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**pCR Title: Updates of IMS Voice Call using GEO satellite access**

**Draft Spec: 3GPP TR 22.887**

**Agenda item: 7.3**

**Document for: Approval**

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*Abstract: This document provides a text update for the use of IMS voice calls using GEO satellite access.*

**1. Introduction**

This contribution is to provide updates to the GEO IMS voice call use case.

**2. Reason for Change**

There were 2 controversial issues discussed/left in the SA1#106 meeting for the use case of IMS voice calls using GEO satellite access:

* Issue#1: whether and how to introduce codec requirements in SA1
* Issue#2: how to introduce KPI parameters and values in SA1

SA1 focuses on what services need to be provided and the high-level system behavior needed to support these services. Supporting satellite access as one kind of access technology was first approved in Rel-17, as shown in Table 7.4.2 in TS 22.261 [2], KPI parameters such as UE type, data rate, etc are discussed for several services (especially new ones such as video surveillance), however, there is a lacking of KPI parameters discussion when supporting IMS voice service, which is a rather default service supported by 3GPP (since Rel-5).

**Proposal#1: data rate and UE type (handheld vs non-handheld) are two KPI parameters that are necessary to be discussed to support IMS using GEO satellite access**

SA1 typically does not delve into technical specifications at the level of codec implementation, as this is often handled by other working groups like SA4 that are more focused on the technical aspects of media processing and delivery. However, the codec has direct relationship to the following aspects, which are related to SA1’s service:

* **Service Quality**: The choice of codecs can directly affect service quality, including voice and video clarity, latency, and user experience. SA1 may need to define requirements that indirectly influence codec choice to ensure these service quality metrics are met.
* **System Interoperability**: Specifying codec requirements can aid in ensuring that different systems and devices can interoperate smoothly, which is crucial for a seamless user experience across different networks and services.
* **Bandwidth and Resource Management**: Different codecs have varying demands on bandwidth and computational resources. SA1 may need to consider these factors to ensure that network resources are used efficiently.

Therefore, when IMS voice service was introduced in 3GPP, codec-related aspects were discussed in SA1 in several ways, as shown in TS 22.228 [3] and highlighted below, e.g.:

* Clause 5 “IP multimedia sessions shall be able to support a variety of different media types. A set of media types shall be identified to ensure interoperability (e.g. default codec selection and header compression)”
* Clause 5 “IMS shall be capable to provide transcoding (at least for voice sessions) where needed when two UEs do not support a common codec”
* Clause 11 “The 3GPP UE shall make available for use by the WebRTC IMS client the codecs whose support is mandatory for the access technology being used to access IMS services”

**Observation#1**: codec-related aspects can be discussed in SA1 from the service’s perspective.

**Observation#2**: as discussed in S1-241247, and newly introduced Annex-A in this pCR, transmission data rate has a direct relationship with codec bit rate, and protocol header. It should be clear that in order to support the transport of IMS voice over a radio medium in given radio conditions, a codec is required that is compatible with the data rate this medium can sustain in these radio conditions.

**Proposal#2: to support IMS voice using GEO satellite access, a codec is needed, compatible with the access network’s transmission data rate, while the codec implementation such as codec bit rate, algorithm delay, etc is to be defined in SA4.**

Generally, setting up an IMS voice call takes (and is expected to take) 4-5 seconds in the terrestrial network. This will expectedly take longer when utilizing GEO satellite access given the propagation delays involved (one-way propagation from terminal to gateway is around 280ms). Considering that the support of voice over GEO satellite access will be useful in particular in situations where no other coverage exists, and where a user may be requiring assistance, longer call set-up delays should not only be possible but also expected by the end user. To consider the customer’s patience and quality of user experience, the call setup time should not be too long. As indicated in [xb] considering the user’s patience, the average speed of answering is suggested to be less than or equal to 30 seconds.

[xb]: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8177735/

**Proposal#3: call setup delay is suggested to be a KPI parameter and the value is suggested to be between [4-20] seconds.**

Mouth-to-ear delay refers to the total time it takes for spoken words to travel from a speaker's mouth to a listener's ear in a communication system. This delay is influenced by several key components, including processing delay, which involves the time for encoding and decoding audio signals; queuing delay, caused by packets waiting in network queues; codec algorithm delay, which stems from the time taken by the algorithm to compress and decompress audio; jitter buffer delay, introduced to counteract variations in packet arrival times; transcoding delay, which occurs when converting audio between different codec formats; and propagation delay, the time it takes for the signal to travel across the network. Each of these factors plays a crucial role in determining the overall quality of voice communication, with excessive delays potentially leading to poor call quality and disruptions in natural conversation flow. Managing these delays is essential to maintain high-quality voice transmission.

**Observation#3**: Many delays, including codec algorithm delay, jitter buffer delay, and transcoding delay, depend on the codec, with the exception of propagation delay.

**Proposal#4: SA1 only accounts for propagation delay, leaving other delays, such as codec delay, jitter buffer delay, and others, to be defined by SA4.**

Considering the data rate over GEO satellites, optimization should not just entail the call setup but also the media transmission stream (as illustrated in clause 5.1.1 of TR 22.887). To optimize for the GEO satellite access technologies it is thus a necessity lower the data rate of the RTP streams with the voice media. This should consist of

* Reduced data rate for speech codec payload
* Reduced data rate for protocol overhead

For IMS voice, the protocol header overhead (RTP+UDP+IP with RoHC and PDCP+RLC+MAC) for the transmission is 56 bits, which is equivalent to 2.8 kbps for the regular VoIP transmission intervall of 20 ms. The ratio between payload and protocol overhead is thus in the worst case 0.4 kbps (S1-241071) to 2.8 kbps meaning the protocol overhead is **seven times higher** than the actual payload.

**Observation**#4: the worst case currently available in 3GPP (AMR at 4.75 kbps plus RTP payload header according to RFC4867 which totals to 5.6 kbps) shows a ratio of 2 for payload / protocol overhead, meaning the protocol overhead is **half** the codec payload.

**Proposal#5:** To ensure a healthy ratio of protocol overhead vs. real payload results from the optimization process, some guidelines are proposed.

**3. Conclusions**

Based on the above observations and proposals, the use case is proposed to be updated with potential requirements, KPI parameters, and values.

**4. Proposal**

It is proposed to agree the following changes to 3GPP TR 22.887 v0.1.0.

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

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 22.261: “Service requirements for the 5G system”

[3] 3GPP TS 22.228: “Service requirements for the Internet Protocol (IP) Multimedia core network Subsystem“.

[4] ITU-T E.800: "Definitions of terms related to quality of service ".

[5] ITU-T G.114: "One-way transmission time".

[6] ITU-T G.107: "The E-model: a computational model for use in transmission planning "

[7] X. Huang, W. Qi, X. Xia, Y. Sun, Z. Sun and M. Peng, "IoT NTN for Voice Services: Architectures, Protocols, and Challenges," in IEEE Network, 2024.

[8] “Satellite firms forge unlikely alliances to create seamless multi-orbit networks”, <https://spacenews.com/satellite-firms-forge-unlikely-alliances-to-create-seamless-multi-orbit-networks/>, March 2024

[9] “Autonomous shipping”, <https://www.imo.org/en/MediaCentre/HotTopics/Pages/Autonomous-shipping.aspx>

[10] Dhinesh Kumar R, Rammohan A, Revolutionizing Intelligent Transportation Systems with Cellular Vehicle-to-Everything (C-V2X) technology: Current trends, use cases, emerging technologies, standardization bodies, industry analytics and future directions. *Vehicular Communications*, Vol.43, 2023, 100638

[11] 5G Automotive Association (5GAA), C-v2x use cases and service level requirements -volume i，5GAA website, <https://5gaa.org/c-v2x-use-cases-and-service-level-requirements-volume-i/>, 2019

[xb] <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8177735/>

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

## 5.1 Use case of IMS Voice Call Using GEO Access

### 5.1.1 Description

Using regular mobile phones to make voice calls via satellite access is becoming increasingly popular, especially due to the advantage satellites have in providing coverage in rural and remote areas [7]. Satellite voice call services in 3GPP provide consistent network connectivity, accessible at any time and place, facilitating smooth communication across both terrestrial and satellite networks.

Since Release 17, GEO satellite access has been included in the 3GPP standards as an access technology for 5G, supporting all types of media like voice, data, and video by default [2]. However, due to the unique challenges of GEO satellites—such as 35,786 km distance from the earth, around 285ms signal delays, and atmospheric attenuation—the data rates cannot be increased simply by expanding the bandwidth, which results in the services supported by Non-Geostationary Satellite Orbit (NGSO) may not be supported by GEO.

Voice calls using the IMS (IP Multimedia Subsystem) platform have been a standard feature since the 3GPP's Release 5 [3]. Due to IMS's capability to support diverse multimedia services and ensure interoperability, several services have subsequently been added, including IMS emergency calls, messaging, group management, push-to-talk, and real-time communications. These enhancements have positioned IMS as a critical tool for connecting different operators and service providers for voice calls across various types of access networks. However, when integrating IMS with GEO satellite access within the 3GPP framework, 3 main aspects impact the quality of experience:

* **One-way transmission delay aspect**: also known as mouth-to-ear delay, is the time from when a call is initiated to when it is heard. This delay significantly impacts the R score in the E-Model [6], which assesses voice call quality. Managing this delay is key in network design to achieve higher R scores. The ITU-T recommends a maximum delay of 400 milliseconds for network planning [5]. However, with GEO satellite access, the propagation delay is much longer than other technologies (285ms), necessitating careful calculation of the delay budget. This careful management is crucial when adapting IMS voice calls to GEO satellite access to ensure greater user satisfaction.
* **Codec bitrate aspect**: codec bitrate refers to a bit rate used to encode/decode human voice speech for digital transmission. The relationship between a codec and data rate is critical, as it determines how efficiency a voice speech can be transmitted in the digital communication systems. For many years, the focus for the development of 3GPP voice codecs was to improve voice quality for clean and impaired channels at keeping the data rate approximately constant. For example, significant improvements regarding the audio quality have been made comparing the AMR codec, which supports bitrates ranging from 4.75 to 12.2 kbps, and the development of the 5G voice codec EVS, which delivers superior sound quality at bitrates between 5.9 and 128 kbps. In contrast, GEO satellite systems typically only support significantly lower data rates within the 3GPP framework.
* **Call setup time aspect**: call setup time is critical in both traditional telephony and modern IMS systems, as it heavily impacts user satisfaction and the perceived quality of the service [4]. Shorter call setup times are particularly important as they can significantly improve the user experience. Advancements in 3GPP standards have led to network optimizations that reduce these delays and enhance processing speeds. However, incorporating GEO systems into these networks poses challenges, typically resulting in longer setup times due to the latency, limited achieved data rate inherent in GEO system.

Thus, this use case is designed to leverage the integration of IMS systems and GEO in 3GPP to enhance the quality of voice call services.

### 5.1.2 Pre-conditions

A screen shot of a computer

Description automatically generated

Figure 5.1.2-1: Mobile phone supports both terrestrial and GEO satellite access to support IMS voice

MNO-A employs its own GEO satellites or those of a satellite operator under service/roaming agreements to offer an IMS voice call service using GEO satellite access.

The GEO satellite access might involve a new satellite deployment or an existing GEO satellite system, as depicted in Figure 5.1.2-1.

Tom uses a mobile phone that can connect to both terrestrial networks and the GEO satellite system. His phone is equipped with encoding and decoding technologies that compress and decompress human voices for transmission via GEO satellite access.

### 5.1.3 Service Flows

**Step 1** (**Tom’s mobile phone subscribes to the IMS voice call service using GEO satellite access):** Tom resides in Mardiv and earns his living by leading a fishing team. Whenever he heads out to fish, he ensures to report his safety once he arrives at the fishing spot. To maintain communication, Tom currently uses two different devices: a satellite terminal for calling his family when terrestrial coverage is unavailable, and a regular mobile phone when within coverage. However, Tom is looking to streamline his communication setup by using a single mobile phone that works anywhere, anytime. MNO-A offers such a service, and Tom has opted into their IMS voice call service using GEO satellite access to stay connected seamlessly.

**Step 2** (**Tom’s mobile phone registers to the IMS platform provided by MNO-A**):

MNO-A has upgraded its IMS platform to support the IMS voice call service using GEO satellite access. As with the existing IMS setup, Tom’s mobile phone must be registered with the IMS platform before he can access the service. During this registration process, the platform records details such as the capabilities of the mobile phone and access network information. To ensure he can use the IMS voice call service, Tom completes the registration, enabling his mobile phone to connect seamlessly through this enhanced IMS platform.

**Step 3**

**Sub-scenario 1** (**Satellite MO call to a terrestrial network**): Tom calls his wife, who is in the city center of Male:

* Aware that he's using a satellite phone, Tom waits patiently for a while before the ringing tone starts.
* As the call is transmitted via satellite, the IMS platform transcodes the voice data stream between a codec that is suitable for low-bit rate transmission at the satellite MO side and a codec that is suitable for the terrestrial side.

**Sub-scenario 2** (**Satellite MT call from a terrestrial network**): Tom’s mother, who is subscribed to MNO-B and located in Bangkok, calls Tom:

* MNO-B’s IMS platform communicates with MNO-A’s IMS platform to transfer the call request to Tom.
* MNO-A’s network locates Tom, paging him to reconnect to MNO-A’s IMS platform.
* Knowing she’s making a satellite phone call, Tom’s mother waits patiently a while before she hears the ringing tone.
* The IMS platforms transcodes the voice codec as in sub-scenario-1.
* During the call, Tom’s mother informs him about an approaching thunderstorm and advises him to head to the nearest safe harbor.

**Sub-scenario 3** (**Satellite MO call to a satellite MT call**): Tom calls his friend Pasi, who also uses a mobile phone equipped with IMS voice service using GEO, to locate the nearest safety port as a thunderstorm approaches:

* The IMS platform does not need to transcode the codec since both mobile phones use the same low bit rate codec suitable for satellite communication.

### 5.1.4 Post-conditions

Thanks to this IMS voice call service using GEO satellite access, Tom can make an IMS voice call anywhere, anytime by using only one mobile phone.

### 5.1.5 Existing feature partly or fully covering use case functionality

**From TS 22.261:**

A 5G system providing service with satellite access shall be able to support GEO based satellite access with up to 285 ms end-to-end latency.

NOTE 1: 5 ms network latency is assumed and added to satellite one-way delay.

A 5G system with satellite access shall be able to support low power MIoT type of communications.

The propagation delay via satellite associated with these orbit ranges can be summarized in Table 7.4.1-1:

**Table 7.4.1-1: Propagation delay via satellite**

|  |  |  |  |
| --- | --- | --- | --- |
|  | UE to serving satellite propagation delay [ms] [NOTE 1] | | UE to ground max propagation delay [ms] [NOTE 2] |
|  | Min | Max |
| LEO | 3 | 15 | 30 |
| MEO | 27 | 43 | 90 |
| GEO | 120 | 140 | 280 |
| NOTE1: The serving satellite provides the satellite radio link to the UE  NOTE2: delay between UE and ground station via satellite link; Inter satellite links are not considered | | | |

**From TS 22.228:**

IMS shall be capable to provide transcoding (at least for voice sessions) where needed when two UEs do not support a common codec.

IP multimedia sessions shall be able to support a variety of different media types. A set of media types shall be identified to ensure interoperability (e.g., default codec selection and header compression).

The IMS network and intermediate networks shall support codec negotiation across one or multiple interconnects to minimise transcoding (and preferably eliminate it) to provide the highest quality service to the user.

If two UEs, belonging to two IMS networks, do not support a common codec for voice service session, the network and/or intermediate networks shall be capable to provide transcoding functionality at the interconnection point.

### 5.1.6 Potential New Requirements needed to support the use case

#### 5.1.6.1 Potential Service Requirements

[PR 5.1.6.001] The 5G system with GEO satellite access shall be able to support IMS voice communication as defined in TS 22.228 [3].

[PR 5.1.6.002] The 5G system with GEO satellite access shall be able to provide mechanisms to optimize IMS voice (e.g. call setup, transmission overhead) considering the transmission data rate, latency and payload.

[PR 5.1.6.003] The 5G system with GEO satellite access shall be able to support a codec suitable for the transfer of voice considering the transmission data rate and latency provided by the 5G system with GEO satellite access.

#### 5.1.6.2 Potential KPI Requirements



|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Scenario** | **UE type** | **Transmission data rate** | | **Call setup time**  NOTE 1 |
| **UL** | **DL** |
| IMS voice call using GEO | Handheld | [1-3] kbit/s | [1-3] kbit/s | [4-30] s  NOTE 2 |
| NOTE 1: call set up time refers to [4];  NOTE 2: the lower bound of 4s originated from the experience in terrestrial VoNR/VoLTE, while the upper bound of the 20s is derived based on the user’s patience suggestions (30s) in [xb]; | | | | |

\* \* \* End of Change \* \* \* \*