 2021.

From the business point of view, Sateliot is working from the first days of its project to find out potential end users opportunities to build a solid base of use cases for MNO.

- Sateliot has signed Memorandum of Understanding (MoU) with some of the most important MNOs:
    - No mobile operator has not been interested in IoT coverage from space
    - They ask for quick answer and seamless integration
    - They ask for IoT NTN RF modules cost equal to cost of IoT TN RF module
    - They ask for recurrent cost similar to their terrestrial networks

- Sateliot has signed MoU with important engineering companies to build up Proof of Concept:
    - They put over the table new challenges IoT solutions to stimulate the market that nowadays have no cost effective answers
    - They propose vertical solutions to MNO and Sateliot propose the coverage extension

- Sateliot has signed MoU with Applications providers to build up Proof of Concept of their solutions in underserved markets or where terrestrial MNO networks are not available:
    - Smart agriculture implementation based on SigFox networks that asks to avoid sensor lock-in but limited by cellular IoT coverage
    - Illegal logging in rainforest working with huge amounts of small GSM repeater to bring coverage deeply in the forest require installation and maintenance
    - Wildfire detectors and moisture monitoring installed in nowhere are limited by the cost of satellite RF module are asking for small cost effective modems compatibles with MNO

- For Sateliot, the approach to the market is a must and in December 2020, we won our first contract with the public administration of Catalonia Government to offer an experimental space IoT application for delay tolerant services based on a CubeSat that will span over a broad spectrum of applications:
    - Coastal water quality control
    - River flow control
    - Wildfire prevention
    - Whether control in high mountain
    - Smart agriculture sensors
    - Rural water tank metering
    - and many others related to improvement in specific processes

Answer to so called delay tolerant services can be achieved in a short time thanks to non-continuous coverage of small satellites LEO constellations but the question is when it will happen if 3GPP doesn't start the normative phase in Rel-17

Sateliot plan to deploy a 100 CubeSat constellation starting from a first delay tolerant service based on a smaller number of satellites. The commercial service will start in 2023 and for that it is important to develop an NB-IoT adaptation under the 3GPP specification to avoid a proprietary solution and take advantage of the ecosystem where chip vendor and RF module vendor will introduce a first release of this NTN protocol. Any other situation where the protocol is not ready in time will implicate a scenario where MNO and the end user will perceive a risk in their investment because the Sateliot solution will be considered a potential lock-in.

Observation#5 - Several companies have already secured investments and are conducting technology and service model developments under the expectation to have a minimum IoT NTN capability under 3GPP Rel-17.

Observation#6 - Multiple potential use cases are identified but the technology roadmap is still uncertain about when a global solution is going to be available, hindering a more active involvement of MNOs, engineering companies and application providers.

Observation#7 - In Sateliot's view, a NB-IoT NTN solution based on the use of sparse LEO constellations of nanosatellites is an economically viable solution to start shaping and unleashing the potential of this market in the coming years.

4. Conclusions

Sateliot strongly believes that the unique success in satellite IoT will come from the alignment of the satellite and mobile communications industries around a global radio interface standard with a seamless integration with MNOs.

Our strategy is clear, we need to help 3GPP to achieve a quick consensus on the IoT NTN solution during the study item, move to the normative phase and show MNOs and applications providers how to take advantage of this global outdoor seamless and cost effective solution from space.

Massive IoT is the focus. MNOs have to realize the big potential of it to transform our society "because a connected world is a better world". MNOs need global coverage and applications. It is among Sateliot's goals to push for the creation of an ecosystem of specialized companies that can bring together solutions where MNOs have the unique opportunity to offer the connectivity and reach billions of new objects connected. Sateliot is a member of strategic organizations and is participating in many forums to stimulate this approach.

The following observations are developed in this document:

- Market opportunity for a global, integrated terrestrial/NTN IoT solution:
    - ➔ **There is a growing market for cellular IoT connections, especially in the massive IoT segment. The addition of NTN features with low marginal costs for cellular IoT devices can only contribute to further expand this market beyond current projections by exploiting the benefits of global / ubiquitous coverage and redundancy.**
    - ➔ **The addition of NTN features into the cellular IoT standards is a necessary message to the industry that the 3GPP community is committed to deliver global solutions for the massive IoT market and help mitigate technology selection risk and fragmentation.**
- Economically viable satellite solutions to support early IoT NTN deployments:
    - ➔ **There are economically viable solutions ready to support early NB-IoT NTN service deployment in the 2022/2023 timeframe and so start harnessing and promoting this market. Among them, solutions based on sparse LEO constellations of nanosatellites are poised to address a wide-range of delay-tolerant IoT applications.**
- Risk of losing market advantage in front of competing technologies:
    - ➔ **Non-3GPP satellite IoT solutions, some already capitalizing on the advantages of the New Space industry and the adaptation of terrestrial LPWA protocols for satellite access, start to be introduced to address the massive satellite IoT market opportunity. Urgent need for 3GPP to act in order to avoid 3GPP cellular IoT standards to lose competitive advantage in front of early movers.**
- Sateliot approach and roadmap towards NB-IoT NTN service delivery:
    - ➔ **Several companies have already secured investments and are conducting technology and service model developments under the expectation to have a minimum IoT NTN capability under 3GPP Rel-17.**
    - ➔ **Multiple potential use cases are already identified but the technology roadmap is still uncertain about when a global solution is going to be available, hindering a more active involvement of MNOs, engineering companies and application providers.**
    - ➔ **In Sateliot's view, a NB-IoT NTN solution based on the use of sparse LEO constellations of nanosatellites is an economically viable solution to start shaping and unleashing the potential of this market in the coming years.**

Because of the above, it is proposed:

- **Proposal: To discuss the way forward to secure the normative phase for an initial/minimum NB-IoT NTN solution to be completed under Release 17, which would allow early launching of commercial services based on 3GPP standards during the 2022-2023 timeframe.**

5. References

[1] RP-192670, "Satellite NB-IoT Urgency for a global standard", MediaTek Inc., Qualcomm, Eutelsat, Novamint, VTT Technical Research of Finland Ltd, Ligado, Inmarsat, 3GPP TSG RAN#86, Sitges, Spain – December 9th-12th, 2019

[2] RP-193235, "Study on NB-Io/eMTC support for Non-Terrestrial Network", MediaTek Inc, 3GPP TSG RAN Meeting #86 Sitges, Spain, December 9-31, 2019

[3] R1- 2100599, "FS_LTE_NBIOT_eMTC_NTN work plan", 3GPP TSG RAN WG1 Meeting #104-e, January 25th – February 5th, 2021

[4] R1-2101779, "Market expectations for IoT NTN", Novamint, 3GPP TSG-RAN WG1 Meeting #104e, January 25th – February 5th, 2021