**3GPP TSG-SA WG4 Meeting #132S4-250826**

**Japan, Fukuoka, 19 – 23 May 2025 Revision of S4aA250027**

**Source: Dolby Laboratories Inc., Novamint,** **Sateliot, EDF, Iridium, EchoStar**

**Title:** **Application scenario for IMS voice call using LEO and MEO satellites**

**Spec: 3GPP TR 26.940 v0.0.2**

**Agenda item: 7.9**

**Document for: Agreement**

**1. Introduction**

At the last Audio SWG ad-hoc call on FS\_ULBC that took place after SA4 #131-bis-e meeting, the sources made a contribution on Application scenarios of IMS voice call using LEO and MEO satellites [6]. The present contribution contains updates on top of [6] as per the feedback received.

At the recent SA#107 meeting, the "Study on Ultra Low Bitrate Speech Codec" has been approved. The WID [1] primarily focuses on use cases like IMS Voice Call over GEO satellites and the resulting transmission parameters. However, as indicated in clause 5.4 of TR 22.887 [2], the future of satellite communications is moving toward hybrid satellite networks utilizing the services from LEO, MEO and GEO satellites and hence use cases like IMS voice call over LEO and MEO satellite and the resulting transmission parameters should also be studied as part of the ULBC study.

Some of the hybrid use cases of IMS voice call using LEO, MEO and GEO satellite accesses is specified in clause 5.4 of TR 22.887 [2], and corresponding requirements and KPIs for LEO, MEO and GEO satellite accesses are provided in Tables 7.4.1-1 and 7.4.2-1 in TS 22.261 [3]. While the example in clause 5.4 of TR 22.887 [2] talks about maritime communication systems, the sources are of the opinion that this scenario is applicable to IMS voice services as well.

The sources recognize GEO satellite application scenario to be the top priority scenario for the FS\_ULBC study but the LEO and MEO scenarios remain very important and hence the sources are of the opinion that ULBC shall have properties that do not conflict with LEO and MEO scenarios.

#### **Reference architecture in 3GPP**

5G Satellite network-based architectures are mentioned in Figure A.8 of Annex A.2 of TR 22.822 [4]. Architectural aspects are expected to have substantial influence on requirements on the ULBC and ultimately on the voice service attributes. Therefore, the sources propose to add a separate clause on architectural aspects. Part of this clause should be a list of relevant interfaces in the end-to-end user plane path of the relevant application scenarios and their properties.

#### **Conversation communication between two-parties**

As stated in Clause 5 of TR22.887, the use case focuses on conversational communication between two parties:

* **Case I:** Mobile-originated satellite-to-terrestrial call and Mobile-terminated satellite-from-terrestrial call
* **Case II:** Satellite-to-satellite call

The IMS platform is utilized due to its ability to ensure interoperability with other operators (e.g., VoLTE/VoNR) and call systems (e.g., fixed-line networks). This means that on the terrestrial side, all originating/termination IMS-supported phone calls with satellite terminal are allowed, leading to interoperability requirements for ULBC to transcode with other operator/system-supported codecs such as AMR and EVS.

**Observation#1**: If the other party in the conversation is on a terrestrial network, transcoding between ULBC and other IMS-supported codecs available in SDP negotiation shall be supported. However, if both parties are using satellite phones that support the ULBC, transcoding may be avoided.

#### **Transmission data rate**

Transmissions data rates for satellite access are highlighted in Table 7.4.2-1 of TS 22.261 [3].

#### **Service continuity**

Service continuity is a concern that has been raised in the past especially for LEO scenarios. This is an aspect that is addressed in various use cases described in TR 22.887 [2]. Furthermore, service continuity and UE-satellite-UE requirements are also listed in TS 22.261 [3] clause 6.46.3 and 6.46.9:

* *Subject to regulatory requirements and operator’s policy, a 5G system with satellite access shall be able to support service continuity (with minimum service interruption) of a UE-Satellite-UE communication when the UE communication path moves between serving satellites (due to the movement of the UE and/or the satellites).*
* *Subject to regulatory requirements and operator’s policy, a 5G system with satellite access shall be able to support different types of UE-Satellite-UE communication (e.g. voice, messaging, broadband, unicast, multicast, broadcast).*

These requirements do include voice services operating over LEO/MEO satellite access.

**Frequent handovers**

Frequent handovers may happen in LEO and MEO scenarios mostly due to faster movement of the satellites. From IMS services point of view, the impact of such handovers should be similar to the handovers in IMS voice call use cases with terrestrial networks (the difference is that the base station is non-stationary) and should generally not impose a major issue (for e.g., what specific route a packet takes or if a packet arrives twice over different paths should not really matter in the IMS systems). It is further noted that extensive study has happened (or ongoing) inside and outside 3GPP on continuous connectivity and handovers with LEO satellites, for example, in 3GPP TR 38.821 [7] conditional handovers are described, and the following paper [8] proposes solutions for handovers for 5G LEO networks.

#### **Propagation delay**

The propagation delays via LEO, MEO and GEO satellites are highlighted in Table 7.4.1-1 of TS 22.261 [3].

**2. Reason for Change**

The present document provides the applied scenarios of ULBC in the context of voice communication via Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellites based on the use case captured in TR 22.887 [2] and requirements captured in TS 22.261 [3].

**3. Proposal**

It is proposed to agree the following changes to draft 3GPP TR 26.940 [5].

In addition, as parts of the description are based on the description of the application scenario of IMS Voice Call over GEO [9], it is suggested to backpropagate some of the edits of the present scenario description. This pertains especially to parts of the scenario description in clause 4.3.4 that are presently not covered in [9]. It also pertains to how the scenario with two satellite links is referred to and to making clear that this is a relevant scenario even if it may occur less frequently.

\* \* \* First Change \* \* \* \*

# 4 Application scenarios

### […]

## 4.3 Scenario 2: IMS Voice Call over LEO/MEO

### 4.3.1 General

This is an application scenario of ULBC in the context of voice communication via Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellites.

### 4.3.2 Background

Satellite communication plays a vital role in extending terrestrial network coverage, ensuring seamless connectivity for users. This technology unlocks new opportunities across various sectors, including smartphones and IoT. While Geostationary Earth Orbit (GEO) satellites may play an important role in delivering ultra-low-data-rate services on a global scale, LEO and MEO based satellite access may represent alternatives with attractive KPIs in terms of propagation delay and data transmission throughput. Moreover, GEO satellites may not provide full coverage at polar regions and hence a multi-orbit satellite strategy may be needed to fill the gaps.

### 4.3.3 Required KPIs

KPIs for LEO, MEO and GEO satellite accesses are provided in Tables 7.4.1-1 and 7.4.2-1 in TS 22.261 [3]. The following Table lists the maximum propagation delays for the three cases:

Table 4.3.3-1: Propagation delay via satellite access

|  |  |  |
| --- | --- | --- |
|  | UE to ground max propagation delay [ms] [NOTE1] | End-to-end latency requirement [ms] [NOTE2] |
| LEO | 26 | 35 |
| MEO | 198 | 95 |
| GEO [NOTE3] | 272 | 285 |

NOTE1: Delay between UE and ground station via satellite link; Inter satellite links are not considered.

NOTE2: 5ms network latency is assumed and added to satellite one-way delay.

NOTE3: Already described in clause 4.2.

According to Table 7.4.2-1 in TS 22.261, for the pedestrian scenario with handheld UE it is required to support experienced data rates on DL of [1] Mbit/s on DL and [100] kbps on UL. This applies for satellite access in general without distinction between GEO and NGSO. This corresponds to an area traffic capacity of 1.5 Mbits/s/km2 on DL and 150 kbit/s/km2 on UL when assuming an overall user density of at least [100]/km2 and an activity factor of [1,5]%. For GEO satellite access specific requirements apply as discussed in clause 4.2.

NOTE: The provided requirements are a working assumption in TS 22.261. These requirements may be subject to change.

### 4.3.4 Scenario Description

Editor's note: it is assumed for the time being that a codec supporting scenario described in clause 4.2 will allow to support this scenario too - it will be revised if there are contradictory evidences.

#### 4.3.4.1 General

The typical UE is a handheld device supporting LEO or MEO satellite access using NB-IoT radio access technology with built-in microphones and loudspeakers or a monaural hands-free set, as outlined in Table 7.4.2-1 in TS 22.261 [3]. This means there is no need for the user to extend the antenna or carry any extra devices to access the IMS voice call service.

Depending on support of duplex transmission mode or half-duplex only on the satellite link, the typical service may be IMS voice-only call service or push-to-talk service. The service may be used for regular and for emergency communications. Such service can be provided as:

- Supplementary regular push-to-talk service provided by the terrestrial operators, especially in areas without terrestrial coverage.

- Main regular push-to-talk service provided by the satellite operators.

- A push-to-talk service using LEO/MEO satellite access in case of emergency situations.

Subject to support of duplex transmission mode over NB-IoT access, such service can preferably also be provided as:

- Supplementary regular IMS voice service provided by the terrestrial operators, especially in areas without terrestrial coverage.

- Main regular IMS voice service provided by the satellite operators.

- An IMS voice call service using LEO/MEO satellite access in case of emergency situations.

Service continuity needs to be addressed meeting corresponding UE-satellite-UE requirements listed in TS 22.261 [3], clauses 6.46.3 and 6.46.9. Frequent handovers may happen in LEO and MEO scenarios mostly due to fast (relative) movement of the satellites. From IMS services point of view, such handovers are expected to be similar to the handovers in IMS voice call use cases with terrestrial networks (the difference is that the base station is non-stationary), where generally they do not impact service quality.

The UEs under consideration may typically be commercial smartphones, but other form factors such as IoT devices or automotive vehicles are not excluded.

In the following, different scenarios establishing an end-to-end voice service are considered.

#### 4.3.4.2 Scenario 2a: One UE connects via LEO/MEO-satellite access only

In a common scenario, one party in the conversation is assumed to be using a handheld mobile terminal over a LEO/MEO satellite network, while the other may be on a terrestrial mobile network (e.g., VoLTE, VoNR), a fixed-line connection, or another IMS-supported platform, as outlined in Figure 4.3.4.2-1, where a sketch of the bi-directional voice data flow for this main scenario is depicted.

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Figure 4.3.4.2-1: Bi-directional voice data flow main scenario

NOTE: Core network typically stands for 3GPP core network and IMS core network.

Editor’s Note: whether and how to include the interfaces and the interface corresponding capabilities are FFS

In particular, for regular IMS voice services originated from UE1 to UE2, as introduced in clause 4.3.4.1, the UE2 (the regular phone) in the IMS voice service may and typically should preferably not even be aware that UE1 is using a LEO/MEO satellite link during the communication.

In case of mere availability of push-to-talk service, users will inevitably become aware of limitations due to communication over a satellite link. As the end-to-end delay may be kept low (LEO) or moderate (MEO), collision situations in case both users talk at the same time are not expected to have bigger impact on the quality of experience of the service.

#### 4.3.4.3 Scenario 2b: Both UEs connect via LEO/MEO-satellite access

In a related scenario, both parties in the conversation are connected to a LEO/MEO or GEO satellite as outlined in Figure 4.3.4.3-1 using IMS-based communication services. This scenario may be less frequent than scenario 2a but not uncommon. Also it becomes more relevant to support multiple contexts including disaster or cyberattack with potentially no terrestrial PLMN available which will be leading to the UEs communicating through NTN.

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Figure 4.3.4.3-1: Bi-directional voice data flow sub-scenario

NOTE: Core network typically stands for 3GPP core network and IMS core network.

Editor’s Note: whether and how to include the interfaces and the interface corresponding capabilities are FFS

When the satellite operates in a transparent payload mode, the voice packets are transmitted to the ground before transmitted to the other UE, even if both UEs are connected to the same satellite.

For regular IMS voice services between UE1 and UE2, the two involved satellite links may cause build-up of substantial end-to-end delay, especially if GEO satellites are involved. Except for the case where both involved satellites are on LEO, this may make it difficult to keep the users unaware of the fact that this is a service over satellites.

In case of mere availability of push-to-talk service, the build-up of end-to-end delay may increase the collision risk in case both users talk at the same time, which will have an impact on the perceived quality of experience. Again, this risk is higher in case GEO satellites are involved and low in case both satellites are on LEO. To avoid such impacts, effective floor control mechanisms are required that can cope with the latencies introduced by the satellite links.

### 4.3.5 Derived high-level prerequisites

Editor’s note: The high-level prerequisites will be derived once the full set of requirements and key interface properties are set.

\* \* \* Second Change \* \* \* \*

# 5 Architectural aspects

### 5.1 Interfaces and interface properties

### 5.1.1 General

This clause identifies the relevant interfaces between architectural entities such as UEs, satellites, ground stations, MGW, eNBs. Relevant interface properties are described.

### 5.1.2 Interfaces

Editor’s note: identify all interfaces such as UE1 -> satellite (UL), UE1 <- satellite (DL), satellite -> ground station (DL), satellite <- ground station (UL), ground station -> eNB1, ground station <- eNB1, eNB1 -> UE2, eNB1 <- UE2, eNB1 -> MGW -> UE2, eNB1 <- MGW <- UE2

### 5.1.3 Interface properties

Editor’s note: Describe basic parameters like applicable radio access technologies (NB-IoT, LTE-M), duplexing mode (half-duplex, full-duplex), min latency, bit rate limits, traffic characteristics, transparent vs regenerative payload options.

\* \* \* End of Changes \* \* \* \*

## References

[1] Tdoc [SP-250378](https://www.3gpp.org/ftp/tsg_sa/TSG_SA/TSGS_107_Incheon_2025-03/Docs/SP-250378.zip), "Study on Ultra Low Bitrate Speech Codec"

[2] TR 22.887, "Study on satellite access - Phase 4"

[3] TS 22.261, "Service requirements for the 5G system"

[4] TR 22.822, "Study on using satellite access in 5G"

[5] 3GPP TR 26.940, "Study on Ultra Low Bitrate Speech Codecs"

[6] Tdoc S4Aa250027, “Application scenario for IMS voice call using LEO and MEO satellites”

[7] 3GPP TR 38.821, “Solutions for NR to support non-terrestrial networks (NTN)”

[8] Enric Juan et al., “Handover Solutions for 5G Low-Earth Orbit Satellite Networks”

[9] Tdoc S4aA250024, "Application scenario for IMS voice call using GEO satellite"